

POR T AUTHORITY OF ALLEGHENY COUNTY

NORTH SHORE CONNECTOR

CONTRACT NO. NSC-009

**Technical Provisions
Volume 2**

**NSC TRAIN SYSTEM (SYSTEM WIDE)
(NSC-009)**

FTA PROJECT NO. PA-03-0315

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Port Authority of Allegheny County
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**Port Authority of Allegheny County
NSC-009 NSC Train Systems (System Wide)**

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END VOLUME 2

SECTION 01738
LOCK OUT/TAG OUT

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals, necessary for lock out/tag out, in accordance with the contract documents.

1.02 RELATED SECTIONS

- A. Section 00700, "General Conditions,"
- B. Section 01300, "Administrative Requirements,"
- C. Section 16250, "Circuit Breaker Room and Tie-Breaker Station General Requirements."

1.03 REFERENCED STANDARDS

- A. ANSI Standard Z 244.1 – 1982.
- B. OSHA Title 29 CFR Part 1910.

1.04 SUBMITTALS

- A. "Register of Scheduled Power Outage on Port Authority Property" three working days prior to the scheduled outage.

ARTICLE 2 PRODUCTS

2.01 GENERAL

All tools, materials and equipment used shall meet the requirements of Authority Policy Statement and Guidelines for Lock Out/Tag Out and Authority Lock Out/Tag Out Guidelines.

ARTICLE 3 EXECUTION

3.01 AUTHORITY LOCK OUT/TAG OUT

- A. Contractor shall refer to attached Authority "Lock Out/Tag Out Statement," "Lock Out/Tag Out Guidelines," and "Register of Scheduled Power Outage on Port Authority Property."

- B. The requirements of this Section are in addition to the Right-of-Way Allocation Request, procedure described in the Terms and Conditions Section 00700 – General Conditions, Article 13, Section 13.14 Transit Corridor/Property Safety Conditions.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

PORT AUTHORITY OF ALLEGHENY COUNTY

POLICY STATEMENT

SUBJECT: LOCK OUT/TAG OUT STATEMENT

The Port Authority owns and operates traction power substations that convert alternating current (AC) to usable alternating and direct currents (DC). This power is then used to feed the overhead and signal systems and subway station. The "feeder" system provides nominally 650 volts DC, has a minimum capacity of 2,000 amps, and is not insulated. Lack of insulation heightens the dangers associated with inadvertent contact. Also, many of the feeder sections are dual feed, which means power is received from two (2) separate substations. The signal power supply is nominally 2,300 volts AC. The feed to the subway stations is 23,000 volts AC. With this sophisticated and potentially deadly electrical system along the entire rail line, Port Authority has developed the attached "Register Of Scheduled Power Outage On Port Authority Property" procedure.

Effective immediately, all scheduled substation power outages will follow the "Register Of Scheduled Power Outage On Port Authority Property" procedure. Among other requirements, a three-working day notice will be mandatory for scheduled outages.

Michael S. Moorman
Manager of Facilities

October 1, 1992

POR T AUTHORITY OF ALLEGHENY COUNTY

LOCK OUT/TAG OUT GUIDELINES

These guidelines are for work performed on or near exposed energized and de-energized parts of electric equipment. These procedures supplement electrical standards, and the intention is to reduce the potential for electrical accidents resulting from unsafe work practices by employees.

These guidelines generally are based on ANSI Z 244.1 - 1982. Contractors may be familiar with OSHA rules, Title 29 CFR Part 1910, which reflect the ANSI standard.

GENERAL

The effects AC electrical currents will have on a person vary from barely perceptible in the range of one millampere (1mA) to involuntary muscle control from 9 to 25 mA. From 75 mA up to 4 amps, the heart can stop momentarily and get out of rhythm, and over 4 amps the heart may stop. Also, a person can get severe injuries from internal burns. At currents as low as 20 mA, breathing can stop, and at higher currents, delayed injuries or fatality can occur.

For DC electrical currents, the effects are more dangerous at higher voltages.

There are three types of electrical burns: electrical burns caused by current flowing through tissue, arc burns which are caused by arcs or explosions close to the body, and thermal contact burns caused by skin contact with hot electrical equipment.

HOW HAZARDS OCCUR

Most electrical systems use earth ground to establish the reference voltage. Any difference in voltage from a device to ground or between devices can cause current flow through a conductor. A person touching a device of one voltage while their body is at ground or another voltage acts as a conductor allowing current to flow. If one person contacts another person whose body is at a different voltage, one or both of the persons could be injured also.

Current flow can cause injury directly, but even minor electric shock can cause secondary injury as a result of involuntary muscle reactions. These include bruises, bone fractures, and injuries resulting from falls.

Equipment and conductors, such as wires and bus bars, that have a heavy current flow can overheat and cause burns. Under very heavy or sudden loads, they can explode, sending sparks of molten metal flying through the air. Explosions or sparks could also ignite flammable liquids or gasses nearby, causing secondary explosions or fire.

NATURE OF ACCIDENTS

Most accidents are caused by unsafe practices which include those caused by faulty equipment, by deterioration of equipment, by environment such as flammable gasses, by faulty tools, and by failure to de-energize.

PROTECTIVE MEASURES

Some of the more common ways to protect employees working near electrical equipment are:

1. Insulation.
2. Guarding live parts.
3. Grounding, especially after other measures have been applied.
4. Eliminating unsafe work practices, such as carrying metal **ladders** near exposed wires.
5. Training and qualifying employees on safe methods.

QUALIFIED EMPLOYEES

There is room for judgment on who is qualified in a particular employment situation. The principal difference is those who are **QUALIFIED** have had training and have demonstrated competence in avoiding the electrical hazards of working on or near exposed energized parts. Those who are **UNQUALIFIED** are those with little or no training.

Training covers safe work practices and includes:

1. Keeping proper distance from energized parts.
2. Avoiding wet or conductive locations.
3. **LOCK OUT/TAG OUT PROCEDURES.**
4. Protective gear.
5. Live line tools.

SCOPE OF THESE GUIDELINES

These guidelines are consistent with ANSI and OSHA.

Covered under these guidelines are:

1. Contractors not under contract with Authority working adjacent to Authority electrical facilities.
2. Contractors under contract with Authority working adjacent to Authority electrical facilities.
3. Contractors working on Authority electrical facilities.
4. Authority work.

GENERAL PROCEDURES

Lock out/tag out is a very specific procedure. Each step must be taken in sequence and completed before the next step is implemented.

LOCK OUT means to place a lock and a tag on each disconnecting device used to de-energize circuits and equipment on which work is to be performed. The lock is to be attached so as to prevent persons from operating the disconnecting device unless they resort to undue force (50 pounds) or the use of tools.

Each tag is to contain a statement prohibiting unauthorized operation of the disconnecting device and removal of the tag.

TAG OUT means that if a lock cannot be applied or if the employer can demonstrate that tagging procedures will provide a level of safety equivalent to that obtained by use of the lock, a tag may be used without a lock.

A tag used without a lock is to be supplemented by at least one additional safety measure that provides a level of safety equivalent to that obtained by the use of a lock. Examples include removal of an isolating circuit element, blocking of a controlling switch, or opening of an extra disconnecting device.

GROUNDING means the attachment of an electrical connection between de-energized parts and earth ground.

To perform a **LOCK OUT** or **TAG OUT**, follow the steps below and on the Register.

1. Prepare for shutdown.
2. Let affected employees know.
3. Turn off equipment.
4. Isolate and ground all energy sources.
5. **LOCK OUT** switches or controls, or attach tags and block controls for **TAG OUT**.
6. Test for stray energy.
7. Perform work.
8. At 30 minutes prior to work completion, it should be "standard practice" to review what must be done to restore service. At this point, personnel should begin to inspect their work for needed completion in order to clear the affected circuit.
9. After work is complete and you are sure that everyone is clear of the equipment to be reenergized, as well as removing your own grounding or other protective devices, you remove only your own lock.
10. Do not re-energize until other work is complete and all locks and tags are accounted for.

REGISTER OF SCHEDULED POWER OUTAGE ON PORT AUTHORITY PROPERTY

The Port Authority operates traction power substations that convert usable AC voltage into DC voltage for use on the rail system. The voltage is then supplied to the overhead system, signaling system, and subway stations. The following procedure is to be followed for all scheduled power outages involving any of the traction power substations.

I. Pre-Outage Activities (Part 1)

The party desiring the power outage must complete and submit a "Register Of Scheduled Power Outage On Port Authority Property" form (attached) **AT LEAST** three working days prior to the scheduled outage. This includes any contractor, agency, or Port Authority Department/Division that requires power to be de-energized. When completing the Register, any party requesting the outage would be referred to as the "Contractor." The contractor must complete Part 1 of the form and submit it to the Power & Signals section for review and approval. The name of the contractor's authorized employee is the person responsible for ensuring that the work description and safety actions are followed during the power outage.

Once received, the Power & Signals (P&S) representative will review the work description and safety actions. If there are any questions or concerns pertaining to the outage, the P&S representative will obtain the required clarification prior to approving the outage. This may require a series of meetings with the contractor. The P&S representative will also discuss the proposed outage with representatives of the Rail Operations Group prior to granting permission for the outage. This may include coordination with Road Operations when manpower is required to safely conduct the business of Port Authority. Once the P&S representative is certain the outage can be safely conducted without providing undue hardship on Port Authority's equipment and/or operations, he/she will approve the outage by signing the appropriate line in Part 1 of the Register.

If one contractor is coordinating the outage for more than one party, that contractor accepts responsibility for all contractors during the outage. If more than one contractor is working, the names of each contractor must be identified in the section for contractor's work description.

If more than one contractor will be working in an area without any one party taking responsibility, each contractor must submit a Register form for an outage.

NO OUTAGE WILL BE PERFORMED UNTIL APPROVED!

Once the outage is approved, the P&S representative will complete the portion of the Register dealing with safety actions related to the work and affected equipment. This will completely describe the actions Port Authority will take at the time of the outage.

Distribution of the Register will be as follows:

Original	Contractor
Copy	P&S
Copy	OCC
Copy	Power Outage Notification Board (P&S)

II. De-energization Activities (Part 2)

Prior to the start of the outage, a P&S supervisor will provide a copy of the Register to the employee(s) who will be taking the safety actions in the traction power substation. The P&S supervisor will also ensure that the employee(s) performing the outage fully understand(s) the safety actions to be performed.

The contractor will report to the substation to initiate the power outage by presenting the original Register.

NOTE: If the contractor does not present the original Register, the outage will be immediately canceled and OCC notified.

The P&S employee will contact the Operations Control Center (OCC) to have the appropriate breaker opened (de-energized). The P&S employee will then rack out that breaker and place a lock from the substation on the breaker or cubical, giving the contractor the corresponding tag. This procedure will be repeated until all the necessary breakers are de-energized.

The P&S employee will then complete the "Safety Actions Completed" portion of the Register and sign under "PAAC Employee's Signature." The contractor must then sign the acceptance part of the Register in Part 2. If the contractor does not sign, the outage is immediately canceled, and OCC or a P&S supervisor is to be notified immediately.

If more than one contractor has requested a particular breaker be de-energized, each must present a Register for their company, and the locks will be "ganged" on the breaker or cubical. (Once the lock is placed on a breaker or cubical and the corresponding tag issued, that lock is not to be removed and power restored until the tag is returned and the contractor signs the appropriate line in Part 3 of the Register.)

If the outage requires action at more than one substation, the contractor(s) must report to each substation with the above actions taken.

For outages longer than 24 hours, signs will be installed on the overhead to define the safe work area. These signs will read "Limit Of Work Area."

For outages less than 24 hours where there is a potential for the contractor(s) or Port Authority forces working near the interface of energized and non-energized lines, the warning signs will be installed.

For every outage, Port Authority will post an outage notice to inform the P&S employees where and when outages will occur.

All entries should be done on the original Register.

III. Re-energization Activities (Part 3)

The contractor must schedule the work to allow ample time to re-energize the circuit prior to the estimated finish time. When the contractor returns to the substation to reenergize the circuit(s), he/she must sign the Register on the Contractor's line in Part 3.

If the contractor does not sign this line, the circuit is not to be re-energized until inspected.

If more than one contractor is working in the area, each must sign the register relating to their company prior to the circuit being re-energized.

If all contractors have not reported back to the substation within 15 minutes of the estimated finish time, OCC is to be notified so an inspection of the area can be performed. Once the inspection is performed, the person performing the inspection will sign the Register on the Contractor's line in Part 3.

Power will be restored when the same contractor's signature appears in Part 3 of the Register that appears in Part 2 of the Register or an inspection has been completed by a Port Authority representative who signs the Register in Part 3 for the contractor.

The contractor will be held responsible for any delay in service and may be charged for Port Authority's expenses for inspection up to and including loss of revenue.

The P&S employee at the substation will then sign the PAAC Acceptance line of the Register. This procedure will be followed at each substation involved in the outage. The original Register will be kept by the P&S employee at the substation and returned to his/her supervisor as soon as possible. The original Register will then be kept in Port Authority's file with a copy returned to the contractor, if requested.

Once all the locks are removed from the breaker or cubical, the breaker will be racked back in and control returned to OCC. OCC will then be contacted to re-energize the circuit.

This procedure has been developed to ensure safe power outages for both Port Authority and any contractors working on or around Port Authority equipment. It is critical that each step be followed completely. If there are any questions regarding this procedure or the ability to safely re-energize a circuit, make sure they are answered as soon as possible or, at a minimum, prior to re-energizing any circuit.



**REGISTER
OF SCHEDULED POWER OUTAGE
ON PORT AUTHORITY PROPERTY**

CONTRACTOR COMPANY NAME _____		TEL _____	PART 1						
<table border="1"><thead><tr><th>ESTIMATED STARTING DATE AND TIME</th><th>ESTIMATED FINISH DATE AND TIME</th><th>WORK LOCATION</th></tr></thead><tbody><tr><td> </td><td> </td><td> </td></tr></tbody></table>		ESTIMATED STARTING DATE AND TIME	ESTIMATED FINISH DATE AND TIME	WORK LOCATION					
ESTIMATED STARTING DATE AND TIME	ESTIMATED FINISH DATE AND TIME	WORK LOCATION							
Contractor's Work Description Including Safety Actions Related to the Work: <hr/> <hr/>									
PAT'S Safety Actions Related to the Work: <input type="checkbox"/> LOCK OUT <input type="checkbox"/> TAG OUT <input type="checkbox"/> OTHER _____ <hr/> <hr/>									
Affected Equipment: _____ <hr/> <hr/>									
Contractor Authorized Employee: _____		Print Name _____	Signature _____						
Permission Granted And Schedule Approved: _____		Signature PAT Authorized Representative _____							
PART 2									
INSTRUCTIONS RECEIVED, SAFETY ACTIONS COMPLETED									
Equipment has been cleared, Safety Devices have been installed.									
PAT Acceptance	Date And Time	Employee Signature							
Contractor	Date And Time	Authorized Signature							
PART 3									
Safety Devices have been removed persons are clear from the Working Area. Contractor warrants that the electrical circuit is safe to energize.									
Contractor	Date And Time	Authorized Signature							
PAT Acceptance	Date And Time	Employee Signature							

FORM NO. 12-0255

- INSTRUCTIONS -
FOR COMPLETION OF REGISTER OF
SAFETY REQUIREMENTS UNDER CONTRACTOR'S WORK
ON PORT AUTHORITY PROPERTY

Under Scheduled Power Outage On Port Authority Property, follow steps below:

Part 1

Contractor's authorized employee must provide his/her name, the company's name and telephone number. By signing the "Register," the contractor certifies that they have read the Authority's "Instructions" for safety requirements, including lock out/tag out procedures, and agrees to abide by these procedures.

Contractor's authorized employee must coordinate safety actions a minimum of three days in advance with PAAC's authorized representative and provide an estimated start and finish date and time and work location, with a brief work description, including safety devices to be used.

PAAC's authorized representative will explain "PAAC's Safety Actions" and identify the "Affected Equipment." Only that equipment identified will be cleared with the outage. Both parties will sign in the appropriate location.

Part 2

Contractor's and Authority's authorized employees will meet, at the predetermined location, and follow their instructions to clear the equipment for the outage. Upon the completion of "Safety Actions" both employees will sign the "Register" in the appropriate location.

Part 3

On or before the estimated finish "Date and Time" the contractor's authorized employee will return to the location and inform PAT's authorized employee of the status in the 'Working Area.' if the circuit is safe to energize, both employees will sign the "Register" and the Authority's employee will remove tags and locks from the affected equipment and energize the circuit.

The Authority retains the right to deny access to or provide work permission to any Authority's work area(s), including ejection of the Contractor from the Authority's property, as deemed in the best interest of the Authority and without cause.

Prolonged outages may require additional agreements.

Any person, other than a contractor, performing work requiring a power outage will assume the obligations and responsibilities of "Contractor."

END OF SECTION

SECTION 01739

QUALITY AND CONFIGURATION MANAGEMENT

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals, necessary for quality and configuration management, in accordance with the contract documents.

1.02 RELATED SECTIONS

- A. Section 01300, "Submittals."
- B. Section 01400, "Quality and Product Reference."
- C. Section 13570, "Signal System Requirements."

1.03 REFERENCED STANDARDS

- A. ANSI/IEEE Standards 730, 828, and 1012.
- B. ISO Standard 9001.

1.04 SUBMITTALS

- A. Quality Assurance Program (QAP).
- B. Software Quality Assurance Plan (SQAP).
- C. Software Verification and Validation Plan (SVVP).
- D. Configuration Management Program (CMP).
- E. Software Configuration Management Plan (SCMP).

1.05 RESPONSIBILITIES

- A. Contractor shall be responsible for the quality of all deliverables, regardless of any approval or interim inspection or test. Compliance with the approved Quality Assurance Program (QAP) shall not relieve Contractor's responsibility to comply with all requirements of the Contract Documents.

- B. All quality assurance activities and associated deliverables, including documentation, tests, audits and inspections shall be performed by an independent quality assurance team, having no direct responsibility for the other work being accomplished by Contractor.
- C. Contractor and its major Subcontractors (those receiving 5 percent or more of the total Contract sum) shall be compliant to ISO-9001 standards at the time of Contract award and remain compliant throughout the Contract.

ARTICLE 2 PRODUCTS

2.01 [NOT USED]

ARTICLE 3 EXECUTION

3.01 QUALITY ASSURANCE PROGRAM (QAP)

- A. Contractor shall establish and maintain a QAP that meets the requirements of the Terms and Conditions Section 01400 – Quality and Product Requirements.

3.02 SOFTWARE QUALITY ASSURANCE PLAN

- A. Contractor shall provide a Software Quality Assurance Plan (SQAP). The SQAP shall comply with the IEEE Standard for Software Quality Assurance Plans (ANSI/IEEE Standard 730) and Contractor shall design its software in accordance with the SQAP after approval by the Engineer. For the purpose of this standard, all software developed and/or delivered pursuant to the Contract Documents shall be deemed to be critical software, and comply with the SQAP.
- B. Semi-custom software and commercial-off-the-shelf (COTS) packages shall be properly tested for their application. At a minimum, ANSI/IEEE Standard 730 requirements for documentation and configuration management shall apply to these previously developed packages.

3.03 SOFTWARE VERIFICATION AND VALIDATION PLAN

- A. Contractor shall provide a Software Verification and Validation Plan (SVVP) for review and approval of the Engineer. The SVVP shall comply with ANSI/IEEE Standard 1012.
- B. Contractor shall verify and validate all software in accordance with this plan and submit documentation for approval of the Engineer.

3.04 FIELD QUALITY ASSURANCE

- A. During the installation and test phase of the Work, a representative of the Contractor's quality assurance department shall be provided on-site and full-time to oversee the

Contractor's QAP and monitor and verify installation and test activities for compliance with the requirements of the Contract Documents.

- B. Field quality assurance personnel shall be experienced in the type of work being accomplished by Contractor and be subject to approval of the Engineer.

3.05 CONFIGURATION MANAGEMENT

- A. The Contractor shall prepare and submit a Configuration Management Program (CMP) to the Engineer for approval. Through this program, the Contractor shall manage changes to the systems design until the end of the guarantee period.
- B. The Contractor shall have and/or implement a Configuration Management Program prior to Conceptual Design Review (CDR).
- C. Commercially applied documentation and control practices may be used up to the Final Design Review (FDR) if the process provides an audit trail of all changes and the Engineer has access to these records.
- D. Pre-FDR, the Engineer's prior approval-disapproval of design changes shall not be a prerequisite, providing that the change does not alter the terms and obligations set forth in the Contract Documents.
- E. The Contractor shall maintain and make available accurate and current configuration records to the Engineer throughout the performance of the Contract and thereafter as required by the Contract Documents.
- F. The risk of procuring, or producing, any hardware or software shall belong solely to the Contractor until such items have been approved by the Engineer.
- G. All items, beginning with the lowest level of repair or replacement, that are identified by the same part and/or specification number shall have the same physical and functional characteristics; shall be equivalent in performance and durability; and shall be interchangeable without alteration to themselves or associated items, other than normal field adjustments. An item shall not be considered interchangeable if it requires modification for fit or performance. Old and new configuration items that require segregation shall be identified either by a new drawing number or a dash number added to the original item (if practical) and a dash number added to the drawing(s).
- H. The CMP shall contain detailed logistics of how the Contractor will monitor, document, and control changes to the Contract Documents' configuration items, including removal of obsolete specifications and drawings from use. Such configuration items encompass all hardware, software, and system elements of the Signaling and Communications Systems.

- I. All potential changes to configuration items shall be evaluated in light of whether the proposed change falls within or outside of the requirements of the Contract Documents.
- J. Contractor shall prepare and submit to the Engineer for approval a Software Configuration Management Plan (SCMP) and shall comply with the SCMP after approval. The SCMP shall comply with the IEEE Standard for Software Configuration Management Plans (ANSI/IEEE Standard 828) and shall describe the methods to be used for:
 - 1. Identifying the software configuration items.
 - 2. Controlling and implementing changes.
 - 3. Recording and reporting change and discrepancy reports implementation status.
 - 4. Conducting configuration audits.
 - 5. Identifying review and approval cycle as well as signature authority.
 - 6. Identifying the personnel responsible for maintaining the baselines and distributing the SCMP.
 - 7. Controlling the software release process, such as the creation of a version description document.

3.06 CONTRACTOR'S CUSTOMARY CONFIGURATION MANAGEMENT PROGRAM

- A. In the event the Contractor has already in place a customary and standard Configuration Management Program that essentially meets the requirements of the Contract Documents, a detailed description of that program may be submitted to the Engineer for approval of its use for the Work.
- B. If the Engineer does not approve the program, the Contractor shall either bring its existing Configuration Management Program into compliance with the Contract Documents or develop a Configuration Management Program as specified in the Contract Documents, subject to the review and approval of the Engineer.

3.07 CLASSIFICATIONS OF CHANGES

- A. The following classifications of changes apply immediately upon completion of the FDR milestone. The FDR milestone represents a design freeze. Any proposed changes to the approved Signaling and Communication Systems design shall be subject to the structured design control procedures that are defined within the Contract Documents.
 - 1. A proposed engineering change to any part, assembly or equipment item shall be designated as a Class I change when one or more of the following is affected:
 - a. Form, fit and function interchangeability.
 - b. Reliability, availability, and maintainability.
 - c. Weight or balance (where it is a factor).
 - d. Authority-furnished equipment.
 - e. Safety.
 - f. Electromagnetic-interference characteristics.

- g. Delivered product (retrofit).
 - h. Delivered training, operation or maintenance manual (where additional Contract funds are required to revise manuals).
 - i. Sources of repairable items (source control drawings).
 - j. Schedules or deliverables.
2. A proposed change to computer software shall be designated as a Class I change when one or more of the following factors are affected.
 - a. Function, performance, reliability, maintainability, correctness, efficiency, flexibility, testability, usability, or outside stated tolerance.
 - b. Interface characteristics.
 - c. Cost.
 - d. Schedules.
 - e. Authority-furnished equipment or software.
 - f. Safety.
 - g. Skill levels, training, or human engineering design.
 3. Any engineering change not affecting form, fit, function, or interchangeability, or falling within the preceding definition of a Class I change, shall be designated as a Class II change. Some examples of Class II changes are correction and clarification of Contract Documents, substitution of alternative material or hardware, or correcting a minor software "bug."

3.08 ENGINEERING CHANGE PROPOSAL (ECP) PROCEDURE

- A. ECP procedure shall apply immediately after the FDR.
- B. All ECPs shall be reviewed by the Contractor's organization responsible for configuration control for total impact-evaluation prior to recommendation and submittal to the Engineer for review and approval, where applicable.
- C. The Contractor shall process each Class I change as an ECP (format to be determined) and submit to the Engineer for approval prior to initiating any implementation action. Any action or cost necessary to correct problems in the product or documentation arising from the Contractor's misclassification shall be borne by the Contractor.
- D. The Contractor shall also classify and control changes originating from subcontractors.
- E. The ECP shall be submitted to the Engineer within ten days after the need has surfaced, accompanied by a cover transmittal identifying the areas impacted, what is gained by approving the ECP, recommended corrective measures, together with the technical documentation and the cost information necessary to fully evaluate the change.
- F. The Contractor shall report all Class I change requests that affect safety and/or that would be categorized as mission-critical (as defined by the Engineer) immediately (fax, phone, or face-to-face). The change request shall be identified by ECP number if reported verbally, then confirmed in writing to the Engineer within eight hours.

- G. Class II ECPs shall be submitted to the Engineer for information normally prior to, but in no event later than, five days after the change has been initiated.
- H. The Contractor may recommend an alternate manner in which to process Class I and Class II changes for software defects. The processing mechanism shall be clearly described in the SCMP. The SCMP shall describe how each requirement of the ECP procedure shall be addressed by Contractor.

3.09 ACCOUNTABILITY

- A. For the duration of the Contract, the Contractor shall maintain records such that the configuration of any item being delivered shall be definable in terms of its component part numbers.
- B. The Contractor shall account for differences between the as-built configuration and the engineering-released design and related documentation.
- C. The status of change approvals and incorporation shall be recorded at each point in product development, test, production and operational usage.
- D. A serialization and configuration record shall be maintained.
- E. The status of interface specifications, control documents and plans shall be maintained.
- F. The status of software shall be maintained once a baseline has been defined.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01755

MOBILIZATION

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for mobilization, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Temporary Facilities
 - 2. Transfer of Temporary Facilities
 - 3. Contractor's offices
 - 4. Contractor's shops
 - 5. Contractor's plants
 - 6. Contractor's storage areas
 - 7. Employee parking
 - 8. Staging and storage yard site cleaning
 - 9. Site restoration related to the work of this Section
 - 10. Maintenance and protection of traffic

1.02 RELATED SECTIONS

- A. Section 01783, "Temporary Facilities"
- B. Section 01787, "Transfer of Temporary Facilities."
- C. Section 01780, "Maintenance and Protection of Traffic."

1.03 REFERENCE STANDARDS

- A. OSHA 29 CFR
- B. MUTCD

1.04 SUBMITTALS

- A. Submit a detailed site lighting plan showing the temporary lighting facilities, electrical service location and circuit diagram for review and approval by the Engineer 30 days before mobilization.
- B. Submit staging area plan showing location of, but not limited to, all temporary facilities, buildings, storage areas, site traffic patterns, public road access including temporary curb cuts, and employee parking. Submit plan for review and approval by the Engineer 30 days before mobilization.

- C. Traffic Control Plan in accordance with Section 01780, "Maintenance and Protection of Traffic."

ARTICLE 2 PRODUCTS

[NOT USED]

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. Contractor shall notify the Engineer at least ten (10) working days prior to the start of mobilization.
- B. It is the Contractor's responsibility to plan its work within the limits provided on the Contract Drawings.

3.02 TEMPORARY LIGHTING FOR CONSTRUCTION PURPOSES

- A. Provide and maintain lighting for construction operations to achieve minimum illumination intensities as indicated in Table D-3 of 29 CFR 1926.56.
- B. Contractor shall limit application of any on-site lighting in accordance with MUTCD, Section 6F.76, so as not to cause glare to traffic
- C. Provide branch wiring from power source to distribution boxes with lighting conductors, pigtails and lamps as required.
- D. Maintain lighting and promptly provide repairs to maintain required lighting levels at all times.
- E. Provide battery-operated or equivalent emergency lighting facilities at construction areas where normal light failures would expose employees to hazardous conditions. Test such facilities monthly.

3.03 STAGING AREA

- A. Secure and maintain staging area(s) to service Worksite.
- B. Install temporary facilities as described in Section 01783, "Temporary Facilities"
- C. Provide all requirements of Section 01780, "Maintenance and Protection of Traffic."

3.04 CLEANING

- A. Keep Worksite including parking lots, roadways and sidewalks within the areas controlled by the Contractor clean of snow and ice. Provide means necessary including, but not limited to, snow plows, shovels, and ice melting agents. Haul snow

to acceptable disposal site if stockpiling on site is not feasible, or as directed by the Engineer.

- B. Do not dispose of snow and ice onto public travel areas.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 01755.001 - Mobilization shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. Item 01755.001 – Mobilization will be paid at the lump sum price and shall include the cost of all work specified in this Section. Payment will be made in accordance with the following schedule:
 1. Whenever work is performed equal to five percent (5%) of the Contract Sum, excluding the price for this Contract Item, twenty five percent (25%) of the amount bid for Mobilization or three percent (3%) of the Contract Sum, excluding the price for this Contract Item, whichever is less, will be paid.
 2. Whenever work is performed equal to twenty-five percent (25%) of the Contract Sum, excluding the price for this Contract Item, forty percent (40%) of the amount bid for Mobilization or an additional two percent (2%) of the Contract Sum, excluding the price for this Contract Item, whichever is less, will be paid.
 3. Whenever work is performed equal to fifty percent (50%) of the Contract Sum, excluding the price for this Contract Item, twenty five percent (25%) of the amount bid for Mobilization or an additional two percent (2%) of the Contract Sum, excluding the price for this Contract Item, whichever is less, will be paid.
 4. Upon receipt of the Certificate of Acceptance of Final Inspection, any remaining amount bid for Mobilization will be paid.

END OF SECTION

SECTION 01775
TESTING LABORATORY SERVICES

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for testing laboratory services, in accordance with the Contract Documents.

1.02 REFERENCE STANDARDS

- A. PENNDOT, Publication 408.
- B. PENNDOT, Publication 19.
- C. ASTM.
- D. AASHTO.
- E. NBS.
- F. AREMA.
- G. NESC.

1.03 SUBMITTALS

- A. Submittal of test results shall be in accordance with Section 01400, Article 11.

1.04 QUALITY ASSURANCE

- A. Contractor shall ensure that the Testing Laboratory(s):
 - 1. Meets recommended requirements in accordance with Section 01400, Article 11.2.
 - 2. Concrete and Steel Testing Laboratory(s) are in accordance with ASTM E329-07, "Standard Specification for Agencies Engaged in Construction Inspection and/or Testing."
 - 3. Submits copies of reports of inspection of facilities made by Materials Reference Laboratory of National Bureau of Standards during the most recent tour of inspection, with memorandum of remedies of any deficiencies reported by the inspection.
 - 4. Calibrates testing equipment at specified intervals by devices of accuracy in accordance with Section 01400, Article 11.11.

ARTICLE 2 PRODUCTS

[NOT USED]

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. Tests shall be performed in accordance with the Contract Documents.
- B. Contractor shall ensure that the Testing Laboratory(s):
 - 1. Cooperates with Engineer, and provides qualified Testing Laboratory personnel.
 - 2. Performs specified inspections, sampling and testing of materials and methods of construction in order to ensure the following:
 - a. Compliance with specified standards.
 - b. Compliance of materials in accordance with the Contract Documents.
 - 3. Notifies Engineer and Contractor of observed irregularities or deficiencies of materials or products immediately and before they are incorporated into the work.
 - 4. Performs additional tests as directed by the Engineer.
- C. Contractor shall employ and pay for the services of independent testing laboratory(s) to perform specified services and testing. Testing laboratory(s) will be subject to the approval by the Engineer. Employment of the laboratory(s) shall in no way relieve Contractor's obligations to perform the work of the Contract Documents.

3.02 LIMITATIONS OF AUTHORITY OF TESTING LABORATORY

- A. Contractor and its Testing Laboratory will not be authorized to:
 - 1. Release, revoke, alter or enlarge on requirements shown in the Contract Documents.
 - 2. Approve or accept any portion of the work.

3.03 CONTRACTOR'S RESPONSIBILITIES

- A. Contractor shall:
 - 1. Assign work to laboratory personnel and provide Engineer access to work.
 - 2. Secure and deliver to the laboratory adequate quantities of representative samples of materials proposed to be used and which require testing.
 - 3. Provide to the laboratory design mixes proposed to be used for concrete, and other materials mixes, that require control by the testing laboratory.
 - 4. Furnish copies of product test reports as required.
 - 5. Furnish incidental labor and facilities:
 - a. To provide access to work to be tested.
 - b. To obtain and handle samples at the Worksite or at the source of the product to be tested.
 - c. To facilitate inspections and tests.
 - d. For storage and curing of test samples.

6. Notify laboratory sufficiently in advance of operations to allow for laboratory assignment of personnel and scheduling of tests.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01777

CONSTRUCTION CERTIFICATION PROGRAM

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for construction certification program, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Participate in the project safety and security certification program.
 - 2. Participate in the system safety and security programs.
 - 3. Provide certification of required safety and security elements of the Work.
 - 4. Provide a System Testing and Systems Integration Testing Coordinator to oversee the systems testing and system integration testing defined within the Contract.
 - 5. Provide Overall Testing and Integration Plan.

1.02 RELATED SECTIONS

- A. Section 01900, "Train Clearance Testing."
- B. Section 01910, "Operations, Maintenance and Repair Data."
- C. Section 01911, "Operations, Maintenance and Information Database."
- D. Section 02471, "Track-to-Earth Resistance Testing."
- E. Section 13582, "Safety and Systems Assurance."
- F. Section 13595, "Signal System Test and Inspection."
- G. Section 15891, "Tunnel Services Mechanical Testing and Commissioning."
- H. Section 16081, "Electrical Testing AC Systems."
- I. Section 16360, "Traction Power Substation Testing."
- J. Section 16830, "Overhead Contact System Test and Inspection."
- K. Section 16889, "Tunnel Services Electrical Testing and Commissioning."
- L. Section 16901, "Communications System Inspection and Test."
- M. Section 16950, "Operation Control Center (OCC) System Upgrade."

1.03 REFERENCE STANDARDS

- A. Port Authority of Allegheny County System Safety Program Plan
- B. Port Authority of Allegheny County North Shore Connector Project Safety and Security Certification Plan (SSCP)
- C. Port Authority of Allegheny County North Shore Connector Project System Safety Program Plan (SSPP)
- D. Port Authority of Allegheny County North Shore Connector Project System Safety Management Plan (SSMP)

1.04 SUBMITTALS

- A. Submit safety and security test plans and procedures as identified in the Contract Documents and in accordance with Port Authority of Allegheny County North Shore Connector Project SSCP, Section 3.13.
- B. Submit safety and security test reports as identified in the Contract Documents and in accordance with Port Authority of Allegheny County North Shore Connector Project SSCP, Section 3.14.
- C. Submit operations and maintenance procedures and training plan/program as identified in the Contract Documents and in accordance with Port Authority of Allegheny County North Shore Connector Project SSCP, Section 3.18, and as required in the Contract Documents.
- D. Submit certification of completed work in accordance with Port Authority of Allegheny County North Shore Connector Project SSCP, Section 3.20, specifically 2nd bullet.
- E. Submit resume of System Testing and Systems Integration Testing Coordinator for review and approval.
- F. Submit an overall testing and integration plan for the NSC-009 Project which shall, at a minimum, include the following:
 1. A matrix showing interaction between various disciplines in the NSC-009 Contract and other Contracts on the North Shore Project.
 2. Identify each test to be performed. Provide a schedule for each test identifying early start, early finish and the duration for each test.
 3. Identify all interfaces between the different systems included in the NSC-009 Contract.
 4. Identify staffing requirements for each test by discipline.
 5. Methodology for performing each interface and integration test.
 6. Provide procedures for certification that indicated tests have been completed and deficient results have been corrected and retested.

7. Provide a list of all test forms to be used for each test.
8. Provide sample test forms.
9. Identify any required disruption to the Authority's operations.
10. Identify any support personnel and equipment that the Authority is to provide.
11. Identify any power outage requirements.

1.05 QUALIFICATIONS

- A. The Contractor shall assign a System Testing and Systems Integration Testing Coordinator to the work for this Project. The System Testing and Systems Integration Testing Coordinator shall be assigned to the work on-site during the Testing Phase. The System Testing and Systems Integration Testing Coordinator shall be responsible for overseeing and coordinating the Contractors Integrated Test Plan for all the work of this Contract as described within the Technical Provisions. The System Testing and Systems Integration Testing Coordinator shall have a minimum of five (5) years experience in testing coordination and oversight for transit signaling, communications, central control systems, traction power, overhead catenary system and fire and life safety systems. If the Contractor cannot provide one employee who is capable of coordinating and overseeing integrated testing for all of the systems described within this paragraph, the Contractor may provide additional employees who are technically competent in one or more of the required systems. These additional employees may assist the System Testing and Systems Integration Testing Coordinator, but in all cases, the System Testing and Systems Integration Testing Coordinator shall be required to lead the systems integration testing effort.
- B. The System Testing and Systems Integration Testing Coordinator shall be authorized to direct the Contractor's personnel so the Systems Integration Testing can proceed without delay. The System Testing and Systems Integration Testing Coordinator shall have experience in related projects of comparable size and complexity.

ARTICLE 2 PRODUCTS

[NOT USED]

ARTICLE 3 EXECUTION

3.01 SYSTEM SAFETY AND SECURITY PROGRAM PLAN

- A. Contractor shall comply with the Port Authority of Allegheny County system safety and security program plans and all related North Shore Connector Project safety and security plans listed in Article 1.03 of this Section.

3.02 NORTH SHORE CONNECTOR PROJECT SAFETY AND SECURITY CERTIFICATION PLAN

- A. Contractor shall comply with the North Shore Connector Project SSCP, including, but not limited to, the following sections:
 - 1. Section 3.12, "Complete Safety and Security Verification Checklist Process for Civil Work"
 - 2. Section 3.13, "Develop and Implement Contractor Test Plans and Procedures"
 - 3. Section 3.14, "Contractor Test Reports/Results"
 - 4. Section 3.18, "Develop Contractor's Operations & Maintenance Procedures and Training Plan/Program"
 - 5. Section 3.20, "Issuance of Safety Certification"
 - 6. Section 5.1, "Responsibilities"

3.03 NORTH SHORE CONNECTOR PROJECT SYSTEM SAFETY PROGRAM PLAN

- A. Contractor shall comply with the North Shore Connector Project SSPP, including, but not limited to, the following sections:
 - 1. Section 3.0.A, "Roles and Responsibilities"
 - 2. Section 3, Table 3-1, "NSC SSPP Responsibilities Matrix"
 - 3. Section 4.0, "System Safety Program Tasks"

3.04 SYSTEM TESTING AND SYSTEMS INTEGRATION TESTING

- A. The Contractor shall perform System Testing and Systems Integration Testing as defined elsewhere within the Contract. The Contractor's System Testing and Systems Integration Testing Coordinator shall oversee these tests and shall support the Authority in the system safety certification process as defined in this section.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the Construction Certification Program work of this Section.
- B. Item 01777.001 – Systems Integration Testing, shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. No separate payment will be made for the Construction Certification Program work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

- B. Item 01777.001 - Systems Integration Testing, will be paid at the lump sum price and shall include cost of all related work specified in this Section.

END OF SECTION

SECTION 01780

MAINTENANCE AND PROTECTION OF TRAFFIC

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for maintenance and protection of traffic, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Maintenance and protection of traffic.
 - 2. Traffic control devices and temporary pavement markings, persons, and facilities.
 - 3. Roadway closures and detours.
 - 4. Special event coordination.
 - 5. Traffic Control Supervisor.
 - 6. Phasing.
 - 7. Removal of MPT facilities.
 - 8. Flaggers.
 - 9. Changeable Message Signs.
 - 10. Temporary Pedestrian Accommodations.
 - 11. Temporary Concrete Barrier and Enclosures.
 - 12. Lane Rental.
 - 13. Coordination with other Authority Contractors.
- C. This is a performance based specification. The Contractor shall be responsible for the selection and complete design of the Traffic Control Plan (TCP). The Contract Documents will serve to provide parameters and design criteria for completing this portion of the Work.

1.02 RELATED SECTIONS

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. Section 01810, "Off-Duty Uniformed Police Officer."

G. [NOT USED]

H. [NOT USED]

I. [NOT USED]

J. [NOT USED]

K. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication 236M.
- C. PENNDOT Publication 213, Work Zone Traffic Control Guidelines.
- D. PENNDOT Publication 111M (TC-8600 and TC-8700 Series).
- E. PENNDOT Publication 72 (RC Series).
- F. PENNDOT Publication 35 (Bulletin 15).
- G. AASHTO.
- H. ADA.
- I. ATSSA.
- J. IMSA.
- K. MUTCD.
- L. PENNDOT Publication 234
- M. PENNDOT Publication 212, Official Traffic Control Devices.
- N. PENNDOT Publication 149
- O. PENNDOT Publication 148 (TC-7800 Series)

1.04 SUBMITTALS

- A. Traffic Control Plan (TCP): Contractor shall develop and submit a proposed TCP to the Engineer for approval in accordance with Section 00500, Article 2.1. The TCP shall provide specific traffic control details of areas requiring short and long term lane closures to accommodate construction activities, material storage and/or deliveries. The TCP shall also designate areas requiring temporary pedestrian accommodations.

Contractor cannot install any temporary traffic control measures until written acceptance of the submitted plan is received from the Engineer. Submit initial plans of temporary pedestrian accommodations for each phase or stage of construction to the Engineer for review and approval. Such plans shall also be subject to review and approval by the City of Pittsburgh Department of Public Works Bureau of Transportation and Engineering and shall be coordinated through the Engineer. Plans should indicate, at a minimum, the following:

1. Construction zones, laydown and storage areas, and location of construction field offices.
2. Pedestrian routes and detours through and around each construction zone.
3. Existing and temporary crosswalks, where applicable. Identify existing crosswalks to be closed.
4. Modifications or revisions to the approved TCP will also require approval from the Engineer and the City of Pittsburgh.

B. [NOT USED]

C. Traffic Control Supervisor: Contractor shall comply with personnel qualifications detailed in Article 1.05 of this Section and submit resume(s) for the selection of a Traffic Control Supervisor or Supervisors for approval by the Engineer. Submit the resumes of potential candidates at the Project Pre-Construction Meeting.

D. [NOT USED]

E. Traffic Control Inspections: Contractor shall submit Traffic Control Inspection Reports within 24 hours.

F. [NOT USED]

1.05 QUALITY ASSURANCE

A. Traffic Control Supervisor. The Traffic Control Supervisor(s) must be approved by the Engineer and have previous experience on jobs of equal complexity, minimum 5 years of progressive experience in the field of traffic safety, and either IMSA Traffic Control Specialist Level 1 or ATSSA Worksite Traffic Supervisor certification. At least one Traffic Control Supervisor position must be filled by a full time employee with a staff of other qualified individuals available on a 24-hour basis. Worksite Traffic Supervisor certification training classes are available through ATSSA. For further information contact ATSSA's Certification Coordinator at (877) 642-4637, extension 134.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

A. In accordance with PENNDOT 408, Section 901 and the MUTCD.

- B. Changeable signs: In accordance with Article 3.07 M, "Portable Full Matrix Changeable Message Signs" of this Section.
- C. Pedestrian control: In accordance with Article 3.07 P, "Temporary Pedestrian Accommodations" of this Section.
- D. Temporary barrier: In accordance with Article 3.07 Q "Temporary Concrete Barrier and Enclosures" of this Section.
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. Except as modified herein, the work of this Section shall be performed in accordance with PENNDOT 408, Section 901 and the following additional requirements:
 1. Vehicular and pedestrian traffic shall be maintained at all times around the Worksite in accordance with the approved Contractor's TCP.
 2. [NOT USED]
 3. Maintain safe pedestrian access to business units adjacent to and throughout the construction area.
 4. Maintain safe access for property owners' vehicles, emergency vehicles and municipal services vehicles to properties adjacent to the construction area.
 5. Lane widths for maintenance of two-way traffic should be equal to lane widths of the existing facility. Temporary travel lane widths shall not be less than 11'-0" for short-term (typically 1-12 hours duration) construction, unless otherwise specified. Lanes shall be paved or decked at all times unless there are exceptions due to construction limitations. Whenever this occurs, the Contractor shall receive prior approval from the Engineer for these exceptions. When one-lane, one-way operation is necessary, a minimum width of 11'-0" shall be maintained.
 6. Bi-directional traffic flow on a single lane through intersections is permissible utilizing flagging operations in accordance with PENNDOT Publication 213 and with approval from the City of Pittsburgh as required. This operation is restricted to nighttime and weekend hours, except before, during, and after stadium or special events and in accordance with the approved Contractor's TCP.
 7. Arrow Panel: Furnish advance arrow panel warning signs Type B for each area that involves a lane closure. Provide an arrow panel capable of displaying and operating in 3 different modes:
 - a. A flashing arrow, sequential arrow or sequential chevron mode;
 - b. A flashing double arrow mode;
 - c. A flashing caution mode.

3.02 PERFORMANCE REQUIREMENTS

- A. The signs, traffic control devices, persons listed or indicated on the Contractor's TCP represent the minimum requirements for this work. The number and types of traffic control signs, devices and persons for this Project shall be a function of the number and location of work zones within the Project limits, the extent of the work and the Contractor's sequence of operations. If the conditions require a revision to the TCP, the Contractor shall submit a TCP revision to the Engineer for approval.
- B. Use PENNDOT approved channelizing devices. Use reflectorized drums in accordance with PENNDOT Publication 213 and the MUTCD.
- C. The Contractor shall not place any traffic control device or signing until required by that specific work. When work is complete, Contractor shall immediately cover work zone traffic control devices and remove work zone traffic control devices within two (2) working days after affected work is complete.
- D. The Contractor shall not place any sign or traffic control device in a location that would block all or a portion of any sidewalks, pedestrian walkway, driveway or entrance to any building or residence unless directed by the Engineer.
- E. Contractor shall not impose traffic restrictions without the prior written approval of the Engineer, in conjunction with the appropriate governing agencies.
- F. Contractor shall limit application of any on-site lighting in accordance with the MUTCD, so as not to cause glare to traffic.
- G. Contractor shall not implement short-term traffic control operations without the approval of the Engineer. The Engineer shall inspect traffic control devices prior to the start of work.
- H. Contractor shall setup and allow for the Engineer's inspection of all temporary signs one-week in advance of starting affected portions of the work. Signs shall be covered until work begins.
- I. End treatments shall be provided for temporary concrete barrier in accordance with PENNDOT's Standards for Roadway Construction, Sections RC-50M, RC-57M, RC-58M, or other method as approved by the Engineer. Where possible, Contractor shall flare temporary concrete barrier outside of the effective clear zone as identified in AASHTO's Roadside Design Guide.
- J. The responsibilities of the Traffic Control Supervisor(s) are as follows:
 - 1. [NOT USED]
 - 2. Meet at regularly scheduled intervals with the Engineer, Authority, adjacent project contractors, the City of Pittsburgh, PENNDOT, and other parties, as applicable, to coordinate progress and scheduling of TCP phase and stage changes, staged construction activities, short-term closures, detours, and other

- issues affecting both vehicular and bus traffic and general access throughout the Project area.
3. Provide written notification to Authority, the Engineer, PENNDOT District 11-0, the City of Pittsburgh, Allegheny County, the Stadium Authority, the Sports and Exhibition Authority, the Pittsburgh Pirates, the Pittsburgh Steelers and affected property owners prior to the implementation of any traffic restrictions within the minimum timeframes defined by Section 00500, Article 2.1.
 4. Administer implementation and maintenance of traffic control schemes, off-duty uniformed police officers and flaggers, and maintenance of traffic control signs and devices.
 5. Inspect and document on a daily basis, 7 days a week, including holidays, the condition of traffic control signs and devices, off-duty uniformed police and temporary pavement markings. Conduct inspections daily. The City of Pittsburgh shall be advised of the schedule of these inspections and shall be given the opportunity to participate in these inspections.
 6. Immediately clean, repair and replace and/or re-align signs and devices as necessary and when directed by the Engineer.
 7. Submit Traffic Control Inspection Reports in accordance with Article 1.04E of this Section. Notify the Engineer 24 hours in advance of each Traffic Control Inspection.
 8. Traffic Control Supervisor shall meet, at a minimum, monthly with businesses and property owners during the course of the Project for the scheduling of Contractor and business deliveries, operational issues, or special access needs.
 9. Traffic Control Supervisor shall make accommodations for allowing the delivery vehicles for Contractor and business property owners access into the Project area for loading and unloading purposes.
 10. Traffic Control Supervisor shall make accommodations for emergency vehicles to enter the Project area and coordinate this access with the City of Pittsburgh's Department of Public Safety. Public Safety contact information can be identified at telephone (412) 255-2963, or at the following internet site:
<http://www.city.pittsburgh.pa.us/ps/>.
 11. Traffic Control Supervisor shall make accommodations to allow for garbage pick-up from businesses and property owner's within and around the Project area.
 12. The Traffic Control Supervisor shall meet on a regular basis with the Engineer to coordinate traffic control related schedules, issues, and requirements throughout the Project area.

3.03 EQUIPMENT AND MATERIAL STORAGE AND HAULING

- A. In accordance with PENNDOT Publication 213.
- B. [NOT USED]
- C. Utilize temporary flagging operations or short-term lane closures to control truck access to and from the Worksite for equipment deliveries, and component delivery, etc.

- D. Do not store materials next to the edge of traffic lanes or block pedestrians' way. Use reflectorized barricades to warn motorists of the existence of stored materials.
- E. Do not store materials and equipment where they will obstruct driver and pedestrian lines of sight and visibility of traffic control devices.
- F. Avoid unloading material or parking construction equipment or employee-owned vehicles on public streets or where they will obstruct surrounding facilities including but not limited to, traffic control devices, walkways, travel lanes, driveways, or building operations unless approved by the Engineer and proper traffic and pedestrian controls are installed by the Contractor at no additional cost to the Authority. .
- G. All construction equipment shall be placed in a work zone or laydown area a sufficient distance from the edge of pavement when not in use so as not to impede traffic operations or pedestrian movements.

3.04 MAINTENANCE OF ROADWAY AND/OR STRUCTURES

- A. The City of Pittsburgh, and PENNDOT reserve the right to enter the Worksite in their jurisdiction and, at their expense, to maintain the existing roadway and/or structures. This maintenance may be during the life of the Project, but will not include items of work including the accommodation of local traffic. These parties do not assume responsibility in any way for maintenance and protection of traffic associated with the Project as a consequence of performing this roadway and/or structure maintenance. City of Pittsburgh and PENNDOT will be responsible for the MPT associated with the work they are performing.

3.05 [NOT USED]

3.06 LOCAL TRAFFIC AND SAFETY

- A. Proceed with the Work to ensure safety and the least inconvenience to local traffic. Maintain local traffic ingress and egress by use of existing roadways.
- B. Provide and maintain local access to and from the nearest intersecting public road or street, unless the appropriate governing agency, or Engineer, otherwise directs. Provide temporary approaches for local vehicular and pedestrian access to and from commuter service, residential, business, industrial, and other public and private facilities as directed.
- C. [NOT USED]
- D. Maintain safe pedestrian walkways through the work zone by detouring pedestrian traffic to unaffected walkways or by providing adequate temporary pedestrian accommodations.

- E. Restrict on-street metered parking to accommodate the suggested temporary traffic patterns, travel lanes, intersection turning movements, work zones, and applicable construction operations. Cover existing parking meters and install No-Parking signs for each occurrence. Submit all restrictions for review and approval by the Pittsburgh Parking Authority, or other governing agency, as applicable.
- F. [NOT USED]

3.07 TRAFFIC CONTROL DEVICES, PERSONS AND FACILITIES

- A. As applicable, remove or cover maintenance and protection of traffic signs during non-working hours so they are not readable to oncoming traffic.
- B. Prior to Pre-Final Inspection or at the completion of applicable construction stages, remove signs and devices from the Worksite or relocate devices in preparation for the next construction stage. All signs and devices shall remain the property of the Contractor, except where specified for turnover to an adjacent or follow-on contract.
- C. [NOT USED]
- D. [NOT USED]
- E. Do not allow employees to park their personal vehicles on any traveled roadway, shoulder, median or seeded area along the highway or any city street so as to take public parking areas without making arrangements with the appropriate parking authorities to purchase these spaces.
- F. Existing Signs:
 1. Cover existing warning, regulatory, guide and directional signs as required to accommodate construction operations.
 2. When covering conflicting existing signs, do not place any adhesive on the sign face. Place adhesive on the back of the sign. Any reflective sheeting damaged by adhesive will constitute damage to the sign and the Contractor shall replace the sign at no additional cost to Authority.
 3. Coordinate the placement of any sign or traffic control device with any existing signing already in place for concurrent construction projects.
- G. Temporary Signs
 1. Temporary construction signing shall be black text on retroreflective orange Type III or Type VII sheeting except where specified otherwise.
 2. Along City streets, construct any special signs in conformance with the MUTCD using eight-inch, upper-case, Series C-Type letters and a minimum one-inch border on Class I orange reflectorized back-ground with black non-reflectorized legend and border.
 3. The retro-reflective sheeting on signs and barricades scratched or damaged to the point that reflectivity is impaired shall be replaced. Damaged, defaced or dirty

devices shall be immediately repaired, replaced or cleaned by the Contractor at no additional cost to Authority.

H. Barricades:

1. Furnish and install barricades in accordance with PENNDOT Publication 212, 213 and the MUTCD.
2. Furnish and install concrete barrier in accordance with Article 3.07 Q of this Section.
3. Furnish and install other types of construction barricade in accordance with Article 3.07 P of this Section.

I. Temporary Pavement Markings:

1. Remove all conflicting or misleading pavement markings in accordance with PENNDOT 408, Section 963.3 using hydro-blasting or other methods as approved by the City of Pittsburgh.
2. Unless otherwise noted, apply work area temporary pavement markings in accordance with PENNDOT Publication 408, Section 901.3(k), Work Area Pavement Markings.
3. [NOT USED]
4. Remove pavement markings that are improperly placed and install in the correct location at no additional cost to Authority.
5. When related portions of the Work are complete, completely remove any temporary pavement markings that were part of this work and the maintenance and protection of traffic as noted above. Restore any removed or damaged pavement markings to their original state, including any markings outside the limits of construction that were modified specifically for traffic control purposes at no additional cost to the Authority.

J. Off-Duty Uniformed Police Officers:

1. Provide off-duty uniformed police officers to control and direct traffic as required by the approved Contractor's TCP and approved by the Engineer in accordance with Section 01810, "Off-Duty Uniformed Police Officer."
2. When an off-duty uniformed police officer is directing traffic at a signalized intersection, ensure that the police officer returns the traffic signals to normal operation prior to leaving at the end of the work shift.

K. Channelizing Devices:

1. Use long-term channelizing devices with Type C steady burn lights for long term lane restrictions.
2. Mount a light on each long-term channeling device used in transition areas and on every third long term channeling device used in tangent sections, unless otherwise indicated.

L. Flaggers

1. Provide a minimum of two properly attired flaggers to control traffic flow as directed by the Engineer. Equip with W21-10 "STOP AND SLOW PADDLE" paddles or red flags as appropriate.
2. Ensure that flaggers are clearly visible to oncoming traffic under their control. Provide communications between flaggers. Instruct flaggers in the proper procedures for controlling traffic before allowing them to control traffic in accordance with PENNDOT Publication 212, PENNDOT Publication 213, PENNDOT Publication 234 and the MUTCD.
3. Do not use flaggers to control traffic within the immediate vicinity of a signalized intersection without the presence of an off-duty uniformed police officer.
4. Provide flagger controlled access, during working hours, for construction vehicle access and staging areas which conflict with pedestrian and vehicle traffic.
5. Provide a W20-7A "Flagger Symbol" sign in advance of all locations where flaggers are used to control traffic. Remove W20-7A "Flagger Symbol" sign when flagger is not physically present.

M. Portable Changeable Message Signs (If Required)

1. Furnish and install a full matrix changeable message sign as required by the approved TCP. Contractor shall obtain materials from a source listed in PENNDOT Bulletin 15 or submit an alternative not listed in Bulletin 15 for approval by the Engineer.
2. Construction shall be in accordance with PENNDOT 408, Section 901.3 except as modified herein.
3. Contractor shall provide all maintenance, fuel, cellular phone service and other operating costs.
4. Contractor shall deploy, relocate and remove the signs as directed by the Engineer.
5. Contractor shall program and reprogram sign messages as directed by the Engineer..
6. If a sign becomes inoperable, it shall be repaired within 24 hours.
7. All sign messages shall be reviewed and approved by the Engineer with coordination between the City of Pittsburgh Department of Public Works, Bureau of Transportation and Engineering and PENNDOT.

N. [NOT USED]

O. [NOT USED]

P. Temporary Pedestrian Accommodations: Contractor shall provide temporary pedestrian accommodations to designate alternative pedestrian pathways in and around the construction activities.

1. Construction fence, chain-link mesh on portable supports, in accordance with PENNDOT 408, Section 624; and PENNDOT Publication 72, Drawing RC-60, with exceptions as listed herein.

2. If mounting via base plates to sidewalk or barrier is selected, this fence shall be in accordance with PENNDOT 408, Section 1016; and PENNDOT Publication 219, Drawing BC-701, with exceptions as listed herein.
3. Temporary crosswalks shall be installed and maintained at locations identified by the TCP.
4. Temporary crosswalks shall be shifted as required to accommodate those work zones specified as staged construction areas.
5. Temporary crosswalk installations shall include signage and pavement markings to delineate the crossing path.
6. Temporary ramps shall be included at each end of the temporary crosswalks in accordance with this Section. Required curb and curb modifications shall be subject to review and approval by the Engineer and shall be in accordance with PENNDOT 408, Sections 636.3 and 694.3 and /or the City of Pittsburgh Department of Public Works Bureau of Transportation and Engineering.

Q. Temporary Concrete Barriers and Enclosures:

1. Contractor shall install, replace or repair, and remove temporary concrete barrier in accordance with PENNDOT 408, Section 627.3 and 628.3.
2. Used barrier sections may be utilized, subject to the approval of the Engineer, provided each section is in like new condition. Any conflicting paint and reflectors from previous use shall be removed prior to placement. Upon final placement of the barrier provide the required color reflector and paint to coincide with the appropriate pavement markings.
3. Contractor shall install, replace or repair and remove additional temporary impact attenuating device in accordance with PENNDOT 408 Section 696.3 and 697.3.

R. Site Conditions, Short Term Operations: Contractor shall clean the shoulder of the work zone area and open the roadway to traffic at the end of each workday unless otherwise directed by the Engineer.

S. When working above a traveled roadway, Contractor shall provide falsework, netting or other means to prevent construction debris, including water, from falling on the area below.

3.08 [NOT USED]

3.09 ROADWAY CLOSURE COORDINATION AND NOTIFICATION

- A.** Coordination for specific closures or restrictions by location shall occur with the applicable agencies or jurisdictions in accordance with Section 00500, Article 2.1.

3.10 ROADWAY CLOSURE SEQUENCING RESTRICTIONS

- A.** Contractor shall not implement full or one-lane road closures at multiple locations simultaneously in accordance with requirements of Section 00500, Article 2.1.

- B. Contractor shall maintain traffic flow and access at specific locations in accordance with additional requirements of Section 00500, Article 2.1.

3.11 STADIUM AND SPECIAL EVENT COORDINATION AND RESTRICTIONS

- A. Contractor shall coordinate all construction sequencing, traffic control, roadway restrictions and/or closures during special events as per the requirements of this Section and Section 00500, Article 2.1.
- B. Contractor shall coordinate scheduled construction activities and related traffic control with all impacted parties including business and property owners. Coordination must be ongoing throughout the construction period. Maintain lines of communication and keep, as a minimum, the following agencies informed of changes:
1. City of Pittsburgh, Special Events Coordinator,
 2. City of Pittsburgh, Department of Public Works,
 3. Local law enforcement, fire and emergency crews,
 4. Stadium Authority,
 5. Sports & Exhibition Authority,
 6. Pittsburgh Steelers,
 7. Pittsburgh Pirates,
 8. University of Pittsburgh,
 9. Port Authority of Allegheny County,
 10. ALCO Parking and Pittsburgh Parking Authority,
 11. The Pittsburgh Downtown Partnership,
 12. The Pittsburgh Cultural Trust,
 13. PENNDOT.
- C. Contractor shall safely accommodate all vehicular, pedestrian and transit traffic; parking, access, and circulation; and safety and security of the work zone as applicable for the current phase and stage of construction, during special events.
- D. Contractor shall schedule additional off duty uniformed police officer(s), in accordance with Section 01810 “Off-Duty Uniformed Police Officer”, to protect vehicular or pedestrian traffic flow through the work zones and ensure site security around the work zones during special events, as required.
- E. Contractor shall suspend heavy truck access, hauling, loading, or unloading activities in accordance with the following PNC Park and Heinz Field Events tables (Table 01780-1 PNC Park Events, Table 01780-2 Opening Day, Play Off Games, World Series, and Table 01780-3 Heinz Field Events.) During these special events, the Contractor shall provide additional police services in accordance with the approved TCP.

Table 01780-1 PNC Park Events
Projected Attendance Above 25,000

Contract	Location	Suspend Heavy Trucking Operations	Continuous Additional Police Services Provided	Ft. Duquesne Boulevard Reverse Lane
NSC -009	NSC Train Systems (System Wide)	2 Hours Before/ 2 Hours After	No	No

Table 01780-2
Pirates Opening Day, Play Off Games, and World Series

Contract	Location	Suspend Heavy Trucking Operations	Continuous Additional Police Services Provided	Ft. Duquesne Boulevard Reverse Lane
NSC -009	NSC Train Systems (System Wide)	5 Hours Before/ 2 Hours After	No	No

Table 1780-3 Heinz Field Events

Contract	Location	Suspend Heavy Trucking Operations	Continuous Additional Police Services Provided	Ft. Duquesne Boulevard Reverse Lane
NSC -009	NSC Train Systems (System Wide)	5 Hours Before/ 3 Hours After	No	No

- F. Contractor shall coordinate with all applicable parties to maintain an up-to-date list of pending special events to allow sufficient advance notice for planning public information, construction or traffic control revisions, event traffic plan revisions and coordination needed during individual events. Schedule updates shall be coordinated through the City of Pittsburgh Special Events Coordinator (Office of Communications, Office of the Mayor) and PSSI (Steelers) and Pirates. A representative listing of typical special events that occur throughout Pittsburgh at various times of the year has been summarized in Table 01780-4 Typical Special Events Summary on the following page (this table is for sample information only and does not constitute a committed schedule of events for any given year, timeframe, or location).

- G. In addition to all other requirements under Article 3.11 of this Section, the Contractor shall provide the following during Heinz Field Events.

1. Phase work accordingly in order to maintain access to Parking Lot No. 1 from Reedsdale Street entrance / exit for Heinz Field Events at all times during construction. Remove equipment, clean / repair pavement and set-up traffic control measures as required to maintain this access. Maintain security to project site during this activity. Remove traffic control measures and re-secure the Worksite after completion of each Event.
 2. A separate means of payment for work associated with Heinz Field Events has been established in the Unit Price Schedule of the Form of Proposal.
- H. In addition to all other requirements under Article 3.11 of this Section, the Contractor shall provide the following during PNC Park events with anticipated attendance over 30,000 (estimated to be 38 events per year).
1. Phase work accordingly in order to maintain access to Parking Lot No. 1 from Reedsdale Street entrance / exit for PNC Park Events with anticipated attendance over 30,000 at all times during construction. Remove equipment, clean / repair pavement and set-up traffic control measures as required to maintain this access. Maintain security to project site during this activity. Remove traffic control measures and re-secure the Worksite after completion of each event over 30,000.
 2. A separate means of payment for work associated with PNC Park events over 30,000 has been established in the Unit Price Schedule of the Form of Proposal.

Table 01780-4 Typical Special Events Summary

SPECIAL EVENT	LOCATION	DATE
Parades		
St. Patrick's Day	Centre / 6th / Grant / Boulevard	March
Memorial Day	Liberty / Penn / Davidson / Fisk	May
Labor Day	Centre / 6th / 5 th	September
Columbus Day	Centre / 6th / 5th / Liberty	October
Afro-American Heritage Day	Centre / 6th / 5th / Liberty	October
Veteran's Day	Centre / 6th / 5th / Liberty	November
Holiday	Centre / 6th / 5 th	November
Sporting Events		
Football – Pittsburgh Steelers	Heinz Field, Approximately 9-12 Home Games	Aug-Dec
Football – Pittsburgh Panthers	Heinz Field, Approximately 6-8 Home Games	Aug-Dec
Baseball – Pittsburgh Pirates	PNC Park, Approximately 75-85 Home Games	April-Oct
Hockey – Pittsburgh Penguins	Mellon Arena, Approximately 35-45 Home Games	Oct-April
Major Events at David L. Lawrence Convention Center		
Pittsburgh Boat Show	Convention Center	January
Pittsburgh Auto Show	Convention Center	February
Pittsburgh Recreational Vehicle Show	Convention Center	February
Pittsburgh Home & Garden Show	Convention Center	March

SPECIAL EVENT	LOCATION	DATE
Festivals and Concerts		
Three Rivers Arts Festival	Point State Park & Vicinity	June
Pittsburgh Progressive Arts Festival	4th Ave., between Wood & Smithfield	June
Summer Music Festival	Allegheny Landing / North Shore	June
July 4 th Celebration	Point State Park	July
Dollar Bank Jamboree	Point State Park	July
Summer Festival	Market Square	July
Pittsburgh Three Rivers Regatta	Point State Park	August
Penn Avenue Festival	Penn Avenue	August
Light-Up Night / Santa Spectacular	Various Areas	November
Carol Sing	5 th and Wood Streets	December
First Night Pittsburgh	Various Areas	December
Miscellaneous Events (About 20 per year)	Market Square	All year
Miscellaneous Concerts (Varies)	Stadiums and Point State Park	All year

SPECIAL EVENT	LOCATION	DATE
Races / Walks / Marches		
Multiple Sclerosis Walk	Point State Park	April
Walk America – March of Dimes	Point State Park	April
City of Pittsburgh Marathon	Various Streets	May
Rosary March	Uptown to Downtown	May
Animal Walk	Various streets	May
Pedal Pittsburgh	Station Square / Various Streets	May
Pittsburgh Runner Bark At Point Park	Point State Park	May
March For Jesus	Centre / 6 th / Grant / 5 th	June
Pittsburgh Triathlon	Various Streets	June
Pittsburgh Vintage Grand Prix	Various Streets	July
Youth Rally & March	Centre Ave / Grant / City County Bldg	July
The Great Ride	Various Streets	July
Arthritis Foundation's Mini Grand Prix	Smallman & Penn	August
Gatorade / Steelers 5K	North Shore	September
The Great Race	Frick Park to Point State Park	September
Light the Night Walk	PNC Park / Mazeroski Way	September
Genesis Run for Adoption	North Shore / Washington's Landing	September
Dollar Bank Junior Great Race	Point State Park	September
Head of the Ohio Regatta	North Shore	October
2nd Annual Breathe E-Z Walk For Asthma	PNC Park & River Walk	October
Run Like Hell 5K	River Ave / North Shore	October

3.12 [NOT USED]

3.13 LANE RENTAL

- A. All closure durations are continuous and begin with the initial restriction of public use.
- B. For lanes in a direction of travel to be considered “open”, there must be unrestricted access for all lanes in that traveling direction over the entire length of the roadway, including unrestricted access to and from all connecting roadways. Final determination as to whether a lane is “open” will be made by the Engineer.
- C. Time extension requests for roadway closures shall be approved by the Engineer, and the City of Pittsburgh
- D. The Contractor is responsible for properly applying for and obtaining all permits from the City of Pittsburgh necessary for the closure of City streets. City Street Closure Permits for the Work will be issued by the City of Pittsburgh to the Contractor, at no cost. If the Contractor fails to comply with the closure duration set forth in any City of Pittsburgh permit, the City of Pittsburgh may assess a permit fee which is currently in the amount of \$5 per 200 square foot of affected roadway/intersection per day of closure until the location(s) are fully reopened to public use.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the related work of this Section.
- B. Item 01780.001 – Parking Lot No. 1 Access for PNC Park Events (Over 30,000 Attendance) shall be measured per each, complete in place.
- C. Item 01780.002 – Parking Lot No. 1 Access for Heinz Field Events shall be measured per each, complete in place.

4.02 PAYMENT

- A. No separate payment will be made for the related work of this Section. Payment for the work shall be included in the payment for related portions of the Work.
- B. Item 01780.001 – Parking Lot No. 1 Access for PNC Park Events (Over 30,000 Attendance) will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. Item 01780.002 – Parking Lot No. 1 Access for Heinz Field Events will be paid at the unit price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 01781

MAINTENANCE AND PROTECTION OF AUTHORITY TRAFFIC

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for maintenance and protection of Authority traffic, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Coordination of transit impacts and related items.
 - 2. Track Access Training.
 - 3. Completion of Authority facility access procedures and permitting.
 - 4. Installation, maintenance, and removal of trench plates, temporary traffic barriers and signing used for the protective, warning, and detouring of Authority traffic through the Worksite.

1.02 RELATED SECTIONS

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. Section 02220, "Demolition."

1.03 REFERENCE STANDARDS

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]

H. AASHTO.

I. MUTCD.

J. [NOT USED]

K. Authority "Track Entry Training Program" Manual.

1.04 SUBMITTALS

- A. Contractor shall submit proposed detailed construction sequencing plan to the Engineer for approval prior to installation. The construction sequencing plan shall conform to the requirements of this Section and as shown on the Contract Drawings.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. Contractor shall provide all necessary standard safety equipment as prescribed in Authority's "Track Entry Training Program" manual.
- E. Authority Movement Director, Route Foremen, and Flagpersons shall be provided by Authority, but paid for by the Contractor. Authority will charge a flat-rate of \$33.00 per hour for each person. Contractor shall request personnel at least 14 days in advance of the work. Costs will be deducted from Contractor's progress payment.

ARTICLE 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Contractor shall execute the work of this Section per the Contractor's detailed construction sequencing plan, which shall be approved by the Engineer prior to the start of the work.
- B. Contractor shall conduct its Work so as not to obstruct or prevent operations and maintenance of Authority facilities except as specifically permitted in the Contract Documents. Authority has the right to enter the Worksite to perform maintenance and operate within Authority facilities. Contractor shall provide Authority access during the execution of the Work if so required.
- C. Contractor shall obtain, and/or complete all necessary approvals, permits, training, and attend all required meetings in accordance with Authority procedures described in the

“Track Entry Training Program” manual and Section 00700, Article 13.14 prior to commencing work within 10 ft. of active trackways. No Contractor personnel shall be permitted in Authority trackway areas without Track Access Training. The Contractor shall plan its work to account for the required Authority approval time requirements.

- D. Coordination between Authority and Contractor will be done through the Engineer.

3.02 CONSTRUCTION AND TRAFFIC CONTROL REQUIREMENTS

- A. Contractor shall schedule and pay for all flagging operations necessary for the safe conduct of its operations within the Authority’s facilities, or which may be required for the proper and timely execution of the Work, shall be provided by Contractor in accordance with Article 2.01 E of this Section
- B. [NOT USED]

3.03 COORDINATION OF TRANSIT IMPACTS AND RELATED ITEMS

- A. Contractor shall provide a minimum of 30 days advance notice to Engineer and Authority before changing traffic patterns as part of major scheduled phases of construction and/or traffic control as identified in the Contract Documents. The intent of this notice is to provide Authority with adequate lead time to prepare for, advertise, and institute any necessary changes in transit patterns needed for subsequent phases of construction. Primary contact will be Chuck Rompala, Assistant Manager, Road Operations at telephone number (412)-566-5321, pager number (412)-750-1429.
- B. For recurrent daily changes in traffic patterns that cannot fulfill the 30 day advance notice requirement, or for any unscheduled changes in traffic patterns that occur for any other reason, the Contractor shall immediately notify the Engineer to coordinate with Authority.
 - 1. [NOT USED]
 - 2. [NOT USED]
 - 3. For issues affecting rail transit operations, contact the Operations Control Center at telephone number (412) 851-4700. Alternate contact will be with Rail Operations Management at (412) 851-4785.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. Contractor shall coordinate with Authority, through the Engineer, to schedule any necessary Authority facility power outages in accordance with Authority Right-of-Way Allocation procedures as-described in the “Track Entry Training Program”. The Contractor shall plan its work to account for the required Authority approval time and coordination meeting requirements.

- G. Lifting of any material or equipment adjacent to or over bus and rail running lanes require use of an Authority Route Foreman. If traffic needs to be stopped, such delay shall not exceed two (2) vehicles in any direction nor five (5) minutes in duration. All stoppages must be approved prior to stoppage by the Engineer, and supervised by Authority Route Foreman.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work of this Section shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01783
TEMPORARY FACILITIES

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for temporary facilities, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Temporary power
 - 2. Temporary lighting
 - 3. Temporary telephone service
 - 4. Temporary sanitary facilities
 - 5. Temporary water facilities
 - 6. Cut-and-cover and station shell temporary facilities
 - 7. Bored Tunnel temporary facilities
 - 8. Temporary access
 - 9. Maintenance and removal
 - 10. Permitting
 - 11. Testing
 - 12. Test Pits and Excavation
 - 13. Backfill and compaction

1.02 RELATED SECTIONS

- A. Section 01755, "Mobilization."
- B. Section 01787, "Transfer of Temporary Facilities."

1.03 REFERENCE STANDARDS

- A. NFPA.
- B. NEC.
- C. BOCA.
- D. ADA.
- E. UL.
- F. OSHA.
- G. MSHA

- H. NEMA.
- I. IES.
- J. Other industry/municipal standards as relevant to the work and per local jurisdiction.
- K. Allegheny County Health Department.
- L. PENNDOT, Publication 408.

1.04 SUBMITTALS

- A. Working Drawings and manufacturer's literature showing temporary facility installations, equipment and materials.
- B. Submit all temporary facility testing procedures for approval by the Engineer.
- C. Test results to be submitted to the Engineer.

ARTICLE 2 PRODUCTS

2.01 TEMPORARY ELECTRICAL EQUIPMENT

- A. Temporary equipment shall consist of transformers, panel boards, grounding, receptacle outlets, switches, wiring and other materials to ensure a complete, grounded operating system that is capable of continuous service.
 - 1. Temporary electrical equipment in accordance with NEC and referenced standards.

2.02 TEMPORARY POWER AND LIGHTING

- A. Temporary power and lighting in accordance with NEC and referenced standards.
 - 1. Temporary lighting fixtures in accordance with OSHA regulations and UL-listed. This includes provisions of shatterproof guards where required.
 - 2. All equipment shall be suitable for the working environment of this Contract.

2.03 PORTABLE ELECTRICAL GENERATORS

- A. Portable electrical generators shall be grounded in accordance with NEC.

2.04 EXTENSION CORDS AND ENCLOSURES

- A. Extension cords shall be grounded type and UL-approved.
- B. Enclosures shall be suitable for the application in accordance with NEMA and NEC.

2.05 TEMPORARY TELEPHONE EQUIPMENT

- A. Equipment shall be compatible with that of the telephone company. Enclosures for instruments and directories at exterior locations shall be weatherproof.

2.06 TEMPORARY SANITARY MATERIALS AND EQUIPMENT

- A. Materials and equipment shall be adequate for purposes intended, and shall neither create unsanitary conditions nor violate requirements of codes applicable to temporary sanitary facilities.
- B. Contractor shall provide temporary toilet facilities in accordance with Allegheny County Health Department requirements.
 1. Toilet facilities shall be enclosed type. Minimum quantity shall be in accordance with Allegheny County Health Department - Article XIV Sewer Management Rules and Regulations
 2. Engineer's staff shall be included in calculation of number of employees to use the facilities, and shall be granted full access to facilities.
- C. Toilet tissue shall be provided and maintained on suitable dispenser.
- D. Enclosures for toilets shall be weatherproof, sight-proof and sturdy type. Interior shall be lighted and ventilated. Privacy screens shall separate toilet fixtures that are in enclosures capable of accommodating two or more persons at one time.
- E. Contractor shall provide potable water in accordance with Allegheny County Health Department Rules and Regulations.

2.07 BORED TUNNEL TEMPORARY FACILITIES

- A. Bored Tunnel Temporary Facilities
 1. The Contractor shall accept transfer, operate, and maintain for duration of Work, a temporary ventilation system, which conforms to the OSHA requirements and those of jurisdictional authorities. The equipment shall be adequate to maintain sufficient supply of fresh air in underground work areas.
 - a. Mechanical ventilation systems shall not be removed without the approval of the Engineer.
 - b. As a minimum, when the tunnels are occupied by workers, the ventilation system shall be designed to deliver fresh air at a volumetric flow rate equal to 60 ft per minute times the cross-sectional area of the tunnel. A higher volumetric flow rate shall be provided if necessary to conform with the OSHA requirements.
 - c. Power to the main ventilation system shall not be interrupted in the event of an alarm of the air monitoring system.
 - d. Advance of the ventilation system shall be made a regular part of the normal tunnel excavation cycle.

2. Temporary Tunnel Lighting System: The Contractor shall accept transfer, operate, and maintain a temporary lighting system in the tunnel which conforms to all regulations of relevant authorities. Lighting in the tunnel shall extend the full length of the tunnel and not be less than that required for safe working and access. An alternative source of power and emergency lighting system shall be provided to allow emergency securing operations and safe evacuation in the event of a primary power failure. An adequate number of hand lamps shall be located at key points underground.
 3. Temporary Pumping: accept transfer, operate, and maintain intermediate pumping stations and reserve pumping capacity at the low point of the tunnel as required to remove groundwater inflows and construction water, and to maintain invert flows below three inches.
 4. Fire Extinguishers: Fire extinguishers shall be provided at a minimum every 100 yards of the running tunnels. They shall be maintained in accordance with the manufacturer's recommendations.
- B. Emergency Generator: accept transfer, operate, and maintain an emergency standby generator of such capacity and configuration as to automatically and instantly come on line in the event of a power failure, without interruption, and to operate ventilation, lighting, pumping, communications and other critical systems.
- C. Bored tunnel temporary facilities will be provided within the new bored tunnel by Authority NSC-003/006 contractor until the effective date of transfer as defined in the Section 01787, "Transfer of Temporary Facilities" and Section 00500 of the Terms and Conditions.
- D. Contractor shall remove all Bored Tunnel temporary facilities at the completion of the Work.

2.08 CUT-AND-COVER TUNNEL AND STATION SHELL TEMPORARY FACILITIES

- A. Cut-and-cover tunnel and station shell temporary facilities including, but not limited to, the following in accordance with OSHA Regulations (Standard -29 CFR) of Section 1926.800 - Underground Construction and all related sections:
 1. Access and Egress to all Work
 2. Emergency provisions including personnel hoisting and self-rescue, emergency lighting, rescue teams, and self breathing apparatus.
 3. Air quality and monitoring of airborne contaminants.
 4. Ventilation.
 5. Illumination.
 6. Fire prevention and control.
 7. Protection at portal openings and access areas.
 8. Haulage and hoisting equipment.
- B. Cut-and-cover tunnel and station shell temporary facilities shall be provided by the Contractor within the existing Gateway Station loop as required to execute the Work.

- C. Cut-and-cover tunnel and station shell temporary facilities will be provided within the new cut and cover tunnel, bored tunnel, and new Gateway Station and North Side Station shells by Authority's NSC-003/006 and NSC-004 R contractors until the effective date of transfer as defined in the Section 01787, "Transfer of Temporary Facilities" and Section 00500 of the Terms and Conditions.
- D. Contractor shall remove all Cut-and-Cover Tunnel temporary facilities at the completion of the Work.

ARTICLE 3 EXECUTION

3.01 INSTALLATION

- A. Products shall be located where they will not interfere with material-handling equipment, storage spaces, traffic and execution of the Work. Installed products shall present a neat and orderly appearance, be structurally sound, and be maintained in a manner that shall ensure continuous service and present no unsafe working conditions.
- B. Temporary sanitary facilities shall be installed in a neat and orderly manner, made structurally and mechanically sound, and serviced, maintained and cleaned to ensure sanitary conditions. Portable toilets shall be securely erected, and shall be anchored to prevent dislocation. Toilets shall be serviced as often as necessary to prevent accumulation of wastes and creation of unsanitary conditions. In no event shall toilets be serviced less frequently than once a week.
- C. Locate toilets in a manner to minimize awareness of the public in surrounding buildings, vehicular, transit, and pedestrian traffic. Toilets shall be serviced at night, after 10:00 p.m. to reduce public intrusion.
- D. Review placement of all temporary facilities with Engineer prior to installation.

3.02 TEMPORARY UTILITY SERVICE

- A. Contractor shall make all arrangements with the utility companies to provide for temporary utility service.
- B. Contractor shall provide temporary utility service from the utility source(s) to the Worksite for the execution of the Work.
- C. Contractor shall coordinate, provide and pay for all equipment needed to distribute temporary utility services from the source(s) to the points of utilization required for the proper and timely execution of the Work.

3.03 DIRECTORIES

- A. One (1) alphabetical and one (1) classified directory published by the telephone company shall be provided at each telephone.

3.04 ACCESS ROADS AND STAGING AREA

- A. Temporary access to public thoroughfares shall be constructed and maintained to serve construction area.
- B. Temporary roads shall be extended and relocated as work progress requires.

3.05 PARKING

- A. Contractor shall arrange for parking areas to accommodate construction staff.
- B. Contractor shall provide additional off-site parking if required, at no additional cost to Authority.

3.06 REMOVAL AND TRANSFER OF TEMPORARY FACILITIES

- A. The Contractor shall coordinate the removal of the temporary facilities. Notify the Engineer five (5) days prior to any temporary facility disconnection and/or removal.
- B. The Contractor shall coordinate with the Engineer and Authority contractors to accept transfer of certain temporary facilities to Contractor ownership in accordance with Section 01787, "Transfer of Temporary Facilities." Contractor shall maintain and remove all transferred facilities.

3.07 EXCAVATION, BACKFILL AND TEST PITS

- A. Provide all necessary excavation, backfill and exploratory test pitting necessary to install, maintain, and remove all temporary facilities.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01784

TEMPORARY PEDESTRIAN ACCOMMODATIONS, FENCE AND BARRICADE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for temporary pedestrian accommodations, fence and barricade, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Contractor design of temporary pedestrian accommodations.
 - 2. Contractor installation of temporary pedestrian accommodations.
 - 3. Construction fence, barricade, and gates of the types indicated.
 - 4. [NOT USED]
 - 5. Temporary ramps, sidewalks, pavement, and curb modifications, as required.
 - 6. Associated light fixtures, electrical supply, and related components.
 - 7. Associated painting, graphics, or other artwork.
 - 8. Removal, accept transfer, reset, or modification throughout construction, as required.
 - 9. Maintenance and operations throughout Work, as required.
 - 10. Trash collection
 - 11. Removal and/or Transfer of temporary facilities.
 - 12. Excavation and Backfill
 - 13. Restoration or site
- C. The Contract Documents provide the performance parameters and design criteria to complete the temporary pedestrian accommodations, fenced barricade portion of the Work. The Contractor shall be responsible to provide a complete design of this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01780, "Maintenance and Protection of Traffic."
- B. Section 01787, "Transfer of Temporary Facilities."
- C. [NOT USED]
- D. Section 02740, "Bituminous Pavement and Sidewalk"
- E. [NOT USED]
- F. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

G. [NOT USED]

H. Section 09900, "Painting"

1.03 REFERENCE STANDARDS

A. PENNDOT Publication 408.

B. PENNDOT Publication 72.

C. PENNDOT Publication 219.

D. ADA.

E. MUTCD.

F. OSHA.

G. American Lumber Standard Committee (ALSC): American Softwood Lumber Standard.

H. NLGA

I. WWPA

J. APA

K. AWPA

L. AASHTO

M. Certified Ballast Manufactures (CBM)

N. Electrical Testing Laboratories (ETL)

O. PENNDOT Publication 35.

P. PENNDOT Publication 212, Official Traffic Control Devices.

Q. PENNDOT Publication 213.

R. PENNDOT Publication 236M.

S. PENNDOT Publication 111M (TC-8600 and TC-8700 Series)

T. UL

1.04 SUBMITTALS

- A. Temporary Pedestrian Accommodations Plan: At least 30 days prior to implementation of associated work, submit initial plans of temporary pedestrian accommodations for each phase or stage of construction to the Engineer for review and approval. Such plans shall also be subject to review and approval by the City of Pittsburgh Department of Public Works Bureau of Transportation and Engineering and shall be coordinated through the Engineer. Plans should indicate, at a minimum, the following:
 - 1. Construction zones, laydown and storage areas, and location of construction field offices.
 - 2. Pedestrian routes and detours through and around each construction zone.
 - 3. Existing and temporary crosswalks, where applicable. Identify existing crosswalks to be closed.
 - 4. Specific proposed temporary pedestrian accommodations by location, including sidewalk, ramps, construction fence, construction barricade, as applicable.
- B. Temporary Pedestrian Accommodations Plan Revisions: Amend and resubmit plans at least 30 days prior to implementing any changes from accepted initial plans of pedestrian elements and at least 30 days prior to any change of construction phasing.
- C. Working Drawings and Calculations: Submit Working Drawings and calculations, signed and sealed by a registered Professional Engineer, to the Engineer for review and approval of the following:
 - 1. Construction details: Submit all construction details, Shop Drawings, or technical literature necessary for specific temporary pedestrian accommodations, including construction fence, construction barricade, covered walkway, temporary handicap ramps, and associated framing details and lighting / electrical power supply for each design, as applicable.
 - a. Said Working Drawings and specifications shall describe all conditions which will be encountered within Worksite and shall be in conformance with applicable codes.
 - b. Upon review and acceptance by the Engineer, submit samples of all materials and components for review by the Engineer.
 - 2. Structural information: Submit foundation and tie-down anchor design, including structural performance calculations for all loading conditions including impact loads resistance for covered walkway.
- D. The Contractor shall allow at least 30 days for the review of each such submittal by the Engineer and the City of Pittsburgh Department of Public Works Bureau of Transportation and Engineering.

ARTICLE 2 PRODUCTS

2.01 CONSTRUCTION FENCE, AND CONSTRUCTION BARRICADE

- A. Chain-link wire fabric fence and related components, posts, braces, fittings, hardware, etc., shall comply with PENNDOT 408, Section 1110.2 and shall be 9 gauge core wire size 2" mesh. Selvages shall be knuckled.
- B. Class A Cement Concrete in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- C. Mortar in accordance with PENNDOT 408, Section 1001.2(e).
- D. Except as modified herein, other necessary materials for fencing installations shall be in accordance with PENNDOT 408, Section 624.2 and Section 1016.2, as applicable.
- E. Temporary concrete barrier shall be in accordance with Section 01780, "Maintenance and Protection of Traffic" and PENNDOT 408, Section 627.2.
- F. Plywood paneling and other lumber shall be in accordance with Article 2.04 of this Section.
- G. [NOT USED]
- H. Hardware, framing, bracing, roofing, lighting, electrical power, tie-down anchors, and other construction details shall be of Contractor design and shall be in accordance with the Contract Documents.

2.02 BITUMINOUS SIDEWALK

- A. Except as modified herein, bituminous sidewalks shall be in accordance with Section 02740, "Bituminous Pavement and Sidewalk."
- B. Cement Concrete. Cement concrete shall be replaced with bituminous material in accordance with PENNDOT 408, Section 420.2.
- C. Temporary Curb Ramps will be bituminous, cement concrete, or lumber construction based on site-specific conditions and subject to review and approval in accordance with Article 1.04 of this Section.

2.03 METALS

- A. Except as specified herein, necessary metals for construction fence, construction barricade, pedestrian covered walkway, signage support steel pipe and coupler frame, handrail, and guardrail shall be as required by Contractor design of the temporary pedestrian accommodations, in accordance with the Contract Drawings and applicable standards, and subject to review and approval by the Engineer.

2.04 WOOD AND PLASTICS

- A. General: Lumber in accordance with PS 20 "American Softwood Lumber Standard" and with applicable grading rules of inspection agencies certified by ALSC Board of Review.
- B. Provide seasoned lumber with 19 percent maximum moisture content at time of dressing and shipment, unless otherwise indicated.
- C. [NOT USED]
- D. [NOT USED]
- E. Plywood panels for walls, fences, and signage: in accordance with PS 1-83 "US Product Standard for Construction and Industrial Plywood." Identify each panel with the trademark of American Plywood Association (APA). Provide plywood as follows:
 1. Type: Exterior plywood with both faces of Medium Density Overlay (MDO).
 2. Grade: Exterior, Group 1 Panel.
 3. Panel thickness: $\frac{3}{4}$ inch.
 4. In accordance with AWPA Standards C2 (Lumber) and Cp (Plywood) for kiln dried materials, dried after treatment.
 5. Pre-treat wood members with water-borne preservatives to a minimum retention of 0.40 pcf.
 6. Coat all cut surfaces in accordance with AWPA M4.
- F. Carpentry anchoring and connection elements shall have hot-dip zinc coating in accordance with AASHTO M 232.
- G. Paint plywood in accordance with Section 09900, "Painting". Apply primer and finish coats suitable for outdoor material use and in accordance with the manufacturers recommendations. Current NSC-003/006 pedestrian facilities utilize the following painting items:
 1. PPG Item No. 9047705 Pitt-Tech I-E/SN Deep Rustic Color/Name: PNC Blue
 2. PPG Item No. 1792201 Seal Grip I/E Acrul LTX DP BSE Color/Name: PNC Blue
- H. Contractor may select a different paint manufacturer; however Contractor shall provide an equivalent or better paint system and consistent looking color scheme to what has been established by the NSC-003/006 contractor.

2.05 [NOT USED]

2.06 FLASHING AND SHEET METAL

- A. Roof flashing for roof joints of walkway sections: Provide roof flashing formed from aluminum sheet 0.032 inch thick.

- B. Aluminum threshold: Provide extruded, clear anodized aluminum finish, saddle threshold, to the full length of the covered walkway section. Secure to plywood floors over section's joints with galvanized wood screws. Provide threshold width to overlap each section's floor at least 3 inches.

2.07 ELECTRICAL

- A. Light fixtures: Provide fixture for each type of lamp complete with standard or special mounting frames, lamps, ballast, and other elements as required.
1. Walkway fluorescent fixtures: Provide UL listed fixture and internal components labeled for wet or outdoor installation, factory sealed and gasketed, and as follows:
 - a. Housing construction: 20 gauge steel seamless with white corrosion resistant finish of baked, epoxy, or porcelain.
 - b. Lens: Molded, high-impact resistant acrylic sheet with concealed gasket.
 - c. Lamp: Rapid start, energy saving lamp.
 - d. Ballast: 120 V, class P, thermally protected, high power factor, and suitable for energy saving lamps. Provide ballast labeled by the ETL to verify compliance with CBM requirements.
 - e. Lens protection: Factory applied, vandal resistant metal guard cage with finish matching the housing finish.
 2. Fluorescent "Lozenge" shape fixture: Provide UL listed fixture and internal components labeled for wet or outdoor installation, factory sealed and gasketed, and as follows:
 - a. Mounting Plate: 16 gauge cold-rolled steel, draw formed, finish on all sides with white polyester powder coat over rust-resistant paint. Provide fixture with horizontal mounting, vandal resistant, one-piece with integral base trim, ultraviolet stabilizer clear polycarbonate with lens.
 - b. Lens: Internal prisms. Lens exterior shall be smooth surface. Lens thickness shall be minimum 0.13 inch with additional thickness of 0.08 inch at prisms. Integral base trim shall be factory with #6 yellow.
 - c. Lamp: 13 watt twin tube fluorescent with appropriate exterior ballast.
 - d. Gasket: One-piece, die-cut closed cell EPDM gasket to seal the entire lens and mounting plate.
 - e. Fasteners: recessed screw heads, stainless steel screws with center reject pin sealed with neoprene o-ring.
- B. Grounding: Provide all lighting and electrical components with a complete grounding system in accordance with building and electrical codes. In addition, provide grounding to all metal frame temporary pedestrian accommodations that include lighting or electrical power in accordance with applicable codes and as follows:
1. Metal frame shall be bonded to the electrical system grounding conductor as well as to locally driven ground rod.
 2. Provide bonding jumpers across any frame fitting or connections that interrupt, or may eventually interrupt, electrical continuity (e.g. – hinges, swivels, gates, adjacent section).

3. Final installation of grounding system shall ensure that no point of the metal framing shall have a resistance measurement to local earth ground exceeding 2 ohms.
- C. Conduit: Provide UL listed conduits with corrosion resistant coating with white color for all electrical system wiring, with all proper fittings in accordance with code requirements for outdoor installations.

ARTICLE 3 EXECUTION

3.01 GENERAL DESIGN AND CONSTRUCTION

- A. The following elements pertaining to Temporary Pedestrian Accommodations, Fence and Barricade are included as work of related sections:
 1. Pedestrian-related traffic control signage shall be work of Section 01780, "Maintenance and Protection of Traffic."
 2. Temporary concrete barrier in standard-use applications (i.e., without the addition of fence or panels as detailed for construction barricade) shall be work of Section 01780, "Maintenance and Protection of Traffic."
- B. General Design Criteria – The Contractor shall follow the Contract Documents to design, install, maintain, operate, and modify temporary pedestrian accommodations, fence and barricade, including the design criteria defined throughout this Section.
 1. Except as specifically noted, all enclosures of work zones which are in place longer than 24 hours shall be accomplished using temporary pedestrian accommodations.
 2. The Contractor shall follow construction phasing, staging, and traffic control plans as shown or described in the Contract Documents and as follows:
 - a. The Contractor shall modify, move, or reconstruct the temporary pedestrian accommodations as necessary to maintain pedestrian movements through or around the Worksite.
 - b. When changes in construction sequencing or traffic control require changes in the type, location or extent of temporary pedestrian accommodations, fence or barricade, the Contractor shall provide the appropriate elements in quantities sufficient to conform with the design criteria.
 3. When more than one criterion or condition applies to a given field condition, the more stringent criteria shall govern.
- C. Safety – Temporary Pedestrian Accommodations shall be located such that:
 1. Placement shall not obstruct existing traffic control devices or informational sign systems. When such obstruction of existing traffic control elements is unavoidable, the existing elements shall be temporarily replaced or relocated as approved by the Engineer.
 2. Temporary pedestrian accommodations shall not jeopardize traffic safety by obstructing views between motorists, pedestrians, and other hazards.

3. Temporary pedestrian accommodations shall not jeopardize personal security by creating isolated routes or limit the ability of pedestrians to detect dangerous conditions or threatening persons.

D. Regulatory standards:

1. All devices shall be in accordance with the reference documents listed in Article 1.03 of this Section.
2. All temporary pedestrian accommodations, including walkways and ramps, shall be ADA compliant.
3. Signing, signalization, and pavement markings for pedestrian crossings of roadways shall conform with all applicable requirements of the latest edition of the MUTCD, as amended.
4. Location and placement of all temporary pedestrian accommodations shall be coordinated with the Traffic Control Plan via the Traffic Control Supervisor and in accordance with the requirements of Section 01780, "Maintenance and Protection of Traffic."
5. Location and placement of all temporary pedestrian accommodations shall also be coordinated through the Engineer with the City of Pittsburgh Department of Public Works Bureau of Transportation and Engineering.

E. Enclosure of Construction Zones and Laydown Areas:

1. Except as specifically noted, all construction zones and laydown areas that are in place longer than 24 hours shall be separated from public access by continuous construction fence, construction barricade, or a combination thereof, constructed in accordance with the Contract Documents. Barriers shall be interrupted only by gates or removable barriers used to allow ingress and egress of construction personnel, equipment and materials.
2. When construction barricade, construction fence would jeopardize traffic safety by obstructing views, alternate site enclosure devices or practices shall be used with the prior written acceptance of the Engineer.
3. For work zone enclosures in place for five days or less, chain-link mesh may be substituted for plywood sign panels on construction fences and construction barricades.

F. Separation of Pedestrians, Construction Zones, and Vehicular Traffic:

1. Construction zones shall be separated from all pedestrian routes by continuous construction fence in accordance with Article 3.02 of this Section, construction barricade in accordance with Article 3.03 of this Section, temporary gates in accordance with Article 3.06 of this Section, or combination thereof, as indicated by the Contract Documents and based on approval by the Engineer.
2. Where no curb exists to separate pedestrian routes from moving construction vehicles, separation of the pedestrian route from the construction zone will be provided by continuous protection via construction barricade in accordance with the requirements of this Section.
3. Where no curb exists to separate pedestrian routes from adjacent vehicular traffic, separation of the pedestrian route from the travel lanes will be provided by

continuous protection via construction barricade per the requirements of this Section, or via temporary concrete barrier in accordance with Section 01780, "Maintenance and Protection of Traffic."

4. Where no curb exists to separate moving vehicular traffic from construction zones, separation of the travel lanes from the construction zone will be provided by continuous protection via temporary concrete barrier in accordance with Section 01780, "Maintenance and Protection of Traffic."
5. When there is danger of objects or materials falling from above due to construction activity, a pedestrian covered walkway with protective decking shall be used in accordance with the requirements of this Section.
6. When there is danger of flying debris due to construction activity, construction barricade and/or pedestrian covered walkway will be used with appropriate side panels in accordance with the requirements of this Section.

G. Walkway Widths

1. Temporary pedestrian accommodations shall be selected and located so that the minimum clear width of a pedestrian route is at least 8'-0".
2. Widths greater than 8'-0" shall be used as required to accommodate pedestrian traffic on a site-specific basis. Maximize temporary walkway width for use before, during and after PNC Park and Heinz Field Events.
3. Widths narrower than 8'-0", down to a typical minimum of 6'-0", may be allowed only where construction limitations require such restrictions as indicated on the Contract Drawings or as approved in writing in advance by the Engineer.
4. Where clear widths narrower than 5'-0" are considered necessary by the Contractor and are approved in writing in advance by the Engineer, provide passing spaces of at least 60 by 60 inches clear at intervals no greater than 200 feet.

H. Delivery Handling, Storage, Assembly and Removal:

1. Elements and materials of temporary pedestrian accommodations, fence and barricade shall be fabricated, handled and stored to facilitate reuse or relocation. Materials and elements shall be properly stored before and between uses, adequately protected, and carefully handled during installation and disassembly.
2. For each work area where temporary pedestrian accommodations are used, perform on-site assembly expeditiously to minimize interference with the general public. Complete and place in service all temporary accommodations indicated, including signage, prior to the start of associated physical construction in the work area.
3. Construct and paint temporary pedestrian elements off site to the greatest extent possible. Deliver, position, and join sections of temporary elements on site only after substrate has been prepared, compacted (if required), and accepted by the Engineer.
4. Prepare and provide walkway sections aligned and with slopes not to exceed 5 percent in the direction of the traveling path, and 2 percent across the traveling path. If greater slope in the direction of travel is unavoidable, provide a walking

- surface slope ratio up to 1(rise) to 12(run) and comply with regulations governing ramp construction. Provide minimum slopes to prevent standing water.
5. Firmly secure temporary pedestrian accommodations, fence and barricade to substrate as required to resist all wind, snow, dead and live loads.
 6. All materials provided by the Contractor under this Section shall be removed by the Contractor when they are no longer required or as directed by the Engineer. In addition, remove all temporary facilities turned over by the NSC-003/006, NSC-004 R, and NSC-007 contractors.
 - a. Repair all surfaces which have been damaged by the installation of the temporary facilities. Remove temporary guide rail and patch pavements.

3.02 CONSTRUCTION FENCE

- A. Provide temporary construction fence that is modular and can be constructed in sections or panels. The fence panels should include a self sustaining base for upright support.
- B. Provide three types of construction fence, for use as indicated by the Contract Documents and as directed by the Engineer, as follows:
 1. Construction Fence, Chain-link Mesh on Portable Supports.
 2. Construction Fence, Chain-link Mesh on Foundation.
 3. Construction Fence, Paneled.
- C. Construction Fence, Chain-link Mesh on Portable Supports:
 1. Construction fence, chain-link mesh on portable supports, in accordance with PENNDOT 408, Section 624; and PENNDOT Publication 72, Drawing RC-60, with exceptions as listed herein.
 2. Temporary fence posts shall be installed using the appropriate supports.
- D. Construction Fence, Chain-link Mesh on Foundation:
 1. Construction fence, chain-link mesh on foundation, in accordance with PENNDOT 408, Section 624; and PENNDOT Publication 72, Drawing RC-60, except as modified herein.
 2. If mounting via base plates to sidewalk or barrier is selected, this fence shall be in accordance with PENNDOT 408, Section 1016; and PENNDOT Publication 219, Drawing BC-701, with exceptions as listed herein.
 3. Foundations, where applicable, will be Contractor designed on a site-specific basis to resist vertical and lateral loads.
 4. Install sign panels where indicated and as directed by the Engineer in accordance with Article 3.05 of this Section and as shown on the Contract Drawings.
- E. Construction Fence, Paneled.
 1. Construction fence, paneled, shall be constructed of MDO plywood in accordance with the Contract Drawings with components in accordance with Article 3.05 of this Section as follows:
 - a. Base portion shall be Type D panel.

- b. Center portion shall be Type C1 or C2 panel.
 - c. Top portion shall be sign panel.
- 2. Foundations will be Contractor designed on a site-specific basis to resist vertical and lateral loads.
- F. For each type of construction fence, the back side of the fence shall face the construction site; the front side shall face the public. The fastener side of line post ties shall be on the back side of the fence.
- G. For each type of construction fence, provide painting, graphics, artwork, lighting, and/or plastic fabric screening as applicable in accordance with Articles 3.05 and 3.11 of this Section.

3.03 CONSTRUCTION BARRICADE

- A. Provide temporary construction barricade that is modular and can be constructed in sections or panels. The base section of each barricade type shall consist of temporary concrete barrier conforming to the requirements of Section 01780, "Maintenance and Protection of Traffic."
- B. Provide two types of construction barricade, for use as indicated by the Contract Documents and as directed by the Engineer, as follows:
 1. Construction Barricade, with Chain-link Mesh
 2. Construction Barricade, with Panels
- C. Construction Barricade, with Chain-link Mesh
 1. Construction barricade, with chain-link mesh, shall be constructed with a chain-link mesh panel mounted directly to a temporary concrete barrier base, or submit an alternate design to be approved by the Engineer.
 2. Mounting of posts, rails, and related components will be in accordance with the Contract Drawings, PENNDOT Publication 219, Drawing BC-701, or of Contractor design in accordance with Article 1.04 of this Section.
 3. Tie-down anchors, where applicable, will be Contractor designed on a site-specific basis to resist wind forces.
 4. Install sign panels where indicated and as directed by the Engineer in accordance with Article 3.05 of this Section and as shown on the Contract Drawings.
- D. Construction Barricade, with Panels
 1. Construction barricade, with panels, shall be constructed as shown on the Contract Drawings with components in accordance with Article 3.05 of this Section as follows:
 - a. Base portion shall be temporary concrete barrier.
 - b. Center portion shall be Type C1 or C2 panel.
 - c. Top portion shall be sign panel.

2. Mounting of posts, rails, and related components will be in accordance with the Contract Drawings, PENNDOT Publication 219, Drawing BC-701, or of alternate Contractor design in accordance with Article 1.04 of this Section.
 3. Tie-down anchors, where applicable, will be Contractor designed on a site-specific basis to resist wind forces.
- E. For each type of construction barricade, the back side of the barricade and fence or panel shall face the construction site; the front side shall face the public. The fastener side of line post ties shall be on the back side of the barricade and fence or panel.
 - F. For each type of construction barricade, provide painting, graphics, artwork, lighting, and/or plastic fabric screening as applicable in accordance with Articles 3.05 and 3.11 of this Section.

3.04 [NOT USED]

3.05 PANEL AND SCREEN DETAILS FOR CONSTRUCTION FENCE, BARRICADE

- A. Provide appropriate panel types as required to complete the assembly of construction fence, construction barricade in accordance with the requirements of this Section, for approval by the Engineer. Panel types will include sign panel and panel types A, B1, B2, C1, C2, D, and E.
- B. Provide painting, graphics, and artwork, for each panel type as applicable in accordance with Article 3.11 of this Section.
- C. Typical installation of panels to support posts will consist of U-clamp fasteners with washers and cap nuts.
- D. Sign Panels:
 1. Sign panel will typically be installed along the top edge of all construction fence, barricade and as directed by the Engineer.
 2. Sign panel will be constructed of MDO plywood, 2'-0" high, and typical 10'-0" length (length may vary specific to each installation).
 3. At the Contractor's option, when the sign panel installation abuts a chain-link mesh panel, provide one of the following:
 - a. At the top of chain-link mesh, extend chain-link mesh 6" minimum above the top of and behind the sign panel. Secure the top of chain-link mesh to the sign panel at 12" intervals with non-penetrating galvanized wood screws with large washers.
 - b. If top of chain-link mesh is at or below the bottom of the sign panel, provide a horizontal top rail attached to the pipe posts, and secure the top of chain-link mesh to the rail at 12" intervals.
 4. Mount light fixtures to sign panel on approximate 5'-0" centers as applicable in accordance with this Section and the Contract Drawings.
- E. Type A Panel:

1. Type A panel will typically be used on the side of covered walkway sections that abut roadways or other public areas.
2. Type A panel will be constructed of MDO plywood with wood face trim and typical dimensions in accordance with the Contract Drawings.

F. Type B1 and B2 Panel:

1. Type B1 and B2 panel will typically be used for full-height enclosure of covered walkway faces that abut construction zones and laydown areas.
2. Type B1 and B2 panel will be constructed of MDO plywood with wood face trim and typical dimensions in accordance with the Contract Drawings.
3. Type B1 panel will be solid without viewing portholes. Type B2 panel will include viewing portholes as follows:
 - a. Large and small circular viewing portholes will be located with typical dimensions as shown on the Contract Drawings.
 - b. Porthole trim will be painted per requirements of this Section.
 - c. Viewing portholes will be screened with a vinyl-coated woven wire mesh mounted to an interior wood ring frame. Where applicable, color of screen will match color of porthole trim.

G. Type C1 and C2 Panel:

1. Type C1 and C2 panel will be standard for the center section of construction fence, paneled, and for construction barricade, with panels.
2. Type C1 and C2 panel will be constructed of MDO plywood with typical dimensions in accordance with the Contract Drawings.
3. Type C1 panel will be solid without viewing portholes. Type C2 panel will include viewing portholes as follows:
 - a. Large and small circular viewing portholes will be located with typical dimensions as shown on the Contract Drawings.
 - b. Porthole trim will be painted per requirements of this Section.
 - c. Viewing portholes will be screened with a vinyl-coated woven wire mesh mounted to an interior wood ring frame. Where applicable, color of screen will match color of porthole trim.

H. Type D Panel:

1. Type D panel will be standard for the bottom section of construction fence, paneled.
2. Type D panel will be constructed of MDO plywood with typical dimensions in accordance with the Contract Drawings.

I. Type E Panel:

1. Type E panel will typically be used on the side of covered walkway sections above Type A panel or temporary concrete barrier following manufacturer's guidelines for those locations where full-height enclosures via Type B1 or B2 panel are not desirable per the following guidelines:

- a. Full-height enclosures shall be omitted within a minimum of 10 feet of street and/or sidewalk corners where views of oncoming pedestrian and/or vehicular traffic would be obstructed.
 - b. When full-height panels would jeopardize traffic safety and/or pedestrian security by obstructing the visibility of or isolating walkways, and/or obstruct the visibility of adjacent businesses, then chain-link mesh (or no covering) shall be used in place of panels. Changes of this type require the approval of the Engineer.
 2. Type E panel will be constructed of chain-link wire mesh with typical dimensions in accordance with the Contract Drawings.
- J. Plastic Fabric Screen
1. Plastic fabric screen will typically be installed where a visual barrier through chain-link mesh segments, or through the side of covered walkway segments, is required in accordance with the Contract Documents.
 2. Design, material, and color of plastic fabric screen will be subject to review and approval by the Engineer in accordance with Article 1.04 of this Section.
 3. Stretch fabric screens taut and secure to supports through grommets with galvanized steel wire or plastic ties.
 4. Where used in conjunction with construction fence or construction barricade, plastic fabric screens shall be fastened to the chain-link mesh on the face opposite the posts and rails.
 5. Where used in conjunction with covered walkways, plastic fabric screens shall be fastened to the steel tube posts on the face opposite pedestrian traffic.

3.06 TEMPORARY GATE

- A. Contractor will furnish, locate, and install temporary gates as required for access to work zones and laydown areas, with locations subject to review and approval by the Engineer.
- B. Temporary gates in accordance with PENNDOT 408, Section 1110, and PENNDOT Publication 72, Drawing RC-61.
- C. Temporary gate widths will be as required for site-specific access, typically between 15'-0" and 24'-0".

3.07 TEMPORARY CROSSWALK

- A. [NOT USED]
- B. Temporary crosswalk locations shall be shifted as required to accommodate those work zones specified as staged construction areas.
- C. Temporary crosswalk installations shall include signage, pavement markings, and typical dimensions. This work will be included as part of Section 01780, "Maintenance and Protection of Traffic."

- D. Flashing lights shall be installed atop temporary crossing signs as indicated and per following guidelines.
- E. Temporary ramps shall be included at each end of all temporary crosswalks in accordance with this Section.

3.08 TEMPORARY RAMPS AND CURB MODIFICATIONS

- A. Temporary ramps will be installed at all temporary crosswalk locations and at entrance/exit points of covered walkway segments as follows:
 1. Typical curb ramp design in accordance with PENNDOT Publication 72, Drawing RC-67.
 2. Where bituminous concrete is used, conform with Section 02740, "Bituminous Pavement and Sidewalk."
 3. Where lumber is used, conform to the lumber and carpentry requirements of this Section.
- B. Required curb and curb modifications shall be subject to review and approval by the Engineer and shall be in accordance with PENNDOT 408, Sections 636.3 and 694.3 and /or the City of Pittsburgh Department of Public Works Bureau of Transportation and Engineering.

3.09 TEMPORARY HANDRAIL AND GUARDRAIL

- A. Pedestrian railing, where required, will be in accordance with PENNDOT 408, Section 1012.
- B. Handrails – The following design loads are required for compliance with ADA
 1. Concentrated load applied at any direction: 250 pounds
 2. Uniformly distributed load applied at any direction: 50 pounds per foot
- C. Guardrails – The following design loads are required for compliance with ADA:
 1. Concentrated load applied to top railing member at any direction: 200 pounds.
 2. Uniformly distributed load applied to top railing member: 100 pounds per foot vertical load simultaneously with 50 pounds per foot horizontal load.

3.10 TRASH BARRELS

- A. Contractor will provide one trash barrel at each of the following locations:
 1. At each entrance to a covered walkway segment and/or temporary walkway.
 2. Mid-block along each city block adjacent to the work zone
 3. Contractor will empty trash barrels on a weekly basis or as directed by the Engineer.
- B. Trash barrels shall be located so as to be accessible to persons in wheelchairs and shall not obstruct the accessible route. Do not place trash barrels inside covered walkways.

3.11 PAINTING, GRAPHICS AND ARTWORK

- A. Specific color schemes, graphics, artwork, or other aesthetic treatments to be installed on temporary pedestrian accommodations should be consistent with the current NSC-003/006 contract facilities.
- B. Contractor shall paint and install graphics and artwork on construction fence, construction barricade, based on the requirements of the aforementioned project-wide program and permit others as approved by Authority to do so. The Authority may provide its own artwork to the Contractor to be displayed. The Contractor will coordinate this artwork with Authority.
- C. Panel types A, B1 and B2 (including porthole trim), C1 and C2 (including porthole trim), and D shall be painted in accordance with Section 09902, "Painting." The Contractor shall paint only sides of the Panel which are facing public access paths.
- D. As directed by the Engineer, Contractor will furnish and install clear $\frac{1}{4}$ " acrylic covers for artwork where occurring on Type C1 panels.

3.12 ELECTRICAL SUPPLY, CONDUIT, WIRING, LIGHTING

- A. Provide electrical supply, conduit, wiring, and lighting conforming to code requirements and in accordance with Article 2.07 of this Section.
- B. Provide light fixtures for construction fence and construction barricade.
- C. Provide all necessary conduits, wiring, electrical supply, and other electrical components needed for such lighting. Bond and ground all electrical equipment. Provide a continuous mechanical and electrical grounding system from the electrical supply cabinet through the electrical distribution system.

3.13 CARPENTRY

- A. Set exposed-to-view carpentry work to required levels and lines, with wood members plumb and true to line, cut, and fitted.
- B. Countersink heads on exposed carpentry work and fill holes unless noted otherwise. Use galvanized fasteners. Use finishing nails only for finishing work. Use screws unless noted otherwise. Select fasteners of size that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting of wood; pre-drill as required.
- C. Wood grounds, nailers, blocking, and sleepers: Provide preservative-treated wood deck framing and blocking. Provide sleepers and grounds of preservative treated lumber dressed to not less than 1-1/2 inch wide.

- D. Wood framing: Do not splice structural members between supports.
- E. Install non-skid adhesive applied on all lumber used as walking surface other than plywood with non-skid finish.
- F. Installation of plywood panels in accordance with applicable recommendations contained in form No. E "APA Design/Construction Guide – Residential & Commercial", for types of construction panels and applications indicated. Fasten panels as indicated below:
 1. Floor: Screwed to framing.
 2. Plywood wall and sign panels: Screwed or clamped to supports.

3.14 [NOT USED]

3.15 MAINTENANCE AND OPERATIONS

- A. Repairs to and operation of temporary pedestrian accommodations and adjacent sidewalks until Final Inspection of the Contract are the responsibility of the Contractor. The term "adjacent sidewalks" as used in this Section shall be defined as follows:
 1. All sidewalks and pedestrian detours constructed by the Contractor.
 2. All existing sidewalk surfaces within 8 feet of temporary pedestrian accommodations.
 3. The walking surfaces of covered walkways.
 4. Other locations noted or specified as part of Contractor's walkway maintenance responsibility.
- B. Elements in storage or under construction, modification, or relocation shall be handled carefully and repaired to as-new condition when damaged.
- C. The Contractor shall remove snow and ice, provide inspection, cleaning, and repair of temporary pedestrian elements and adjacent sidewalks during both working and non-working hours, including weekends and holidays. The Contractor shall, at the beginning and end of each work shift, inspect the temporary pedestrian accommodations and adjacent sidewalks for deficiencies and undertake corrective action as specified below.
- D. Keep temporary pedestrian accommodations and adjacent sidewalks free of snow and ice.
 1. Remove snow and keep in clean condition to avoid snow accumulation. The Contractor shall remove snow throughout the Project area in accordance with the City of Pittsburgh snow removal codes. If there are no applicable codes the Contractor shall remove snow during weekdays by 7:00 AM until 10:00 PM, and during weekends and holidays by 9:00 AM until 5:00 PM.
 2. Keep pedestrian walking surfaces free of ice at all times.

3. When temperature is predicted to be below 32 degrees F, and/or when snow or ice accumulation is predicted by the National Weather Service, apply non-toxic melting agent to maintain all pedestrian walking surfaces clear of ice hazard.
 4. Offsite disposal of snow shall be in accordance with all applicable regulations. Where snow is disposed of within Contractor's Worksite, it shall be done so as not to reduce pedestrian and vehicular visibility, create excessive runoff onto public ways, detours or adjacent property, or produce any other hazardous condition.
- E. Keep temporary pedestrian accommodations clean.
1. Sweep all walking surfaces as required to keep them free of dirt, debris, and rubbish, but not less than once a day.
 2. Remove trash from all other surfaces not less than once every day.
 3. Wash down exposed surfaces at least once a week.
 4. Empty trash barrels as required before barrels overflow or attract pests or insects, but not less than once a day. Wash interior and exterior of barrels as required to maintain clean, sanitary condition of trash barrels, but not less than once a week.
 5. Keep pedestrian elements free of graffiti, stickers, and flyers. Remove or paint over graffiti within 1 working day.
- F. Keep pedestrian elements illuminated.
1. Interior of pedestrian covered walkways shall be continuously illuminated.
 2. Exterior and sign panel lights shall be illuminated dusk-to-dawn, every day.
 3. Repair or replace, within 1 day, non-functional, burned out, broken, and missing light bulbs and fixtures.
- G. Keep pedestrian elements in "like-new" condition.
1. Keep pedestrian elements painted. Check weekly for cracked, peeling, and fading paint. Correct deficiencies noted within 7 days.
 2. Check elements and materials weekly for loose joints and connections, cracked or delaminated materials, and any other physical deterioration. Correct deficiencies within 3 working days.
 3. Upon discovery of a safety deficiency immediately restrict the use of the unsafe element, notify the Engineer without delay, and correct the deficiency immediately.
 4. Keep directional signage clean, legible, in place, and up-to-date at all times. Revise directional signage as required. Promptly remove or cover signage that has outdated information.
- H. Adjust temporary Pedestrian Accommodations as required and as directed by the Engineer.
1. [NOT USED]
 2. Move or install construction fence at other locations as required to allow for pedestrian movement while still securing the Worksite.
 3. Repair pavement and sidewalk as required.

4. Repair any holes in any sidewalk not to be replaced. Secure the bottom of the hole, fill with non-shrink grout, finish to match existing sidewalk.
5. Clean temporary pedestrian accommodations in accordance with Article 3.15E of this Section.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 01784.001 – Temporary Pedestrian Accommodations shall be measured as a lump sum unit, complete in place.
- B. [NOT USED]

4.02 PAYMENT

- A. Item 01784.001 – Temporary Pedestrian Accommodations will be paid at the lump sum price and shall include the cost of all related work specified in this Section.
- B. [NOT USED]

END OF SECTION

SECTION 01785
CONSTRUCTION SURVEYING

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for construction surveying, in accordance with the Contract Documents
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Survey for all temporary and permanent work and right-of-way.
 - 2. Existing structure confirmation
 - 3. Calculations

1.02 [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication 122M.
- C. "Geometric Geodetic Accuracy Standards with Specifications for using GPS Relative Positioning Techniques," Federal Geodetic Control Committee.

1.04 SUBMITTALS

- A. Submit survey field books including date, work description, Contractor's name and person responsible for the survey work and in accordance with PENNDOT Publication 122M Part A Chapter 7.
- B. Submit Professional Land Surveyor resumes for approval by the Engineer.
- C. [NOT USED]
- D. Submit existing tunnel survey cross section Data as requested in Article 3.06.B.

1.05 QUALIFICATIONS

- A. Employ a Professional Land Surveyor with at least 10 years of experience. The registered professional must be qualified in the use of procedures for establishing horizontal and vertical geometry, structure location, utility layout and dimensions as may be required.
- B. [NOT USED]

C. [NOT USED]

ARTICLE 2 PRODUCTS

2.01 CONSTRUCTION SURVEYING

- A. In accordance with PENNDOT 408, Section 686.2, except as modified herein:
 - 1. 686.2 (g) change Bridge to Structures
 - 2. 686.2 (l) delete section.

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION SURVEYING

- A. Perform all survey work in accordance with Pub 122M, PENNDOT's Surveying and Mapping Manual.
- B. Construction Surveying includes surveying for new construction based on precise horizontal and vertical geometry established from surveys and topographic mapping based on Pennsylvania State Plane Coordinate System in the North American Datum of 1983 (NAD 1983) and the North American Vertical Datum of 1988 (NAVD 1988).
- C. Project horizontal geometry is based on Pennsylvania State Plane Coordinate System at sea level elevation. To convert grid lengths see note in Contract Drawings.
- D. Provide surveying as required by the Work.
- E. Provide the Engineer with survey control points to check quality of construction activities.
- F. The Contract Documents include pertinent survey information including horizontal traverse and vertical benchmark information established during design.
- G. The Contractor is responsible for verifying traverse points and benchmark elevations to be utilized during the Work. Notify the Engineer immediately of any errors, omissions or discrepancies. Record geometric and/or coordinate ties on all lines produced. Provide the Engineer with all coordinate networks used in staking the Project, including coordinate geometry, horizontal geometry, and reference network points.
- H. Contractor assumes full responsibility for dimensions and elevations taken from control stakes and for the setting of structure locations and line and grade stakes.
- I. Obtain approval from the Engineer for any variance or exception to field stakeout points before performing any work.
- J. Reference all designated work points. Reference each work point on a direct line through any adjacent work point(s). Establish three reference points for the work

point. The distance between a work point and its first reference point is to be less than 100 feet.

- K. Establish a Second Order, Class II (1:20,000) traverse network for the Work. Show precision ratio, and comparisons of longitudinal distances. Establish a Second Order, Class II Control Benchmarks level loop.
- L. Furnish the Engineer prior to any construction activities with a field stakeout drawing, based on the structure plan stakeout, showing only centerline/base line stations, referenced angles, and reference lengths. Show three described vertical benchmarks.
- M. Furnish the Engineer prior to any construction activities with a drawing showing a triangulation network or traverse network at each structure.

3.02 [NOT USED]

3.03 [NOT USED]

3.04 UTILITY SURVEYING

- A. Existing utilities that conflict with the proposed construction shall be relocated or removed as noted in the Contract Drawings. In order for the utility lines not to be in conflict in their proposed locations, their relocations shall be coordinated with the utility companies and in strict accordance with the Contract Documents.
- B. Contractor shall provide surveying to stakeout the proposed relocated utility lines shown in the Contract Documents.

3.05 [NOT USED]

3.06 PAAC EXISTING GATEWAY STATION LOOP

- A. The Contractor shall be aware of the plans for existing Gateway Station Loop, are not on the same Datum of the current design. See Port Authority of Allegheny County, Stage I Light Rail Transit System, Liberty Avenue Subway and Gateway Center Shell, Construction Contract No. CA-450, Sheet 6 (Dwg. No. C-063-1) for Datum information.
- B. Contractor shall perform a cross section survey of the existing tunnel at each location for jet fan installation within the existing Stage I tunnel structure. The jet fans have received a clearance waiver for installation. The Contractor shall perform as-build cross sections at stations 1014+50 and 1016+50 within the existing Stage I tunnel and submit the survey results to the Engineer prior to procurement of the jet fans. Results shall include raw point data and CAD drawings, to scale, of each section. The cross section shall be inclusive of the entire tunnel section, including plinth and rail locations, existing facilities on floor, roof, and walls, tunnel wall/roof fillet location, and catenary.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A.** No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A.** No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01787

TRANSFER OF TEMPORARY FACILITIES

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for transfer of temporary facilities, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 1. Transfer of temporary facilities.

1.02 RELATED SECTIONS

- A. Section 01783, "Temporary Facilities."

1.03 INSTALLING CONTRACTOR SUBMITTALS

- A. Post-installation Submission
 1. The installing contractor shall submit for Engineer's review and comment, current manual and training program within ninety (90) days after temporary facility installation and beginning of operation. This submission shall include all data documenting the installation, and enough data documenting operation and maintenance information format. Include written responses to all pre-installation submission comments.
 2. The installing contractor shall submit four (4) copies of complete manual, to the Engineer for review and comment, in current form a minimum of twenty-one (21) days prior to pre-final inspection of the temporary facility.
 3. The installing contractor shall submit four (4) copies of final manual, to the Engineer, in final form seven (7) days prior to final inspection. The Engineer shall forward one (1) copy to the Follow-On Contractor for review prior to final inspection of the temporary facility.

1.04 DEFINITIONS

- A. Follow-on Contractors: The Contractor awarded a Contract for an adjoining or shared worksite which will assume responsibility of previously installed temporary facilities from the installing contractor. The Follow-on Contractor will assume ownership of the identified temporary facility from the installing contractor, including maintenance, repair and removal, effective on the date identified in writing by the Engineer. It is anticipated that the date these items are provided to Follow-on Contractors is based on Conditional Acceptance of that portion of the Work.

1.05 FORM OF SUBMITTAL

- A. The installing contractor shall collect and document temporary facility data in the form of operation and maintenance manuals for use by Follow-on Contractor's personnel. Each manual shall include a detailed history of the installation, maintenance, and performance for each component of each temporary facility that will be turned over to the Follow-on Contractor as described in this Section. Each temporary facility to be turned over shall have its own manual.
- B. Digital Format
 - 1. The installing contractor shall furnish two (2) copies of each manual in Microsoft Word Format, Version 6.0 or higher, Adobe PDF or HTML complete with detailed index and appropriate document linking.
 - 2. The installing contractor shall furnish two (2) digital copies of all equipment drawings using CADD in .dgn, .dwg or .dxf format, if applicable. Photographs and image files shall be supplied in any of the following formats: .bmp, .gif, .jpg. or .tif.
- C. Hard Copy Format
 - 1. Size shall be 8-1/2 inches by 11 inches.
 - 2. Paper shall be 20 pound minimum, white, for typed pages.
 - 3. Text shall be manufacturer's printed data or neatly typewritten.
 - 4. Text shall be written in English.
 - 5. Drawings and text shall use English units.
 - 6. Drawings shall be provided with reinforced punched binder tabs and shall be bound in with text. Largest drawing size permitted shall be 11 inches by 17 inches, folded to the size of the text pages.
 - 7. Cover shall identify each volume with typed or printed title.
- D. Binders
 - 1. Binders shall be commercial quality three-ring binders with durable and cleanable plastic covers.
 - 2. Maximum ring size shall be two inches.
 - 3. When multiple binders are used, the data shall be correlated into related, consistent groupings.

1.06 CONTENT OF MANUAL

- A. The installing contractor shall compile product data and related information appropriate for the maintenance and operation of temporary facilities furnished under this Section.
- B. Operating, maintenance and repair data shall be prepared as specified in this Section and as referenced in other pertinent sections of the Contract Documents.

- C. The installing contractor shall provide two (2) training sessions for personnel from the Follow-on Contractor in the maintenance, repair, and operation of all equipment furnished. A minimum training session of combined classroom and field training shall be provided for designated Follow-on Contractor personnel. The installing contractor shall coordinate the training program with the Engineer, regarding format, content and schedule.
- D. Table of contents shall be neatly typewritten and arranged in a systematic order for each volume.
- E. The manual shall list:
 - 1. Manufacturer of all materials.
 - 2. Name of the installing contractor's contact person.
 - 3. Address and telephone number.
 - 4. A list of each product provided, indexed to the content of the volume, shall be included.
 - 5. List, with each product, the name, address, and telephone number of the local source of supply for parts and replacement.
 - 6. Each product shall be identified by product name and other identifying symbols as set forth in Contract Documents.
- F. Product Data
 - 1. Only those sheets which are pertinent to the specific product shall be included.
 - 2. Each sheet shall be annotated to:
 - a. Clearly identify the specific product or part.
 - b. Clearly identify the data applicable.
 - c. Delete references to inapplicable information.
- G. Drawings-Product Data shall be supplemented with drawings as necessary to clearly illustrate:
 - 1. Relations of component parts of equipment and systems.
 - 2. Control and flow diagrams.
- H. Written text, as required to supplement Product Data for the particular installation shall:
 - 1. Be organized in a consistent format under separate headings for different procedures.
 - 2. Provide a logical sequence of instructions for each procedure.
- I. A copy of each warranty issued shall be included.
 - 1. Information sheet for Follow-on Contractor personnel shall be included, giving:
 - a. Proper procedures in the event of failure.
 - b. Instances which might affect the validity of warranties.
- J. A copy of each governing agency permit issued for each such temporary facility shall be included.

1. Information sheet for Follow-on Contractor personnel shall be included, giving:
 - a. Copy of actual permit including all associated requirements.
 - b. Permit transfer process, if applicable.
 - c. Expiration date.
 - d. Agency contact including name, telephone number, and address.

1.07 OPERATION AND MAINTENANCE MANUAL

- A. Organization: The installing contractor shall organize and index the material in the manuals, treating each item as part of a whole system / temporary facility and not as a grouping of disassociated parts. Subdivide manual sections to the extent required by the subject matter, including, but not necessarily limited to the following topics:
 1. Table of contents.
 2. General system or subsystem description and operation.
 3. Block diagrams.
 4. Design and Working Drawings.
 5. Functional schematics.
 6. Functional wiring diagram.
 7. Lubrication and cleaning, including frequency, methods, and trade identifications of recommended materials.
 8. Component location and description.
 9. Inspection and maintenance standards including wear limits, settings, and tolerances.
 10. Installation and removal sequence.
 11. Test and evaluation procedures.
 12. Spare parts lists and special tools.
 13. Materials and finishes.
 14. Warranty information.
 15. Weekly inspection reports including detailed records describing any maintenance performed, including repairs made to the temporary facility components.
 16. Maintenance costs including parts and labor.
 17. Utility billings and fees.
- B. The detailed contents of sealed assemblies need not be displayed, but their functions must be explained and the appropriate operational specification characteristics listed, as well as procedures for test and replacement.
- C. Wiring Diagram Section and Maintenance and Renewal Sections: The installing contractor shall include information needed to sustain optimum operation.
 1. Include general familiarization material; location, function, and operation of all controls, gauges, indicators, and switches; emergency procedures; and trouble diagnosis methods. Any specialized tools to perform required maintenance and troubleshooting shall be turned over to the Engineer to give to the Follow-on Contractor.
 2. Organize the manual logically, with systems and elements considered in descending order of importance.

3. These Sections shall provide, in convenient form, all the information needed for servicing, including lubrication, inspection, running maintenance and adjustment, and online trouble diagnosis.
- D. Repair and Maintenance Sections: The installing contractor shall include complete illustrated, exploded views of all assemblies, and complete, illustrated, exploded views for identifying all system parts.
- E. Materials and Finishes Section: The installing contractor shall include manufacturer's data, giving full information on products:
 1. Information required for reordering specifically manufactured products.
 2. Instructions for care and maintenance.
 3. Manufacturer's recommendation for cleaning agents.
 4. Identifying cleaning agents which are detrimental to the product.
- F. Parts Section: The installing contractor shall enumerate and describe each component with its related parts, including the supplier's part number, the installing contractor's number and, commercial equivalents.
 1. Use cutaway and exploded drawings to permit identification of parts not readily identified by description.
 2. Parts common to different components, including bolts and nuts, shall bear the same installing contractor's number with a cross-reference to the other components of which they are a part. Identify each part or component as being part of the next part of the next larger assembly or subassembly.
- G. Warranty Section: The installing contractor shall include a copy of each manufacturer's warranty issued shall be included, and an information sheet for Follow-on Contractor personnel shall be provided, including:
 1. Proper procedures in the event of failure.
 2. Instances which might affect the validity of warranties.

1.08 INSTRUCTION OF FOLLOW-ON CONTRACTOR'S PERSONNEL

- A. The installing contractor shall conduct two (2) separate sets of instructional sessions to instruct each of the Follow-on Contractor's respective personnel in proper use, operation, and daily maintenance of equipment furnished and to be turned over to that Follow-on Contractor. Coordinate training through the Engineer.
- B. The installing contractor shall demonstrate equipment operation with the Engineer present. Determine that control system, operating components, and safety devices are functioning properly.
- C. The installing contractor shall use the operations and maintenance manual as textbook for demonstration and instruction, modifying and adding to the manuals in accordance with the Engineer's direction and as necessary to ensure adequacy of manuals for use by each Follow-on Contractor's personnel.

- D. The installing contractor training shall specifically include the following:
 - 1. Operations training shall be tailored specifically to temporary facility equipment, and designed to teach the day-to-day operation of all equipment. The training shall be sufficient to bring personnel to a level of operating proficiency such that the Follow-on Contractor can assume ownership of the temporary facility.
 - 2. Maintenance training shall be tailored specifically to equipment, and designed to develop the knowledge and skills required to maintain all item(s) delivered under this Section. Maintenance training shall be subdivided into two major levels, covering the following:
 - a. System level maintenance training:
 - 1) Theory of operation of the system and its major components.
 - 2) System configuration.
 - 3) Preventative maintenance, consisting of written procedures and schedules for the periodic maintenance of all equipment.
 - 4) Written and validated inspection procedures and a system-level troubleshooting guide (to the lowest field replaceable unit).
 - b. Shop level maintenance training:
 - 1) Detailed theory of operation to module, board, and/or device level.
 - 2) Component level troubleshooting and component replacement.
 - 3) Testing and alignment procedures of repaired units.
- E. The instruction sessions shall occur prior to pre-final inspection for the installing contractor and transfer of the temporary facility ownership to the Follow-on Contractor. Coordination of the transfer shall be through the Engineer.
- F. Training shall be provided by the installing contractor personnel who is most familiar with the day to day operations of the facility to be transferred.

ARTICLE 2 PRODUCTS

2.01 NSC-003/006 AND NSC-004 R TEMPORARY FACILITIES

- A. The NSC-009 Contractor is considered the Follow-on Contractor to the NSC-003/006 and NSC-004 R contractors and will take ownership of, but not limited to, the following temporary facilities from the NSC-003/006 and NSC-004 R contractors:
 - 1. NSC-003/006 Bored Tunnel and Cut-and-Cover Tunnel and Station Shell Temporary Facilities from Receiving Pit to Sta. L6051+94 (end of open boat at the interface with NSC-007).
 - 2. NSC-004 R Cut-and-Cover Tunnel and Station Shell Temporary Facilities from existing Gateway Station Loop to Receiving Pit, inclusive.
 - 3. NSC-003/006 Temporary Pedestrian Facilities located in Parking Lot No. 1 as shown in the Contract Drawings.
 - 4. NSC-003/006 Laydown Area No. 2 as shown on the Contract Drawings.

2.02 NSC-007 TEMPORARY FACILITIES

- A. The NSC-009 Contractor is considered the Follow-on Contractor to the NSC-007 contractor and will take ownership of, but not limited to, the following temporary facilities from the NSC-007 contractor:
 - 1. Temporary access roadway into Parking Lot No. 1, including traffic control signs and Special Parking Lot 1 signage.
 - 2. Parking Lot No. 1 lighting poles, 3 each
 - 3. Parking Lot No. 1 attendant booth, 1 each
 - 4. Temporary Pedestrian Facilities located in Parking Lot No. 1 to the intersection of Art Rooney Avenue and Reedsdale Street as shown on the Contract Drawings.
 - 5. Laydown Area No. 1 as shown on the Contract Drawings.

ARTICLE 3 EXECUTION

3.01 CONTRACTOR REQUIREMENTS

- A. The installing contractor shall provide temporary facilities to the Follow-on Contractors which have been well maintained and meet current regulatory agency requirements.
- B. The temporary facilities, at transfer must be in good repair as approved by the Engineer.
- C. The installing contractor shall transfer title to all temporary facilities materials and equipment to the Follow-on Contractor at the time designated by the Engineer.
- D. The installing contractor shall transfer all temporary facility warranties, permits, utility and maintenance contracts to the Follow-on Contractor. Each item shall be concurrent with no outstanding issues including, but not limited to, fees owed or alleged violations which may result in fines or legal action.
- E. The installing contractor is to pay all temporary facility service costs including, but not limited to, utility usage and service fees, maintenance contracts, and warranties. The installing contractor is to pay all such costs incurred through the turnover date identified by the Engineer and the prorated portion of any service bills through such date.

3.02 FOLLOW-ON CONTRACTOR REQUIREMENTS

- A. The Follow-on Contractor shall accept ownership responsibilities of each designated temporary facility immediately after Authority issuance of a Conditional Acceptance for the specific temporary facility or facilities that are ready for turnover from the installing contractor.

- B. The Follow-on Contractor shall assume responsibility to maintain, repair and operate their respective facilities including continued documentation of the Operations and Maintenance Manuals in accordance with this Section effective the date identified by the Engineer.
- C. The Follow-on Contractor shall accept transfer of their respective temporary facility warranties, permits, and third party billings for changes from the effective turnover date and forward, including, but not limited to, utility cost and maintenance contracts. The Follow-on Contractor shall assume all requirements of said documents, permits and agreements.
- D. Should the transferred facilities not be to the standards required for the Follow-on Contractor's needs, the Follow-on Contractor shall be responsible for, and implement all alterations and/or additions to the temporary facility including, but not limited to, utility service, additional components, and permits, as required, or as directed by the Engineer at no additional cost to Authority.

3.03 PRE-FINAL INSPECTION

- A. As the temporary facilities are coordinated for transfer, the installing contractor shall request a pre-final inspection for each identified temporary facility. The temporary facility pre-final and final inspections will be conducted similar to the procedures set forth in Section 01700, Article 4.
- B. At the time of the temporary facility pre-final inspection, the Follow-On Contractor shall attend to participate and may offer requests to the Engineer identifying temporary facility damage and identify any concerns with the current temporary facility. The Engineer will evaluate the Follow-on Contractors input and determine if any such input identifies a temporary facility deficiency. All identified temporary facility deficiencies will be included as part of the pre-final inspection punchlist. The Engineer has all final judgment on all Follow-On Contractor input.
- C. Once the temporary facility pre-final inspection has occurred, the installing contractor shall not make any modifications to the temporary facility unless approved by the Engineer. Should a modification be required, the Follow-On Contractor will be entitled to review all documentation regarding the modification and may request additional inspection to satisfy any concerns. Additional temporary facility pre-final inspection punchlist items may result from the implementation of modifications to such temporary facilities.

3.04 NSC-003/006, NSC-004 R, AND NSC-007 TEMPORARY FACILITY AVAILABILITY

- A. Authority anticipates that the temporary facilities listed in Article 2.01 and 2.02 of this Section will be transferred to the Follow-on Contractor (NSC-009) no sooner than the "Early Date of Availability" and no later than the "Late Date of Availability" as set forth in Section 00500, Article 2.1.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01791

REMOVE, STORE AND RE-ERECT EXISTING COMPONENTS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary to remove, store and re-erect existing components, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. [NOT USED]
 - 2. [NOT USED]
 - 3. The re-installation of existing facilities, including any work necessary to restore the utilities, serving these facilities.
 - 4. Deliver Items to be returned to owner.

1.02 RELATED SECTIONS

- A. [NOT USED]
- B. Section 003305 Cast-in-Place Concrete and Cement Concrete Structures

1.03 SUBMITTALS

- A. [NOT USED]
- B. Submit the Existing Parking Lot Booth Condition Survey, for approval by the Engineer.
- C. [NOT USED]
- D. Submit the Parking lot Special Signage Condition Survey, for approval by the Engineer.
- E. [NOT USED]

1.04 DEFINITIONS

- A. "Components", as described in this Section, is defined to mean the physical facilities described in Article 3 herein that the Contractor will reinstall, as described within the Contract Documents.

ARTICLE 2 PRODUCTS

2.01 GENERAL

- A. Contractor shall provide wiring, service lines, pipes, and conduit to provide parking lot booths with the same utility services in their proposed locations.
- B. [NOT USED]
- C. Any components described within this section damaged by the actions of the Contractor during the removal, storage or re-installation phases of the work activities shall be replaced or repaired by the Contractor at no cost to Authority and with the approval of the Engineer and the owner of the component.

2.02 MATERIALS

- A. Caulking – Premium grade, high-performance, moisture cured, one-component, polyurethane-base, non-sag elastomeric caulk. Color to be determined by the Engineer depending upon the application.

ARTICLE 3 EXECUTION

3.01 REMOVE AND STORE PARKING LOT BOOTHS

- A. At least three weeks prior to removing the existing parking lot booths, the Contractor shall meet with the Engineer, parking lot owner and the utility companies that provide service to the parking lot booth. The booths are located at or adjacent to Stations as follows: L6044+50 (along Tony Dorsett Drive) and R6049 + 60. Contact Ralph Reetz of ALCO Parking @ 412-323-4467. At that time, the Contractor will document the position and condition of all facilities affected by the construction activities included under this Section to the satisfaction of the owner and the Engineer. The documentation may include Working Drawings, sketches or photographs to clearly delineate the items to be removed and reinstalled. These items may include, but not limited to, transformers, footings, bollards, meters, timers, utility equipment and the booths themselves. This booth condition survey will be submitted to the Engineer.
- B. For each utility impacted, the Contractor shall prepare a Working Drawings to disconnect the utility's facilities from the existing parking lot booths. This plan shall be submitted to the Engineer and utility company a minimum of two weeks prior to the anticipated disconnection date. One week prior to the disconnection date the Contractor shall meet with the utility representatives and the Engineer to resolve any outstanding issues and request approval to proceed with the portion of work.
- C. Upon receipt of approval to proceed from each utility company, the Contractor shall disconnect the utilities from the parking lot booth. The Contractor shall comply with procedures required by the utility companies. If requested by the utility company, the

Contractor shall permit utility company representatives to witness the utility disconnection.

- D. The Contractor shall carefully remove the existing parking lot booths and store them in a secure location. The Contractor shall ensure that the parking lot booth interior remains dry during the storage period. If required, the Contractor shall produce the booth(s), and all stored items associated with the reinstallation of the booths. At this time, the Engineer will compare (document) the condition of the booths and associated equipment to their condition at the time of removal. The Contractor must furnish booths and associated equipment in the same or improved condition to fulfill the requirements of the Contract Documents. This will be subject to the approval of the Engineer and the parking lot booth owner.

3.02 RE-ERECT PARKING LOT BOOTH

- A. If required, and as described above the Contractor shall coordinate the re-erection activities to the satisfaction of the owner and the Engineer..
- B. The Contractor shall construct a parking lot booth foundation at the location indicated on the plans. This proposed foundation(s) shall meet or exceed the dimensions of the existing foundation(s).
- C. The Contractor shall carefully move and erect the parking lot booth at the proposed location. Any damage to the interior or exterior of the parking lot booth, including damage due to weather or vandalism, shall be repaired or replaced at no cost to Authority. Repairs are subject to approval by the Engineer. The location of the re-erected booth will be at or adjacent to Station L6052+50 as depicted in the Contract Documents.
- D. For each utility impacted, the Contractor shall prepare a plan to connect the utility's facilities to the existing parking lot booths. This plan shall be submitted to the utility company at least two weeks prior to the anticipated connection date.
- E. Upon receipt of approval to proceed from each utility company, the Contractor shall connect the utilities to the parking lot booth. The Contractor shall comply with procedures required by the utility companies. If requested by the utility company, the Contractor shall permit utility company representatives to witness the utility connection.
- F. Coordinate all work with final pavement, sidewalk and roadway restoration activities so that no trenching or disturbance of new facilities is required.

3.03 [NOT USED]

3.04 [NOT USED]

3.05 RE-INSTALL PARKING LOT SPECIAL SIGNAGE

- A. The Contractor shall re-install the stored parking lot special signage to its previously existing location or as directed by the Engineer. The Contractor may reinstall the signage with their associated stored posts, supports, or mounting hardware, where possible, onto new foundations that meet or exceed the dimensions of the existing foundations. Alternatively, the Contractor may provide new posts, supports, or mounting hardware that meet or exceed the quality of construction and materials of the existing elements. All assemblies are subject to approval by the Engineer and the parking lot owner.
- B. Any damage to stored signs, including damage due to weather or vandalism, shall be repaired or replaced by the Contractor at no cost to Authority or the owner. Repairs are subject to approval by the Engineer and the parking lot owner.

3.06 [NOT USED]

3.07 [NOT USED]

3.08 RELOCATE EXISTING PARKING LOT BOOTH

- A. Refer to Article 3.01 of this section for removal of the existing facility, except delete any reference to storage. The existing booth will be removed and immediately re-erected so ALCO Parking may maintain their operation during construction of NSC-006.
- B. Refer to Article 3.02 of this Section for re-erection of the existing facility.
- C. Coordinate with ALCO parking prior to beginning any work in order to minimize disruption to their operations.

3.09 [NOT USED]

3.10 [NOT USED]

3.11 [NOT USED]

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. [NOT USED]
- B. [NOT USED]

- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. Item 01791.008 – Re-Install Parking Lot Special Signage shall be measured per each, complete in place.
- H. [NOT USED]
- I. [NOT USED]
- J. [NOT USED]
- K. [NOT USED]
- L. Item 01791.013 – Permanent Relocation of Existing Parking Lot Booths shall be measured as a lump sum unit, complete in place.

PAYMENT

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. Item 01791.008 – Re-Install Parking Lot Special Signage will be paid at the unit price and shall include the cost of all related work specified in this Section.
- H. [NOT USED]
- I. [NOT USED]
- J. [NOT USED]
- K. [NOT USED]

- L. Item 01791.013 – Permanent Relocation of Existing Parking Lot Booths will be paid at the lump sum price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 01800

EROSION AND SEDIMENTATION CONTROL

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for erosion and sedimentation control, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. [NOT USED]
 - 2. Silt barrier fence.
 - 3. [NOT USED]
 - 4. [NOT USED]
 - 5. [NOT USED]
 - 6. Rock construction entrances with wash racks.
 - 7. Temporary stabilization.
 - 8. Temporary asphalt berms.
 - 9. Excavation
 - 10. Backfill and Compaction
 - 11. Removal and Disposal

1.02 RELATED SECTIONS

- A. Section 01783, "Temporary Facilities."
- B. [NOT USED]
- C. [NOT USED]
- D. Section 01815, "Construction Dust Control."
- E. [NOT USED]
- F. [NOT USED]
- G. Section 02316, "Excavation."
- H. Section 02320, "Backfill."
- I. [NOT USED]
- J. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT, Publication 408.
- B. PaDEP, Erosion and Sediment Pollution Control Program Manual.
- C. ASTM.
- D. AASHTO.

1.04 [NOT USED]

1.05 REGULATORY REQUIREMENTS

- A. General National Pollutant Discharge Elimination System (NPDES) Permit for Stormwater Discharges Associated with Construction Activities.
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. Authority shall provide the Contractor with the original approved NPDES Permit and Erosion and Sedimentation Control Plan. Contractor shall make application for any permit amendments or revisions to the permitted plans and Narrative that are required because of changes in the anticipated construction procedures at no additional cost to Authority. The required applications, plans, and documents shall be furnished to the Engineer, the PaDEP, and the Allegheny County Conservation District (ACCD). No changes shall be made to the sequence and scope of operations until all necessary approvals have been obtained.
- G. The ACCD shall perform a final inspection and acceptance prior to removal of erosion and sedimentation control devices.
- H. PaDEP, 25 Pa. Code § 102

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Silt Barrier Fence
 - 1. Geotextiles in accordance with PENNDOT 408, Section 735, Class 3, Type A.
 - 2. Posts in accordance with PENNDOT 408, Section 865.2(b)(c).
 - 3. Fasteners in accordance with PENNDOT 408, Section 865.2(d).

- B. [NOT USED]
- C. [NOT USED]
- D. Sediment Inlet Protection
 - 1. Inlet Filter Bags
 - a. Geotextile in accordance with PENNDOT 408, Section 735.1, Class 3, Type A except as modified herein:
 - 1) Use a 401-lock chain stitch seam or a heat-bonded seam.
 - 2) Permanently attach a manufacturer's label to each bag designating the maximum allowable flow rate of the bag in gallons per minute.
 - 2. Reinforcement Bars in accordance with PENNDOT 408, Section 709.1.
 - 3. Temporary Asphalt Berm in accordance with Article 2.01H of this Section.
 - 4. Sandbags
 - a. Sandbag Material:
 - 1) Polypropylene, polyethylene, or polyamide woven fabric with a minimum unit weight of four (4) ounces per square yard.
 - 2) Mullen burst strength shall exceed 300 psi.
 - 3) Ultraviolet stability shall exceed 70%.
 - 4) The sandbags shall be 16 to 18 inches in length, 8 to 10 inches in width and 4 to 6 inches in thickness.
 - b. Sand in accordance with PENNDOT 408, Section 703.1(a), Type B, #1.
- E. Pumped Water Filter Bag
 - 1. Filter Bag
 - a. Geotextile, non-woven in accordance with PENNDOT 408, Section 735, Class 2, Type B except as modified herein:
 - 1) Shall be capable of trapping particles larger than 150 microns.
 - 2) Permanently attach a manufacturer's label to each bag designating the maximum allowable flow rate of the bag in gallons per minute.
 - 3) The maximum allowable flow rating of the pumped water filter bag, as listed on the bag label, shall be at least twice the rating of the pump in gallons per minute.
 - 4) Do not use a pump rated at more than 750 gpm with pumped water filter bags.
 - 2. Bedding Material
 - a. Coarse Aggregate (No. 57) in accordance with PENNDOT 408, Section 703.2(a)1, Stone, Type A.
 - 3. Geotextile under Bedding
 - a. Geotextile in accordance with PENNDOT 408, Section 735, Class 3, Type A.
- F. Rock Construction Entrance
 - 1. Coarse aggregate (No. 1) in accordance with PENNDOT 408, Section 703.2(a)1, Stone, Type A.
 - 2. Temporary Asphalt Berm in accordance with Article 2.01H of this Section.

3. Geotextiles in accordance with PENNDOT 408, Section 735, Class 4, Type A.

G. Wash Rack

1. Welded Steel Grate

- a. Reinforcement Steel in accordance with PENNDOT 408, Section 709.
- b. Fabricated Structural Steel in accordance with PENNDOT 408, Section 1105.

H. Temporary Asphalt Berm

1. Asphalt in accordance with PENNDOT 408, Section 420.2.
2. Bituminous Tack Coat in accordance with PENNDOT 408, Section 460.2.

I. [NOT USED]

ARTICLE 3 EXECUTION

3.01 INSTALLATION

A. General

1. Contractor shall install Erosion and Sedimentation Control devices in accordance with the approved Erosion and Sedimentation Control Plan. Erosion and Sedimentation Control devices shall be installed prior to earth disturbance.
2. Erosion control features indicated on the approved plan shall be incorporated into the Project, as outlined in the construction sequence identified in the Erosion and Sedimentation Control Plan.

B. Silt Barrier Fence

1. Contractor shall place silt barrier fence at the locations shown on the Erosion and Sedimentation Control Plans and according to the details provided therein.

C. [NOT USED]

D. [NOT USED]

E. Sediment Inlet Protection

1. Sediment inlet protection shall be provided at the locations shown on the Erosion and Sedimentation Control Plans and according to the details provided therein.

F. Dewatering Excavated Areas

1. [NOT USED]

2. [NOT USED]

3. Any water pumped from excavated areas shall pass through one of the following erosion and sedimentation control devices.

a. Pumped Water Filter Bags

b. [NOT USED]

4. [NOT USED]

5. Pumped Water Filter Bags or Sedimentation Tanks shall be placed, as shown on the plans and at all pumped water discharge locations. Installation of these controls shall be according to the details found in the Erosion and Sedimentation Control Plan.

G. Rock Construction Entrances

1. Contractor shall construct rock construction entrances at the locations shown in the Erosion and Sedimentation Control Plan and as needed, wherever construction vehicles will be exiting onto a paved roadway (public or private) to ensure sediment is not deposited on roadways.
2. The rock construction entrances shall be constructed according to the details provided in the Erosion and Sedimentation Control Plan.

H. Wash Rack

1. The Contractor shall construct wash racks at locations shown in the Erosion and Sedimentation Control Plan and as needed, wherever construction vehicles will be exiting onto a paved roadway (public or private) to ensure sediment is not deposited on roadways.
2. The wash racks shall be constructed according to the details provided in the Erosion and Sedimentation Control Plan.
3. The wash rack shall discharge to a sediment removal facility prior to outfall.

I. [NOT USED]

J. Temporary Asphalt Berm

1. Temporary Asphalt Berm shall be provided at the locations shown on the Erosion and Sedimentation Control Plan and according to the details provided therein.
2. Place bituminous tack coat in accordance with PENNDOT 408, Section 460.3.
3. Place asphalt and compact with roller or hand tamper.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 01800.001 - Erosion and Sedimentation Control shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. Item 01800.001 - Erosion and Sedimentation Control shall be paid at the lump sum price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 01810

OFF-DUTY UNIFORMED POLICE OFFICER

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for off-duty uniformed police officer, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. Section 01780, "Maintenance and Protection of Traffic."
- B. Section 01781, "Maintenance and Protection of Authority Traffic."

1.03 SUBMITTALS

- A. Submit to the Engineer, three (3) weeks prior to the required services, a weekly request for off-duty uniformed police officer(s), including the following information:
 1. Number of police officers requested for the week.
 2. Location of assignment for each including dates and times required.
 3. Type of work to be performed.
 4. Reason for the police officers.
- B. City of Pittsburgh certified invoices, with supporting documentation, for all City of Pittsburgh off-duty uniformed police officers.
- C. Contractor's certified proof of payment to the City of Pittsburgh for City of Pittsburgh provided police officers.

ARTICLE 2 PRODUCTS

2.01 [NOT USED]

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. All Contractor requests for off-duty uniformed police officers must be approved by the Engineer prior to the scheduling of officers. Off-duty uniformed police officers shall be provided by Authority's Police Department and the City of Pittsburgh Police Department. The office of the Chief of Police of Authority will coordinate all of the staffing of the off-duty uniformed police officers from Authority's police force and the City of Pittsburgh police force to be provided to accommodate the needs as identified by the Contractor.

- B. The Contractor shall provide the Chief of Police of Authority the weekly request for off-duty uniformed police officer(s), as reviewed and approved by the Engineer not less than one week in advance of the need for off-duty uniformed police officer(s). The Contractor shall contact the Office of the Chief of Police of Authority at (412) 255-1350, not less than two working days in advance of the start of any previously identified and approved request, to confirm that the off-duty uniformed police officer(s) is still required and has been scheduled as previously requested. In the event that a requested off-duty uniformed police officer should no longer be required, the Contractor shall provide the Office of the Chief of Police of Authority and the Engineer no less than two working days written notice of the cancellation of such requested police officer, including off-duty uniformed police officer(s) that have been previously approved but not yet confirmed. The cost of an off-duty uniformed police officer is a minimum of four (4) hours pay at straight time, or actual time worked paid at a rate of time and a half (1 ½), which ever is greater for each occurrence.
- C. Provide off-duty uniformed police officer traffic control as indicated in accordance with the Contractor's TCP, and as otherwise directed by the Engineer. Conditions for use include, but are not limited to, the following typical scenarios:
 - 1. Intersection control of locations specified by the TCP that are impacted by construction activities, detour traffic, or peak hour traffic.
 - 2. Intersection control of additional locations as directed by the Engineer following coordination with the City of Pittsburgh and based on actual field conditions experienced during construction.
 - 3. Special construction, access, or delivery activities as directed by the Engineer.
 - 4. Special Events which require additional off-duty uniformed police officers based on the construction activities.
- D. The specific requirements for the use of off-duty uniformed police officer traffic control, including locations, time periods, duration, schedule, etc., will be coordinated with the Engineer and the City of Pittsburgh via the Contractor's Traffic Control Supervisor or other responsible party.
- E. When off-duty uniformed police officer traffic control is used at signalized intersections, ensure that the police officer returns the traffic signal to normal operation prior to leaving the intersection.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 01810.001 – City of Pittsburgh Off-Duty Uniformed Police Officer shall be measured as directed by the Engineer. Off-duty uniformed police officers provided by Authority will not be measured.

4.02 PAYMENT

- A. Item 01810.001 – City of Pittsburgh Off-Duty Uniformed Police Officer will be paid for as part of a Predetermined Amount (PDA), and shall include the cost of all work specified in this Section.
 1. Payment shall be based on actual billings from the City of Pittsburgh for the Off-Duty Uniformed Police Officer in accordance with Article 3 of this Section, as approved by the Engineer. Any Off-Duty Uniformed Police Officer provided for any other purpose shall not be paid for by Authority.
 2. Contractor shall pay, at its own cost and expense, and shall not receive reimbursement from Authority pursuant to this pay item for, the cost of all City of Pittsburgh off-duty uniformed police officer(s) that report to provide traffic control due to failure of the Contractor to properly cancel any off-duty uniformed police officer(s) that were previously requested by the Contractor. In addition, Contractor shall reimburse Authority for the cost of all Authority off-duty uniformed police officer(s) that report to provide traffic control due to failure of the Contractor to properly cancel any off-duty uniformed police officer(s) that were previously requested by the Contractor.
 3. The following shall be submitted to the Engineer as applicable for each pay estimate including this portion of the Work:
 - a. Certified timesheets or other approved payroll documentation from City of Pittsburgh.
 - b. Certified proof of payment to the City of Pittsburgh by Contractor.

END OF SECTION

SECTION 01815
CONSTRUCTION DUST CONTROL

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for construction dust control, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Excavation,
 - 2. Aggregate and compaction,
 - 3. Rock construction entrances,
 - 4. Vehicular wash racks,
 - 5. Wet suppression,
 - 6. Cold weather suppression,
 - 7. Wind screens and barriers,
 - 8. Street periodic cleaning,
 - 9. Building facility periodic cleaning,
 - 10. Dust and debris disposal.

1.02 RELATED SECTIONS

- A. Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricade"
- B. Section 01800, "Erosion and Sedimentation Control."
- C. Section 02220, "Demolition."
- D. Section 02320, "Backfill."
- E. Section 02353, "Geotextile."
- F. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT, Publication 408.
- B. PENNDOT Publication 35, Bulletin #15
- C. EPA - Clean Air Act

1.04 SUBMITTALS

- A. Contractor shall submit a Project Dust Control Plan in accordance with Section 01500, Article 1.6.B.6
- B. [NOT USED]
- C. Contractor shall submit a Dust Control Plan specific to the work of demolishing the existing Gateway Station loop as shown in the Contract Documents and in accordance with the requirements of this Section. Submit to the Engineer for approval of the Engineer. Submit plan fifteen (15) days prior to beginning any phase of work within the existing Gateway Station. Include control measures Data, work phasing, all required agency approvals and permits, and work schedule.

ARTICLE 2 PRODUCTS

2.01 TEMPORARY MEASURES

- A. Calcium Chloride in accordance with PENNDOT 408, Section 721.
- B. Water in accordance with PENNDOT 408, Section 720.
- C. Rock Construction Entrances and wash racks in accordance with Section 01800, "Erosion and Sedimentation Control."
- D. Aggregate in accordance with Section 02320, "Backfill."
- E. Geotextile for wind screens and wind barriers in accordance with Section 02353, "Geotextile" with a 50% porosity.

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. Provide temporary measures to reduce the surface and air transport of dust from the Worksite, utilizing management practices including, but not limited to:
 1. Apply an aggregate base to exposed soil surfaces;
 2. Install rock construction entrances and construction vehicle wash racks;
 3. Wet and/or Vacuum Suppression; and
 4. Applying Calcium Chloride to exposed areas.
- B. Coordination between Contractor and local business and residential owners which relate to construction dust control shall be through the Contractor's Community Relations Representative described in Section 00700, Article 6.
- C. Wet suppression shall be used to provide temporary control of dust in an environment outside the tunnel structure. Several applications per day may be required. The

Contractor shall apply wet suppression on a routine basis as necessary or as directed by the Engineer.

1. Wet suppression consists of the application of water or a wetting agent in solution with water. Ensure wetting agent is not used on plantable areas.
 2. Wet suppressing equipment may include sprinkler pipelines, tanks, tank trucks, or other devices capable of providing regulated flow, uniform spray, and positive shut-off.
- D. Calcium Chloride shall be used to control dust instead of wet suppression when freezing conditions exist. Calcium chloride shall be uniformly applied by a mechanical spreader at a rate as recommended by the manufacturer. Ensure that no vegetative areas are treated.
- E. Provide wind screens and wind barriers to minimize the airborne spread of dust. Attach geotextile to construction fencing or solid wooden fence to shield construction areas, if necessary. Construction fencing details shall be in accordance with Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricade."
- F. [NOT USED]
- G. Install erosion and sedimentation control facilities in accordance with the Contract Documents to prevent pollutants from infiltrating into storm water systems.
- H. The Contractor's Project dust control work shall be in accordance with Section 01500, Article 1.6
- I. Erect and maintain dustproof partitions and temporary enclosures where required to limit dust and dirt migration and to separate occupied portions of the buildings from fumes and noise.
 1. Construct dustproof partitions of not less than nominal 4 inch studs, 1/2" gypsum wallboard with taped joints on the occupied side, and 3/4" fire-retardant plywood on the demolition side, or as otherwise shown on Contract Drawings.
 2. Insulate partitions to provide noise protection for occupied areas.
 3. Seal joints and perimeter. Equip partitions with dustproof doors and security locks.
 4. Protect air-handling and other mechanical and electrical equipment required to remain.
 5. Provide weatherproof enclosures for exterior openings resulting from demolition work. Weatherstrip openings to the exterior.

3.02 PUBLIC ROADWAY DUST CONTROL

- A. If dust and dirt collect on public streets, the Contractor shall have streets within the project limits and surrounding areas swept by street sweepers in order to minimize the distribution of dust. Should the Contractor choose to utilize the C/P Public Works resources to perform this portion of the Work, it shall be at no additional cost to

Authority. The contact for the C/P Department of Public Works is Jack Barley 412-255-6773.

3.03 [NOT USED]

3.04 EXISTING GATEWAY STATION

- A. The Contractor is responsible for providing dust control for the work associated with the demolition of the existing Gateway Station Loop. Provide positive protection to minimize disturbance to the remaining structure. Do not begin demolition within the tunnel until the Engineer and Authority has approved the dust control system.
- B. Provide and maintain dust and debris protection from tunnel roof to floor to isolate the work area from the remaining tunnel. Utilize plastic sheeting, plywood, or sheetrock to seal the work area from other tunnel areas. Provide proper ventilation for the work area through the work site to the surface.
- C. Do not infringe on Authority revenue or maintenance operations without prior written consent from the Engineer.
- D. [NOT USED]
- E. [NOT USED]
- F. Keep all existing trench and drains serviceable throughout the work. Clean periodically as required.
- G. Keep the existing fire suppression system free from construction debris and dust.
- H. Post "DO NOT ENTER: CONSTRUCTION AREA" signs on the Wood Street Station side of the closure wall.
- I. Dispose of construction debris through the demolition construction area on a daily basis to minimize accumulation of dust.
- J. At conclusion of the work, remove all temporary dust control and clean dust and debris which might have escaped from the work area to the satisfaction of the Engineer. Periodic cleaning of the existing Gateway Station shall be anticipated by the Contractor as part of the work of this Section

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01840

SPARE PARTS AND TEST EQUIPMENT

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment and incidentals, necessary for spare parts and test equipment, in accordance with the contract documents.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements,"
- B. Section 13570, "Signal System Requirements,"
- C. Section 13579, "Design Requirements,"
- D. Section 16700, "Communications."
- E. Section 16220, "Traction Power Substation 27 kV AC Switchgear
- F. Section 16221, "Traction Power Substation 27 kV Interrupter Switches"
- G. Section 16230, "Traction Power Substation Transformer- Rectifiers Units
- H. Section 16235, "Traction Power Substation- Auxiliary Power System
- I. Section 16240 "Traction Power Substation- DC Switchgear
- J. Section 16250, "Traction Power Substation – Negative Return Switch Boards
- K. Section 16270, "Traction Power Substation – Battery System"
- L. Section 16340, "MV Load Interrupter Switchgear"
- M. Section 16430, "LV Switchgear"
- N. Section 16602, "OCS Overhead Contact System"

1.03 SUBMITTALS

- A. Recommended spare parts list.
- B. List of special tools and test equipment.

ARTICLE 2 PRODUCTS

2.01 GENERAL

- A. All spare parts shall be identical to the installed items, unless approved by the Engineer as a suitable replacement, and shall meet all requirements of the Contract.
- B. Parts availability for signal system equipment shall be for a period of 15 years after Acceptance and for communication system equipment shall be for a period of 7 years after Acceptance.
- C. Parts availability for Traction Power and OCS equipment shall be for a period of 20 years after Acceptance.
- D. All items shall be complete, calibrated, and ready for installation except for wire or cable necessary for connections.

ARTICLE 3 EXECUTION

3.01 SCOPE OF WORK

- A. During Pre-revenue Operations, the Contractor shall maintain an inventory of spare parts, tools, material, supplies, and equipment which supports testing and commissioning and allows work to continue uninterrupted by shortages of these items.
- B. At Final Design Review (FDR), Contractor shall submit a priced Recommended Spare Parts List, Recommended Tools List, and Recommended Test Equipment List. The lists shall include quantities necessary for the Authority to operate and maintain the Signaling and Communication Systems for two years of revenue service. It shall be categorized by subsystem or component, assemblies and subassemblies, and shall include at least the following information for each item:
 1. Contractor's stock number.
 2. Supplier and manufacturer's model number and part number.
 3. Name and address of supplier or manufacturer.
 4. Nomenclature (description).
 5. Drawing reference number.
 6. Lead time for delivery.
 7. Identification of the next larger assembly or sub-assembly.
 8. Unit price.
- C. The Contractor shall certify that all prices are current prices as offered to others for a purchase of the same quantity. Any overpricing will be subject to deduction by the Authority from monies due to the Contractor.
- D. The lists shall be submitted in hard copy format and electronic format as directed by the Engineer.

- E. From the lists the Engineer will select parts, tools and test equipment that the Authority will purchase. The Contractor shall deliver the selected items to the locations specified by the Engineer. All items shall be packed for warehouse storage and clearly marked and identified as directed by the Engineer. Delivery shall be made no later than one month prior to Revenue Service on the North Shore Connector. Earlier delivery shall be subject to approval of the Engineer.
- F. If the Contractor is permitted by the Engineer to use the Authority's spare parts to satisfy a warranty requirement, the Contractor shall promptly replenish any such parts at no cost to the Authority.
- G. Separate from the tools and test equipment that the Authority purchases from the Contractor's Recommended Tools and Test Equipment Lists, and for no additional payment from the predetermined amount, the Contractor shall provide as part of the work of this Project, two of each type of special tool, test equipment, fixture, extender board, and device necessary to install, adjust, test, operate, and maintain the Signaling and Communication Systems. Such special items are those which are not commercially available as stock or production items from more than one supplier. The Contractor's Lists of Special Tools and Test Equipment shall be subject to review and approval by the Engineer.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01850

CONSTRUCTION MONITORING PROGRAM

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to , providing all labor, materials, tools, equipment, and incidentals necessary for construction monitoring program, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Interior and Exterior Pre-construction Inspection Reports.
 - 2. Construction Activity Reports.
 - 3. Interior and Exterior Post-construction Inspection Reports.
 - 4. [NOT USED]

1.02 [NOT USED]

1.03 SUBMITTALS

- A. Qualifications of independent engineering firm and personnel who will perform the pre- and post-construction inspections.
- B. Submit a sample for each report described in this Section for review and approval by the Engineer before beginning the work.
- C. Separate Pre-construction Inspection Reports for each structure and facility. Submit each report, including drawings, photos, and videos. Complete the pre-construction inspection reports at least 2 months before beginning any construction work
- D. Construction Activity Reports: Submit descriptions of the work performed according to the following schedule: monthly.
- E. Post-Construction Inspection Reports, as required by the Engineer, for each structure or facility to verify that no change has occurred. Submit 5 copies of each report, including drawings, photos, and videos.

1.04 [NOT USED]

1.05 [NOT USED]

ARTICLE 2 PRODUCTS

2.01 [NOT USED]

ARTICLE 3 EXECUTION

3.01 PRECONSTRUCTION INSPECTIONS

- A. Perform pre-construction inspections on the portions of the structures identified below:
 - 1. North Shore Connector Tunnels including, Gateway Station, North Side Station, Allegheny Station, Existing Gateway Station, and existing Wood Street Station within the work limit.
- B. [NOT USED]
- C. [NOT USED]
- D. Notify the Engineer at least 2 weeks before conducting each preconstruction survey.
- E. Include the following, as a minimum, for each survey:
 - 1. Conduct a detailed examination of the portions of the structures identified above.
 - 2. Document the examinations with color still photographs and/or videotapes. Document the conditions observed in writing or by verbal description on the videotape, noting in particular evidence of damage or defects such as cracks, loose or missing plaster, damaged masonry or roofing, separations in materials or caulking, windows and doors that stick or do not fit properly in their frames, walls or floors that are not vertical or horizontal, and evidence of water or groundwater seepage into the building. The scope and number of photographs and videos shall be sufficient to document all pre-existing conditions.
 - 3. Interview structure personnel regarding existing conditions, known damage or defects, and historical building/structure damage or repairs.
 - 4. [NOT USED]
 - 5. Document the inspection of the structure with color still photographs and/or videotapes. Document the conditions observed in writing, by time stamp or by verbal description on the videotape, noting in particular evidence of damage or defects such as cracking, displacements, damaged or cracked concrete, spalls or delaminations, sheared or bent bolts, and distortion of the structural members or elements.
- F. The Contractor shall repeat photographs and videotapes for portions of the work subject to conditional acceptance of work identified in Section 01700, Article 4.

- G. Submit separate reports for each structure area or station location. At a minimum, include the following for each report:
1. Names and responsibilities of the inspecting party.
 2. Written summary of inspection dates and inspection activities.
 3. Information from interviews (including refusal to cooperate on the part of the property owner).
 4. Documentation of existing conditions, including videos, photos, and sketches.
 5. Written identification of photos, and written indexes of videos.

3.02 MONITORING

- A. Monitor and provide reports on instrumentation in accordance with Contract Documents.

3.03 POST-CONSTRUCTION INSPECTIONS

- A. Contractor shall prepare a Post-Construction Inspection Report as directed by the Engineer for each structure for which a Pre-Construction Inspection Report was prepared. Perform and document the inspections, and provide reports, as described above. Document any changes from the pre-construction conditions.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01900
TRAIN CLEARANCE TESTING

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for the train clearance testing, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Design, manufacture, supply, testing, and data reporting of the Train Clearance Testing program for LRV vehicle clearance dynamic envelope and station platform clearances of the system.
 - 2. The Contractor shall verify that the dynamic clearance as illustrated in the referenced figures is also sufficient to allow the passage of all Authority rail maintenance vehicles (i.e. tamper, ballast regulator, overhead maintenance vehicle, various high rail vehicles, etc.)
 - 3. Pantograph Clearance Testing is included in Section 16830.
- C. The Contract Documents provide the performance parameters and Design Criteria to complete the Train Clearance Testing portion of the Work. The Contractor shall be responsible to provide a completed design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01777, "Construction Certification Program"
- B. Section 02450, "General Track Construction"
- C. Section 09902, "Painting"
- D. Section 16830, "Overhead Contact System Test and Inspection"

1.03 REFERENCE STANDARDS

- A. ANSI
- B. ASTM
- C. AREA
- D. IEEE
- E. North Shore Connector, Manual of Design Criteria

F. Project Related Track Clearance Waivers

G. ADA

1.04 SUBMITTALS

- A. Submit copies of Train Clearance Testing Program to the Engineer in compliance with the requirements of Article 3.02 of this Section.
- B. Shop Drawings
 - 1. Submit drawing for the manual rail clearance cart and platform measuring tool or jig, showing layout, size of system components, operational requirements and details of materials and methods of field test measuring.
- C. Manufacturer's Literature
 - 1. Submit literature completely describing products installed and measuring devices, including cameras as part of the work.
- D. Clearance Testing Report Forms
 - 1. The Contractor shall submit for approval the proposed Train Clearance Testing forms prior to beginning the vehicle and station platform clearance testing.
 - 2. The Contractor shall submit the completed Train Clearance and Platform Clearance test results and accompanying digital photographs in three (3) neatly bound folders and in electronic format.

ARTICLE 2 PRODUCTS

2.01 GENERAL

A. Materials

- 1. The Contractor shall provide all manufactured or fabricated items, materials, labor, cartage, tools, plant, appliances and fixings necessary for the proper execution of the work, together with all minor and incidental works.
- 2. Should the Contractor propose any deviations from the specified requirements, such variations shall be submitted in writing to the Engineer for approval.
- 3. Measuring devices shall be capable of meeting the measurement tolerances required for this work.
- 4. Clearance adjustable rods should emulate LRV body points.
- 5. Digital cameras should be used to record rail clearance test points, station platform test locations, and the interface with OCS.

B. CLEARANCE CART

- 1. Contractor shall obtain/build a portable cart to demonstrate acceptable clearance tolerances.

2. Clearance cart construction should take into consideration the following conditions:
 - a. Maximum roll, failed suspension.
 - b. Worst case vehicle construction tolerances.
 - c. Worst case combination of end truck and center truck suspension, car body, and truck motions.

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. All equipment shall be readily and safely accessible for all clearance testing positions.
- B. All fastenings shall be firmly secured with adjustable devices and arms to be able to be securely fastened in their extended or retracted positions as necessary.

3.02 TRAIN CLEARANCE TESTING PROGRAM

- A. Testing and commissioning shall include, but not be limited to, the following:
 1. Clearance testing of all new or modified Inbound and Outbound trackwork and Special Trackwork;
 2. Clearance Testing of the new Wood Street Double Crossover; and
 3. Clearance Testing of all the new completed station platforms.
- B. All test results shall be documented for submission.
- C. The clearance testing vehicle shall be developed and constructed by the Contractor to be used for the Project length to demonstrate LRV Dynamic Envelope clearances as prescribed in the North Shore Connector Manual of Design Criteria.
- D. All LRV lateral, vertical, longitudinal, and roll motions with and without failure conditions, shall be included in the vehicle dynamic clearance envelope design and calculations.
- E. All LRV operating conditions, with proper allowance for vertical and lateral movement of springs, wheel wear, flange wear, roller bearing wear; lateral body lean, failed springs and other elements affecting the rail vehicle shall be considered.
- F. Platform clearance checks shall be taken into consideration, including ADA requirements regarding elevation differences between the platform and LRV, and distance between the face of the platform edge and the face of the LRV door opening. These requirements are provided in the Manual for Design Criteria.
- G. Contractor shall demonstrate acceptable clearance tolerances with a clearance vehicle before the new track is tested with an Authority LRV.

- H. After a successful clearance test using the clearance test vehicle, the Contractor shall perform a dead LRV pull test using an Authority furnish LRV. The Contractor shall furnish a high rail vehicle capable of pulling an Authority LRV.
- I. If interference exists, the assumed vehicle operating conditions, system location, and degree of interference shall be identified for each case. If interferences are identified, notify the Engineer immediately. The results of the analysis shall be submitted to the Engineer for review and approval.

3.03 WOOD STREET CROSSOVER

- A. The Contractor shall perform the train clearance test on the new Wood Street Double Crossover prior to turning the new crossover to the Authority for revenue service.
- B. The Contractor shall perform both the clearance car envelope test and a dead LRV pull test prior to Authority utilizing the Double Crossover for Revenue Service.
- C. The Wood Street Crossover installation has been identified as having two (2) clearance violations associated with infringements on the emergency walkways. The Contractor shall locate and paint restricted clearance areas with striping and provide signs indicating where there is not any clearance prior to beginning Dual Turnback operations.

3.04 MAINLINE NEW TRACKWORK

- A. The Contractor shall perform the train clearance test on the new mainline trackwork and special trackwork.
- B. The Contractor shall perform both the clearance car envelope test and a dead LRV pull test prior to the system integration testing milestone identified in Section 00500, Article 2.6.A.1.b).4).

3.05 NEW STATION PLATFORMS

- A. The Contractor shall measure the clearances to the edges of each platform both horizontally and vertically from the top of rail compared to the tolerances listed in the Design Criteria Manual. This test is to be performed prior to the system integration testing milestone identified in Section 00500, Article 2.6.A.1.b).4).
- B. A report of the platform clearance measurements shall be submitted.
- C. The Contractor shall perform a platform clearance test using either a powered or pulled Authority furnished LRV.

3.06 CLEARANCE WAIVERS

- A. There has been design clearance infringements identified and approved by Authority. Detailed Waivers, including back-up data and calculations will be provided by Authority to the successful Bidder for use in the Work.

DESIGN CRITERIA WAIVERS TABLE 01900-1

Waiver No.	Waiver Location	Comments
GW1	Left Track; Right Side; Between Stations 6036+54 and 6036+87.5	Reduced clearance envelope on the Left Track from 10.13' to 9.52' at the mirror location. This infringement assumes 4" bored tunnel construction tolerance and the cast-in-place secondary liner being built.
GW2	Right Track; Left Side; Between Stations 6036+54 and 6036+87.5	Reduced clearance envelope on the Right Track from 9.57' to 9.08' at the mirror location. This infringement assumes 4" bored tunnel construction tolerance and the cast-in-place secondary liner being built.
GW3	Right Track; Right Side; Between Stations 6036+42 and 6036+87.5	Reduced running clearance envelope on the Right Track from 6" to 3.72". This infringement assumes 4" bored tunnel construction tolerance.
	Wood Street Double Crossover	Reduced applied clearance on the Right Track from 46' to 40.9' and affects the required space for 46' in front of the point of switch and 53' beyond the point of switch toward the frog.
	Jet Fans at Station 1014+50 and 1016+50; Left and Right Track between Gateway Station and Wood Street Station	Reduced Pantograph clearance due to the new Jet fans. Actual Jet fans selected may affect this dimension.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 01900.001 – Train Clearance Testing Program shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. Item 01900.001 – Train Clearance Testing Program will be paid at the lump sum price and shall include the cost of all work specified in this Section.

END OF SECTION

SECTION 01910

OPERATIONS, MAINTENANCE AND REPAIR DATA

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for operations, maintenance and repair data, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Develop technical manuals that comprehensively address all phases of system configurations, operations, maintenance, and repair and spare part provisioning. Information for bench-level troubleshooting and repair to the component-level shall also be included.
 - 2. Provide training and support materials to enable Authority personnel to operate and maintain the new traction power substation and associated feeder connections to the OCS, and signaling and communications systems. The training program shall include detailed instructions, demonstrations and supervised hands-on training.

1.02 RELATED SECTIONS

- A. Section 13570, "Signal System Requirements."
- B. Section 16200, "Traction Power Substation General Requirements."
- C. Section 16210, "Traction Power Substation Basic Electrical Materials and Methods."
- D. Section 16700, "Communications."

1.03 QUALITY ASSURANCE

- A. Data shall be prepared by the manufacturer's personnel:
 - 1. Trained and experienced in the maintenance and operation of the products and equipment.
 - 2. Completely familiar with the requirements of this Section.
 - 3. Skilled as technical writers to the extent required to communicate essential data.
 - 4. Skilled as draftsmen competent to prepare required drawings.

1.04 SUBMITTALS

- A.** Data shall be prepared in the form of instructional manuals for use by Authority's personnel, and suitable for use as a detailed specification for contracted maintenance services.
- B.** All manuals supplied as final documentation shall include all changes to the systems through the time of Acceptance by Authority. Revisions to final draft and approved manuals shall be recorded on a control list, acceptable to Authority, in the front of each manual. Requirement for manual updates shall continue through the Contractor Guarantee Period for any changes that have a significant impact, as determined by the Engineer, on Authority's operations or maintenance.
- C. Digital Format**
 - 1. Contractor shall furnish two (2) copies of each manual in Microsoft Word Format, Version 6.0 or higher, Adobe PDF or HTML complete with detailed index and appropriate document linking.
 - 2. Contractor shall furnish two (2) digital copies of all equipment drawings using CADD in .dgn, .dwg or .dxf format (latest versions).
 - 3. Photographs and image files shall be supplied in any of the following formats: .bmp, .gif, .jpg, or .tif.
- D. Hard Copy Format**
 - 1. The Contractor shall supply twenty five (25) copies of operating and maintenance manuals for all systems and equipment supplied under this contract. Authority may copy all materials for its use in operations and maintenance.
 - 2. Size shall be 8-1/2 inches by 11 inches.
 - 3. Paper shall be 20 pound minimum, white, for typed pages.
 - 4. Text shall be manufacturer's printed data or neatly typewritten.
 - a. Text shall be written in English.
 - b. Drawings and text shall use English units.
 - 5. Drawings shall be provided with reinforced punched binder tabs and shall be bound in with text. Largest drawing size permitted shall be 11 inches by 17 inches, folded to the size of the text pages.
 - 6. Cover shall identify each volume with typed or printed title.
- E. Binders**
 - 1. Binders shall be commercial quality three-ring binders with durable and cleanable plastic covers.
 - 2. Maximum ring size shall be one inch.
 - 3. When multiple binders are used, the data shall be correlated into related, consistent groupings.

1.05 CONTENT OF MANUAL

- A. Contractor shall compile Product Data and related information appropriate for Authority's maintenance and operation of products furnished under this Contract.
 - 1. Operating, maintenance and repair data shall be prepared as specified in this Section.
- B. The Work of this Section shall consist of providing instruction of Authority personnel in the maintenance, repair, and operation of all equipment furnished. A minimum of two (2) instructional sessions of sixteen hour periods of combined classroom and field training shall be provided for eight (8) Authority designated personnel per class. The training program shall be coordinated with the Engineer, regarding format, content and schedule.
- C. Submittal of equipment data and completion of instruction of Authority personnel is a mandatory requirement for payment for equipment.
- D. Table of contents shall be neatly typewritten and arranged in a systematic order for each volume.
 - 1. The manual shall list:
 - a. Manufacturer.
 - b. Name of responsible principal.
 - c. Address and telephone number.
 - 2. A list of each product provided, indexed to the content of the volume, shall be included.
 - 3. List, with each product, the name, address, and telephone number of the local source of supply for parts and replacement.
 - 4. Each product shall be identified by product name and other identifying symbols as set forth in Contract Documents.
- E. Product Data
 - 1. Only those sheets which are pertinent to the specific product shall be included.
 - 2. Each sheet shall be annotated to:
 - a. Clearly identify the specific product or part.
 - b. Clearly identify the data applicable.
 - c. Delete references to inapplicable information.
- F. Drawings-Product Data shall be supplemented with drawings as necessary to clearly illustrate:
 - 1. Relations of component parts of equipment and systems.
 - 2. Control and flow diagrams.
- G. Written text, as required to supplement Product Data for the particular installation shall:
 - 1. Be organized in a consistent format under separate headings for different procedures.

2. Provide a logical sequence of instructions for each procedure.
- H. A copy of each warranty issued shall be included.
1. Information sheet for Authority's personnel shall be included, giving:
 - a. Proper procedures in the event of failure.
 - b. Instances which might affect the validity of warranties.

1.06 OPERATION AND MAINTENANCE MANUALS

- A. Organization: Organize and index the material in the Manuals, treating each item as a whole and not as a grouping of disassociated parts. Subdivide manual sections to the extent required by the subject matter, including, but not necessarily limited to the following topics (as applicable):
1. Maintenance and Repair Manuals:
 - a. Complete table of contents.
 - b. General system or subsystem description and operation.
 - c. Block diagrams.
 - d. Functional schematics to component level.
 - e. Functional wiring and cabling diagrams to component level, including all interconnecting wire lists with source and destination descriptions for each wire.
 - f. Preventive maintenance tasks and procedures including lubrication and cleaning, recommended frequency, methods, and trade identifications of recommended materials.
 - g. Applicable repair procedures.
 - h. Component location and description.
 - i. Inspection and maintenance standards including wear limits, settings, and tolerances.
 - j. Installation and removal sequence.
 - k. Spare parts lists and special tools.
 - l. Materials and finishes.
 - m. Warnings and precautions to be observed during maintenance actions.
 - n. Any other information necessary to ensure proper maintenance and repair.
 - o. Warranty information.
 - p. Index.
 2. Operation Manuals:
 - a. Include the following in each manual, as applicable:
 - 1) Detailed operating instructions.
 - 2) Test and evaluation procedures.
 - 3) Safety precautions, e.g. emphasis on "high resistance" grounding.
 - 4) Functional relationship with other equipment or systems.
 - 5) Operational limits and restrictions.
 - 6) Illustration depicting control layout and other pertinent features required to supplement description of operational procedures.
 - 7) Recommended operating modes.

- 8) Other information necessary for proper and efficient operation.
- B. The detailed contents of sealed assemblies need not be displayed, but their functions must be explained and the appropriate operational specification characteristics listed, as well as procedures for test and replacement.
- C. Wiring Diagram Manual and Maintenance and Renewal Catalog: This shall contain the information needed to sustain optimum operation.
 1. Include general familiarization material; location, function, and operation of all controls, gauges, indicators, and switches; emergency procedures; and trouble diagnosis methods.
 2. Organize the manual logically, with systems and elements considered in descending order of importance.
 3. The Catalog and Manual shall provide, in convenient form, all the information needed for servicing, including lubrication, inspection, running maintenance and adjustment, and online trouble diagnosis.
- D. Repair and Maintenance Sections: Include complete illustrated, exploded views of all assemblies, and complete, illustrated, exploded views for identifying all system parts.
- E. Materials and Finishes Section: This shall include manufacturer's data, giving full information on products:
 1. Information required for reordering specifically manufactured products.
 2. Instructions for care and maintenance.
 - a. Manufacturer's recommendation for cleaning agents.
 - b. Identifying cleaning agents which are detrimental to the Project.
- F. Parts Section: This shall enumerate and describe each component with its related parts, including the supplier's part number, the Contractor's number, commercial equivalents, and space for entry of Authority's part numbers.
 1. Use cutaway and exploded drawings to permit identification of parts not readily identified by description.
 2. Parts common to different components, e.g., bolts and nuts, shall bear the same Contractor's number with a cross-reference to the other components of which they are a part. Identify each part or component as being part of the next part of the next larger assembly or subassembly.
- G. Warranty Section: A copy of each warranty issued shall be included, and information sheet for Authority's personnel shall be provided, including:
 1. Proper procedures in the event of failure.
 2. Instances which might affect the validity of warranties.

1.07 INSTRUCTION OF AUTHORITY'S PERSONNEL

- A. The Contractor will furnish a training program which enable Authority to operate, maintain, and update all systems, equipment, and materials supplied under the Contract. Training shall specifically include the following:
1. Operations training shall be tailored specifically to Authority equipment, and designed to teach the day-to-day operation of all equipment. The training shall be sufficient to bring personnel to a level of operating proficiency such that routine vendor support is not needed.
 2. Maintenance training shall be tailored specifically to Authority equipment, and designed to develop the knowledge and skills required to maintain all item(s) delivered under the Contract. Maintenance training shall be subdivided into two major levels, covering the following:
 - a. System level maintenance training:
 - 1) Theory of operation of the system and its major components.
 - 2) System configuration.
 - 3) Preventative maintenance, consisting of written procedures and schedules for the periodic maintenance of all equipment.
 - 4) Written and validated inspection procedures and a system-level troubleshooting guide (to the lowest field replaceable unit).
 - b. Shop level maintenance training:
 - 1) Detailed theory of operation to module, board, and/or device level.
 - 2) Component level troubleshooting and component replacement.
 - 3) Testing and alignment procedures of repaired units.
- B. Initial training shall be done by the Contractor who shall then provide Authority with the tools to conduct ongoing training after completion of the Work.
- C. The Contractor shall provide an all-encompassing training program for Authority personnel involved in the operations and maintenance of the traction power and signaling and communications systems. Separate courses and materials shall be provided for all the three systems. Training at both the system level and the equipment level shall be included. The Contractor shall design and provide distinct, separate training courses, subject to review and approval by the Engineer, including:
1. System-familiarization training (at least 24 hours) for Authority's management, supervisory, and operations personnel.
 2. Maintenance training (at least 80 hours), including troubleshooting and repair, for Authority's maintenance supervisors, technicians, and engineers.
 3. Detailed operations instruction and training (at least 40 hours) to Authority's personnel responsible for operations, which will be defined by Authority. Normal and abnormal operating situations shall be included in this training.
 4. Solid State and Microprocessor Equipment (for signal and communications personnel only): Three levels of training shall be provided for operating and maintenance personnel in the use and maintenance of solid state equipment. Manuals and pamphlets as required shall be provided in addition to those required elsewhere in these specifications.

- a. The first level of training (at least 24 hours) shall be for all signal and communications personnel in troubleshooting at the board level. Training shall include use of diagnostics and identification of failure for each type of board. This shall also include training for maintenance of the system as a whole, repairs and replacement of equipment, use of test equipment and fault diagnosis and remedy. A brief step by step pamphlet describing such procedures shall be provided to each student.
 - b. A second level of training (at least 16 hours) shall be for engineering personnel. This training should enable these participants to subsequently train other personnel in troubleshooting and maintenance of solid state systems. Detailed manuals shall be provided to each student.
 - c. A third level of training (at least 40 hours) shall be in the use of the Application Dependent Firmware tools designed to modify signal and communication logic. This training shall enable these persons to subsequently train other personnel in all aspects of the use, maintenance, and modification of the application program and equipment provided. Detailed manuals and pamphlets shall be provided to each student.
 5. The anticipated number of students in every one of the above courses will not exceed twenty-five.
- D. The Contractor shall provide operations and maintenance training for all Signal, Communication and traction power equipment, hardware and software items including but not limited to the items listed below. Final list of items for which the Contractor provides training shall be subject to approval of the Engineer.
1. Signal System
 - a. Interlocking equipment
 - b. TWC
 - c. Track circuits
 - d. All wayside signal equipment. Refer to Section 13574, "Wayside Signal Equipment."
 - e. Local control panels
 - f. Relays
 2. Communication System
 - a. Fiber optic outside plant
 - b. Copper outside plant
 - c. CTS including SONET, NMS, GPS, DACS
 - d. Power supply
 - e. Telephone system
 - f. Radio system including base stations and voting equipment
 - g. CCTV
 - h. VMS/PA
 - i. SCADA including RTUs
 3. Traction Power:

- a. General and operational training shall be provided in the following areas:
 - 1) Traction power equipment operation
 - 2) Safety and emergency procedures
 - 3) Test equipment operation
 - 4) SCADA operation and communication with the OCC
 - b. Maintenance and repair training shall be provided for Traction Power equipment (including, but not limited to):
 - 1) High-voltage ac switchgear assembly
 - 2) DC switchgear assembly
 - 3) Transformer-rectifier unit
 - 4) Auxiliary power system
 - 5) Station battery system including communication module
 - 6) AC and dc switchgear test stations
- E. The Contractor shall provide a Training Program Plan to the Engineer for approval. The plan shall include performance objectives, a training schedule, and a plan for "training the trainers" (instructors who will eventually teach Authority personnel). Approval of the Training Program Plan by the Engineer is required prior to the implementation of any training program.
- F. The plan shall assist the Contractor in managing the training process. The plan shall describe each course and how the requirements of the course will be met.
- G. The plan shall include a narrative description that documents the design for training Authority personnel, including management, supervisors, operations, and maintenance personnel.
- H. The plan shall provide an accurate identification of the training courses, a general description of each course, the intended audience, the size of class, Authority facilities required, the sequence of classroom and hands-on instruction, the estimated hours required for both and the number of sessions, all of which shall be subject to approval of the Engineer.
- I. The plan shall also include, but not be limited to, the following:
- 1. Sequence of learning activities;
 - 2. Outline of the content of each specified course;
 - 3. Overview description of syllabi, instructor and student materials;
 - 4. Description of the learning strategies to be used (such as classroom presentation, hands-on practice, computer-based training, simulation, paper and pencil exercises, etc.). The area(s) of the traction power and signaling and communications systems that each learning strategy applies to will also be identified.
 - 5. Methods and criteria for evaluating performance, including an objective grading system to report progress during the training;

- J. The plan shall identify all requirements for Authority-furnished material and access to existing systems.
- K. The plan shall also provide the order in which training is to be presented and the objective for each task for which training is required.
- L. In the plan, the Contractor shall describe its training experience that is relevant to the curriculum.
- M. The organization chart and the experience of the Contractor's department that has the prime responsibility for preparation and presentation of the training programs shall be included.
- N. The qualifications of the assigned instructors shall also be included. Training personnel shall be knowledgeable in their subject area and have proven training experience. Such previous training experience shall be proven to the Engineer upon request.
- O. Instructors shall be totally fluent and give instruction in English. Instructors' English fluency shall include technical terminology and commonly used expressions.
- P. The plan shall describe the Contractor's approach to, resources and hours required to provide hands-on training and assistance to traction power and signaling and communications personnel during pre-revenue operations and the initial period of revenue service.
- Q. The Contractor shall provide training on all traction power and signaling and communications systems interfaces.
- R. Grading System:
 - 1. The Contractor shall establish and utilize an objective grading system to report the progress of instructors and each trainee during a course. Student evaluations shall be prepared by the instructor. Grading shall be kept confidential and furnished only to personnel designated by Authority, with each trainee furnished a copy of his individual test results and/or assessment.
- S. Course Assessment:
 - 1. The Contractor shall establish and utilize course and instructor assessment forms. Assessment forms shall be completed by each student at the completion of each course and shall be forwarded to Authority. Course and instructor assessments shall be kept confidential and shall be furnished only to personnel designated by Authority.
- T. Training Facilities and Equipment:

1. Training shall be held in Authority's facilities. The Contractor shall utilize equipment provided as part of the Contract for the training. Training shall use actual equipment delivered, duplicates of equipment delivered or scheduled to be delivered, simulators, or any combination.
 2. The Contractor shall provide materials to support the training courses, including: instruction guide, training aids, student workbooks, and operation and maintenance manuals:
 - a. Instructor Guide: Provide instructor guides containing course outline, agendas, objectives, lesson plans, training aids, presentation guidelines, suggested discussion questions, and criteria for measuring student performance.
 - b. Training Aids: Provide training aids, such as mock-ups, scale models, and overhead transparencies or PowerPoint slides. All training aids shall be of durable construction and shall become the property of Authority. Verify that any equipment or tools used during training are in good working condition both before and after training sessions.
 - c. Student Workbooks: Provide student workbooks that include course objectives, a course agenda, schedule of sessions, copies of overhead transparencies, lecture outlines, and any additional printed material used during the course.
- U. The Contractor shall provide documentation, grades, and course assessments that validate that 100 percent of the students identified in the Training Program Plan have successfully completed the operations courses prior to Pre-revenue Acceptance Test and successfully completed the maintenance courses prior to the Revenue Service.
- V. Authority reserves the right to determine the precise time and date of the class and class size in order to maintain normal revenue operations.
- W. Authority reserves the right to videotape training sessions provided by the Contractor.
- X. The instruction sessions shall be Thirty (30) days prior to turnover of facility to Authority for Authority use and operation.
- Y. The Contractor, at no additional cost to Authority, shall prepare and include additional information into the training program, as determined necessary by Authority.

1.08 SUBMITTAL SCHEDULE

- A. Operations and Maintenance Manuals (Signal and Communications)
 1. Preliminary Submission
 - a. Submit for Engineer's review and comment, proposed manual and training program formats, course instructor qualifications, and outlines of contents within sixty (60) days prior to installation.

2. Pre-final Submission
 - a. Submit for Engineer's review and comment complete manual and training program content in final format within fourteen (14) days after installation. This submission shall include written responses to all preliminary submission comments.
3. Final Submission
 - a. Submit for Engineer's review and comment, complete manual and training program within thirty (30) days after installation. This submission shall include written responses to all Pre-final submission comments.
4. Submit copies of complete manual in final form.
5. Submit manual updates and revisions seven (7) days prior to Acceptance of Final Inspection, at no additional cost to Authority.

B. Operations and Maintenance Manuals (Traction Power Substation)

1. The following information shall be submitted for approval:
 - a. Operation and Maintenance manuals including but not limited to the following items:
 - 1) Overall substation operation and maintenance, including positive and negative feeder cables to the OCS
 - 2) Stray current drainage equipment
 - 3) Supervisory control interface terminal cabinet (IFTC) and all contents, including the local annunciator panel
 - 4) SCADA/Fiber Optic cabinet and communications with OCC
 - 5) High-voltage ac switchgear assembly
 - 6) DC switchgear assembly
 - 7) Transformer-rectifier unit
 - 8) Negative polarity grounding device
 - 9) Bus and busways
 - 10) Key interlocks
 - 11) Auxiliary power system
 - 12) Station battery system including communications module
 - 13) 650 Vdc feeder cable system
 - 14) Ac and dc switchgear test stations
 - 15) Enclosure auxiliary systems (lighting, HVAC, fire alarm, etc.)
 - b. Submittals for the Operations and Maintenance (O&M) Manuals shall conform to the following sequence:
 - 1) Contractor shall submit a complete listing of the table of contents of the complete O&M manual prior to the Engineer's approval of 50% of project completion status.
 - 2) Contractor shall submit seven (7) copies of a complete first draft of the O&M manual prior to delivery of the substation.
 - 3) Contractor shall submit the final copies of the O&M manual prior to start of substation testing.
 - c. Training Program Materials, conforming to the following sequence:

- 1) Contractor shall submit a complete listing of the table of contents of the complete training program prior to the Engineer's approval of 50% of project completion status.
 - 2) Contractor shall submit seven (7) copies of a complete first draft of the training program prior to delivery of the substation.
 - 3) Contractor shall submit the final copies of the training program prior to start of substation testing.
- d. Training Plan: Provide transparencies (slides) in electronic format, MS PowerPoint.
 - e. Final submittal: After approval by Authority, submit the following finished documents:
 - 1) Operation and Maintenance Manuals.
 - 2) Training Program.
 - 3) Training Plan.

ARTICLE 2 PRODUCTS

[NOT USED]

ARTICLE 3 EXECUTION

[NOT USED]

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01911

OPERATIONS, MAINTENANCE AND INFORMATION DATABASE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for operations, maintenance and information database, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. Section 13570, "Signal System Requirements."
- B. Section 16200, "Traction Power Substation General Requirements."
- C. Section 16210, "Traction Power Substation Basic Electrical Materials and Methods."
- D. Section 16700, "Communications."

1.03 SUBMITTALS

- A. Submit the database along with Project Record Documents.

ARTICLE 2 PRODUCTS

[NOT USED]

ARTICLE 3 EXECUTION

3.01 EQUIPMENT

- A. Contractor shall input and record manufacturer's supplied equipment information.
- B. Contractor shall create one table including all provided equipment. The database shall be in Microsoft Access. The database name shall be the Contract Number. Contractor shall populate the database with the following criteria.

Field Name	Field Size	Field Type
Facility Name	25	Text
Contract Number	12	Text
Technical Provision Section	5	Text
Equipment Acronym	25	Text
Equipment Location	25	Text
Manufacturer	20	Text
Model Number	10	Text
Serial Number	25	Text
Electric Load	10	Text
Voltage	10	Text
Power Supply	10	Text
Weight/Capacity	6	Text
Local Rep	20	Text
Local Rep Phone	12	Text
Authority File No.	15	Text
Manual Name, Volume No. and Section No.	25	Text
Warranty	6	Number
Date of Acceptance	10	Date/Time
Comments		Memo

- C. All other properties and/or criteria shall be as defaulted by Microsoft Access.
- D. Contractor shall input each item into the database as a separate database record.

3.02 DEFINITION OF FIELD NAMES

- A. Facility Name: This field is for the input of the name of the facility the equipment is installed under. For example, North Side Station.
- B. Contract Name: This field is for the input of the construction Contract Number under which the equipment is installed. For example, NSC-003.
- C. Section: This field is for the input of the construction Technical Provision section number the equipment was specified under, for example 08305.
- D. Equipment Acronym: this field is for the input of the equipment acronym as designated in or on the Contract Documents.
- E. Equipment Location: This field is for the description of the equipment location.
- F. MFR: This field is for the input of the manufacturer of the equipment installed.

- G. Model Number: This field is for the input of the model number of the installed equipment.
- H. Serial Number: This field is for the input of the serial number of the installed equipment.
- I. Electric Load: This field is for the input of the electrical load (if any) of the installed equipment. The units of the load shall be included. For example 10HP, 5KW.
- J. Voltage: This field is for the input of the equipment operating voltage. The input shall include volts, phase, and hertz. For example, 480V-3-6, 277V-1-60.
- K. Power Supply: This field is for the input of the local panel name and circuit number from which power is supplied. The input shall be based on the project panel naming and numbering system.
- L. Local Rep: This field is for the input of the name of the local representative for the equipment supplied.
- M. Local Rep Phone: This field is for the input of the phone number of the local representative identified above.
- N. Authority File No.: This field is for the input of Authority project file number. Authority to complete this item. Contractor shall create the field.
- O. Warranty: This field is for the input of the length in years of the warranty of the installed equipment.
- P. Date of Acceptance: This field is for the date of the Certificate of Acceptance of Final Inspection for the installed equipment and the date for which the warranty period starts.
- Q. Comments: This field is for any general comments related to the installed equipment.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 01920

CUTTING AND PATCHING

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for cutting and patching, in accordance with the Contract Documents
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Cutting and Patching Plan
 - 2. Cutting
 - 3. Hauling and disposal of material
 - 4. Patching

1.02 SUBMITTALS

- A. Cutting and Patching Plan: Submit a plan describing procedures at least 10 days before the work for cutting and patching will be performed, to the Engineer for approval. Include the following information:
 - 1. Extent: Describe cutting and patching, show how they will be performed, and indicate why they cannot be avoided.
 - 2. Products: List products to be used and firms or entities that will perform the work.
 - 3. Dates: Indicate when cutting and patching will be performed.
 - 4. Utilities: List utilities that cutting and patching procedures will disturb or affect.

1.03 QUALITY ASSURANCE

- A. Structural Elements: Do not cut and patch structural elements.
- B. Miscellaneous Elements: Do not cut and patch the following elements or related components in a manner that could change their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety:
 - 1. Water, moisture or vapor barriers.
 - 2. Membranes and flashings.

1.04 DEFINITIONS

- A. Cutting: Removal of existing concrete and other material as necessary to permit installation or performance of other work.
- B. Patching: Fitting and repair work required to restore surfaces to original conditions after installation or other work.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Existing materials: For exposed surfaces, use materials that visually match existing adjacent surfaces to the fullest extent possible.
 - 1. If identical materials are unavailable or cannot be used, submit materials that, when installed, will match the visual and functional performance of existing materials to the Engineer for approval.

ARTICLE 3 EXECUTION

3.01 EXAMINATION

- A. Examine surfaces to be cut and patched and conditions under which cutting and patching are to be performed.
 - 1. Compatibility: Before patching, verify compatibility with an suitability of substrates, including compatibility with existing finishes or primers.
 - 2. Proceed with installation only after unsafe or unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Temporary support: Provide temporary support of work to be cut.
- B. Protection: Protect existing construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of the Work that might be exposed during cutting and patching operations.
- C. Adjoining areas: Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.

3.03 PERFORMANCE

- A. General: Proceed with cutting and patching at the earliest feasible time, and complete without delay.
 - 1. Cut existing construction to provide for installation of other components or performance of other work, and subsequently patch as required to restore surfaces to their original condition.
- B. Cutting: Cut existing construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction.
 - 1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.

2. Existing finished surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
 3. Asphalt: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
 4. Concrete: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
 5. Mechanical and electrical services: Cut off pipe or conduit in walls, partition, or slabs on grade to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
- C. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other work. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified in the Contract Documents.
1. Inspection: Test and inspect patched areas after completion to demonstrate integrity of installation.
 2. Exposed finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
 3. Slab-on-Grade: Patch and repair slab-on-grade surfaces. Provide an even surface of uniform finish, color, texture, and appearance.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this section. Payment for the work shall be included in the payment for related portions of the work.

END OF SECTION

SECTION 01940

CLEANING

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for cleaning, in accordance with the Contract Documents.

1.02 SAFETY REQUIREMENTS

- A. Worksite shall be maintained in accordance with governmental requirements applicable to worksite cleanlinesss, and in a neat, orderly and hazard-free condition until Final Acceptance of the Work. Worksite, sidewalks and walkways, and public sidewalks, roadways, streets and walkways adjacent to the Worksite, shall be kept free from hazards caused by construction activities, and shall be regularly inspected for hazardous conditions caused by construction activities.
- B. Hazards Control
 - 1. Volatile wastes shall be stored in covered metal containers, and shall be removed from the Worksite daily.
 - 2. Accumulations of wastes that create hazardous conditions shall be prevented.
- C. Cleaning and disposal operations shall be conducted in accordance with anti-pollution laws and governmental requirements applicable to those operations. Rubbish, volatile wastes and other construction waste shall not be buried nor burned on the Worksite, and shall not be disposed of into storm drains, sanitary drains, streams and other waterways.

ARTICLE 2 PRODUCTS

2.01 CLEANING MATERIALS

- A. Cleaning materials shall be of the types recommended by the manufacturer of the surface to be cleaned.

ARTICLE 3 EXECUTION

3.01 INTERIM CLEANING

- A. Broom cleaning shall be executed every workday during the Time of Completion. Structures, grounds and areas of the Worksite, and public and private properties immediately adjacent to the Worksite and temporary sanitary facilities, shall be maintained "Broom Clean" and free from accumulations of waste materials and

rubbish that has been caused by construction operations. Waste materials and rubbish shall be placed in dump containers.

- B. Loose material shall be either removed or secured either at the end of each workday or more often to maintain Worksite in hazard-free condition.
- C. Dump containers shall be emptied promptly at least once a week. Contents shall be legally disposed of at either public or private dumping areas off Authority's property.
- D. Waste materials, debris and rubbish shall be handled in a controlled manner, and shall not be dropped nor thrown from heights.
- E. Spillage, of other than potable water, shall be immediately removed.
- F. Cleaning operations shall occur at times when dust and other contaminants will not fall on wet and newly painted surfaces.
- G. Debris on the site, city streets, or sidewalks shall be removed immediately upon verbal or written notification from the Engineer.

3.02 FINAL CLEANING

- A. Final cleaning shall occur before application to Authority for Final Inspection.
 - 1. Inspection of surfaces that are exposed to view shall be conducted in preparation for the Final Inspection.
 - 2. Any grease, dust or foreign materials shall be removed from any exposed piping.
 - 3. Paved surfaces shall be broom-cleaned, and other ground surfaces shall be rake-cleaned.
 - 4. Any debris, waste materials, or materials left over from construction shall be removed from the job site.
 - 5. Cleaning shall be maintained until the Final Inspection of the Work.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this section. Payment for the work shall be included in the payment for related portions of the work.

END OF SECTION

SECTION 02020

HANDLING OF UNFORESEEN HAZARDOUS AND CONTAMINATED BUILDING MATERIALS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for the handling of unforeseen hazardous and contaminated materials, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Removal and disposal of hazardous and contaminated materials present prior to demolition.
 - 2. Removal of all remaining potentially hazardous materials.

1.02 RELATED SECTIONS

- A. Section 01815, "Construction Dust Control."
- B. Section 02220, "Demolition."

1.03 REFERENCE STANDARDS

- A. General Requirements
 - 1. All work shall be undertaken in accordance with applicable federal, state, county, and local regulations, standards, codes and guidelines.
 - 2. The most recent edition of regulations, standards, codes and guidelines shall be in effect; and the Contractor shall have copies available at the work site. Where conflict among the regulations, standards, codes and guidelines and these specifications exists, the more stringent requirement shall govern.
 - 3. The Contractor shall be solely responsible for supervising, directing and controlling all work under this contract; for the means, methods, techniques and procedures for hazardous and contaminated materials removal, and the handling of asbestos-containing material, lead-containing paint and contaminated materials; for disposing of asbestos-containing materials, lead-containing paint and contaminated materials at a permitted site; and for safety precautions and programs incident to the work.
- B. Federal and State References
 - 1. Title 40 Code of Federal Regulations:
 - a. Part 763, Asbestos-Containing Materials in Schools Rule (AHERA).
 - b. Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAP).

- c. Parts 141 and 142, Safe Drinking Water Act.
2. Title 29 Code of Federal Regulations: Section 1926, Safety and Health Regulations for Construction and Section 1910, Safety and Health Regulation for General Industry, as applicable.
3. EPA 560/5-85-024: Guidance for Controlling Asbestos-Containing Materials in Buildings.
4. American National Standards Institute:
 - a. ANSI Z9.2: American National Standard Fundamentals Governing the Design and Operation of Local Exhaust System.
 - b. ANSI Z88.2: American National Standard Practice for Respiratory Protection.
5. American Society for Testing and Materials:
 - a. ASTM Proposed Specification P-189, "Specification for Encapsulants for Friable Asbestos Containing Building Materials".
 - b. ASTM E-84, Surface Burning Characteristics of Building Materials, Test for.
6. Commonwealth of Pennsylvania:
 - a. Department of Labor and Industry: Asbestos Occupations Accreditation and Certification Act of 1990, No. 194 as amended by Act. No. 161 effective 2/20/99.
 - b. Pennsylvania Department of Environmental Protection Title 25 Rules and Regulations: Chapter 124, National Emission Standards for Hazardous Air Pollutants.
 - c. Department of Labor and Industry: Worker and Community Right- To-Know Act 1984-159.
 - d. Pennsylvania Department of Environmental Protection: Act 97, the Solid Waste Management Act of July 7, 1980.
 - e. Pennsylvania Department of Environmental Protection Title 25 Rules and Regulations: Chapter 109, Pennsylvania Safe Drinking Water Act.
7. Allegheny County Subpart 6 – Asbestos Sources:
 - a. §2105.60 – Asbestos Abatement Contractors Licenses
 - b. §2105.61 – Asbestos Abatement Accreditation Requirements
 - c. §2105.62 – Asbestos Abatement Applicability, Federal Requirements, Notices, and Permits
 - d. §2105.63 – Asbestos Abatement Procedures

1.04 SUBMITTALS

- A. Schedule: Submit a schedule in accordance with Section 02220, “Demolition” indicating proposed methods and sequences of operations for demolition work that involves contaminated or hazardous material to the Engineer for review and approval prior to start of work, which shall include, but not be limited to, the following:
 1. Detailed sequence for the completion of the removal and disposal of all hazardous waste from the existing building.

2. Detailed sequence of demolition, on-site storage of all potentially contaminated removed material, potentially contaminated removed material testing and subsequent disposal from the existing building.
- B. Asbestos Abatement. The Contractor shall submit the following for the approval of the Engineer:
 1. Superintendent's qualifications and certification numbers as required by laws and regulations cited under Paragraph 1.03 B.1 , B.6, and B.7.
 2. Manufacturer's certification that vacuums and ventilation equipment required to contain airborne asbestos fibers conform to ANSI Z9.2.
 3. Project schedule for each building work area showing, as a minimum, the dates for set-up, initial inspection, removal, removal inspection, cleaning, clearance testing, re-establishment of objects and systems. The Contractor will adjust the schedule as necessary to complete work within contract time and submit revised copies to Engineer.
 4. A description of the means, methods, techniques and procedures to be used for:
 - a. Work area isolation.
 - b. Removal and negative pressure enclosure systems.
 - c. Negative pressure ventilation within the containment.
 - d. Substrate cleaning and sealant application.
 - e. On-site handling and storage of asbestos-containing and contaminated material.
 - f. Work area cleanup.
 - g. Worker protection and air monitoring.
 5. If the means, methods, techniques and procedures established by the Contractor must be changed, the Contractor shall in writing notify the Engineer and appropriate regulatory agencies of the alternate to be utilized.
 6. A statement signed by each removal worker acknowledging that the worker has received instruction pertaining to asbestos hazards, use and fitting of respirators, use of protective equipment, decontamination procedures, and additional project-related personal protective procedures and measures, and certification numbers as required by laws and regulations cited under Paragraph 1.03 B.1, B.6, and B.7.
 7. Material Safety Data Sheet (OSHA Form 20) and manufacturer's specifications for solvents, surfactant, substrate sealant and penetrant/fiber encapsulant.
 8. Solid Waste Permit for asbestos disposal at PADEP-approved landfill
 9. Not later than ten (10) working days prior to commencing work, submit required written notifications to the Pennsylvania Department of Environmental Protection, Pennsylvania Department of Labor and Industry, U.S. Environmental Protection Agency, Allegheny County, and any other local authorities having project jurisdiction. Provide copies of such notifications to the Engineer.
 10. The Contractor shall not commence work until the Engineer has in writing acknowledged receipt and review of the superintendent's qualifications; project schedule; means, methods, techniques and procedures; and surfactant, substrate sealant and penetrant/fiber encapsulant information.

C. Worker Protection from Exposure to Lead. The Contractor shall submit the following for the approval of the Engineer:

1. Prior to starting work, Contractor shall submit a complete written work plan in accordance with 29 CFR 1926.62(e)(2). The plan shall provide a complete explanation of the methods, materials, equipment, and control procedures that will be implemented to ensure that the subject work is performed according to the applicable specifications and regulations and to ensure the continuous protection of Contractor's and Engineer's personnel and facilities.
2. Exposure Assessment
 - a. The Contractor shall maintain objective historical data that indicates the anticipated airborne exposure to lead during the performance of this work activity. The Contractor shall propose the mechanism or plan that will demonstrate the applicability of this data to the current anticipated work conditions.
 - b. Lacking historical data, a project-specific lead exposure assessment shall be initiated. Monitoring shall be done under the supervision of a professional industrial hygienist, and sample analysis shall be performed by an AIHA-accredited laboratory, or equivalent.
3. Engineering and Work Practice Controls
 - a. The Contractor shall submit a summary of engineering and work practice controls to be used to limit lead exposure in the performance of this work. An emphasis should be placed on lead-containing surface coating disturbance methods that capture surface coating debris at the source (i.e. HEPA vacuum equipped power tools). When mechanical ventilation is used to control lead exposure, the Contractor shall include an explanation of how system performance will be evaluated in order to ensure effectiveness.
 - b. The Contractor shall establish "regulated areas" at the boundaries surrounding activities where lead exposures are expected to exceed 50 µg/m³. This includes areas of lead-containing material disturbance, dust collection equipment, and any locations where lead-containing surface coating debris is handled or transferred to storage containers. The Regulated Areas shall be demarcated by ropes, tape, walls, or other similar means, and the Contractor shall control access to only those persons properly trained and protected.
4. Personal Protective Work Clothing and Equipment
 - a. The Contractor shall submit a list of the personal protective work clothing and equipment to be used. Submitted with the list shall be a summary of procedures addressing its use, maintenance, replacement, and laundering. Plans and procedures addressing decontamination and/or disposal are also to be included.
5. Hygiene/Housekeeping
 - a. Contractor may not allow surface coating debris to be spread beyond the immediate work area and must thoroughly clean up and remove all surface coating debris from all work areas. The Contractor shall protect Engineer's fixtures, equipment, furniture, and materials from accumulations of surface

- coating debris. Should any fixtures, equipment, furniture, or materials be covered by surface coating debris, Contractor shall clean them and remove debris.
- b. The Contractor shall submit plans and procedures designed to maintain work areas as free as practicable of accumulations of lead and surface coating debris. These shall address, where applicable, the provisions for:
 - 1) handwashing facilities;
 - 2) shower and change area facilities;
 - 3) eating areas;
 - 4) break areas; and
 - 5) general housekeeping
 6. Worker's Certification
 - a. Contractor agrees to maintain properly qualified supervision on the job site at all times while work is in progress. Such supervision shall qualify as competent persons as defined by 29 CFR 1926.62(b). The Contractor's supervisor shall ensure that workers understand and are complying with all regulations and requirements. A resume or summary list of training and experience that qualifies this individual to serve in the Competent Person capacity shall be included.
 - b. The Contractor shall submit a completed worker qualification certification form (a sample copy of which appears herein as Attachment 1) for each employee before he or she is assigned to this job. The Engineer reserves the right to reject any worker from performing work hereunder, based on Contractor's or its employee's refusal to submit the requested data in Attachment 1.
 - c. Contractor warrants that all employees performing work involving lead are properly trained in the safety and work to be used in the performance of this job.

1.05 DEFINITIONS

- A. Amended Water: Water to which a surfactant has been added.
- B. Authorized Visitor: The Engineer, the Abatement Observation Firm, and any representative of a regulatory or other agency having project jurisdiction.
- C. Containment: Physical means employed to control fiber dispersion, such as dropped plastic, custom bags or enclosed portable scaffolding.
- D. Equipment Decontamination System: Facilities designed for the controlled transfer of material, equipment and tools into or out of the work area.
- E. Fixed Object: A piece of equipment or furniture in the work area which cannot be removed.

- F. HEPA Filter: A high efficiency particulate air filter capable of removing particles 0.3 microns in diameter with 99.97% efficiency.
- G. Moveable Object: Includes, but not limited to, blinds, screens, grilles, access panels, trim pieces, equipment and furniture in the work area which can be removed; includes detachable electrical, lighting, heating and ventilation equipment and other items secured to surfaces from which asbestos-containing material shall be removed.
- H. Negative Pressure Ventilation System: A portable HEPA exhaust system capable of maintaining a constant air flow from uncontaminated into contaminated areas, providing a minimum of four (4) air changes per hour and discharging outside the building.
- I. Regulated Work Area: A room, space or area within which removal is to be undertaken or which may become contaminated as the result of removal activity.
- J. Remove: Remove and dispose of items.
- K. Sealant: A viscous liquid recommended by the EPA based on Batelle Laboratories for the Evaluation of Sealants for Encapsulation of Friable Asbestos-Containing Materials.
- L. Worker Decontamination System: Facilities for storing street clothes, cleaning protective equipment, showering and storing contaminated clothing.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Demolition and Removal: Items indicated to be removed but of salvageable value to the Contractor may be removed from the site as work progresses. Sale of removed items on site shall not be permitted.
- B. Worksite Protection
 - 1. Contractor shall be required to provide any additional or temporary lighting required throughout the project.
 - 2. Perform demolition in such manner as to eliminate hazards to persons and property and to minimize interference with use of adjacent areas, utilities and structures.
 - 3. Prevent the spread of flying particles and dust. Sprinkle rubbish and debris with water or to take other measures to keep dust to a minimum and within the designated construction zone.
 - 4. In addition to local jurisdiction fire and safety rules to be observed in the performance of the work, include the following:
 - a. Wherever a cutting torch or other equipment that might cause a fire is used, provide and maintain fire extinguishers nearby and ready for immediate use. All possible users shall be instructed in the proper use of fire extinguishers.

- b. Hydrants shall be accessible at all times. No debris shall be permitted to accumulate within a radius of 15 feet of fire hydrants.
 - 5. Provide safeguards, including temporary covered passageways as required by authorities having jurisdiction, warning signs, barricades, temporary fences, warning lights, and other similar items that are required for protection of all personnel during demolition and removal operations.
 - 6. Environmental Controls
 - a. Comply with Section 01815, "Construction Dust Control."
 - b. Use water sprinkling, temporary enclosures, and other suitable methods to limit dust and dirt rising and scattering in air to lowest practical level. Comply with governing regulations pertaining to environmental protection.
 - c. Do not use water when it may create hazardous or objectionable conditions such as ice, flooding or pollution.
- C. Air Sampling and Analyses for Asbestos Abatement
- 1. Air sampling and analysis will be undertaken prior to and throughout the removal and cleanup activities, and at the conclusion of final cleanup and will be subject to the most stringent applicable federal, state and local rules and regulations.
 - 2. Contractor Responsibility
 - a. Undertake work area air sampling and analysis to establish worker exposure. Air sample analysis must be performed by a laboratory accredited by the American Industrial Hygiene Association utilizing methods set forth in 29 CFR 1926.1101, Appendix A. If airborne fiber concentrations exceed regulatory limits, the Contractor shall advise workers and the Engineer, and immediately discontinue work until the cause is identified and corrected. The use of a continuous reading fiber monitor will not relieve the Contractor of the responsibility to comply with regulatory requirements.
 - b. Furnish the Engineer with copies of laboratory analytical reports.
 - c. Prior to and throughout the removal and cleanup work, air sampling may be conducted outside of the work area, and outside of the affected building at the containment exhaust outlet. If fiber concentrations exceed 0.01 fibers/cc by phase contrast microscopy outside the work area, or are in excess of ambient levels at the containment exhaust outlet, the Contractor's superintendent will notify the Engineer. The superintendent will immediately determine the cause of the excess fiber count and undertake corrective action. These analytical results will normally be available to the Engineer within 36 hours after sample collection.
 - d. Conduct clearance testing as described in Paragraph 3.05.F.
 - 1) The clearance test level shall not be in excess of 70 structures per square millimeter, (average of 5 clearance samples), or shall not be in excess of ambient sample concentrations when compared utilizing statistical analysis. These levels shall be determined utilizing transmission electron microscopy. If Phase Contrast Microscopy is used as the analytical method, the clearance test level shall not be in excess of 0.01 fibers/cubic

centimeter (f/cc). These analytical results will normally be available to the Engineer within 48 hours after sample collection.

D. Personnel Protection for Asbestos Abatement

1. Worker protection procedures and measures are the sole responsibility of the Contractor.
2. The Engineer will have employees in the building during Contractor work activities. The Contractor shall employ containment, removal, handling and storage procedures that will protect all people from exposure to asbestos fibers and other contaminates that might be present.
3. At all times the Contractor shall utilize personnel protection procedures and measures commensurate with job conditions.
4. The Contractor shall be prepared to provide authorized visitors with suitable protective clothing and equipment whenever they desire to enter the work area. The Contractor shall require that all persons entering the work area wear said clothing and equipment, and refuse entry to those who do not comply. The Contractor shall also make available to authorized visitors the use of worker decontamination facilities.

E. Worker and Equipment Decontamination Systems for Asbestos Abatement

1. The Contractor will be responsible for providing separate worker and equipment decontamination systems. The systems will be designed by the Contractor to minimize fiber or air transfer between the work area, the decontamination systems, and building areas outside the work area and decontamination systems. Wastewater will be pre-treated to the extent required by local municipal ordinance prior to discharge to the sewerage system, or other suitable arrangements made for its containment and disposal.

F. Worker Protection from Exposure to Lead

1. The Occupational Safety and Health Administration (OSHA) regulates worker lead exposure and has assigned a lead permissible exposure limit (PEL) of 50 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). This is a time-weighted average concentration for a normal eight-hour day or forty-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
2. Contractor is solely responsible for the health and safety of its workers during the execution of this contract. Work shall be conducted under the assumption that all surface coatings contain lead and, in accordance with all applicable local, state, and federal regulations, including, but not limited to, 29 CFR 1926.62 Lead Exposure in Construction, 1910.134 Respiratory Protection, and U.S. EPA and PA DEP regulations applicable to this work effort. These regulations and their successors shall be binding upon Contractor and considered part of this Contract. The methods used to handle materials and precautions taken shall be determined by Contractor and responsibility for use of such methods shall rest solely with the

Contractor. The Contractor, however, is required to use accepted "state-of-the-art" methods.

3. The procedures specified in this section are guidelines for minimum performance. The Contractor is responsible for his own methods of operations and conformance to regulatory codes, rules and guidelines. The Contractor is required to obtain all permits, licenses and approvals to perform the work, including any rights to use patented systems

1.07 QUALITY ASSURANCE

- A. Requirements of Regulatory Agencies: The construction requirements of Federal, State, County, or other political subdivision specifications exceeding the requirements of the codes, standards and approving bodies referenced herein shall be met and complied with.
 1. Comply with requirements of the National Fire Protection Association Pamphlets (NFPA) referenced in the various Specifications Sections, and as directly appropriate to work and workmanship of this Contract.
- B. Certificates and Permits: Upon completion of work, and prior to final payment, furnish formal certification of final inspections to the Engineer from authorities having jurisdiction and secure required permits, if any, from same. Additionally, prepare detailed diagrams and drawings which may be required by those authorities having jurisdiction.
- C. Source Quality Control: Products used throughout these specifications are those of companies having established reputations in the manufacture of the particular materials, equipment, or apparatus specified. Such products may be of their own make, or products of others for which they assume full responsibility when used in said outfits (which are not manufactured completely by them), and with replacement parts available.
- D. Worker's Qualifications: In acceptance or rejection of completed work, no allowance will be made for lack of skill on the part of the Contractor's forces performing such work.
- E. Contractor is solely responsible for the health and safety of its workers during the execution of this contract. Work shall be conducted under the assumption that all surface coatings contain lead and, in accordance with all applicable local, state, and federal regulations, including, but not limited to, 29 CFR 1926.62 Lead Exposure in Construction, 1910.134 Respiratory Protection, and U.S. EPA and PA DEP regulations applicable to this work effort. These regulations and their successors shall be binding upon Contractor and considered part of this Contract. The methods used to handle materials and precautions taken shall be determined by Contractor and responsibility for use of such methods shall rest solely with the Contractor. The Contractor, however, is required to use accepted "state-of-the-art" methods.

1.08 QUALIFICATIONS

A. Asbestos Abatement

1. The Contractor shall furnish a competent full-time superintendent who will be responsible for supervising, directing and controlling all work under this contract; for the means, methods, techniques and procedures for asbestos removal, and the handling of asbestos-containing and contaminated materials; and for safety precautions and programs incident to the work. The Superintendent shall be accredited in accordance with applicable laws and regulations cited under Paragraph 1.03 B.1, B.2, B.6, and B.7.
2. All Contractor personnel shall be accredited to conduct response actions in accordance with Paragraph 1.03 B. 1 and 6.

B. Worker Exposure to Lead

1. Contractor agrees to maintain properly qualified supervision on the job site at all times while work is in progress. Such supervision shall qualify as competent persons as defined by 29 CFR 1926.62(b). The Contractor's supervisor shall ensure that workers understand and are complying with all regulations and requirements.
2. The Contractor shall submit a completed worker qualification certification form (a sample copy of which appears herein as Attachment 1) for each employee before he or she is assigned to this job. The Engineer reserves the right to reject any worker from performing work hereunder, based on Contractor's or its employee's refusal to submit the requested data in Attachment 1.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Furnish all materials necessary for performing the work.

2.02 TOOLS AND EQUIPMENT

- B. Provide all tools and equipment necessary for performing the work.

ARTICLE 3 EXECUTION

3.01 PREPARATION FOR DEMOLITION

- A. Conduct demolition operations to prevent injury to people and damage to adjacent buildings. Provide safe passage of people and traffic around demolition areas.
 1. Erect temporary protection, such as walks, fences, and railings, as required to provide free and safe passage of workmen and general public around the work area.

3.02 POLLUTION CONTROLS

- A. Limit the spread of dust and dirt. Do not use water when it may damage existing construction or create hazardous or objectionable conditions.
- B. Remove and transport debris in a manner that shall prevent spillage on adjacent surfaces and areas and prevent infiltration of such debris into building drainage systems.

3.03 ASBESTOS ABATEMENT WORK

- A. General:
 - 1. All materials removed shall be handled and disposed of as asbestos-containing materials unless otherwise noted.
 - 2. Contractor shall perform field work as necessary to determine asbestos-containing material quantities and locations.
 - 3. Floor tile mastic will be removed to bare concrete. Concrete will be considered bare, if no mastic residue is visible upon scraping.
 - 4. Critical barriers will include windows.
 - 5. The Engineer will approve the schedule and order of completion of the Asbestos Abatement work, as determined by the Contractor.
 - 6. Abatement within all Work Areas shall be conducted within negative pressure enclosures systems in accordance with Allegheny County, Pennsylvania State, and Federal Regulations. The Glove-bag method can be used for pipe and/or pipe fitting insulation if approved by the Allegheny County Department of Health.
 - 7. All abatement activities will be completed within each Abatement Work Area before Final Clearance Testing of that Work Area.
- B. General Preparation
 - 1. Twenty-four (24) hours prior to completion of work area preparation, the Contractor shall notify the Engineer so that an inspection may be scheduled. The Contractor's superintendent shall verify that the following preparatory arrangements have been made prior to this inspection:
 - a. Shut down electric power in wet work areas. Provide temporary power and lighting per code requirements and provide ground-fault interrupter circuits as power source for electrical equipment.
 - b. Isolate the work area, and establish emergency exits.
 - c. Shut down and isolate heating, cooling and ventilating air systems. This includes the sealing of all HVAC system openings: air intake, exhaust openings, and external louvers.
 - d. Clean moveable objects using HEPA filtered vacuum equipment and/or wet methods as appropriate and remove to a temporary storage location identified by the Engineer.
 - e. Cover fixed objects where appropriate. Take additional precautions to prevent water and physical damage to floors and walls, and in covering fixed objects having elevated temperatures.

- f. Install negative pressure ventilation system with make-up air provisions.
 - g. Contain and dispose of wastewater resulting from wet stripping.
 - h. Establish procedures for on-site handling and storing of asbestos-containing and contaminated materials.
 - i. Obtain local permits and licenses.
 - j. Obtain NESHAP approval for dry removal where circumstances prohibit the use of wet methods.
2. The Contractor's superintendent shall accompany the Engineer on the inspection, and immediately undertake corrective action that may be necessary as a result of the inspection.

C. Asbestos Removal

1. The negative pressure enclosure shall be under a negative pressure sufficient to minimize fiber escape and in accordance with Appendix F to Title 29 Code of Federal Regulations, Section 1926.1101. The Contractor shall be prepared to demonstrate to the satisfaction of the Engineer that air flow through all openings, with the exception of the negative pressure ventilation system discharge, is directed into the containment area. If such cannot be demonstrated, the Contractor shall discontinue work until adequate negative pressure is established.
2. Where custom containment bags or collapsible portable containments are to be used, measures shall be taken to prevent the entrance of unauthorized personnel into the work area.
3. Asbestos material shall be wetted with amended water during the stripping operation to minimize fiber dispersion, and shall be kept moist until placed into impermeable containers and sealed. Wet removal methods, techniques and procedures may be supplemented with the use of penetrant/fiber encapsulant liquids. When dry removal is employed, the asbestos-containing material shall be wetted after stripping.
4. After completion of stripping work, the substrate shall be cleaned to remove all visible material.
5. During stripping and substrate cleaning, air within the containment shall be misted as necessary to minimize fiber dispersion.
6. The negative pressure ventilation system shall be operated continuously from the start of removal work through the acceptance of the results of clearance tests specified in Paragraph 1.06 C. 2.d and Paragraph 3.05 F.3.
7. Twenty-four (24) hours prior to completion of removal work, notify the Engineer so that an inspection of removal work may be scheduled. The Contractor's superintendent shall first have inspected the work area to ensure complete removal, and substrate cleaning.

D. Removal Inspection

1. Visible accumulations of asbestos-containing material and asbestos-contaminated material shall be removed from the work area prior to the inspection.
2. All adhesive or tape residue shall be removed from exposed surfaces with appropriate solvents to minimize surface damage.

3. The Contractor shall provide access equipment required for the inspection.
4. The Contractor's superintendent shall accompany the Engineer on the inspection, and immediately undertake corrective action as directed by the Engineer. If excessive fiber is found to exist on substrate material, the inspection will be terminated and the contractor directed to repeat the stripping and/or substrate cleaning work.
5. The Contractor shall not apply substrate sealant until this inspection and corrective actions have been completed.

E. **Clean-Up And Clearance Testing**

1. Remove protection from walls and floors; all openings shall remain sealed.
2. Clean all work area surfaces using HEPA filtered vacuum equipment and/or wet methods as appropriate. Upon completion of this first cleaning notify the Engineer so that an inspection may be scheduled. Wait 24 hours, and again clean all work area surfaces. Upon completion of the second cleaning, the Contractor's superintendent shall accompany the Engineer on the work area inspection and immediately undertake additional cleaning that may be necessary as a result of the inspection.
3. As soon as the Engineer determines that work area surfaces are dry, clearance test samples will be collected in accordance with 40 CFR, Part 763.90 (i) or NIOSH Method 7400. If air sampling analytical results show an excess of 70 structures per square millimeter by Transmission Electron Microscopy or when the sample results are statistically greater than ambient levels outside of the containment area, or 0.01 f/cc by Phase Contrast Microscopy, clean-up, testing and analysis will be repeated at the Contractor's expense. If air sampling analytical results fail to meet this criteria in work area where custom containment bags or collapsible portable containment have been utilized, the repeat clean-up will be undertaken for the entire work area within which the containment was located.

F. **Disposal Procedures**

1. Impermeable containers with required labeling shall be delivered in enclosed or covered trucks or dumpsters to the disposal site. Disposal must be at a permitted site. Copies of landfill receipts shall be forwarded to the Engineer.

3.04 WORKER PROTECTION FROM EXPOSURE TO LEAD

A. **Surface Coating Debris Management**

1. Criteria for Surface Coating Debris Management
 - a. The Engineer is considered the generator of the waste for this project. The Contractor shall handle, contain, store, test, transport and dispose of surface coating debris in accordance with applicable local, state and federal regulations.

B. **Surface Coating Debris Storage**

1. Prior to transport off-site for disposal, the Contractor shall temporarily store surface coating debris at a location acceptable to the Engineer.

2. Until verified to the contrary by laboratory testing, the surface coating debris shall be handled and stored as if it were a hazardous waste.
3. Surface coating debris shall be stored in covered, leak-proof containers, meeting current EPA and Department of Transportation requirements.
4. Temporary on-site storage of the debris shall not exceed 90 days from the date wastes are first placed in the storage container in accordance with 40 CFR 262.34.

C. Waste Classification Of Surface Coating Debris

1. The Contractor shall be responsible for collecting and having analyzed representative samples of the surface coating debris. Samples shall be tested for toxicity using the Toxicity Characteristics Leaching Procedure (TCLP) for metals sufficient to determine whether the debris is a hazardous waste as defined in 40 CFR '261.3, or a residual waste, as defined in 25 PA Code ' 287.1, and shall include such analysis as required by the disposal facility. Tests shall be conducted by a qualified environmental laboratory acceptable to the Engineer. The Contractor shall be responsible for the costs of sample collection and laboratory analysis.
2. Prior to the disposal of the surface coating debris and within seven (7) days of the receipt of the laboratory analysis, a complete copy of the laboratory analysis shall be submitted to the Engineer together with the Contractor's determination as to whether the debris is a residual waste or a hazardous waste.
3. If the surface coating debris is determined to be a hazardous waste in accordance with 40 CFR '261.3, then the waste shall be handled, containerized, labeled, stored, transported, and disposed of as a hazardous waste in accordance with applicable regulations.
4. If the surface coating debris is not a hazardous waste, as determined in accordance with 40 CFR '261.3, then the waste shall be handled, containerized, labeled, stored, transported, and disposed of as a residual waste in accordance with applicable regulations.

D. Surface Coating Debris Transportation

1. All off-site disposal transporters must be licensed by the appropriate regulatory agency or agencies to transport the type of waste they will haul from the project site. All transportation of waste from the site is to be done in a safe and responsible manner, meeting all applicable local, state, and federal regulations. Any waste testing required for transport is the Contractor's responsibility.
2. All wastes transported off-site shall be transported in Department of Transportation approved, covered containers. The containers shall be labeled in accordance with 40 CFR 262.31 and .32, and the transport vehicle shall be properly placarded in accordance with EPA and Department of Transportation requirements (40 CFR 262.33 and 49 CFR Part 172, Subpart F).
3. The Contractor shall identify the transporter and provide the transporter's EPA identification number.

4. The Contractor shall prepare appropriate EPA manifests for all hazardous wastes which are destined for disposal. The manifests shall be prepared in accordance with 40 CFR Part 262, Subpart B.
5. The Contractor shall obtain the generator's and transporter's signatures on the manifests.
6. The Contractor shall provide a signed copy of each manifest to the Engineer before waste shipment.
7. Prior to the off-site transport and disposal of the surface coating debris, the waste description and weight must be recorded on a log. The log, which is to be maintained on-site, shall also include the name of the transporter, the destination, and the date and time of departure.
8. Transport shall comply with applicable Department of Transportation regulations and any other applicable federal or state regulations pertaining to transport of hazardous wastes.

E. Surface Coating Debris Disposal

1. The Contractor is required to obtain the services of a permitted waste disposal facility which is authorized to accept surface coating waste generated during the project. The Contractor shall submit to the Engineer written evidence that the waste disposal facility is willing and is authorized to accept the waste. The Contractor shall identify the disposal facility, method of disposal and provide the disposal facility's EPA identification number.
2. The Contractor shall verify that the disposal facility has provided a fully completed, fully signed copy of each waste manifest to the Engineer within 30 days of receipt of the wastes.
3. The Contractor shall require that for each manifested hazardous waste shipment, the disposal facility shall provide to the Engineer an appropriate Certificate of Disposal.
4. The Contractor shall verify that the disposal facility has provided a fully completed, fully signed Certificate of Disposal to the Engineer within 30 days of the date of disposal for each manifested shipment of waste.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02020.001 – Contaminated Material Handling shall be measured as directed by the Engineer.

4.02 PAYMENT

- A. Item 02020.001 – Contaminated Material Handling will be paid for as part of a Predetermined Amount (PDA), as such work is directed to be performed by the Engineer. The value to be paid for the directed work of this Contract Item will be established, at the discretion of Authority, by one or more of the following methods

1. By use of unit prices for items of work that have an established unit price for other Contract Items under the Contract,
2. By a negotiated amount, subsequent to receipt of the Contractor's submission of a proposal, following the procedures for establishing a price for a negotiated Change Order in Section 00900, Article 1.7,
3. By force account, following the procedures for establishing the value of force account work as set forth in Section 01200, Article 4, and/or by Authority on the basis of the Engineer's estimate of an equitable value for the work to be performed. This would be a unilateral value as determined by Authority.

END OF SECTION

Attachment 1

WORKER QUALIFICATION CERTIFICATION	
Employee Name:	ID No.:
Employer Name:	
Address:	
Job Title:	
Report prepared by:	Printed or Typed Name
Signature	Date
This person is qualified as a Competent Person: YES [] NO []	
Date of last lead training program attended: _____	
Date of last Blood Lead Level (BLL) exam: _____	
Current BLL < 40 µg/dL	YES [] NO []
If YES, BLL < 50 µg/dL	YES [] NO []
Respiratory Protection	
Date of last respiratory training program attended: _____	
Respirator Fit Test: Date tested: _____ Pass/Fail: _____	
Manuf./Model 1)	Size _____
2)	Size _____
Date of last medical evaluation for respirator use: _____	
Supervisor's printed or typed name: _____	
Signature	Date

SECTION 02220

DEMOLITION

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for demolition, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Demolition, removal, relocation, and/or restoration of existing facilities and systems.
 - 2. Storage, removal, disposal and/or salvage of demolition items.
 - 3. Removal, salvage and delivery to Authority as indicated and as directed.
 - 4. Temporary facilities
 - 5. Construction Dust Control
 - 6. Demolition/decommissioning of existing Gateway Station and Loop
 - 7. Demolition of temporary tunnel closure wall
 - 8. Demolition of single crossover and other facilities at Wood Street Station
 - 9. Coordination with the NSC-004 R contractor
- C. The Contract Documents provide the performance parameters and design criteria to complete the demolition/decommissioning of existing Gateway Station and Loop portions of the Work. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01781, "Maintenance and Protection of Authority Traffic"
- B. Section 01783, "Temporary Facilities."
- C. Section 01850, "Construction Monitoring Program"
- D. Section 01815, "Handling of Unforeseen Hazardous and Contaminated Building Materials."
- E. Section 02453, "Special Trackwork"
- F. Section 01940, "Cleaning."
- G. Section 02020, "Contaminated Materials Handling"
- H. Section 04200, "Unit Masonry."

- I. Section 15885, "Mechanical Tunnel Fire Protection"
- J. Section 15890, "Tunnel Ventilation Jet Fans".
- K. Section 16050, Basic Electrical Requirements."
- L. Section 16602, Overhead Contact System General Requirements."

1.03 REFERENCE STANDARDS

- A. ANSI
- B. AASHTO
- C. AWS
- D. NFPA
- E. NEC
- F. UL

1.04 SUBMITTALS

- A. Schedule: Submit a schedule indicating proposed methods and sequences of operations for demolition / decommissioning work to the Engineer for review and approval prior to start of work, which shall include, but not be limited to, the following:
 1. Coordination for shutoff, decommissioning, relocation, demolition, capping and continuation of Authority facilities services.
 2. Detailed sequence of demolition / decommissioning, on-site storage of all potentially contaminated material, potentially contaminated material testing and subsequent disposal from the existing facilities.
 3. Locations of temporary partitions and means of ingress and egress.
 4. Design Installation and Removal of temporary tunnel cutoff wall, including detailed layout, signage and emergency walkway.
 5. Access plan for demolition within existing tunnel.
 6. Salvage material delivery to Authority
 7. Wood Street Station single crossover demolition and Authority Revenue Service weekend shutdowns
 8. Relocation 23kv power feeder
 9. Emergency Ventilation Fans EM-9 and EM-10 power and communication feeders
- B. Submit Working Drawings and calculations for all facilities to be relocated, demolished and decommissioned.

1.05 DEFINITIONS

- A. Demolition: Remove and dispose of items except those indicated to be reinstalled, salvaged, or to remain the property of Authority. Remove and salvage items indicated; clean, service and otherwise prepare them for reuse; store and protect against damage; tag or otherwise identify in preparation for reinstallation in the same locations or as directed.
- B. Existing to Remain: Protect existing facilities and installations indicated to remain against damage and soiling during demolition. When permitted by the Engineer, items may be removed to a suitable, protected storage location during demolition and then cleaned and reinstalled in their original locations.
- C. Decommission: Authority facilities to be prepared for long term shut down by disconnection, disengaging, or shutoff of facility input and output, including, but not limited to electrical, gas, water, communications, and video services.

1.06 PROJECT CONDITIONS

- A. Partial Demolition and Removal: Items indicated to be removed which have salvageable value to the Contractor may be removed from the Worksite as work progresses. Sale of removed items on site will not be permitted. Items identified to be salvaged do not apply and shall remain the property of Authority. Return all designated items to be salvaged to Authority as prescribed by the Contract Documents.
- B. Protection
 - 1. Perform demolition/decommissioning in such manner as to eliminate hazards to persons and property and to minimize interference with use of adjacent areas, utilities and structures.
 - 2. Prevent the spread of flying particles and dust. Take measures to keep dust to a minimum and within the designated construction zone.
 - 3. Protect from damage existing finish work and portions of the existing structures which are to remain in place. Any damage to adjacent surfaces, equipment or supplies shall be repaired or replaced by the Contractor at its own expense and to the satisfaction of the Engineer.
 - 4. In addition to local jurisdiction fire and safety rules to be observed in the performance of the work, include the following:
 - a. Wherever a cutting torch or other equipment that might cause a fire is used, provide and maintain fire extinguishers nearby and ready for immediate use. All possible users shall be instructed in the proper use of fire extinguishers.
 - b. Standpipes shall be accessible at all times.
 - c. No debris shall be permitted to accumulate.
 - d. Maintain all emergency walkways and egresses through out the duration of the Work.
 - 5. Provide safeguards, including but not limited to, warning signs, barricades, temporary fences, warning lights, and other similar items that are required for

- protection of all personnel and facility users during demolition/decommissioning and removal operations.
6. Dust shall be contained within spaces under demolition. Clean up each area and/or room at the end of each removal operation. All debris shall be removed at least daily and spaces shall be kept clean.
 7. Clearly identify all facilities that have been decommissioned and all facilities which are to remain in service. Identifications shall be clearly marked on each facility with its disposition clearly identified so the NSC-004 R contractor and Engineer can establish demolition restraints.
 8. Gateway Station has a Art Mural located on the tunnel center wall between stations 1008+75 and 1009+75. The Contractor shall protect this mural from any damage during its decommissioning/demolition of the Gateway Station and Loop. Prior to tunnel and Station turnover to NSC-004 R for structural demolition work, remove temporary protection to allow NSC-004 R to remove the mural as part of the NSC-004 R Work.

C. ENVIRONMENTAL CONTROLS

1. Comply with Section 01815, "Construction Dust Control."
2. Use water sprinkling, temporary enclosures, and other suitable methods to limit dust and dirt rising and scattering in air to lowest practical level. Comply with governing regulations pertaining to environmental protection.
3. Do not use water when it may create hazardous or objectionable conditions such as ice, flooding or pollution.
4. Contractor may be granted access to the existing Stage I tunnel as prescribed in Section 00500, Article 2.1.O.

1.07 PRECAUTIONS

- A. Proceed with caution in areas of existing utilities. Damage to existing in-service facilities or to newly constructed facilities (whether they have been placed into service yet or not) by demolition work shall be repaired to the satisfaction of the facility owner at no additional cost to Authority.
- B. All work in the vicinity of the existing Wood Street Station and Gateway Station / Loop must be performed with extreme caution. The Contractor shall be responsible for all damages to the existing facilities which are designated to remain. Repair all damage at no additional cost to Authority.
- C. In the event that the Contractor discovers any on-site material that the Contractor believes may be hazardous materials, the Contractor shall immediately notify the Engineer by telephone or in person, to be followed immediately by written notification.
- D. The Contractor will be working around and relocating existing facilities and rooms which must remain in service to maintain Authority revenue services, including, but

not limited to, the relocated 23 kv power feeder, power and control cable for emergency ventilation fans EM 9 and EM 10 fiber optic communication cabling (under Gateway high platform), existing electrical room, existing transformer room, existing communication room, and emergency egresses. Use extreme caution while working with or around these facilities. Take precautions to protect these facilities to prevent accidental damage to the facilities during the execution of the Work.

E. EXISTING GATEWAY AND WOOD STREET STATIONS

1. The existing Gateway Station and Loop will be decommissioned / demolished and the Wood Street Station shall have the double cross over installed and the Authority Revenue Service dual turnback operation instituted by the Contractor by the Project milestone date prescribed in Section 00500, Article 2.6.A.1.b).1).
2. Prior to the milestone date described in Article 1.07.E.1, the Contractor shall demolish the existing single crossover and install a double crossover at the Wood Street Station. The Contractor shall convert Wood Street Station into a dual turnback terminus operation for Authority LRV operations. The double crossover will be installed through the use of 16 weekend shutdowns of the Authority Revenue Operations. Weekends shutdowns are governed by requirements provided in Section 00500, Article 2.1. Once the conversion to turnback terminus is complete, the Contractor shall isolate the catenary system and shall install a temporary closure wall in the existing tunnel to be located at Sta. 1012+35, located approximately half way between Gateway Station and Wood Street Station.
3. Prior to the milestone date described in Article 1.07.E.1 of this Section, the Contractor shall also relocate the existing Gateway Station 23kv power supply out of the existing duct bank, located along the inbound track wall in the emergency walkway at the base of the tunnel wall in the Gateway Loop area. The Contractor shall relocate the 23 kv (2 – 5" metal conduits) overhead from the inbound side of the tunnel to the outbound side in accordance with the Contract Documents. The 23 kv feeder shall be relocated outside the immediate NSC-004 R structural demolition zone as shown on the Contract Drawings. This relocation is required to provide continuous power to the transformer and electrical rooms, which will continue to feed various essential Authority facilities including Emergency Ventilation Fans EM 9 and EM 10 which are located in a tunnel blockout room situated between Gateway and Wood Street Stations, across from the single cross over and temporary tunnel closure wall.
4. Prior to the milestone date described in Article 1.07.E.1 of this Section, additional conduit shall be installed by the Contractor along the path of the 23 kv feeder to relocate the power and controls for emergency ventilation fans EM-9 and EM-10 which are controlled out of the existing Communications Room and powered out of the existing Electrical Room. These fans are essential to the emergency operations of the tunnel outbound of the temporary tunnel closure wall and beyond Wood Street Station which will remain in service during the Work.
5. There are existing fiber optic communication cables located under the existing Gateway Station platform which form the link between Gateway Station facilities

- and Authority OCC. These facilities are essential to Authority Operations and will remain in service throughout the Work.
6. Existing Gateway Station Ancillary Rooms which will remain in operation include the Transformer, Electrical, Communication, and Emergency Egresses (2). Emergency Egress access points are located at the eastern end of the existing platform and at the end point of the pocket track located within the Gateway Loop.
 7. The Contractor shall locate, plan for, construct around, and protect all the above mentioned facilities and rooms during any demolition/decommissioning work. These facilities and rooms must remain in service during the Work.

ARTICLE 2 PRODUCTS

2.01 OVERHEAD CATEINARY SYSTEM

- A. The NSC-004 R Contractor will remove the existing Gateway overhead contact system as part of the NSC-004R contract.
- B. The Existing catenary system to be removed and salvaged includes, but is not limited to, the following:
 1. Existing messenger and trolley wire from new construction overlap at station 6009+88 on the right track, around the loop to the other construction overlap at station 6009+45 on the left track.
 2. Insulators, clamps, feeders and support assemblies no longer needed.
 3. Catenary tunnel support structures that are no long required.

2.02 BLUE LIGHTS AND EMERGENCY TELEPHONES

- A. There are Blue Light / Emergency telephone stations located on both inbound and outbound tunnel walls at approximately 200' spacing. Authority will reroute the existing facilities to be fed from Wood Street Station.
- B. The PAAC Stage I construction drawing associated with the Blue Light and Emergency Telephones locations have been included in the Contract Documents.

2.03 STANDPIPES AND EXTINGUISHERS

- A. Existing standpipes are located around the Gateway Station Loop as shown on the Contract Drawings. The Contract Drawings provide the PAAC Stage I construction drawings.
- B. Existing extinguishers are located approximately 200 feet apart as shown on the Contract Drawings.
- C. The standpipes and extinguishers located between existing Gateway Station and Wood Street Station will not be impacted by the Work and shall remain serviceable.

- D. The standpipes at locations of the new jet fans located between existing Gateway Station and Wood Street Station shall be re-routed to allow mounting of the jet fans from the tunnel side walls. The locations of the new jet fans are shown on the Contract Drawings.
- E. The standpipes and extinguishers in the exiting Gateway Station Loop will be impacted by the demolition work as shown on the Contract Drawings. Removal and/or relocation of these standpipes and extinguishers will be required during the demolition.

2.04 STATION/TUNNEL AMBER LIGHTING

- A. There are Station / Tunnel Lighting systems located on both inbound and outbound tunnel walls and in the Gateway Station platform area. The location of these are shown on plans included in the Also Drawings. All station and tunnel lighting, within the limits of the NSC-004 R structural demolition, shall be removed and disposed of. The Contractor shall provide temporary cable facilities as required for operation of the station and tunnel lighting that are to remain in service but whose cables are impacted by the demolition activities.
- B. Lighting service includes type "N" fixtures and junction boxes which illuminate the Art mural located on the tunnel wall opposite of the Gateway Station low platform.
- C. Station Platform lighting consists of "A" fixtures, ceiling mounted.
- D. Tunnel Lighting "LP" consist of "B" fixtures bracket mounted to the tunnel wall.

2.05 SMOKE/FIRE PROTECTION INTRUSION ALARM DEVICES

- A. There are ceiling mounted smoke and fire detectors located throughout the Gateway platform area. The locations of the smoke and fire detectors are shown on the "Also" drawings contained within the Contract.
- B. There are ceiling mounted intrusion alarm devices and cables throughout the Gateway platform area. The locations of the intrusion alarm devices and cables are shown on the "Also" drawings contained within the Contract.

2.06 SPEAKERS

- A. There are ceiling mounted speakers located throughout the Gateway platform area. The locations of the speakers are shown on the "Also" drawings contained within the Contract.

2.07 23KV ELECTRICAL FEED

- A. The existing 23 kv power is feed from the 1st Avenue Substation. The power feed supplies the Gateway Station through two - 23 kv power cables located in the concrete

duct bank (emergency walkway) which is located at the base of the existing tunnel wall on the inbound (existing left track) side, traveling around the Loop to approximate Sta. 1004 + 10 where the conduit crosses the track bed in the base slab and outlets in the electrical room, proceeding up to the transformer room along the Electrical / Transformer room walls.

2.08 SIGNAL SYSTEM

- A. The Contractor shall remove and dispose of existing Signal 16N, its tripper and all control cables. Signals 18S, 20S and all associated control cables shall also be removed and disposed of. The Contractor shall also remove and dispose of Electric Switch Machine No.3, all connecting rods, junction boxes and control cables.

2.09 LEAKY CO-AXIAL CABLE

- A. A leaky co-axial cable for the existing radio system is attached to the tunnel wall throughout the existing Gateway Station area . The cable shall be removed from the tunnel wall from approximate station 1001+50 to station 1009+00. The Contractor shall cut the cable at both ends of the removed section and terminate both runs with a terminating resistor.

2.10 TUNNEL VENTILATION SYSTEM

- A. The existing tunnel ventilation equipment located in the existing Gateway Station Loop to be removed and disposed or salvaged includes, but is not limited to, the following:
 1. Axial ventilation fans (GW-EM-11, GW-EM-13)
 2. Under platform ventilation fans (GW-UPV-07)
 3. Jet fans (GW-BF-01, GW-BF-02, GW-BF-03, GW-BF-04)
 4. Dampers (GW-ED-13, GW-EB-13, GW-ED-11, GW-EB-11)
 5. Attenuators (no designator)
 6. Evases (no designator)
 7. Motor Control Centers (no designator)
- B. All other equipment associated with the tunnel ventilation systems shall be removed and disposed of by the Contractor. The Contractor shall survey and report all other associated equipment to the Engineer and Authority prior to disposing of this equipment.
- C. The existing tunnel ventilation systems are located in the following rooms located around the existing Gateway Station Loop:
 1. RM102 (GW-EM-13, GW-ED-13, GW-EB-13, attenuators, evases)
 2. RM107 (GW-EM-11, GW-ED-11, GW-EB-11, attenuators, evases)
 3. RM108 (Motor Control Center)
 4. RM109 (GW-UPV-07, attenuators, evases)
 5. Loop track way (GW-BF-01, GW-BF-02, GW-BF-03, GW-BF-04)

- D. The existing tunnel ventilation systems in rooms 103, 122 and 123 are to remain operational throughout all stages of demolition and construction. This includes, but is not limited to, the following equipment:
1. Axial ventilation fans (GW-EM-9, GW-EM-10) (Room 122)
 2. Dampers (GW-ED-9, GW-BD-9) (Room 122)
 3. Motor Control Center (RM123)

2.11 TUNNEL MECHANICAL DRAINAGE SYSTEMS

- A. The existing tunnel mechanical drainage (sump pump) systems to be removed and disposed or salvaged include, but are not limited to:
1. Tunnel drainage pump (no designator)
 2. Sump Pump No. 1 (no designator)
 3. Sump Pump No. 2 (no designator)
 4. Related equipment including, but not limited to, stainless steel grates (intake strainers), pipework, valves, instruments, cables and any other equipment associated with each tunnel mechanical drainage system.
- B. The existing sump pumps are located in room Room 101.

2.12 WAYSIDE APPLICATOR

- A. There is a wayside (rail greaser) applicator located at Sta. 1003+00 approximately.
- B. The wayside applicator is manufactured by Protec Rail Products, Inc., Protector Series

2.13 EMERGENCY GENERATOR

- A. There is a gas powered emergency generator located in Room 110. The emergency generator is a Kohler 70RZ72, 70 kva, 480 V, 3 phase, 4 W, natural gas, complete with battery rack, charger, control's and associated equipment. Fuel consumption is 10 gal/hr. Original generator was supplied by Palco Generators (724) 424-3900.
- B. Emergency generator room also houses emergency power panel ELP1 and EPP, automatic transfer switch, lighting panel LPI, electrical distribution panel PP-3, 30 kva stepdown transformer, fire alarm PB13 and flashing unit, generator exhaust and silencer, gas service line and gas meter.
- C. Contractor to supply Liquid Propane (LP) fuel supply including regulator capable of reducing pressure to 4 ounces and supplying 362 cubic feet of vapor gas/hour.

2.14 SUSPENDED CEILING

- A. Gateway Station has a suspended ceiling consisting of perforated metal baffles (4'-0" X 4'-0") which are connected together and to the station ceiling with 1/4" flathead cap screw connections.

- B. Suspended ceiling covers the roof of the Gateway Station in the platform area.

2.15 WOOD STREET SINGLE CROSSOVER

- A. As identified in Section 02453, "Special Trackwork."

ARTICLE 3 EXECUTION

3.01 INSPECTION

- A. Prior to commencement of any demolition / decommissioning work, perform a pre-construction inspection of all Gateway Station and Loop and Wood Station facilities in accordance with Section 01850, "Construction Monitoring Program."
- B. Notify the Engineer in writing of any discrepancies between the Contract Drawings and existing conditions at the Worksite which affect demolition work to be completed.
- C. At the completion of work, perform a post-construction inspection in accordance with Section 01850, "Construction Monitoring Program." The Contractor and the Engineer shall together make a thorough re-survey of all areas affected by the work. Provide a written report on conditions, together with surveys, video, and photographs taken from same locations as those made prior to demolition. The report shall itemize any damage caused by the Contractor to adjacent elements, equipment, and other surfaces, despite protection measures. The report will form the basis for determining the extent of repair work required by the Contractor to restore elements, equipment and surfaces to their previous condition.
- D. Prior to the Contractor beginning existing Gateway Station Loop demolition/decommissioning work, the Contractor shall schedule pre-demolition/decommissioning meeting and coordination walkthrough of the existing tunnel. The pre-demolition/decommissioning meeting and walkthrough shall be scheduled 30 days prior to the Contractor's anticipated start of demolition/decommissioning work associated with the Gateway Station and Loop. The walkthrough shall include the NSC-004 R contractor, Engineer, and Authority maintenance and operations staff. Coordinate the walkthrough with all involved through the Engineer.
 1. The intent of the meeting and walkthrough is to coordinate existing tunnel facilities to be demolished / decommissioned, relocated, removed, and/or disconnected by the Contractor to help facilitate the NSC-004 R follow-on structural demolition work, including but not limited to, temporary shoring placement and facility relocation installation.
- E. At the conclusion of the existing Gateway Station and Loop demolition/decommissioning work, the Contractor shall schedule and participate in a second site inspection and coordination walkthrough of the existing tunnel. The walkthrough shall be scheduled 30 days prior to the Contractor's anticipated completion of demolition work. The walkthrough shall include the NSC-004 R

contractor, Engineer, and Authority maintenance and operations staff. Coordinate the walkthrough with all involved through the Engineer.

1. The walkthrough should occur seven days prior to the anticipated turnover date of the existing tunnel to allow for the Contractor to address final walkthrough requirements provided by the Engineer.
2. The intent of the walkthrough is to confirm that all necessary existing tunnel facilities have been relocated, removed, and/or disconnected and that all involved are in agreement that the NSC-004 R demolition work may progress.

3.02 FACILITY SERVICES

- A. Maintain existing facilities indicated to remain in service and protect them against damage during demolition operations.
- B. Do not interrupt or disrupt existing facilities serving occupied or operating systems, except when authorized in writing by the Engineer and Authority. Provide temporary services during interruptions to existing facilities, as acceptable to the Engineer and Authority. Provide not less than 2 weeks notice to the Engineer if shutdown of service is required.
- C. Locate, identify, disconnect and seal or cap off facility services that are not indicated to remain. Provide bypass connections as necessary to maintain continuity of service to occupied areas of buildings when approved by the Engineer and Authority.
- D. Maintain fire protection services at all times during demolition operations, including emergency walkways and egresses. Certain fire protection and emergency walkways are impacted by the Work and alterations are prescribed in the Contract Drawings.
- E. All Contractor connections to existing Authority facilities will be overseen by Authority maintenance staff. Contractor shall contact John Green at (412) 488-3052. Coordinate the Authority staff participation seven (7) days prior to intended need. Payment for the time of the Authority personnel oversight shall be in accordance with the Authority reimbursement requirements set forth in Section 00500, Article 2.1.O.

3.03 PREPARATION

- A. Conduct demolition/decommissioning operations to prevent injury to people and damage to adjacent facilities to remain. Provide safe passage of people around demolition areas.
 1. Erect temporary protection, such as walks, fences, railings, and canopies, as required to provide free and safe passage of staff to occupied portions of the facility.
 2. Protect walls and other existing finish work that are to remain and are exposed during demolition operations. Protect floors with suitable coverings when necessary.

- B. Erect and maintain dustproof partitions and temporary enclosures where required to limit dust and dirt migration and to separate occupied portions of the buildings from fumes and noise in accordance with Section 01815, "Construction Dust Control".

3.04 POLLUTION CONTROLS

- A. Limit the spread of dust and dirt. Do not use water when it may damage existing construction or create hazardous or objectionable conditions.
- B. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas and prevent infiltration of such debris into tunnel drainage systems.
- C. Hazardous and Contaminated materials, if discovered, shall be handled and disposed in accordance with Section 02020 "Handling of Unforeseen Hazardous and Contaminated Building Materials."

3.05 DEMOLITION/DECOMMISSIONING - GENERAL

- A. The work includes, but is not limited to, the demolition, decommission, removal and/or salvage, relocation and termination of the existing tunnel facilities including, but not limited to, the following:
 1. Overhead Catenary System; NSC-009 to decommission and cut system wires; NSC-004 R to remove and dispose;
 2. Emergency Blue Lights Emergency Telephones; PAAC to relocate or remove;
 3. Dry Standpipes, valves, and fixtures; Remove and dispose, salvage expansion joints by NSC-009;
 4. 4' Fire line, 1" water line, 3" drainage line under the Gateway Station high platform; NSC-009 to remove 4" and 1"; 3" to remain;
 5. Tunnel Drainage Fiberglass inlet grates; Salvage by NSC-009;
 6. Fire extinguishers for Tunnel and Station; Salvage by NSC-009;
 7. Gateway Station and Tunnel Lighting; Remove as required and dispose by NSC-009;
 8. Smoke and Fire Detection Systems; Salvage by NSC-009;
 9. Station Speakers; Remove and dispose by NSC-009;
 10. 23 kv Electrical Feed; To be relocated by NSC-009;
 11. Signaling Systems; Remove and dispose by NSC-009;
 12. Leaky Co-axial Cable; Remove and Dispose by NSC-009;
 13. Tunnel Ventilation System; Fans, actuators, and dampers be salvaged by NSC-009
 14. Temporary tunnel closure wall; To be built, maintained and removed by NSC-009
 15. Wayside Applicator, including grease within the applicator; Salvage by NSC-009;
 16. Emergency Generator; NSC-009 to disconnect gas feed and supply liquid propane fuel feed;
 17. Suspended Ceiling; Remove and dispose by NSC-009;
 18. Wood Street Single Crossover; Remove and dispose by NSC-009
 19. Safeside Chemical Detectors; PAAC to salvage
 20. PAAC change machine; PAAC to salvage

21. Water drip pans; Remove and dispose by NSC-009;
 22. CCTV cameras; PAAC to salvage;
 23. Station VMS signage; Salvage by NSC-009
 24. Defibrillator station; PAAC to salvage the defibrillator, NSC-009 to salvage the case.
 25. Sump pumps and accessories; Remove and dispose, NSC-009 to salvage the sump pumps and stainless steel grates (intake strainers)
 26. Rail; Remove and dispose by NSC-004 R;
 27. Electrical service; shutdown by NSC-009 as required
 28. Gas service; shutoff by NSC-009 and Gas Company, salvage gas meter
 29. Water service; shutoff by NSC-009
 30. Emergency egresses; to remain in service
- B. Demolish and remove existing structures and facilities only to the extent required by new construction or as indicated. Use methods to complete the work within limitations of governing regulations and as follows:
1. Proceed with demolition/decommissioning systematically.
 2. Neatly cut openings, piping, conduit, and holes plumb, square and true. Use cutting methods least likely to damage facilities to remain or adjoining surfaces. To minimize disturbance of adjacent surfaces, use hand or small power tools designed for sawing or grinding, not hammering and chopping. Temporarily cover openings to remain.
 3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
 4. Visually identify any suspect asbestos-containing materials (ACM) within normally inaccessible spaces made accessible through demolition operations. Immediately notify the Engineer if such materials are encountered. The presence, removal, and disposal of asbestos or other contaminated material shall be confirmed and performed in accordance with Section 02020, "Handling of Unforeseen Hazardous and Contaminated Building Materials". No other work or personnel access shall be allowed during contaminated material abatement until the area is certified as healthy. Particle monitors are to be established and maintained and records kept in areas where asbestos has been found.
 5. Remove decayed, infested or unsuitable materials and promptly dispose of off-site.
 6. Dispose of demolished items and materials promptly. On-site storage or sale of removed items is prohibited.
 7. Promptly repair damages caused to adjacent facilities, elements, construction or surfaces to remain by demolition operations.
- C. When unanticipated mechanical, electrical or structural elements that conflict with the intended function or design are encountered, investigate and measure the nature and extent of the conflict. Promptly submit a written report to the Engineer. As directed by the Engineer, rearrange the demolition operations as necessary to continue overall Work progress without undue delay.

- D. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
- E. Demolish, remove, demount and disconnect abandoned mechanical and electrical materials and equipment as follows:
 - 1. Inactive and obsolete piping, fittings and specialties, equipment, ductwork, controls, fixtures and insulation. Piping embedded in floors and walls may remain if such materials do not interfere with new installations and are not indicated for removal by the Engineer or as shown.
- F. Provide temporary facilities within the work areas including, but not limited to, the following:
 - 1. Temporary lighting as required for operations and emergency access/egress.
 - 2. Temporary power
 - 3. Temporary water
 - 4. Protection and continue proper accessibility to existing facilities to remain including emergency walkways and egresses.

3.06 DECOMMISSION OF OVERHEAD CATENARY SYSTEM

- A. Prior to the NSC-004 R Contractor removing the existing overhead contact system the double crossover at Wood Street shall be in operation, and the existing catenary is terminated at the construction overlaps near Gateway Station.
- B. The Contractor shall be responsible for ensuring that the removal of any portion of the existing overhead contact system at Wood Street and the Gateway Construction Overlaps are staged and coordinated so that Authority revenue operations are not impacted by this work.

3.07 DECOMMISSION AND DEMOLITION OF EMERGENCY BLUE LIGHTS AND EMERGENCY TELEPHONES

- A. This work will be performed by PAAC.

3.08 DEMOLITION OF DRY STANDPIPES AND FIRE EXTINGUISHERS WITHIN TUNNEL AND STATION

- A. Standpipes shall be re-routed and/or capped as indicated on the Contract Drawings.
- B. The Contractor shall be responsible for ensuring that any alterations made to the existing standpipes, or any additions required during the demolition are in accordance with the requirements of NFPA14 and NFPA130.

- C. Any standpipes that are terminated due to the demolition shall be installed with combination vacuum breakers/air vents for drainage as well as air venting. Refer to Section 15885, "Mechanical Tunnel Fire Protection" for details.
- D. The Contractor shall be responsible for ensuring that the removal or relocation of any with the requirements of NFPA10, NFPA14 and NFPA130.
- E. The Contractor shall submit calculations and working plans of any alterations to the standpipes to the Engineer and Authority for approval prior to any demolish work.
- F. Liberty Avenue Tunnel standpipes
 1. As part of the demolition work, the Contractor shall re-route the standpipes at stationing L1014+50 and L1016+50 as preparation for the jet fans to be installed at this location in accordance with the Contract Documents.
 2. At these locations the standpipes are located to the underside of the tunnel roof. The Contractor shall install 90 degree bends in the standpipes at least 10 jet fan diameters before and after the ends of the jet fan assembly. This is to ensure that the standpipes cause minimal disturbance to the jet fan flow.
 3. The rerouting of the standpipes underneath the jet fans will depend on the mounting arrangement as described in Section 15890, "Tunnel Ventilation Jet Fans" and shown on the Contract Drawings. It shall be the Contractors responsibility to ensure that the rerouted standpipes do not interfere with the jet fan assemblies.
- G. The Contractor shall ensure that any rerouted standpipes do not cause obstruction to the emergency walkways. Standpipes shall be kept at least 8 feet above the walkway.
- H. Throughout the demolition of all piping, special care shall be continuously exercised to protect all openings to prevent the admission of any dirt, stones or other foreign substances that would subsequently obstruct the system. Close pipe openings with caps or plugs during demolition.
- I. Acceptance Testing Certification and Approvals
 1. Perform acceptance testing and certification of standpipe systems affected by the demolition and obtain approvals in accordance with applicable requirements of NFPA14.
 2. Perform acceptance testing and certification of standpipe systems affected by the demolition and obtain approvals as required by the City of Pittsburgh.
 3. All testing shall occur as part of the North Shore Connector final commissioning and is not a requirement prior to turnover to NSC-004 R.

3.09 DECOMMISSION AND DEMOLITION OF GATEWAY STATION LIGHTING

- A. Contractor shall de-energize the lighting systems, including art mural highlight lighting, at the electrical control panel.

- B. All lighting fixtures, including art mural highlight lighting within the limits of the NSC-004 R structural demolition shall be removed and disposed of.
- C. All lighting wiring shall be disconnected from the fixtures in a clean and safe manner in accordance with NEC. Any lighting to remain, shall be rewired and kept operational. Temporary wiring for emergency lighting should be fed from a source that has a UPS backup.

3.10 DECOMMISSION AND DEMOLITION OF SMOKE AND FIRE DETECTION SYSTEMS

- A. All smoke detectors and sprinkler fixtures, within the limits of the NSC-004 R structural demolition, shall be removed and salvaged.
- B. The Contractor shall provide temporary cable facilities as required for operation of smoke and fire detection systems that are to remain in service but whose cables are impacted by the demolition activities.

3.11 DECOMMISSION AND DEMOLITION OF STATION SPEAKERS

- A. All Gateway Station speakers, within the limits of the NSC-004 R structural demolition, shall be removed and disposed of.
- B. The Contractor shall provide temporary cable facilities as required for operation of station speakers that are to remain in service but whose cables are impacted by the demolition activities.

3.12 DECOMMISSION, DEMOLITION, AND RELOCATION OF 23KV ELECTRICAL FEED

- A. Contractor shall install the 23 kv relocation conduit and cable as shown in the Contract Documents, and as coordinated with the NSC-004 R contractor per the pre-demolition/decommissioning meeting and coordination walkthrough prescribed in Article 3.01.D of this Section.
- B. The existing 23 kv feeders shall not be de-energized during Revenue Operations timeframes. The Contractor shall convert the service to the relocated path and reconnect into the existing transformers during a weekend shutdown of Authority Revenue Services due to the necessity of this power service to supply emergency ventilation fans EM-9 and EM-10. The emergency ventilation fans must be operational prior to Revenue Service resumption as allotted in Section 00500, Article 2.1.
- C. Once the 23kv power has been transferred to the relocated conduit path through the Gateway Station and Loop and is operational, remove the dead feeder cable from the existing duct bank and dispose.

3.13 DECOMMISSION AND DEMOLITION SIGNALING SYSTEMS

- A. The Contractor shall not decommission any portion of existing Gateway Interlocking until the new double crossover and turn-back operation at Wood Street Interlocking is in service.
- B. The Contractor shall be responsible for ensuring that the removal of any portion of the existing signaling system at Wood Street and Gateway Interlocking are staged and coordinated so that Authority revenue operations are not impacted by this work.

3.14 DECOMMISSION AND DEMOLITION LEAKY CO-AXIAL CABLES

- A. The Contractor shall not decommission any portion of leaky co-axial cable system within the limits of existing Gateway Station until the new double crossover and turn-back operation at Wood Street Interlocking is in service.

3.15 DECOMMISSION AND DEMOLITION TUNNEL VENTILATION SYSTEM

- A. The Contractor shall be responsible for the decommissioning, removal, cleaning, packing, storage and transport of all tunnel ventilation systems identified in the Contract Documents.
- B. All tunnel ventilation systems shall remain operational until a temporary cut-off wall is constructed by the Contractor, between the existing Gateway Station and Wood Street Station as required by the Contract Documents.
- C. Once the temporary cut-off wall is constructed by the Contractor, the existing ventilation elements at Gateway Station proper and in the Gateway Loop shall be decommissioned. The Contractor shall propose a decommissioning schedule for the tunnel ventilation system. This shall be submitted to the Engineer for approval prior to any demolition activities.
- D. The exiting ventilation fans in the Liberty Avenue Tunnel (GW-EM-9 and GW-EM-10) shall remain operational throughout all stages of the Work.
- E. The decommissioning of the axial ventilation fans and under platform ventilation fans shall include, but not be limited to:
 1. The isolation of power from the MCC room to each item to be decommissioned.
 2. The termination of power and control cables at the equipment.
 3. The removal of dampers, attenuators, evases, and all associated ductwork.
 4. The removal of the fans from mountings.
 5. The removal of fan mountings.
 6. The removal of all associated equipment (e.g. cables, conduit, junction boxes, mountings, etc) from the room that were required as part of the fan installation.
- F. The decommissioning of the jet fans shall include, but not be limited to:
 1. The isolation of power from the MCC room to each jet fan.

2. The termination of power and control cables at the equipment.
 3. The removal of the jet fans from high level mountings.
 4. The removal of the jet fan mountings from the tunnel wall. The Contractor shall repair any damage to the tunnel wall after the removal of the jet fan mountings.
 5. The removal of all associated equipment (e.g. cables, conduit, junction boxes, mountings, etc) from the track way that were required as part of the jet fan installation.
- G. The decommissioning of the dampers shall include, but not be limited to:
1. The isolation of power from the MCC room to each damper.
 2. The termination of power and control cables to each actuator.
 3. The removal of each actuator from the damper.
 4. The removal of damper modules from the openings.
 5. The removal of all associated equipment (e.g. cables, conduit, junction boxes, mountings, etc) from the room that were required as part of the damper installation.
- H. The Contractor shall supply any cradles required to remove the jet fans or axial fans from mountings and required for packing and transportation. These cradles and any associated equipment shall remain the property of Authority upon completion of the demolition portion of the Work. The Contractor shall be responsible for the transport and off-loading of the cradles to a site nominated by Authority.
- I. The Contractor shall inspect the condition of the salvaged tunnel ventilation equipment and notify the Engineer in writing of any defects or corrosion. The salvaged tunnel ventilation equipment shall be suitably packed for handling and long term storage. Clear identification of the equipment shall be provided on the packaging to indicate the original location and assembly. The Contractor shall be responsible for the transport and off-loading of the tunnel ventilation equipment to a site identified by Authority.
- J. The Contractor shall be responsible for all temporary ventilation during the demolition as required for, but not limited to, the following:
1. Workplace health and safety,
 2. Fire life safety, and
 3. Pollution and dust control.

3.16 DECOMMISSION AND DEMOLITION MECHANICAL DRAINAGE SYSTEMS

- A. The mechanical drainage (sump pump) systems shall remain operational until such time that adequate drainage is provided in the new facility and/or inlet pipework into the existing sump pit is capped.
- B. The sump pits shall be completely drained before the removal of the sump pumps. The Contractor shall provide additional sump pumps if required to completely drain the sump pit.

- C. The Contractor shall terminate all power and control cables to the sump pumps before removal.
- D. The Contractor shall ensure that the sump pumps are cleaned and all mud, debris and moisture is removed from the internals of the sump pump. The Contractor shall inspect the condition of the sump pumps and notify the Engineer in writing of any defects or corrosion.
- E. The salvaged sump pumps and associated stainless steel grates (intake strainers) shall be suitably packed for handling and for long term storage. Clear identification of the equipment shall be provided on the packaging. The Contractor shall be responsible for the transport and off-loading of the sump pumps and associated equipment to a site identified by Authority.

3.17 DECOMMISSION AND DEMOLITION WAYSIDE APPLICATOR

- A. Detach the applicator hosing from the rail and the applicator box. Secure all internal/external elements. Drain existing grease from the applicator and place in sealed buckets.
- B. Keep Applicator upright to prevent spillage of grease which may remain in the equipment.
- C. Deliver the Applicator and grease to Authority as a salvageable item described in this Section.

3.18 DEMOLITION OF TEMPORARY TUNNEL CLOSURE WALL

- A. The tunnel ventilation equipment is required to be installed and commissioned before the Contractor can remove the temporary tunnel closure wall located between Gateway and Wood Street Stations. Do not begin demolition of temporary tunnel closure wall until receipt of written approval from the Engineer.
- B. Cut all wall embedment's and/or attachments to the existing structure flush with the existing surface and restore surface to original finish.
- C. Remove temporary emergency walkway steps, lighting, signage, and rail crossings when permanent facilities are operational or as approved by the Engineer.
- D. Ensure that all existing railroad facilities and set for functionality once systems are restored.
- E. Do not begin temporary Tunnel Closure Wall demolition until in receipt of written approval from the Engineer.

3.19 DECOMMISSIONING OF THE EMERGENCY GENERATOR

- A. Contractor shall convert the generator to a fuel supply of LP by disconnecting the existing gas fuel feed and providing a LP regulator connection capable of reducing pressure to 4 ounces while supplying 362 cubic feet of vapor gas/hr fuel rate. The Contractor shall have the generator's timing adjusted to provide for the new fuel source. Contact Equitable Gas Company to coordinate the disconnect gas service at street level. Remove gas service line from new LP connection to street level to allow NSC-004 R water service feed to be installed.
- B. Equitable Gas Company, 200 Allegheny Center Mall, Pittsburgh, PA 15212-5352, George Pozzuto (412) 395-3127. Salvage the existing gas meter located in Room 110. Coordinate delivery of meter with the gas company.
- C. Keep generator and Authority facilities dependant on the generator on line at all times unless approved by Authority and Engineer for shut down. Some facilities including sump pumps are to be decommissioned as part of the work and can be permanently disconnected from the generator backup service as the work requires.
- D. Supply additional LP fuel as required during the work to keep the emergency generator in service.
- E. Palco Generators were the original suppliers of the generator. Contact information: 724-424-3900.

3.20 DEMOLITION OF STATION SUSPENDED CEILING

- A. Remove and disassemble the suspended ceiling from the limits of the Emergency Egress at the end of the Gateway Station platform to the limits of the 23 kv feeded and Emergency Ventilation fan power and control cabling relocation limits inclusive.
- B. Contractor shall dispose of all ceiling materials.
- C. Contractor may remove suspended ceiling prior to the implementation of the Wood Street Station to facilitate the relocation of the 23 kv and EM-9 and EM-10 feeders.
- D. Relocated 23 kv feeders and EM-9 and EM-10 feeders can not be activated until the existing Gateway Station is abandoned of patron service.

3.21 DEMOLITION WOOD STREET SINGLE CROSSOVER

- A. The Contractor shall demolish the existing single crossover located just ahead (toward Steel Plaza) of the Wood Street Station. This work shall be phased as shown in the Contract Documents and will occur during weekend shutdowns of Authority Revenue Service as described in the Contract Documents.

- B. Dispose of single crossover as the demolition work progresses. Do not store debris, tools or other material within the Wood Street Station proper unless preapproved by the Engineer. Wood Street station will be operational to patrons throughout the Work.

3.22 DECOMMISSIONING OF SAFESIDE CHEMICAL DETECTORS

- A. Authority has two (2) Safeside Chemical Detectors located in the Gateway Station. One is located at the emergency egress at the eastern (outbound) end of the platform, the second is located on the station wall, station side, adjacent to the low platform.
- B. Coordinate decommissioning and removal with Authority safety staff, Kevin Jones and/or Mike Zamiska through the Engineer.

3.23 DEMOLITION PAAC COIN MACHINE

- A. Authority will salvage the existing coin machine. Contractor shall coordinate the removal through the Engineer.

3.24 DEMOLITION OF CEILING DRIP PANS

- A. Authority has installed drip pans in the suspended ceiling in the Gateway Station area. Remove and dispose of the drip pans.

3.25 DECOMMISSION AND DEMOLITION OF AUTHORITY CCTV CAMERAS

- A. Authority will salvage the existing CCTV Cameras. Contractor shall coordinate the removal through the Engineer.

3.26 DECOMMISSION AND DEMOLITION OF DEFIBRILLATOR STATION

- A. Prior to beginning demolition, contact the Engineer and schedule for Authority safety representative to remove the defibrillator from the station. Engineer will contact Kevin Jones and/or Mike Zamiska of Authority Safety staff to coordinate removal of the device.
- B. Disconnect power to the station and remove the station. Salvage the station once removed.

3.27 TUNNEL DRAINAGE

- A. Remove and salvage the fiberglass inlet grates which are located within the NSC-004 R demolition limit.
- B. Please temporary protection overtop each inlet to provide for a safe walking environment once the grates have been removed. Secure the temporary protection to the base slab.

3.28 SALVAGED MATERIALS

- A. Salvaged Items:** Where indicated in the Contract Documents as salvage, carefully remove indicated items, clean and prepare for storage and delivery to Authority. Tag or otherwise identify all items for salvage. Salvaged items shall be removed intact.
- B. Prior to removal of a salvageable item the Contractor, Engineer, and Authority shall perform an item pre-assessment study to document the current condition of the salvageable item. At delivery of salvage item to Authority, Contractor, Engineer, and Authority personnel shall perform a post-assessment of the item prior to Authority acceptance. Any damage which has occurred between the two assessment dates shall be considered the responsibility of the Contractor and shall be repaired or replaced at the Contractor's expense. Repairs shall be determined to be sufficient by Authority. Both pre and post assessments shall be submitted in writing to Authority and the Engineer.**
- C. Storage of items to be reinstalled shall be at a safe and secure location as agreed upon by the Engineer, clear of the NSC-004 R demolition limits.**
- D. Existing Gateway Station and Loop**
 - 1. Items including, but not limited to, the following will be removed and salvaged by the NSC-004 R contractor:
 - a. Pocket track bumper block attenuator
 - 2. Items including, but not limited to, the following will be removed and salvaged by the Contractor:
 - a. Circuit interrupters, transformers and AC switch gear
 - b. Tunnel standpipe expansion joints,
 - c. Ventilation fans, dampers, and actuators
 - d. Mechanical drainage systems (sump pumps), including stainless steel intake strainer grates
 - e. Tunnel drainage fiberglass inlet grates located within the NSC-004 R demolition limits
 - f. Defibrillator station; Authority will remove the Defibrillator
 - g. Fire extinguishers
 - h. VMS Signage
 - i. Smoke detectors
 - j. Wayside Applicator and grease
 - k. Emergency generator gas service meter (Equitable Gas Ownership)
 - 3. Items including, but not limited to, the following will be removed and salvaged by the Authority:
 - a. Emergency Blue Lights and Emergency Telephones
 - b. Safeside Chemical Detectors (2)
 - c. Change Machine
 - d. CCTV cameras
 - e. Defibrillator device

4. All identified items for Contractor salvage shall be delivered to Authority's South Hills Junction Maintenance Yard located at 611 West Warrington Avenue, Building #4, Pittsburgh, PA 15226
5. The Contractor shall coordinate Authority salvage items delivery with Greg Graham at (412) 488-3220.
6. The Contractor shall coordinate vehicle access to Authority tunnel with John Green at (412) 488-3052.

3.29 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove debris, rubbish and other materials and equipment resulting from demolition operations not indicated to be salvaged. Transport and dispose of materials off-site in accordance with the requirements of the Contract Documents.
- B. If hazardous materials are encountered during demolition operations, comply with applicable regulations, laws and ordinances concerning removal, handling and protection against exposure or environmental pollution and in accordance with Section 02020, "Handling of Unforeseen Hazardous and Contaminated Building Materials."

3.30 CLEANING AND REPAIR

- A. Upon completion of demolition work, remove tools, equipment and demolished materials from the Worksite. Remove all protection. Restore interior areas of the building to the same or better condition as before demolition.
- B. Repair demolition performed in excess of that required. Return elements of construction and surfaces to remain to condition existing prior to commencement of demolition work. Repair adjacent existing facilities or installations soiled or damaged by demolition and/or facility work to the satisfaction of the Engineer at no additional cost to Authority.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02220.001 – Demolition of Existing Gateway Station Loop Facilities shall be measured as a lump sum unit, complete in place.
- B. Item 02220.002 - Unforeseen Facility Demolition shall be measured as directed by the Engineer.
- C. Item 02220.003 – Demolition of Temporary Tunnel Closure Wall shall be measured as a lump sum unit, complete in place.
- D. No measurement shall be made for the demolition of the existing Wood Street Station single crossover portion of the work of this Section.

4.02 PAYMENT

- A. Item 02220.001 – Demolition of Existing Gateway Station Loop Facilities will be paid at the lump sum price and shall include the cost of all related work specified in this Section.
- B. Payment 02220.002 - Unforeseen Facility Demolition shall be paid for as part of a Predetermined Amount (PDA), as such work is directed to be performed by the Engineer. The value to be paid for the directed work of this Contract Item shall be established, at the discretion of Authority, by one or more of the following methods
 1. By use of unit prices for items of work that have an established unit price for other Contract Items under the Contract,
 2. By a negotiated amount, subsequent to receipt of the Contractor's submission of a proposal, following the procedures for establishing a price for a negotiated Change Order in Section 00900, Article 1.7,
 3. By force account, following the procedures for establishing the value of force account work as set forth in Section 01200, Article 4, and/or
 4. By Authority on the basis of the Engineer's estimate of an equitable value for the work to be performed. This would be a unilateral value as determined by Authority.
- C. Item 02220.003 – Demolition of Temporary Tunnel Closure Wall will be paid at the lump sum price and shall include the cost of all related work specified in this Section.
- D. No separate payment will be made for the demolition of the existing Wood Street Station single crossover portion of the work of this Section. Payment for portion(s) of the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 02316

EXCAVATION

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for excavation, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. The excavation of material to prescribed limits.
 - 2. [NOT USED]
 - 3. The removal of any debris or subsurface structures/facilities that are encountered during excavation.
 - 4. [NOT USED]
 - 5. [NOT USED]
 - 6. [NOT USED]
 - 7. [NOT USED]
 - 8. The transport and disposal of all excavated material off the Worksite.
 - 9. [NOT USED]
 - 10. [NOT USED]

1.02 RELATED SECTIONS

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]
- H. [NOT USED]
- I. [NOT USED]
- J. Section 03305, "Cast-In-Place Concrete and Cement Concrete Structures."
- K. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. AASHTO.
- C. ASTM.
- D. PaDEP, Management of Fill Policy.

1.04 [NOT USED]

ARTICLE 2 PRODUCTS

2.01 [NOT USED]

ARTICLE 3 EXECUTION

3.01 EXCAVATION

- A. In accordance with PENNDOT 408, Sections 203 and 204, except as modified herein:
 - 1. Delete Section 203.1(b).
 - 2. Modify Section 203.1(a), Bullet 3: Delete “having a bottom width of 2.5m (8’) or more.”
 - 3. Delete Section 203.3(b), (g), (i), (j), and (k)
 - 4. Modify Section 203.3(e): Change “slope lines” to “grading limits as shown in the Contract Drawings.”
 - 5. [NOT USED]
 - 6. [NOT USED]
 - 7. Delete Section 204.3(b), (e), (g), (h), and (i).
 - 8. Delete Section 203.4 and 204.4
 - 9. Modify Section 203.1(a), Bullet 1: Change reference from “Standard Drawings” to “Contract Drawings. Delete “drainage structures, “ and “grade separation structures, retaining walls, and wing walls.”
 - 10. Modify Section 203.1(a), Delete Bullet 7.
 - 11. Modify Section 203.1(a), Bullet 2: Delete “for benches and”
 - 12. Modify Section 203.1: Delete “and structures”
 - 13. Modify Section 203.1(c), Revise the read: “For roadway rehabilitation, sawcutting and removal of existing pavement to neat lines outside the limits of the support of excavation systems, as indicated or directed”
- B. [NOT USED]
- C. [NOT USED]

- D. Existing concrete pavement and sidewalk is to be removed to the nearest joint. If the existing joint falls outside the disturbance limits as indicated on the Contract Drawings, the contractor shall alert the Engineer. Saw cutting of concrete pavement shall be directed by the Engineer.
- E. Contactor shall conduct operations and provide equipment that is suitable for use with full consideration of the highest hydrostatic head which may be encountered as identified in Section 00300.
- F. [NOT USED]
- G. [NOT USED]
- H. Class 2 and 4 Excavations are considered portion(s) of the work associated with drainage/sanitary sewer and utility facility installation.
- I. [NOT USED]

3.02 [NOT USED]

3.03 [NOT USED]

3.04 TRANSPORT OF EXCAVATED MATERIAL

- A. Contractor shall utilize sealed beds on trucks hauling wet excavated material between the construction site and the disposal site to minimize spillage of material.
- B. Contractor shall utilize tarps or similar coverage on open beds on trucks carrying dry excavated material to control fugitive dust.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02316.001 – Class 1 Excavation shall be measured per cubic yard, complete in place.
- B. [NOT USED]
- C. [NOT USED]
- D. No measurement shall be made for the Class 2 Excavation portion of the work of this Section.
- E. No measurement shall be made for the Class 4 Excavation portion of the work of this Section.

4.02 PAYMENT

- A. Item 02316.001 – Class 1 Excavation will be paid at the unit price and shall include the cost of all related work specified in this Section.
- B. [NOT USED]
- C. [NOT USED]
- D. No separate payment will be made for the Class 2 Excavation portion of the work of this Section. Payment for portion(s) of the work shall be included in the payment for related portions of the Work.
- E. No separate payment will be made for the Class 4 Excavation portion of the work of this Section. Payment for portion(s) of the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 02320

BACKFILL

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for backfill, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Aggregate
 - 2. Placement and compaction of backfill

1.02 RELATED SECTIONS

- A. [NOT USED]
- B. [NOT USED]
- C. Section 02340, "Subgrade."
- D. Section 02353, "Geotextile."
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]
- H. [NOT USED]
- I. Section 02721, "Subbase."
- J. [NOT USED]
- K. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication 19.
- C. PENNDOT Publication 34 (Bulletin 14).
- D. PENNDOT Publication 35 (Bulletin 15).

E. ASTM.

F. AASHTO.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Sand in accordance with PENNDOT 408, Section 703.1(a), excluding slag.
- B. Soil in accordance with PENNDOT 408, Section 206.2(a) (1.a)
- C. AASHTO No. 57 in accordance with PENNDOT 408, Section 703.2(a), limestone only.
- D. AASHTO No. 67 in accordance with PENNDOT 408, Section 703.2(a), limestone only.
- E. PENNDOT No. 2A in accordance with PENNDOT 408, Section 703.2(a), limestone only.
- F. [NOT USED]
- G. [NOT USED]
- H. [NOT USED]
- I. Supply aggregate from a PENNDOT Bulletin 14 approved source.
- J. [NOT USED]
- K. [NOT USED]

2.02 [NOT USED]

ARTICLE 3 EXECUTION

3.01 PREPARATION

- A. Prepare embankment foundation in accordance with Section 02340, "Subgrade."

3.02 [NOT USED]

3.03 PLACEMENT AND COMPACTION

- A. Compact backfill material in accordance with PENNDOT 408, Section 206.3(b) and (c).
- B. [NOT USED]

3.04 [NOT USED]

3.05 [NOT USED]

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. [NOT USED]
- B. Item 02320.002 – AASHTO No. 57 Coarse Aggregate shall be measured per cubic yard, complete in place.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]

4.02 PAYMENT

- A. [NOT USED]
- B. Item 02320.002 – AASHTO No. 57 Coarse Aggregate will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]

END OF SECTION

SECTION 02340

SUBGRADE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals, necessary for subgrade, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. [NOT USED]
- B. Section 02721, "Subbase."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication 19.

ARTICLE 2 PRODUCTS

[NOT USED]

ARTICLE 3 EXECUTION

3.01 SUBGRADE

- A. In accordance with PENNDOT 408, Section 210.3.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 02353

GEOTEXTILE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for geotextile, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. Section 01800, "Erosion and Sedimentation Control."
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication #72.
- C. PENNDOT Publication 35 (Bulletin 15).

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Geotextiles in accordance with PENNDOT 408, Section 735 and the Contract Documents.

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION OF GEOTEXTILE

- A. In accordance with the Contract Documents and PENNDOT 408, Section 212.3.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A.** No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 02450

GENERAL TRACK CONSTRUCTION

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for general track construction, in accordance with the contract documents.

1.02 RELATED SECTIONS

- A. Section 02452, "Direct Fixation Track Construction."
- B. Section 02453, "Special Trackwork Construction."
- C. Section 02456, "Track Appurtenances and Other Track Material."
- D. Section 02462, "Direct Fixation Rail Fasteners."
- E. Section 02464, "Special Trackwork."
- F. Section 02466, "Steel Rail."
- G. Section 02468, "Rail Welding."
- H. Section 02471, "Track-to-Earth Resistance Testing."
- I. Section 03630, "Plinth Anchoring System."

1.03 REFERENCE STANDARDS

- A. AREMA, Latest Edition, "Portfolio of Trackwork Plans" and "Manual For Railway Engineering"
- B. ASTM.
- C. ASNT.
- D. U.S. Army Corps of Engineer Specifications.

1.04 SUBMITTALS

A. Contractor shall submit the following:

1. Construction equipment data showing compliance with wheel contour, gauge, loads and clearances for on-track equipment.
2. Procedures for unloading and stocking materials.
3. Procedures for artificially adjusting rail for anchoring including data on mechanical vibrators for relieving internal rail stresses prior to anchoring.
4. Complete record of standard and insulated joint locations and short rails (less than 3'-10") in a format approved by the Engineer. Record shall be kept current.
5. Procedures on handling and anchoring CWR.
6. Product data: manufacturer's printed information and recommendations for all materials, equipment, and products, per specification or "Approved Equal".
7. Certification of calibration of specified torque wrench by independent testing laboratory accepted by Engineer.
8. Rail laying records.
9. Pre-construction inspection reports.
10. Qualifications of registered Surveyor.
11. Quantity of Strap Guard required from Authority.
12. Qualifications of all testing laboratories to be used.
13. Post construction track survey.

1.05 GENERAL WORK

- A. This Section includes track construction procedures and requirements that are common to direct fixation track and direct fixation special trackwork, including laying and fastening continuous welded rail, joining rail, anchoring rail, final alignment, inspection, and cleanliness of the Worksite.
- B. All materials required for track construction, unless specified as Authority furnished materials, shall be furnished by Contractor.
- C. Unless indicated otherwise, all rails shall be head-hardened continuous welded rail (CWR).
- D. Bonded or bolted rail joints shall be installed only where indicated. Unless otherwise indicated all bonded and bolted joints shall be of a six hole pattern.

1.06 DEFINITIONS

- A. Trackwork Definitions: The following terms, with their coinciding definitions, represent the standard glossary of trackwork terms and supplement the definitions contained elsewhere in the Contract Documents and in the AREMA Manuals For Railway Engineering. In the event of a conflict between the AREMA definition and a definition contained herein, the definition contained herein will apply.
 1. Approach slab: A concrete slab located at interface of ballasted track with direct fixation track to provide a transition from direct fixation track to ballasted track.

2. Bonded joint: A rail joint that uses high-strength adhesives in addition to bolts to hold rail together. The bonded joint may be insulated or non-insulated.
3. Hydraulic Bumping post: A device attached to the structure, designed to stop a rail vehicle from slow speed at the end of a track.
4. Cant: Inward inclination of the running rails, nominally 1:40.
5. Closure rails: The lead rails connecting the heels of the switch points to the toe of the frog in a turnout.
6. Cross level: The vertical relationship of the top of one running rail to that of the opposite running rail at any point in the track.
9. Crossover
 - a. Crossover, double: Two (2) single crossovers, which intersect each other between the two (2) adjacent and generally parallel tracks, forming a connection between them. Sometimes referred to as a "diamond" crossover.
 - b. Crossover, single: Two (2) turnouts, with track located between the frogs and arranged to form a continuous passage between two (2) adjacent and generally parallel tracks.
 - c. Crossing diamond: A special trackwork assembly consisting of two (2) end frogs and two (2) center frogs that together comprise the central portion of a double crossover.
 - d. Crossover connecting rails: The additional running rails forming the connecting tracks in either single or double crossover units.
10. Curve
 - a. Circular curve: A horizontal curve defined by the arc definition and specified by a radius.
 - b. Spiral curve: A transition curve connecting a tangent to a circular curve and defined by the Barnett Spiral.
 - c. Vertical Curve: A parabolic curve connecting different profile grades.
 - d. Lead Curve: The curve in a turnout imposed between the switch and the frog.
11. Direct fixation rail fastener: A resilient device for securing running rail to a concrete plinth in direct fixation track.
 - a. Rail clip assemblies: One (1) or more components of the direct fixation rail fastener used to attach the running rail to the body of the direct fixation rail fastener.
 - b. Anchorage assemblies: One (1) or more components of the direct fixation rail fastener used to attach the body of the direct fixation rail fastener to a concrete plinth .
 - c. Anchorage insert: A component of the anchorage assemblies which is embedded in the concrete plinth and is threaded to hold the anchor assembly bolts.
12. Dutchman: A short piece of running rail temporarily placed between the ends of CWR to reduce the damage which would occur to the rail ends as a result of rail mounted track equipment passing over those ends.
13. Electrical isolation: The electrical resistance required between the running rail and the ground to prevent harmful levels of stray current from the D.C. Traction Power circuit.

14. Emergency guard rail: Structural steel angle affixed to direct fixation track plinths, with back of angle facing the gauge side of the running rail so as to guide a derailed truck (See track charts for locations).
15. Grade crossing: The crossing of a railway track and a vehicular roadway at the same elevation. Conventionally constructed of timber, asphalt, rubber or concrete.
16. Heartwood face: The side of a timber tie about which the growth rings are concave.
17. Pocket track: A track located between the two (2) main tracks on which a train may lay over or reverse direction.
18. Primary Track: Primary Track is track for vehicles that carry revenue passengers.
19. Profile grade line (PG): The datum line, which defines the vertical alignment of the track, applied at the top of the low rail.
20. Rail
 - a. Continuous welded rail (CWR): A number of standard length rails welded together into a single length.
 - b. Jointed rail: Rails with a nominal length of 39', 78' or less joined together by means of joint bars and bolts.
 - c. Running rail: Rail, which supports and guides the flanged wheels of the rail vehicle.
 - d. Special trackwork rail: Rails within the special trackwork areas, normally manufactured in a shop rather than fabricated in the field.
 - e. Inside rail: On curved track, the rail closest to the curve center; the rail with the shorter radius. Sometimes referred to as the "low rail."
 - f. Outside rail: On curved track, the rail farthest from the curve center; the rail with the longer radius. Sometimes referred to as the "high rail."
21. Rail brace: A device, which provides lateral support on the field side of stock rails, to maintain the track gauge.
22. Rail field side: The side of the rail farthest from the center of track.
23. Rail gauge side: The side of the rail nearest the center of the track.
24. Roadbed: The earth bed or foundation that supports the ballast, ties and rail of a track structure.
25. Rod
 - a. Front rod: A rod connecting the switch point rails to the lock (detector) rod.
 - b. Switch rod: A rod that connects two switch point rails together.
 - c. Operating rod: A rod connecting the switch rod to the switch operating mechanism.
 - d. Lock rod: A rod connecting the front rod to the lock mechanism.
26. Secondary Track: Pocket Tracks and other tracks which do not carry vehicles that carry revenue passengers.
27. Special fastener
 - a. Special direct fixation fasteners for use in special trackwork, designed to replace the AREMA standard rail braces, gauge plates, switch plates, heel plates and hook twin tie plates commonly used under switches and frogs.
28. Superelevation: The design vertical distance that the outer rail is set above the inner rail on a curve.

29. Switch machine: A device for remote controlled mechanical operation of a switch or derail.
30. Switch rail (switch point): A tapered rail, which diverts the wheel, flanges to the desired track.
31. Track
 - a. Direct fixation (DF) track: Track constructed of two rails and direct fixation rail fasteners attached to concrete or other surfaces.
32. Track appurtenances or other track materials (OTM): Miscellaneous materials required to complete track construction, other than rail, special trackwork, ties, special fasteners, grade crossings, and ballast.
33. Track Foot: Unit of measurement for all types of track construction measured along the center line of track.
34. Zero thermal stress temperature: The rail temperature at which in-track continuous welded rail will have zero thermal stress.

1.07 QUALITY ASSURANCE

- A. Equipment: Construction equipment must not exceed the physical dimensions and weights determined by Authority. Construction equipment data shall be submitted to Authority for review and construction equipment must be inspected by Authority before being allowed on project site.
1. Use wheel contour and gauge for trackwork equipment which is compatible with the Pittsburgh light rail track system. See Contract Documents for special trackwork, wheel profile and gauge. Note that the existing trackwork contains flange bearing frogs with narrow flangeways.
- B. Tolerances
1. Allowable deviation from indicated geometric design for trackwork installation is $+/-1/4"$ total deviation and $+/-1/8"$ in middle ordinate of a 62' chord in both Vertical and Horizontal alignments.
 2. Track gage to be 62 $\frac{1}{2}"$, $+1/8"$, $-0"$, measured $\frac{1}{2}"$ below top of rail.
 3. Installation of emergency guard rails as measured from rail gauge line to face of guard rail:
 - a. At locations of directly fixation to concrete: $+ \frac{1}{4}"$, $- \frac{1}{4}"$.
- C. Electrical Testing
1. Tests of electrical resistance and continuity shall be performed by an independent testing agency retained by the Contractor.
 2. The following items will be electrically tested:
 - a. Insulated joints (bonded): Minimum resistance, 10^7 ohms each.
 - b. Running rail/continuity: Maximum resistance 0.010 ohms per 1,000' at 68 degrees F.
 - c. Track to ground resistance with both rails connected electrically : Minimum resistance, see Section 02471, "Track-to-Earth Resistance Testing."

- d. Running rail to running rail resistance: same as Track-to-Earth, see Section 02471, "Track-to-Earth Resistance Testing."
3. Contractor installations which fail the electrical tests will be re-tested at Contractor's expense after corrective measures have been executed by the Contractor.
4. Propulsion bonds for negative return will be inspected visually

1.08 MATERIAL FURNISHED BY THE AUTHORITY

- A. Strap Guard Rail: Authority will furnish, free of charge, Authority Standard Strap Guard Rail to Contractor. All strap guard fixation hardware shall be provided by the Contractor. Contractor shall provide (7) calander days notice before any material pickup. Authority will load Authority supplied strap guard rail on the Contractor's truck with proper prior notice. Contractor will transport, fabricate, and install, the guard rail into the trackwork as shown in the Contract Documents, at his expense. The guard rail is stocked by Authority in nominal un-drilled straight lengths of 30', including some shorts. The guard rail ends are not square. The Contractor shall square up all guard rail ends used on the Project by use of abrasive saws only and shall drill in accordance with all applicable AREMA "Specifications for Steel Rails". Contractor shall submit a request to Engineer for the amount of strap guard rail required in the track and special trackwork. The material will be made available to Contractor at the Authority's storage yard in Pittsburgh, PA or within 50 miles of the project site location. Contractor shall inspect, load and assume responsibility for the material prior to moving it from the yard. All handling, transporting, shipping, bending, drilling and installation costs shall be at Contractor's expense. Contractor shall inventory, account for, and return any excess material to Authority prior to completion of the Contract.

1.09 QUALIFICATION TESTS

- A. General: All qualified tests required by this and other Sections of the trackwork specifications, except as noted, shall be performed by a qualified independent testing laboratory approved by the Engineer, at Contractor's expense.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Contractor shall load, transport, unload, store and handle all trackwork materials in a manner which will prevent damage to the trackwork materials. Items which are included in the AREMA "Manual of Railway Engineering" shall be handled as described therein.
- B. All material on site shall be moved in a manner which prevents damage to existing above and below ground installations.
- C. Damage to existing installation or Authority owned materials, caused by Contractor shall be repaired, corrected, or replaced by Contractor at no cost to the Authority.

ARTICLE 2 PRODUCTS

2.01 METAL TAGS

- A. Brass or anodized aluminum; 1-3/8" wide by 2" long by 1/16" thick; and stamped with numerals 1/8" high. Tags to be stamped in 1/8" increments from zero superelevation to maximum superelevation. Adhesive for bonding tags to concrete shall be TACA Corp.'s "Temprage," PRECO's "Rockweld," W.R. Grace Co.'s "Expoxite," or approved equal.

ARTICLE 3 EXECUTION

3.01 INSPECTION

- A. The construction shall be inspected prior to installation of trackwork for any discrepancies with proposed installation plans.
- B. Existing installations shall be inspected for damage prior to construction.
- C. Exposed conduit, conduit stub-ups, and drainage fittings shall be examined for conformance to vertical and horizontal positioning and required interface with surface-mounted appurtenances.
- D. Alignment and elevation of existing work shall be examined for interface with work of this Section. Bench marks and horizontal control points shown in the Contract Documents shall be used. Adjustments at interfaces with existing work, to produce alignment and elevations indicated for work of this Section, must be authorized by the Engineer before work of this Section is started.
- E. Contractor shall prepare and submit a pre-construction report detailing discrepancies in existing installations.

3.02 PREPARATION

- A. Track alignment shall be established based on the Contract Documents, the survey monuments shown and the following:
 1. Track gauge is 5.21' between rails of a track measured 1/2" below top of rail.
 2. Alignment of track is based on the centerline of track, equidistant between the gauge sides of the running rails.
 3. Alignment of track utilizes station equations which must be adhered to.
 4. Rail cant
 - a. Incline rails inwardly at a 1-in-40 ratio. Do not incline rails within limits of special trackwork, except for that provided by the standard DF fastener plates within the special trackwork area.

- B. Set top of rail and superelevation based on the Contract Documents, and the following:
 - 1. Obtain superelevation by maintaining the inner rail at the required profile grade line indicated in the Contract Documents and raising the outer rail above the inner rail.
 - 2. Start superelevation at the point of tangency and increase uniformly to full superelevation of the outer rail at the junction of the spiral with the circular curve unless otherwise noted.
 - 3. Obtain superelevation on curves without spirals over equal lengths on the tangent and curve by increasing linearly throughout the indicated lengths as shown on the Contract Documents.
 - 4. Use metal tags to mark the beginning and ending points of superelevation and locate at $\frac{1}{4}$ " increments between the beginning and ending points for curved track. Attach metal tags stamped with the superelevation in increments from zero superelevation to maximum superelevation for each end of the curve at points approximately 1' inside the outer rail. Face metal tags to read in ascending order.

3.03 LAYING CONTINUOUS WELDED RAIL

A. General

- 1. Unload and lay continuous welded rail in a manner which will prevent damage to the concrete plinths, rails and structures.
- 2. Prepare and submit rail laying records which provide weight, type, mill-brand, rolling year, and heat number of end rails in rail string; date and time of placing rail string; length of rail string; air and rail temperature; stationing of both ends of rail string; weather conditions; and rail end gap to nearest $\frac{1}{8}$ ".
- 3. Place CWR string on direct fixation rail fasteners. Arrange ends of opposite rails to be more than 9'-10" apart when measured along centerline of track. Unless otherwise indicated, rails shorter than 13' shall not be installed in track.
- 4. Install rail with rail stamping on the field side of the track.
- 5. All rail to be 115RE section, Head-Hardened, as manufactured in accordance with the current AREMA "Specifications for Steel Rails", as produced by Mittal Steel or "Approved Equal". No fully heat-treated rail shall be used. Hardness of Head-Hardened rail shall be within the range of 352 to 388 Brinell-Hardness (BHN), with a minimum of 352 (BHN) at $\frac{3}{8}$ " below head surface."

B. Cutting and Drilling of Rails

- 1. Cut rails square and clean with an abrasive disk type rail cutoff saw. Flame cutting will not be permitted. Do not cut rails for installation of standard or bonded joints within 2.5' of a shop weld. Sawcut rail end, in which pulling hole has been drilled, 1" from hole, away from rail end and perpendicular to rail; discard portion containing hole.
- 2. For joining rails with standard joints, drill and space bolts holes in rail in accordance with AREMA Manual for Railway Engineering Volume 1, Chapter 4.
- 3. For joining rails with bonded standard joints, drill and space bolt holes in rail to provide no gap between rail ends.

4. For joining rails with bonded insulated joints, drill and space all bolts holes in rail to provide gap for insulated end post between rail ends.
 5. Drill holes perpendicular to rail web using template as drilling guide. Do not use the joint bar as a drilling guide. Drill to be used must be approved by Engineer.
 6. Collect and remove from the Worksite all drilling particles.
- C. Beveling of Rail Ends: Bevel rail ends at standard bolted joint locations in accordance with current AREMA Standard Plan No. 1005-40. Bevel rail ends in bonded joints in accordance with the manufacturer's written specifications.
- D. Determining Rail Gap
1. At joints to be welded: Align CWR with abutting CWR, and adjust end of CWR to thickness of field-weld away from abutting CWR.
 2. Calculate rail gap, by the formula for jointed rail:

$$G = 0.0117 * L * (t-T) + Q. \quad (* = \text{multiplication})$$

Where G = Gap, in mm
 t = Optimum anchoring temperature in Celsius; 27 degrees C
 T = Temperature of rail at the time of laying in Celsius.
 L = Length of rail in meters (on-half the sum of the length of the two rail strings adjacent to the joint).
 Q = Required gap for welding, end-post thickness if joint will be bonded insulated type, and 3 mm if bolted standard joints.
 3. Negative values indicate that the rail length is too long and the rail must be cooled to zero stress level.
 4. Determine rail temperature by placing thermometer on shaded side of rail base next to web and allowing thermometer to remain there until no change in temperature is detected, but for not less than five (5) minutes. Use standard AREMA standard rail thermometer as specified in AREMA Manual for Railway Engineering, Volume 1. A digital thermometer may be used if approved by Engineer.
 5. If rail gap is wider than 1 1/2", insert a Dutchman equal to rail gap minus 1/2" after rail has been aligned with abutting rail to prevent damage to rail ends during laying and other operations requiring passage of on-track equipment over rail joints. Remove Dutchman before anchoring rail, and if rail temperature would cause rail gap to close.
- E. Initial Fastening of Rail: Prior to using on-track equipment, Contractor shall temporarily anchor rail to gauge on every fifth fastener or tie if rail is either on tangent or on curves with a radius larger than 1900' and on every third rail fastener if rail is on curves with a radius of 1900' or less.
- F. Anchoring CWR
1. Install rail anchoring devices when the rail is within the permissible anchoring temperature range of 72 degrees F to 90 degrees F. Anchor opposite rail only when its temperature is within 3 degrees F of the previously anchored rail's temperature at the time of its anchoring.

2. Prior to joining CWR strings, adjust the CWR strings for the zero thermal stress temperature, vibrate to relieve internal rail stresses, and fully anchor. Join CWR strings when the rail gap is at the specified gap. If the rail gap is not within recommended tolerances for joining CWR strings, Contractor will un-anchor the CWR strings for 325' on each side of the rail gap, and readjust each CWR string to within the specified zero thermal stress range. Re-anchor the CWR strings before installing the rail joint. If the recommended rail gap cannot be obtained in this manner, sawcut a section of rail from the end of one of the CWR strings and insert a rail not less than 13' long to ensure the recommended rail gap. If Contractor elects to use an artificial means of adjusting the rail for anchoring, the method and equipment proposed must first be reviewed and accepted by Engineer.
3. Zero thermal stress in CWR may be achieved by heating, cooling, or pulling the rails, or a combination thereof. When zero thermal stress is obtained, anchoring shall begin immediately. The stress within the rail shall remain with the specified zero thermal stress range until the rail is fully anchored. Once zero thermal stress has been obtained, maintain the correct rail gap during installation of joint bars. Vibrators used for relieving internal rail stresses shall be of a type acceptable to Engineer and shall not damage the CWR.
4. Record the rail temperature and other information listed in Section 02468, "Rail Welding," Figure 02468-1.
5. Record the rail temperature every thirty (30) minutes during the anchoring process. If the rail temperature deviates from the specified zero thermal stress range, cease anchoring until the rail temperature returns to within the specified range. Submit records to Engineer.

G. Joining Continuous Welded Rail

1. Unless otherwise indicated in the Contract Documents, all CWR strings shall be joined by field welding.
2. Remove Dutchman if one has been inserted in rail gap.
3. Join rail ends together by either pulling rail ends together, vibrating rails, or heating rails, or a combination thereof, if required to obtain required gap for jointing.
4. Do not locate the center of standard joints or bonded standard joints within the following locations:
 - a. Not closer than 10' from the standard joint in opposite rail.
 - b. Not closer than 13' from the center of shop welds, or standard joints in the same rail.

H. Final Alignment

1. The Contractor shall make a survey of the completed track prior to acceptance. The final horizontal and vertical alignment, gauge, cross level and superelevation shall be within the specified tolerances. Survey points shall be at not more than 20' intervals.
2. Track deviations, as disclosed by the survey, which exceed specified tolerances shall be corrected by Contractor at no additional cost to Authority.

3. Submit survey to Engineer.

3.04 FIELD QUALITY CONTROL

- A. After completing installation, all welds shall be tested ultrasonically in accordance with Section 02468, "Rail Welding."
- B. Welds which fail the ultrasonic test shall be replaced. Contractor shall replace the defective weld with a rail at least 19'-6" in length, centered about the faulty weld, and two (2) field welds. Replacement welds shall not be within 10' of an existing weld or joint.
- C. Testing of all welds and replacement of faulty welds are Contractor's responsibility and will be performed at no additional cost to Authority.
- D. Contractor shall cooperate with the Engineer during the field quality control testing.
- E. Contractor shall operate work trains and equipment over trackwork and turnouts only after approval by the Engineer.

3.05 CLEAN UP

- A. Loose debris, track materials, clusters of rail grinding particles and spilled concrete shall be removed. Exposed stirrups shall be cut and wires shall be tied flush with the concrete surfaces.
- B. All concrete trackway shall be swept clean and washed down with water.
- C. All drainage inverts, pipes, sumps and other conduits shall be examined for spilled concrete, rail grindings, ballast material and other debris. All such obstruction shall be removed at no additional cost to Authority.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 02452
DIRECT FIXATION TRACK CONSTRUCTION

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for Direct Fixation Track Construction, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities: direct fixation track construction Type I without strap guard rail, Type II with single strap guard rail, Type III with dual strap guard rail, and Type IV with dual emergency guard rail and no strap guard rail, as shown on the Contract Documents and as follows:
 - 1. Furnish materials including:
 - a. Plinth concrete.
 - b. Stirrup and plinth reinforcing steel.
 - c. Direct fixation rail fasteners with anchorage assemblies and rail clips.
 - d. Running rail, joint bars, bolts, shims, and rail welds.
 - e. Track appurtenances and other track material as required to complete the construction.
 - 2. Construct Direct Fixation Track including:
 - a. Locating deck rebar placed by others
 - b. Layout of hole spacing for "stirrup" installation
 - c. Drilling of deck for "stirrup" installation
 - d. Install, orient, and epoxy in place required "stirrups"
 - e. Layout and Forming of plinth concrete
 - f. Placing reinforcement, embedded inserts and direct fixation fastener anchorage inserts.
 - g. Placing plinth concrete for direct fixation track
 - h. Installing direct fixation rail fasteners.
 - i. Installing continuous welded rail, strap guard rail, and emergency guard rail, anchoring rail, aligning and joining rail at indicated grades, lines and elevations.
 - j. Track appurtenances and other track material as required to complete the construction.
 - 3. Constructing demonstration section.
 - 4. Performing electrical testing.
 - 5. Performing final adjustments and clean up of site area.
- C. The Contract Documents provide the performance parameters and design criteria to complete the Direct Fixation Track Construction portion of the Work. The

Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 02450, "General Track Construction."
- B. Section 02453, "Special Trackwork Construction."
- C. Section 02456, "Track Appurtenances and Other Track Material."
- D. Section 02462, "Direct Fixation Rail Fasteners."
- E. Section 02464, "Special Trackwork."
- F. Section 02466, "Steel Rail."
- G. Section 02468, "Rail Welding."
- H. Section 02471, "Track-to-Earth Resistance Testing."
- I. Section 03211, "Reinforcement Bars and Dowels."
- J. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- K. Section 03630, "Plinth Anchoring Systems."

1.03 REFERENCE STANDARDS

- A. ASTM
- B. CRD

1.04 SUBMITTALS

- A. Submit the following:
 1. Samples: Insert positioning template. Direct Fixation Fastener Assembly will be permitted to be used as Insert positioning template.
- B. Shop Drawings, Working Drawings and Data.
 1. Shop Drawings: Method and procedure for computing and establishing cant and cross level of track in the formwork.
 2. Working Drawings: Submit detailed drawings of jig and formwork for plinth construction. Contractor shall illustrate manner of setting the top surface elevations of the plinth concrete.

3. Certificates and reports: Submit a Certificate of Compliance with ASTM Standards for each product submittal.
 4. The Contractor's design drawings shall be sealed by a Professional Engineer registered in the State of Pennsylvania.
- C. Product data and manufacturers' recommendations for specified and "Approved equal materials and products.
- D. Certification and calibration records for all tools and equipment to be used.

1.05 DEFINITIONS

- A. Direct Fixation Track Construction Type I without strap guard rail.
- B. Direct Fixation Track Construction Type II with single strap guard rail.
- C. Direct Fixation Track Construction Type III with dual strap guard rail.
- D. Direct Fixation Track Construction Type IV with dual emergency guard rail and no strap guard rail.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. [NOT USED]

1.07 QUALITY ASSURANCE

- A. Tolerances
 1. The allowable deviations for plinth concrete are:
 - a. Horizontal: Plus or minus $\frac{1}{4}$ ".
 - b. Vertical: Plus or Minus $\frac{1}{8}$ ".
 - c. Transverse cross slope: plus or minus $\frac{1}{8}$ " from required.
 - d. Uniformity of slope: deviation from a 3' straight-edge placed in all directions: $\frac{1}{8}$ ".
 2. The allowable deviations for placement of anchorage assembly positioning templates are:
 - a. Horizontal : $\frac{1}{4}$ " with respect to centerline of track.
 - b. Vertical elevation at centerline of inserts : Plus or Minus $\frac{1}{8}$ ".
 - c. Difference in deviation from vertical between adjacent anchor assemblies: $\frac{1}{16}$ ".
 - d. Uniformity of concrete bearing surface formed by the positioning template – free of voids greater than $\frac{1}{2}$ " in size and less than ten percent (10%) of area occupied by voids. Maximum $\frac{1}{32}$ " gap between straight-edge and concrete surface all around.

3. Deviation from gauge, cross level, superelevation, horizontal alignment and vertical alignment: Section 02450, "General Track Construction."

1.08 QUALIFICATIONS

- A. Contractor shall demonstrate the ability to correctly install the direct fixation track in conformance with Contract requirements by constructing a demonstration section having a length of at least 115'.
- B. The demonstration section installation location will be approved by the Engineer, and on acceptance will be a portion of the permanent direct fixation trackwork construction.
- C. The remaining direct fixation track construction shall not proceed until the demonstration installation has been constructed by Contractor, inspected and accepted by the Engineer.

ARTICLE 2 PRODUCTS

2.01 TRACK PLINTH CONCRETE REINFORCEMENT

- A. In accordance with Contract Drawings and Section 03211, "Reinforcement Bars and Dowels."

2.02 CONCRETE

- A. Concrete: Class AAA, Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

2.03 GROUT

- A. General Requirements
 1. Grout shall be for repairing voids in second-pour concrete only. No grout pad will be allowed under the direct fixation plate assembly to adjust the vertical placement of the direct fixation plate/rail. Grout to be of type that exhibits zero percent (0%) shrinkage in plastic state and not more than one-tenth percent (0.1%) expansion in hardened state when tested in accordance with CRD-C621, Sections 10.1 and 10.2.
 2. Provide a grout which does not initially set sooner than sixty (60) minutes as determined by ASTM C191.
 3. Provide a grout which develops a compressive strength of at least 5000psi at the end of twenty-eight (28) days as determined by ASTM C109.
- B. Materials: Pre-measured, pre-packaged, cement-based, non-metallic (aluminum powder or iron filings), non-shrink type grout.

C. Manufacture

1. Supply technical services of grout manufacturer's representative when producing grout for installation.
2. Retemper grout in accordance with manufacturer's printed instructions.
3. Water utilized in making grout shall be potable.

2.04 DIRECT FIXATION TRACK FORMING JIG

A. Plinth bearing area forming jig shall be rigid steel construction providing the following features:

1. Hold all rails, DF Fastener assemblies, complete with shims(s) and anchor assemblies, at proper horizontal and vertical alignments shown in Contract Drawings, including superelevation and rail cant. Rail cant is 1:40 inward with respect to the plane through the top of the running rails, except for special trackwork areas, which shall be level.
2. Vertical and horizontal adjustment devices for holding the jig in proper alignment during the placement of concrete.
3. Sufficient rigidity and bracing to prevent displacement of jigs during placement of concrete and normal construction activities.
4. No portion of the jig shall be imbedded in the plinth concrete, during or after placement of concrete.

B. A sufficient number of jigs shall be on-hand to form at least 200' of direct fixation track.

2.05 DIRECT FIXATION RAIL FASTENERS AND ANCHORAGE ASSEMBLIES

A. Section 02462, "Direct Fixation Rail Fasteners."

2.06 CURING COMPOUND

A. White pigmented, non-wax, liquid type conforming to ASTM C309, Type 2; Feb America, Inc.'s "Febcure," or approved equal.

2.07 THREAD SEALANT

A. Low melting point wax; Sanchem, Inc.'s "NO-OX-ID 'A' Special," or approved equal.

2.08 RUNNING RAILS

A. Section 02466, "Steel Rail."

2.09 JOINT BARS

- A. Section 02456, "Track Appurtenances and Other Track Material."

2.10 STRAP GUARD RAIL

- A. Strap guard rail, as specified in Section 02450, "General Track Construction".

2.11 SHIMS

- A. Shims: ASTM D1248, High Density, Type 3, Class C, Grade W8, Hardness 60D to 65D.
- B. Polyethylene Shims shall be furnished by the direct fixation fastener manufacturer.

ARTICLE 3 EXECUTION

3.01 INSPECTION

- A. Contractor shall refer to Section 02450 , "General Track Construction" and prepare a pre-construction inspection report.
- B. Concrete deck shall be inspected for defects and installation variances which would affect the subsequent work.

3.02 PREPARATION

- A. Alignment and elevation points shall be established in accordance with Section 02450, "General Track Construction."
- B. Plinths shall be laid out per typical sections and requirements shown in Contract Drawings, including, but not limited to, overall plinth length and quantity of direct fixation fasteners per plinth.
- C. The existing concrete deck surface shall be etched with muriatic acid and washed with water.
- D. Locate deck rebar (placed by others) and layout plinth anchor hole/stirrup locations per Section 03630,"Plinth Anchoring System".

3.03 INSTALLATION

- A. Plinth Concrete
 - 1. Establish bench marks for top of rail by referencing to control points established for the Project.

2. Drill and epoxy plinth anchoring system at locations laid out per 3.02 B. above and per Section 03630.
3. Install reinforcing steel within the plinths in accordance with Section 03211, "Reinforcement Bars and Dowels" and the typical sections shown in the Contract Drawings.
4. Set forms for plinth concrete for direct fixation track per typical sections and details provided in the Contract Drawings.
5. Secure DF fastener assemblies, shims, and anchor inserts, at typical spacings shown in Contract Drawings, to rails: Place and attach approved rail holding devices and set rails to horizontal and vertical alignments shown on Contract Drawings.
 - a. In tangent track set DF Fastener assemblies in pairs directly opposite each other and perpendicular to the centerline of track.
 - b. In curved track, set DF Fastener assemblies in pairs opposite each other and radial to the centerline of track.
 - c. Set the template pairs so that maximum fastener spacing will not exceed 2'-6" for tangent track and curves with radii greater than 500', 27" for curves with radii less than 500' but greater than 300', and 24" for radii less than 300'.
6. Reinforcement steel may be bent, but not cut, to achieve insert clearance.
7. Place plinth concrete and trowel concrete surfaces.
8. Finish surfaces between fasteners to a true plane between edges of template or DF fastener assembly.
9. Do not remove forms until concrete has been in place for not less than twenty-four (24) hours or has attained a compressive strength of not less than 1,000psi.
10. Grout shall not be used to correct plinth concrete which is not within required tolerances.
11. Concrete, which is not within required tolerances and cannot be corrected without disturbing anchorage inserts, shall be removed and replaced.
12. After concrete has cured, per above, remove rail, DF fastener assemblies, anchor bolts, and shims.
13. Repair any voids in the direct fixation rail fastener area with approved grout.
14. Cure concrete with curing compound specified in this Section.
15. Concrete placement shall be done such that DF fastener assemblies and all hardware are not fouled with concrete. Fasteners shall be free from all concrete before final reassembly. Any complete fastener, or part thereof, that is damaged during concrete removal shall be replaced with no additional cost to Authority.
16. Plinths that require more than 1" of shims for final vertical rail alignment shall be demolished and recast.

B. Direct Fixation Rail Fasteners

1. Prior to positioning the direct fixation rail fasteners, sweep, wash clean, and dry the plinth concrete.
2. Install fasteners after plinth concrete has attained the specified twenty-eight (28) day compressive strength, but not sooner than, ten (10) days after concrete has been placed.

3. Coat threads of anchor bolts with thread sealant specified in this Section before engaging bolts in inserts.
 4. Position the direct fixation rail fastener and required shims to proper horizontal and vertical alignments. Engage anchor bolt into insert treads by hand for at least three (3) full turns, do not apply torque by wrench or mechanical means until threads are engaged three (3) turns. Torque bolts per manufacturer's specifications
- C. Laying, Joining and Anchoring CWR.
1. In accordance with Section 02450, "General Track Construction."
 2. Adjust rail, if required, to final vertical alignment with polyethylene shims. Place shim between the rail fastener and the concrete. At least one (1) polyethylene shim is to be used under each direct fixation rail fastener, but not more than two (2) shims total under each fastener.
 3. Fully anchor rail fasteners to plinth concrete with anchor bolts tensioned to torque as recommended by rail fastener manufacturer. Tighten anchor bolts on both sides of rail simultaneously. Before and during installation of rail fasteners, the equipment to be used for torquing anchor bolts shall be checked daily and shall be within 5lb-ft of the calibrated and certified torque wrench specified.
 4. Final track alignment: After final aligning and surfacing of track, not less than $\frac{1}{2}$ " of lateral rail adjustment in each fastener shall remain for tightening gauge to compensate for rail wear and alignment adjustment.
- D. Installation of strap guard rail shall be as indicated on the typical sections relating to curved track on the Contract Documents.

3.04 FIELD QUALITY CONTROL

- A. Contractor shall perform the electrical tests in accordance with Section 02450, "General Track Construction" and Section 02471, "Track-to-Earth Resistance Testing."
- B. Running rail exhibiting high electrical resistance or non-conductance shall be corrected and retested by Contractor at no cost to Authority.
- C. Track installations which exhibit low resistance to ground shall be corrected and retested by Contractor at no additional cost to Authority.

3.05 ADJUSTMENT AND CLEANING

- A. In accordance with Section 02450, "General Track Construction."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02452.001 – Direct Fixation Track, Type I shall be measured per linear foot, complete in place.
- B. Item 02452.002 – Direct Fixation Track, Type II shall be measured per linear foot, complete in place.
- C. Item 02452.003 – Direct Fixation Track, Type III shall be measured per linear foot, complete in place.
- D. Item 02452.004 – Direct Fixation Track, Type IV shall be measured per linear foot, complete in place.

4.02 PAYMENT

- A. Item 02452.001 – Direct Fixation Track, Type I will be paid at the unit price and shall include the cost of all related work specified in this Section.
- B. Item 02452.002 – Direct Fixation Track, Type II will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. Item 02452.003 – Direct Fixation Track, Type III will be paid at the unit price and shall include the cost of all related work specified in this Section.
- D. Item 02452.004 – Direct Fixation Track, Type IV will be paid at the unit price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 02453
SPECIAL TRACK CONSTRUCTION

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for Special Track Construction, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 1. Furnish materials including:
 - a. Special Trackwork.
 - b. Special Trackwork Direct Fixation Rail Fasteners.
 - c. Special Trackwork rail and running rail.
 - d. Reinforced concrete plinths, DF fasteners, joints, frogs, switch rods, rail braces, bolts, screws, castings and rail grinding.
 - e. Track appurtenances and other track material as required to complete the construction.
 2. Install Special Trackwork including but not limited to, reinforced concrete plinths, DF fasteners, gauge plates, joints, frogs, switch rods, rail braces, bolts, and castings, as shown on the Contract Drawings for the following:
 - a. One (1) No. 4 Special Construction Crossover.
 - b. One (1) No. 6 Double Crossover. (Staged Demolition of existing No. 6 single crossover and Staged Installation Only-Materials previously purchased under separate contract)
 - c. One (1) No. 8 Special Construction Double Crossover.
 3. Construct Special Trackwork including:
 - a. Install Special Trackwork components, special trackwork, standard or direct fixation fasteners as required, reinforced concrete plinths, rail, strap guard rail, anchoring, aligning, and joining rail to indicated grades, lines, and elevations.
 - b. Locating deck rebar placed by others
 - c. Layout of hole spacing for "stirrup" installation
 - d. Drilling of deck for "stirrup" installation
 - e. Install, orient, and epoxy in place required "stirrups"
 - f. Layout and Forming of plinth concrete
 - g. Placing reinforcement, embedded inserts and direct fixation fastener anchorage inserts.
 - h. Placing plinth concrete for standard and special trackwork direct fixation track.
 - i. Installing direct fixation rail fasteners.

- j. Installing continuous welded rail, strap guard rail, anchoring rail, aligning and joining rail at indicated grades, lines and elevations.
 - k. Track appurtenances and other track material as required to complete the construction.
- 4. Rail grinding.
 - 5. Perform electrical tests.
 - 6. Perform final adjustments and clean up of site area.
- C. The Contract Documents provide the performance parameters and design criteria to complete the Special Track Construction portion of the Work. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01781, "Maintenance and Protection of Authority Traffic."
- B. Section 02450, "General Track Construction."
- C. Section 02452, "Direct Fixation Track Construction."
- D. Section 02456, "Track Appurtenances and Other Track Material."
- E. Section 02462, "Direct Fixation Rail Fasteners."
- F. Section 02464, "Special Trackwork."
- G. Section 02466, "Steel Rail."
- H. Section 02468, "Rail Welding."
- I. Section 02471, "Track-to-Earth Resistance Testing."
- J. Section 03630, "Plinth Anchoring Systems."

1.03 REFERENCE STANDARDS

- A. AREMA, Latest edition, "Portfolio of Trackwork Plans" and "Manual For Railway Engineering"

1.04 SUBMITTALS

- A. Contractor shall submit the following:

1. Shop Drawings of all turnout and crossover assemblies and layouts, including and showing all rails, joint locations, insulated joint locations, plates, fasteners, switch rods, and concrete plinth locations and sizes.
2. Shop procedures for the layout, handling, assembly, inspection, and disassembly of all special trackwork.
3. Report of factory inspection of assembled product by an independent inspection agency, approved by the Engineer, at no additional cost to the Authority.
4. Product and manufacturers' recommendations for all products specified or submitted as "approved equals".
5. The Contractor's design drawings shall be sealed by a Professional Engineer registered in the State of Pennsylvania.

1.05 DEFINITIONS

- A. [NOT USED]

1.06 ENVIRONMENTAL REQUIREMENTS

- A. [NOT USED]

1.07 QUALITY ASSURANCE

A. Tolerances

1. Gauge: Plus 1/8", minus 0".
2. The variance from the designed distance for the turnout lead: Less than 3/16".
3. The variance from the designed location for the point of intersection of a turnout (PITO): Less than 1/4" as determined by the frog position.
4. The variance from the designed distances between points of intersection (PI) and/or points of intersection of turnout (PITO) within a specific turnout unit: Less than 1/4" as determined by the frog position.
5. The variance from the designed distances of the turnout offsets to the curved closure rail: Less than 1/8".
6. The gap between the switch rail and the stock rail from the point of switch to the No. 2 switch rod: Less than 1/32".
7. With the switch points in normal position, they shall be square within 1/2".
8. Maximum gap between switch points and slide plates: 1/32".

- B. Verify all special trackwork shown in the Contract Documents and note any variances on Shop Drawings.

ARTICLE 2 PRODUCTS

2.01 RUNNING RAIL

A. Section 02466, "Steel Rail."

2.02 SPECIAL TRACKWORK

A. Section 02464, "Special Trackwork."

2.03 JOINT BARS, BOLTS, NUTS AND WASHERS

A. Section 02456, "Track Appurtenances and Other Track Material."

2.04 DIRECT FIXATION FASTENERS

A. Section 02462, "Direct Fixation Rail Fasteners."

2.05 LUBRICANTS

A. A dry film lubricant shall be provided for application to special plates. The lubricant shall have low electrical conducting properties as approved by the Engineer.

2.06 STRAP GUARD RAIL

A. Section 02450, "General Track Construction."

ARTICLE 3 EXECUTION

3.01 INSPECTION

A. Section 02450, "General Track Construction."

3.02 PREPARATION

A. Contractor shall design, layout and construct reinforced concrete plinths of a sufficient size and spacing, and conforming to the general layout shown in the Contract Drawings for each different special trackwork assembly and the typical section provided in the Contract Drawings, to accommodate the Direct Fixation fastener assemblies being installed. Plinth layout and sizing for the No. 6 Double Crossover shall be coordinated with the shop drawings of the previously purchased double crossover.

B. Top of rail elevation markers shall be set.

C. Contractor shall locate deck rebar (placed by others) and layout plinth anchor/stir-up locations per Section 03630, "Plinth Anchoring System".

3.03 INSTALLATION

- A. Layout all special trackwork in accordance with the Contract Drawings and the approved shop drawings.
- B. Staged demolition of the existing single, trailing point No.6 crossover at “Wood” Street along with the staged installation of the new, No. 6 double crossover, previously procured, shall be performed during numerous, full shutdown, weekend outages, with revenue service being returned after each outage. Contractor to note that all demolition and installation work will take place within an existing subway tunnel, with limited access and clearances.
- C. The Contractor will be required to demolish and remove the existing trackwork, reinforced concrete support structure, and existing embedded steel channel, down to the existing tunnel shell concrete. Please reference PAAC Stage I, Wood Street Construction documents for existing construction.
- D. The existing “Wood” Street No. 6 crossover and existing mainline tracks are placed on approximately 12'-5 1/2" track centers. The existing mainline tracks, approaching the new, No.6 Double Crossover, will require horizontal realignment to match the 12'-6" track centers of the new No. 6 double crossover. The longitudinal and lateral centerline of the existing No. 6 single crossover shall be located and referenced. The new No.6 Double Crossover shall be located so that its longitudinal and lateral centerlines match the location of the centerlines referenced for the existing crossover. The existing top of rail elevations for both tracks, within the overall limits of realignment and/or replacement, shall be surveyed and referenced. These elevations shall be used during the realignment and installation of all temporary trackwork required for staged construction and all final trackwork construction.
- E. Contractor to provide existing and proposed alignment and profile drawings for review and approval before starting staged demolition and construction.
- F. “Wood” Street staged demolition and construction will require temporary track construction and materials to meet the “Return to Service” requirement. A recommended construction method, sequence, and overall demolition/installation outage window has been provided in the Contract Drawings for reference.
- G. Contractor to support and anchor the temporary track structure in a method acceptable to Authority. Method of support and anchorage shall be designed by Contractor and submitted for approval.
- H. Existing drainage inlets, four (4) total, located on each track, approximately at the location of the existing switch point, shall be protected and maintained for the new layout.

- I. Contractor shall protect station platform areas from demolition and construction debris, and clean station areas after each outage before returning track to service.
- J. All existing and new switch points shall have point detection when returned to revenue service after each outage. Point protection for new switches to be provided by newly installed switch machines.
- K. Layout special trackwork in accordance with the Contract Drawings and the approved shop drawings.
- L. Bonded insulated joints and standard joints shall be installed in accordance with Section 02456, "Track Appurtenances and Other Track Material."
- M. Installation of Strap Guard Rail shall be as indicated on the Contract Documents.
- N. Contractor shall install special trackwork to the dimensions, limits, and stationing shown on the Contract Drawings.

3.04 FIELD QUALITY CONTROL

- A. In accordance with Section 02450, "General Track Construction"
- B. Contractor shall demonstrate to the Engineer that switch points move freely without binding or excessive force in each completed Special Trackwork switch section.

3.05 ADJUSTMENT AND CLEANING

- A. In accordance with Section 02450, "General Track Construction."
- B. Riser plates shall be cleaned before applying a uniform coat of lubricant over entire sliding surface.
- C. Final adjustment of switch shall be performed in cooperation with the Train Control Contractor and as scheduled by the Engineer.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02453.001 - No. 4 Special Construction Crossover at Allegheny shall be measured as a lump sum unit, complete in place.

- B. Item 02453.002 - No. 6 Double Crossover at Wood Street shall be measured as a lump sum unit, complete in place
- C. Item 02453.003 - No. 8 Special Construction Double Crossover at Allegheny shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. Item 02453.001 - No. 4 Special Construction Crossover at Allegheny will be paid at the lump sum price and shall include the cost of all work specified in this Section.
- B. Item 02453.002 - No. 6 Double Crossover at Wood Street will be paid at the lump sum price and shall include the cost of all work specified in this Section.
- C. Item 02453.003 - No. 8 Special Construction Double Crossover at Allegheny will be paid at the lump sum price and shall include the cost of all work specified in this Section.

END OF SECTION

SECTION 02456
TRACK APPURTENANCES AND OTHER TRACK MATERIAL

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for track appurtenances and other track material, in accordance with the Contract Documents.
- B. The Contract Documents provide the performance parameters and design criteria to complete the Special Hydraulic Bumping Post and Sliding Bumping Post portions of the Work. The Contractor shall be responsible to provide a complete design for these portions of the Work.

1.02 RELATED SECTIONS

- A. Section 024501, "General Track Construction"
- B. Section 02452, "Direct Fixation Track Construction."
- C. Section 02453, "Special Trackwork Construction."
- D. Section 02462, "Direct Fixation Rail Fasteners."
- E. Section 02464, "Special Trackwork."
- F. Section 02466, "Steel Rail."
- G. Section 03211, "Reinforcement Bars and Dowels."
- H. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

1.03 REFERENCED STANDARDS

- A. American Railway Engineering and Maintenance of Way Association (AREMA) Latest Edition.
- B. American Society for Testing and Materials (ASTM).
- C. American Welding Society (AWS).

D. National Electrical Manufacturers Association (NEMA).

E. American Society for Testing and Materials (ASTM).

1.04 SUBMITTALS

- A. Submit Shop Drawings or product specifications for all material covered in this Section. The Contractor's design drawings shall be sealed by a Professional Engineer registered in the State of Pennsylvania.
- B. Submit certificates and Test Reports as follows:
 - 1. Test results of insulated joints as required below.
 - 2. Accepted joint installation report.
 - 3. Test samples of insulated joints only after drawings and installation procedures have been approved.
- C. Independent test laboratory (must be approved by Engineer)

1.05 DEFINITIONS

(NOT REQUIRED)

1.06 ENVIRONMENTAL REQUIREMENTS

(NOT REQUIRED)

1.07 QUALITY ASSURANCE, INSULATED JOINTS

A. Field Quality Control

- 1. Before installing insulated joints, have each joint installing crew prepare 2 samples of that joint.
- 2. Have an independent testing laboratory test each insulated joint sample as specified in 1.04B.

B. Testing: Test 2 samples for resistance to longitudinal pull apart, and test 1 sample for rolling load test, and test 1 sample for electrical resistance.

- 1. Longitudinal pull apart test (not required for insulated strap guard type joints):

a. Preparation

- 1) Assemble bonded insulated joint complete, on 2 pieces of 115-pound RE rail each 2' long.
- 1) Saw joint assembly in half where rails are butted together and at right angles to centroid of rail.
- 1) Ensure that sawing does not overheat and damage adhesive.

- 1) Affix a device which will confine the reaction at the sawn end to the face of the joint bar when a load is applied at the centroid of the rail at the opposite end.
- b. Testing
 - 1) Apply test load longitudinally in increments of 25,000lbs maintaining each increment until longitudinal deflection of rail ceases before increasing load to next increment.
 - 1) Increase load in increments until a total load of 650,000lbs is attained or failure occurs.
 - 1) At each increment of loading, measure and record load, and differential movement of rail and joint bars, to nearest 0.001”
- c. Acceptance criteria
 - 1) Stability: No indication of slippage of rail joint before total test load of 650,000lbs is reached.
 - 1) Differential movement in all directions: not more than 1/8”.
 - 1) Difference between original position of joint bar and rail and final position thereof after final test load has been released: not more than 0.030”.
 - 1) Basis of rejection: Failure of joint to satisfy above requirements.
2. Stroke rolling loading test (not required for insulated strap guard type joints):
 - a. Preparation: Mount bonded joint on a 2'-9" stroke rolling load test machine and support on 3' centers; center joint as indicated in AREMA, Chapter 4, Figure 2-56.
 - b. Testing: Apply 44,500lb load on rail for 2,000,000 cycles. Measure and record deflection at rail centerline to nearest 0.001" when wheel load is over points A and B for every 500,000 cycles.
 - c. Develop moment diagram.
 - d. Acceptance criteria
 - 1) After 2,000,000 cycles: Exhibit no evidence of failure by bending of bonded insulated joint.
 - 1) Deflection exhibited by bonded insulated joint: Not further than 0.065”.
3. Electrical resistance test (not required for insulated strap guard type joints):
 - a. If specimen satisfies mechanical acceptance criteria of preceding tests, test specimen for electrical resistance.
 - b. Preparation: Assemble bonded insulated joint complete, in accordance with manufacturer's instructions, on two pieces of 115 pound RE rail, one rail 2' long, the other 3'-6" long. Support both rails on electrically nonconductive material.
 - c. Testing
 - 1) Apply 500 volts DC to rail across bonded insulated joint for 3 minutes. During that time, measure and record, to nearest 0.1 ampere, current flow through joint.
 - 1) Apply 50 volts AC to rail across joint for 3 minutes for each increment of measurement at frequencies of 20 hertz to 10 kilohertz in increments of 20 hertz to 100 hertz, 200 hertz to 1,000 hertz, and 2 kilohertz to 10 kilohertz.

- After 3 minutes, measure and record impedance within accuracy of plus or minus 2 percent.
- d. Acceptance criteria
- 1) Resistance for 500 volts DC: Not less than 10 megohms.
 - 1) Impedance for all frequencies between 20 hertz and 10 kilohertz with 50 volts AC not less than 10 megohms.

1.07A QUALITY CONTROL, FASTENING ASSEMBLY

A. Electrical Testing

1. Have an independent testing laboratory select 2 samples of fastener assemblies and test as specified in Paragraphs 1.07B, 1.07C, and 1.07D herein.

B. Dry Resistance

1. Connect one lead of high potential tester to the rail head of an assembled fastening assembly and ground lead connected to the tie plate, apply 500 volts DC for 3 minutes. Use the current value obtained to calculate resistance.
2. Acceptable resistance to 500 volts DC: not less than 10 megohms.

C. Wet Resistance

1. Immerse tie pad in distilled water for 6 hours at 212 degrees F for polymer based elastomers and for 336 hours at 158 degrees F for natural rubber based elastomers.
2. After tie pad has been removed from water reassemble tie pad, rail fastening system, and rail, spray down with distilled water and test for electrical resistance as follows:
 - a. With 1 lead of high potential tester connected to the rail head and the other lead ground to rail tie plate, apply 500 volts DC for 3 minutes, and test for electrical resistance. Use current value obtained to calculate resistance.
 - b. Allowable resistance: Not less than 1 megohm.

D. Wet Impedance

1. With the rail tie pad and fastening system still wet, apply a potential of 50 volts AC between rail head and tie plate until reading has stabilized for 30 seconds of measurement for frequencies 1 kHz, 2 kHz, 6 kHz, 8kHz, and 10 kHz.
2. After reading has stabilized for 30 seconds, measure impedance of each frequency within an accuracy of plus or minus 2 percent and record each frequency.
3. Impedance for frequencies between 2 kHz and 5 kHz with 50 volts AC shall be 10,000 ohms, at 6 kHz shall be 9,000 ohms, at 8 kHz shall be 7,000 ohms, and at 10 kHz shall be 6,000 ohms.

ARTICLE 2 PRODUCTS

2.01 GLUED INSULATED JOINTS FOR RUNNING RAIL WITHOUT STRAP GUARD RAIL

- A. Glued insulated joints shall be used for all insulated joints where practical. In areas that cannot use glued insulated joints, insulated joint bars shall be polyurethane encapsulated steel, 36" long, six (6) hole, such as, "Toughcoat" manufactured by Allegheny Rail products or an approved equal.
- B. Joint bar for joining rail without strap guard rail: 36" long; quenched and tempered carbon steel; fabricated in accordance with AREMA Chapter 4, Part 1, Table 1, for 115-RE rail; shall have six, 1-1/4" diameter holes spaced in accordance with AREMA Chapter 4, Part 1, Table 1; have a length tolerance of 1/8"; have a straightness tolerance of 0.030" on 36" along contact surface; and have no marking on contact surface. If required, modify bar to accommodate rail fasteners.
- C. Adhesive: Allegheny Rail Products "Temprange" or approved equal.
- D. Mesh: Fiberglass; Allegheny Rail Products or approved equal.
- E. Pin Bolts and Insulation for Bonded Insulated Joint or approved equal.
 - 1. Bolt: 9-1/8" by 1-1/8" diameter pin-type; ASTM A325; Huck Corp's C50LR-BR-36-68 or approved equal.
 - 2. Washer: ASTM A325, flat, 2-1/4" O.D. by 1-3/16" I.D. by 1/8" thick.
 - 3. Collar: 1-1/8" diameter; ASTM A325; Huck Corp's LC-2R36 or approved equal.
 - 4. Bushing: Fiberglass conforming to NEMA LI-1, Grade G10.
 - 5. Post: High-pressure laminate conforming to NEMA LI-1, Grade CE.

2.02 INSULATED JOINTS FOR RUNNING RAIL WITH STRAP GUARD RAIL

- A. Four Hole Strap Guard Insulated Joint Kit No. 228-97-16-001 including 1-1/8" diameter x 6" long bolts (1-1/4" dia. Hole), as Manufactured by Allegheny Rail Products or approved equal.

2.03 NON-INSULATED BOLTED RAIL JOINTS

- A. All joint bars and fastening parts used in bolted non-insulated rail joints shall conform to Chapter 4, Part 1 and Part 2 of the AREMA Manual for Railway Engineering as related to quenched carbon steel joint bars. Unless otherwise indicated in the Contract Documents, all non-insulated bolted joints shall be of the six hole pattern.

2.04 FIXED RAIL ANCHOR ASSEMBLIES

- A. Furnish and install insulated fixed rail anchor assemblies as manufactured by L.B. Foster Company, Transit Products Division or approved equal, at locations indicated on the Contract Drawings and as modified herein. NSC-009 Contractor must coordinate the type, J-Bolt layout, size, and quantity of the insulated fixed rail anchor

assemblies being used with the NSC-007 Contractor so that the correct J-Bolts can be placed properly by the NSC-007 Contractor. All J-Bolts to be included with insulated fixed rail anchor assemblies and provided to the NSC-007 Contractor for placement and installation.

- B. The insulated rail anchor assemblies shall consist of four insulated fixed rail anchor units installed between five standard direct fixation fastener assemblies. The fixed rail anchor shall include the anchor bracket assembly, anchor angle assembly, and angle bars conforming to ASTM A36 Standard Specification for Carbon Structural Steel.
- C. The anchor shall support, insulate itself from, and completely restrain the running rail, in both the horizontal and vertical planes, through the use of an anchor bracket and the following hardware:
 - 1. Three insulated plated bolt/heavy lock washer/hex nut assemblies, 1-1/4" diameter x 6-3/4" long, equally spaced within the rail web area, and appropriately sized to withstand rail and structure interaction forces. Bolts, washers, and hex nuts shall conform to ASTM Standard A490.
 - 2. Four anchor J-Bolt/heavy lock washer/hex nut assemblies, 1-1/2" diameter. The Contractor shall provide the required length to properly install the anchor based upon the plinth and anchor thicknesses. Top of anchor bolt assembly shall be a minimum of 1-7/8" below the proposed top of rail elevation and sized appropriately to withstand rail and structure interaction and thermal expansion forces.
 - 3. Two anchor angle bar assemblies, with mating surfaces contoured to fish properly with the web of the 115#RE running rail section.

2.05 SPECIAL HYDRAULIC BUMPING POSTS

- A. Bumping post to be of the hydraulic design, as previously manufactured by Western-Cullen-Hayes, or approved equal.
- B. Bumping posts to be sized appropriately to be capable of resisting a PAAC two car train, 300,000lbs. total weight, traveling at 10mph.
- C. Vertical centerline of bumping post strike head to be compatible with PAAC rail cars.
- D. Contractor to provide a bumping post bolt hole template to the Contract NSC-007 Contractor to allow required bumping post anchor bolts to be properly placed.
- E. All Anchor bolts to be included with hydraulic bumping post and provide to NSC-007 Contractor for placement and installation.

2.06 SLIDING BUMPING POST

- A. Sliding bumping post assemblies shall be installed at the end of each track, between Wood Street and Gateway Stations, prior to reaching the location of the temporary closure wall, placed by others.
- B. Location of bumping post in relation to temporary closure wall shall be as shown on the Contract drawings.
- C. Sliding bumping post assemblies shall be connected to the 115RE running rail by the use of bolted friction shoes and be suitable for direct fixation track construction.
- D. Overall size, bumping head height, and quantity of braking shoes required for bumping post shall be designed to withstand the forces and speed shown in section 2.05 B and 2.05 C above.
- E. Each sliding bumping post shall have two, temporary, bolted, insulated joints installed ahead of the bumping post assembly. The cost of these insulated joints shall be included in the unit cost of the sliding bumping post.

2.07 EMERGENCY GUARD RAIL – DIRECT FIXATION TRACK

- A. Steel: ASTM A36 (mill finish).
- B. Bolts and Threaded Parts: ASTM A307

ARTICLE 3 EXECUTION

3.01 INSTALLATION OF FIXED RAIL ANCHOR ASSEMBLIES

- A. Installation of the Fixed Rail Anchor assemblies must be coordinated with the NSC-007 Contractor so that the correct quantity, size, orientation, and layout of the required J-Bolts is achieved. J-Bolts are to be embedded in the structural slab and cast-in-place by others. J-Bolts are to be secure and vertical.
- B. Contractor to prepare demonstration rails to allow the NSC-007 Contractor to cast the J-Bolts in the correct placement. Demonstration rails shall be a minimum of 19'- 6" long, that are completely assembled with all pieces of the insulated fixed rail anchor assemblies, including all J-Bolts, and set to the proper gage and horizontal and vertical alignments. NSC-007 Contractor shall place concrete to the limits of his Contract (deck only). All work above the concrete deck shall be performed by the NSC-009 Contractor. Demonstration rails may be reused at multiple insulated fixed rail anchor assembly locations if preferred.
- C. The second pour track plinth concrete is to be poured around the J-Bolts.
- D. J-Bolts are to be of sufficient length to provide adequate excluded thread to install the anchor assembly in accordance with the Contract Drawings.

3.02 BUMPING POSTS

- A. Install all types of bumping posts as indicated on the Contract drawings and in accordance with the manufacturers installation instructions.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the non-guard rail type insulated joint portion of the work of this Section.
- B. No separate measurement shall be made for the guard rail type insulated joint portion of the work of this Section.
- C. No separate measurement shall be made for the bolted joint portion of the work of this Section.
- D. No separate measurement shall be made for the rail fastening assembly portion of the work of this Section.
- E. No separate measurement shall be made for the emergency guard rail portion of the work of this Section.
- F. Item 02456.001-Insulated Fixed Rail Anchor Assemblies shall be measured per each, complete in place.
- G. Item 02456.002-Special Hydraulic Bumping Posts shall be measured per each, complete in place.
- H. Item 02456.004-Sliding Bumping Posts shall be measured per each, complete in place.

4.02 PAYMENT

- A. No separate payment will be made for the non-guard rail type insulated joints portion of the work of this Section. Payment for such portions of the work shall be included in the payment for related portions of the Work.
- B. No separate payment will be made for the guard rail type insulated joints portion of the work of this Section. Payment for such portions of the work shall be included in the payment for related portions of the Work.

- C. No separate payment will be made for the bolted joints portion of the work of this Section. Payment for such portions of the work shall be included in the payment for related portions of the Work.
- D. No separate payment will be made for the rail fastening assembly portion of the work of this Section. Payment for such portions of the work shall be included in the payment for related portions of the Work.
- E. No separate payment shall be made for the emergency guard rail portion of the work of this Section. Payment for such portions of the work shall be included in the payment for related portions of the Work.
- F. Item 02456.001-Insulated Fixed Rail Anchor Assemblies will be paid at the unit price and shall include the cost of all related work specified in this Section.
- G. Item 02456.002-Special Hydraulic Bumping Posts will be paid at the unit price and shall include the cost of all related work specified in this Section.
- H. Item 02456.004-Sliding Bumping Posts will be paid at the unit price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 02462
DIRECT FIXATION RAIL FASTENERS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The Work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for Direct Fixation Rail Fasteners, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. The designing, manufacturing, and testing of high restraint direct fixation fasteners for standard trackwork and low restraint fasteners for special trackwork, including rail clips and anchors.
- C. The Contract Documents provide the performance parameters and design criteria to complete the Direct Fixation Rail Fastener portion of the Work. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 02452, "Direct Fixation Track Construction."
- B. Section 02453, "Special Trackwork Construction."

1.03 REFERENCED DOCUMENTS

- A. American Railway Engineering and Maintenance Association (AREMA): Portfolio of Trackwork Plans: Specification for Special Trackwork.
 - 1. Association of American Railroads (AAR): Signal Section 13- 52, Part 58, Hard Fiber.
 - 2. American Society for Testing and Materials (ASTM)
 - a. A36 Structural Steel.
 - b. A148 High Strength Steel Castings for Structural Purposes.
 - c. B633 Electrodeposited Coatings of Zinc on Iron and Steel.
 - d. D395 Rubber Property - Compression Set.
 - e. D412 Rubber Properties in Tension.
 - f. D429 Adhesion Testing-Method B
 - g. D471 Rubber Property - Effect of Liquids.
 - h. D518 Rubber Deterioration - Surface Cracking.
 - i. D573 Rubber Deterioration in an Air Oven.
 - j. D1149 Rubber Deterioration - Surface Ozone Cracking in a Chamber (Flat Specimen).

- k. D1229 Rubber Property - Compression Set at Low Temperature.
- l. D2240 Rubber Property-Durometer Hardness
- m. E162 Flame Propagation
- 3. Industrial Fasteners Institute's Standards (IFIS)
 - a. IFI 100.
 - b. IFI 101.
- 4. National Electrical Manufacturers Association (NEMA): LI-1- 1971 Fiber Washers and Sleeves.
- 5. National Fire Protection Association (NFPA): No. 258-T, Smoke Generated by Solid Materials Test (1974).

1.04 SUBMITTALS

- A. The following shall be submitted:
 - 1. Shop Drawings
 - a. Indicate relationship of fastener and all significant components of the testing equipment, including the test block and anchor assemblies.
 - b. Indicate complete details of special trackwork.
 - c. Show special rail fasteners complete with rail braces, riser plates, rail fastenings, rail stops, elastomer, and anchorage assembly.
 - d. The Contractor's design drawings shall be sealed by a Professional Engineer registered in the State of Pennsylvania.
 - 2. Detailed description of all test procedures.
 - 3. Assembly and installation instructions: Furnish manufacturer's printed recommendations.
 - 4. Method of unloading and stacking materials: Submit sixty (60) days prior to scheduled date of first delivery.
 - 5. Copies of all certification, qualification and production tests.
 - 6. Samples: Special direct fixation rail fasteners: Two (2) for each cycle of qualification testing. Standard direct fixation rail fasteners: Two (2) for each cycle of qualification testing.
 - 7. Qualifications of Independent Testing Laboratory
- B. Six copies of each of the following shall be submitted:
 - 1. Metal components of the rail fasteners.
 - a. Mill certification of conformance to specifications for the following requirements:
 - 1) Chemical constituents: Allowable maximum percentages.
 - 2) Hardness.
 - 3) Physical requirements: Allowable defects.
 - b. Analysis reports: Certified statements of results of specified tests.
 - 2. Elastomer: Certificate of conformance to specified test requirements.
 - 3. Electrical insulating materials: Certificates of conformance to specified requirements.
 - 4. Rail fastener assemblies: Certificates of conformance that fasteners have passed the specified tests.

5. Reports of results of specified tests
6. Quality control program: Evidence of fabrication plant qualifications.

1.05 [NOT USED]

1.06 [NOT USED]

1.07 QUALITY ASSURANCE

A. Design Criteria for High Restraint Direct Fixation Fasteners Including Anchorage

1. Function
 - a. Secure and distribute loads of 115RE rail and special trackwork to concrete track bed.
 - b. Provide vertical and lateral stability to the rail.
 - c. Restraine rail from movement in longitudinal direction.
 - d. Dampen vibrations generated by moving wheels on the rail.
 - e. Electrically insulate rail from track bed.
2. Parts
 - a. Have as few components as economically and technically feasible to facilitate assembling, disassembling, and maintaining in the field by means of standard hand tools.
 - b. Standard direct fixation fastener top plates shall be a minimum of $\frac{1}{2}$ " thick, bottom plates shall be a minimum of $\frac{3}{16}$ " thick. Plates shall be of ductile iron casting or steel and shall be vulcanize bonded into a singular fastener body with a minimum elastomer thickness of $\frac{5}{8}$ ". Rail clip holder shall be integral with the top plate. There shall be a positive means (other than by friction) of preventing lateral movement of the rail in relation to the fastener body.
 - c. Special trackwork direct fixation fastener top plates shall be steel with a thickness not less than $\frac{1}{2}$ ". The plate shall be vulcanize bonded with all other components into a single fastener body with a minimum elastomer thickness of $\frac{5}{8}$ ". Rail clip holder shall be fixed to the top plate. There shall be a positive means of preventing lateral movement of the rail in relation to the fastener body, except for lateral adjustment of the rail.
3. Accommodation of rail removal: Design rail fastener to permit the release of rail fastening system so that rail may be removed by raising rail vertically until it is completely free of fastener without disturbing the horizontal or vertical alignment of the fastener.
4. Accommodation of fastener removal: Design rail fastener and anchorage system to permit the removal of in-place fasteners without raising the rail by more than 3".
5. Type of anchorage assemblies
 - a. Embedded in concrete
 - 1) Anchor bolt: Steel conforming to SAE J429, Grade 5, $\frac{7}{8}$ " diameter, 9 UNC Class 2A threads electroplated with zinc in accordance with

- ASTM B633, Type III, SC2, and length sufficient to provide 2" thread engagement in insert;
- 2) Washers: Self-locking type, 7/8" diameter, steel; Disc-Lock, or accepted equivalent.
 - 3) Insert: Steel conforming to SAE J429, Grade 5, Type III, SC2, 7/8" diameter, 9 UNC Class 2B internal threads and 2" of thread engagement for anchor bolt; female type, not shorter than 5' or longer than 5-1/2", and have nonwelded collar and rotation prevention device or shape; with nylon or plastic pull away type plug.
6. Rail fastening system
- a. Rail fasteners employing non-threaded rail hold-down assemblies, except special trackwork fasteners, shall provide on each side of the rail base a positive means of preventing more than 1/8" total lateral movement of the rail base relative to the fastener, in event of failure or loosening of one (1) or both hold-down assemblies. Fasteners which employ threaded elements in the rail hold-down assembly, except special trackwork fasteners, shall not permit more than 1/8" total lateral movement of the rail base relative to the fastener, when the threaded elements are finger tight.
 - b. Threaded elements
 - 1) Strength: ASTM A325 Type 1.
 - 2) Nominal diameter: 3/4"
 - 3) Thread: 9 UNC Class 2A fit
 - 4) Nut: Self-locking hex head threaded 9 UNC Class 2B fit, torque nut conforming to IFI-100 and IFI-101.
 - 5) Washer: Self-locking type, 3/4", steel; Disc- Lock, or accepted equivalent.
 - 6) Bolt threads: Electroplated cadmium coated per ASTM A165 Type I.
7. Lateral rail adjustment
- a. Design rail fastener so that lateral adjustment of rail for specified increments is made by a method which does not require removal, substitution or addition of component to fastener.
8. Rail restraint: Design fastener so that the longitudinal and lateral rail restraint properties of the fastener assembly shall be identical in both directions respectively in all positions of the rail on the fastener.
9. Compressive strength of elastomer: Design fastener so that the compressive strain on the elastomer does not exceed twenty-five percent (25%) of its compressive thickness for a load of 15,000lbs. applied vertically to the rail in fully assembled fastener.
10. Bearing: Design rail fastener so that
- a. Fastener has full bearing on elastomer for each specified position of lateral adjustment.
 - b. Elastomer when installed in fastener assembly shall not be displaced under a "no load" condition.
11. Configuration: Design the rail fastener so that:
- a. The fastener assembly rail seat shall be steel or ductile iron for standard fasteners and steel for special trackwork fasteners, continuous and shall

- impart a 1:40 cant to rail in standard track and no cant within special trackwork. Underside of the fastener base is flat and parallel to the plane of the rail seat and without projections into concrete or tie.
- b. Distance as installed, from base of anchor hold-down bolt head to the base of the fastener shall not exceed 2-1/2". The overall vertical distance between base of rail and base of fastener shall be at least 1-3/8" and not more than 2-3/16".
 - c. Overall dimensions of the fasteners, including the elastomer, shall be not less than 7" nor wider than 8" measured parallel to the rail and vary in length, not shorter than 15" or longer than 16" for standard fasteners (66" for special trackwork fasteners) measured normal to the rail.
 - d. Rail fastener shall be designed to provide for a minimum of two (2) anchorage assemblies; sized to accommodate 7/8" diameter anchor bolts when anchored in concrete. Center of anchor shall not be closer than 1-1/4" from each edge of fastener.
 - e. Each rail fastener shall provide a means of lateral adjustment having a minimum range of plus or minus 1/2" in increments of 1/8". Lateral or longitudinal stability of rail shall not be reduced in any adjusted position. Friction alone shall not be used as a means of adjustment.
 - f. Each rail fastener shall provide an electrical leakage distance of not less than 1/2" under all load conditions, measured from ground portion of fastener in direct contact with the rail by the most direct path that does not pass through insulating material.
 - g. To the extent possible, the leakage distance path shall be without recesses or other geometric configurations capable of collecting and holding moisture, dust or other materials creating a conductive path to ground.
12. Elastomer: Determine all dimensions affecting the shape of the elastomer in the rail fastener to ensure complete conformance to the specified physical requirements.
- B. Allowable deviations from indicated plate dimensions
- 1. Thickness: 1/32".
 - 2. Straightness: Using a 36" straightedge oriented in any direction 1/32".
 - 3. Hole diameters 1/32".
 - 4. Hole centerline locations 1/16".
 - 5. Deviation from straightness of edges of riser plates parallel and adjacent to base of rail: 1/32".
 - 6. Deviation from over-all planar dimensions: 1/8".
- C. Testing of standard and special Direct Fixation Rail Fasteners: In lieu of qualification testing of rail fastener assemblies, Contractor may submit for Engineer approval, certification by an independent testing laboratory stating that fasteners have passed the tests specified in this Article, within the last ten (10) years of the Contract date or equivalent tests and that fasteners comply with design criteria as specified.

1. Standard fastener, model F20R4, and special trackwork fastener, "H" Series, as manufactured by L.B. Foster, Transit Products division are acceptable subject to the approval of submittals required under Article 1.04 of this Section.
- D. Qualification Testing:
 1. Submit for Engineer approval prior to fabrication and testing, Shop Drawings detailing fasteners and detailed description of steps required for their complete installation as well as their replacement or individual components and detailed description of all tests.
 2. Arrange testing to be performed by a testing facility and in accordance with procedures approved by Engineer at no additional expense to Authority. Testing may be performed at Contractor's facility providing that facilities and testing procedures meet the approval of the Engineer.
 3. All testing performed by Contractor shall be witnessed by a representative provided by Engineer.
 4. Method of selection: At random equal numbers of fasteners from the initial lot of fifteen (15) fasteners produced.
 5. Quantity of fasteners selected: Four (4) each of the fasteners. If additional fasteners are necessary they shall be furnished at no additional cost to Authority.
 6. Visual inspection: Measure and examine each of the fasteners from the initial lot of fasteners produced for conformance with specifications and in compliance with Engineer approved Shop Drawings.
 7. Complete assembly test
 - a. Clean and dry components of test assembly.
 - b. Assemble one (1) complete rail fastener and mount to a section of 115RE rail not shorter than 12".
 - c. Mount test assembly on concrete block, having compressive strength of not less than 4,000psi; secure test assembly to the block by the anchorage assembly as specified in 1.07A.5.a of this Section to simulate actual field installation.
 - d. Immediately prior to starting tests, stabilize temperature of fasteners at 68 degrees F, plus or minus 2 degrees F.
 - e. Perform testing only when ambient temperature is 68 degrees F, plus or minus 2 degrees F unless otherwise specified.
 - f. If a single rail fastener is unstable for test purposes, mount two (2) complete fasteners on a section of 115RE rail not less than 12" long with not less than 1" longitudinal separation between the fasteners, and apply double the test load at a point midway between the two (2) fasteners.
 8. Sequence of tests on assembled rail fasteners: Four (4) rail fasteners designated as fasteners A, B, C, and D shall be assembled and mounted as specified in Article 1.07D.7 and shall be subjected to the following sequence of performance tests.
 - a. Rail fasteners A, B, C, and D: Subject each rail fastener to the static tests specified in Articles 1.07D.10 through 1.07D.16 and the Dynamic to Static Stiffness Ratio Test as specified in Article 1.07D.22. Rail fastener B shall then be subjected to the Corrosion Test as specified in Article 1.07D.23.

- b. Rail fastener A: Subject rail fastener to the Vertical and Lateral Repeated Load Test as specified in Article 1.07D.17 and then retest rail fastener through each of the static tests specified in Article 1.07D.8.a above, without replacement of any component. Do not disassemble rail fastener from the rail after the Repeated Load Test With One Anchor as specified in Article 1.07D.18 and do not reposition any rail clip.
 - c. Rail fastener B: Subject rail fastener to the Heat Aging Test as specified in Article 1.07D.19 and then retest rail fastener through each of the static tests specified in Article 1.07D.8.a above, without replacing any component.
 - d. Rail fastener C: Subject rail fastener to the Heat Aging Test as specified in Article 1.07D.19, and then retest rail fastener as specified in Article 1.07D.20, Uplift Repeated Load Test. Retest rail fastener through each of the static tests specified in Article 1.07D.8.a above, without replacing any component.
 - e. Rail fastener D: Subject rail fastener to the Push-Pull Test as specified in Article 1.07D.21, and then retest rail fastener through each of the static test specified in Article 1.07D.8.a above, without replacing any component. For the Longitudinal Restraint Test, specified in Article 1.07D.14, rail fastener shall not be disassembled from the rail after the Push-Pull Test, nor shall the rail hold-down assemblies be repositioned.
9. Qualification failure: Should any fastener fail a test, the entire sequence of tests as specified in Article 1.07D.8 shall be performed on a new rail fastener of the same size. If the rail fastener must be modified to pass any tests, Working Drawings of the new rail fastener design shall be submitted for Engineer approval. A new lot of at least fifteen (15) rail fasteners, including at least four (4) that are 33 1/2" or longer, of the new design shall be produced and all tests performed on the new rail fastener design. This cycle shall be continued until rail fasteners are approved, but no longer than four (4) months after receipt of Notice to Proceed. The cost of all such additional testing of any component that does not comply with the Contract Documents shall be at the Contractor's expense.
10. Vertical load test
- a. Total test load: 15,000lbs. developed in increments of 900lbs.
 - b. Point of application: Downward at centerline of the fastener normal to rail head.
 - c. Test procedure
 - 1) For each load increment, measure continually and record immediately the vertical deflection of the rail head to the nearest 1/64".
 - 2) Remove load and measure and record the final position of the rail head.
 - 3) Plot record values for vertical loads against deflection on a graph.
 - d. Test acceptance criteria
 - 1) Slope of the load-deflection curve (spring rate of fastener): Not less than 120lbs per inch nor more than 300lbs per inch. Constancy of slope: Within ten percent (10%) over the load range.
 - 2) Recovery of fastener to original position: within 1/2" within one (1) minute.

- 3) Stability: No movement of components caused by other than deflections, and no visual sign of failure by slippage, yielding, or fracture.
- 4) Ratio of deflection to thickness of elastomer:
 - a) Maximum value for initial test: 4 to 1 or twenty-five percent (25%).
 - b) Basis of determination: the deflection measured at 15,000lbs divided by thickness of elastomer in inches; not to exceed twenty-five percent (25%) of elastomer thickness.
 - c) Value for repeated tests on same fastener: within twenty percent (20%) of initial test values.

11. Vertical uplift test

- a. Test loads: Increasing in increments of 190lbs alternated upward and downward, apply up to 2,000lbs pounds total uplift load.
- b. Point of application: Center of the rail head along the centerline of the fastener.
- c. Test procedure
 - 1) Continually measure and immediately record the loads and corresponding deflections to the nearest 1/64" on a load versus time graph, and a deflection versus time graph, respectively.
 - 2) Remove load, and measure and record the final position of the rail head.
 - 3) Apply reaction force to the concrete test block to which the fastener is anchored.
- d. Test acceptance criteria
 - 1) Ratio of the deflection for the total uplift test load to the deflection for the total vertical downward test load: Shall not exceed two-hundred percent (200%) for special rail fasteners and between plus five percent (5%) and plus one-hundred, twenty-five percent (125%) for standard rail fasteners of the deflection for a 2,000lb downward vertical load as determined from the vertical load test.
 - 2) Stability: No indication of backlash and freeplay when the vertical load is continuously varied from vertical upwards to vertical downwards.
 - 3) Recovery of fastener to original position: within 1/2" within one (1) minute after application of the 2,000lb upward test load and again after application of the 2,000lb downward test load.

12. Lateral load test

- a. Test load: Increasing in increments of 900lbs, apply up to 7,500lbs horizontally to rail head while under a constant vertical load downward at center line of rail head of 13,500lbs.
- b. Point of horizontal load application: 5/8" below top of rail along the centerline of the fastener normal to the rail.
- c. Test procedure
 - 1) Continuously measure and immediately record the lateral deflection of the rail head. Plot recorded values for lateral loads versus deflection on a graph.
 - 2) Remove lateral load, and measure and record the final position of the rail head.

- d. Test acceptance criteria
 - 1) Maximum lateral deflection for 4,000lb lateral test load: 1/8".
 - 2) Maximum lateral deflection for 7,500lb lateral test load: ¼"
 - 3) Maximum difference between original and final position of the rail head: 1/16"
 - 4) Stability: No visual signs of failure by slippage, yielding or fracture during testing.

13. Lateral restraint test

- a. Set load: Lateral load increasing in increments of 450lbs, from zero to 2,500lbs.
- b. Test loads: Two (2) equal lateral loads increasing simultaneously in increments of 450lbs, from zero to 2,500lbs.
- c. Point of application: Normal to and at base of rail, symmetrically on each side of the fastener centerline and within limits of fastener.
- d. Test procedure: Apply and release set load; set deflection indicators at zero; apply test loads; and measure and record, after each increment of loading, the deflection at the intersection of the centerline of the fastener and the gauge line of the rail to the nearest 1/64".
- e. Test acceptance criteria
 - 1) Maximum lateral deflection of rail when fully loaded: 1/8".
 - 2) Maximum difference between the original and final positions of the gauge line: 1/16".
 - 3) Stability: No visual signs of failure by slippage, yielding or fracture during testing.

14. Longitudinal restraint test (High Restraint Fasteners Only)

- a. Rail end support: Roller or other frictionless support properly elevated to prevent the longitudinal load from binding the rail to the fastener.
- b. Test load: Increments of 180lbs, increased to 10,000lbs for special fasteners and 3,000lbs for standard fasteners or until rail deflects 5/8" from its original position, whichever occurs first. The rate at which load is applied shall be between 90lbs and 900lbs per minute.
- c. Point of test load application: longitudinally to the rail at its centroid.
- d. Duration per increment of test load: until longitudinal deflection of rail ceases.
- e. Procedure
 - 1) Mark rail and rail clip at a point common to both.
 - 2) Measure and record the longitudinal deflection for each load to the nearest 1/64".
 - 3) Remove the longitudinal load and measure and record the final position of rail.
 - 4) Plot the recorded values for longitudinal loads against deflection.
- f. Test acceptance criteria
 - 1) Difference between original and final rail position: not more than 1/8", plus slippage between rail clip and rail.
 - 2) Stability: No visual yields, fractures, bond failures, and slippages during and after test, except slippage that may occur between rail clip and rail.

15. High voltage withstand test

- a. Effect of high voltage on quality of elastomer
 - 1) Procedure: Place ground plate between rail fastener and concrete test block. Apply a DC potential of 15KV between rail head and ground plate for one (1) minute.
 - 2) Acceptance criteria: neither cracks, pinholes, electrical flashover, or arching nor fracture to occur.

16. Electrical resistance and impedance test

- a. Dry resistance
 - 1) Remove moisture, if any, from rail fastener assembly and with one (1) lead of high potential tester connected to rail head and ground lead connected to anchor bolt, apply 500 volts DC for three (3) minutes. Use the current value obtained to calculate resistance.
 - 2) Acceptable resistance to 500 volts DC: not less than 10 megohms.
- b. Wet resistance
 - 1) Release ground plate, rail fastener, and anchorage assembly from concrete test block and rail; immerse rail fastener in distilled water for seventy (70) hours at 212 degrees F for neoprene based elastomers and for three-hundred, thirty-six (336) hours at 158 degrees F for natural rubber based elastomers.
 - 2) After rail fastener has been removed from water without drying and with no portion of the rail fastener cooler than 95 degrees F, reassemble and anchor ground plate, rail fastener, and rail on the concrete test block.
 - 3) Connect one (1) lead of high potential tester to rail head and ground lead to anchor bolt, apply 500 volts DC for three (3) minutes and test for electrical resistance. Use current value obtained to calculate resistance.
 - 4) Allowable resistance: not less than 1 megohm.
- c. Wet impedance
 - 1) With the rail fastener assembly still wet and with no portion of the assembly cooler than 95 degrees F, apply a potential of 50 volts AC between rail head and grounded anchor bolt.
 - 2) After reading has stabilized for thirty (30) seconds, measure impedance frequencies of 1,000; 2,000; 4,000; 6,000; 8,000; and 10,000 hertz within an accuracy of plus or minus two percent (2%) and recorded for each frequency.
 - 3) Impedance for frequencies between 20 Hz and 5 KHz with 50 volts AC shall be 10,000 ohms; at 6 KHz shall be 9,000 ohms, at 8 kHz shall be 7,000 ohms, and at 10 kHz shall be 6,000 ohms.

17. Vertical and lateral repeated load test

- a. Procedure
 - 1) Apply test loads to the rail head, so as to produce a vertical downward load of 13,500lbs and lateral loads 5/8" mm below top of rail and along the centerline of the rail fastener normal to the rail of 4,900lbs to the gauge side and 3,200lbs to the field side.
 - 2) Alternate the lateral loads and combine with alternated application and release of the vertical load for a total of 3 million complete cycles. (One

- cycle consists of one (1) application each of the lateral field side load and of the gauge side load and two (2) applications of the vertical load).
- 3) Regulate the frequency to prevent the temperature of the components from exceeding 158 degrees F.
 - 4) Do not retorque the threaded elements subsequent to the completion of 500,000 cycles of loading without written approval of the Engineer.
- b. Acceptance criteria
 - 1) Minimum cycles of test load application with no visual evidence of failure: Three (3) million.
 - 2) Allowable visual failure by slippage, yielding abrasion, or fracture at any time during the test: None.
18. Vertical and lateral repeated load test with one (1) anchor test
- a. Procedure
 - 1) After completion of Vertical and Lateral Load Test as specified in Article 1.07D.17, reassemble rail fastener using only the original components subjected to testing.
 - 2) Apply the Vertical and Lateral Repeated Load Test with gauge side anchor bolt removed for 15,000 cycles.
 - b. Acceptance criteria: minimum cycles of application with no visual evidence of failure by slippage, yielding or cracking: 15,000 cycles.
19. Heat aging procedure
- a. Test specimen: fully assembled rail fastener, except that the anchor bolts need not be installed.
 - b. Procedure: age test specimen in an air oven for a period of seventy (70) hours at a temperature of 212 degrees F (158 degrees F for natural rubber fasteners) in accordance with ASTM D573.
 - c. Acceptance criteria: none, the purpose being to age the rail fastener for additional testing.
20. Uplift repeated load test
- a. Test loads
 - 1) Apply loads to the rail head so as to produce a vertical downward load of 11,900lbs and a vertical upward load of 2,000lbs at the centerline of the fastener in a direction normal to the rail.
 - 2) Longitudinal load: starting at 100lbs and increasing in increments of 100lbs up to a maximum load of 600lbs, at interval of not less than one (1) increment per 100 cycles of vertical loading.
 - b. Test procedure
 - 1) Alternate the upward and downward loads for 1.5 million cycles.
 - 2) Regulate the frequency to prevent the temperature of components of the test specimen from reaching 158 degrees F.
 - 3) Do not retorque threaded elements subsequent to 500,000 loading cycles without written approval of the Engineer.
 - 4) During the final 500,000 loading cycles of vertical loading, apply the longitudinal load at centroid of rail as specified above and apply the vertical load at a rate of not less than 25 cycles per minute.

- 5) For each load increment, measure the longitudinal deflection of the rail to the nearest 1/64" and record.
 - 6) Remove the longitudinal load and measure and record the final position of the rail. Plot the recorded values for the longitudinal load versus deflections on a graph.
- c. Test acceptance criteria
 - 1) The rail fastener shall withstand 1.5 million cycles of load application with no evidence of failure.
 - 2) Upon visual inspection, no component of the rail fastener shall exhibit any evidence of failure by yielding, abrasion, or fracture.
 - 3) The rail shall exhibit no visual evidence of wear or grooving that would contribute to a failure of the rail.
 - 4) The plot of the loads versus deflections for the longitudinal load portion of the test shall show that movement of the rail was due to the elastic deformation and not slippage of the rail through the rail fastener.
21. Push-pull test
 - a. Test load: 4,200lb cycling longitudinally or sufficient load to move rail plus or minus 1/8".
 - b. Points of application: Centroids of the rail at both ends.
 - c. Procedure
 - 1) Push and pull with the test load for 1 million complete cycles.
 - 2) Repositioning or retorquing of the rail hold-down assembly will be allowed after every 250,000 cycles but not for the last 250,000 cycles.
 - d. Test acceptance criteria: rail fastener shall withstand 1 million cycles of loading with no evidence of failure. Upon visual examination no component of the rail fastener shall exhibit any evidence of failure by yielding, abrasion, slippage or fracture. The rail shall exhibit no evidence of wear or grooving contributing to a failure of the rail.
 22. Dynamic to static stiffness ratio test
 - a. Initial static vertical downward test load: 5,000lbs to deflect the fully assembled fastener .
 - b. Rate of application: 10 cycles per second.
 - c. Procedure
 - 1) Apply initial dynamic vertical downward test load to the rail head over the centerline of fully assembled rail fastener for 1,000 cycles.
 - 2) Increase the dynamic test load in increments of 1,000lbs up to a total of 12,000lbs maximum. Record the dynamic load corresponding to each load increment.
 - 3) Immediately after completing the dynamic load measurements, measure and record the static deflection of 2,250lb increments, for loading of 5,400lbs to 12,150lbs. Allow rail fastener to stabilize for at least one (1) minute before each increment of testing is applied.
 - 4) Measure the deflections within an accuracy of 5/1000", and measure the test loads within an accuracy of two and a half percent (2.5%).
 - d. Test acceptance criteria: The dynamic and static stiffness shall each be calculated by dividing the difference between each increment of recorded

loads by the respective difference between each increment in recorded deflections. The ratio of dynamic to static stiffness shall then be determined by dividing the mean of dynamic stiffness by the mean of the static stiffnesses. The ratio shall not exceed 1.5 for neoprene and 1.4 for natural rubber.

23. Corrosion test

- a. Test procedure: Rail fastener body unit without loose components shall be exposed to a five percent (5%) chloride solution per ASTM B117 for one-thousand (1,000) hours.
- b. Test acceptance criteria: There shall be no loss of adhesion from this test at any elastomer and steel boundary deeper than 1/8" nor shall there be pitting or corrosion depressions deeper than 1/16" measured from plane of the affected surface.

24. Elastomer

- a. General: Have elastomers certified by an independent testing laboratory approved by the Engineer to possess the physical properties specified in the following tabulation as determined by the respective ASTM specifications identified therein.
 - 1) Test material: Two specimens certified by the accepted independent testing organization to have been taken from a batch of compound used for producing the elastomer component of the fastener and having the same quality cure equivalent to the quality cure of the elastomeric component.
 - 2) Test preconditioning: Not less than seven (7) days at 73 degrees F, at 50 percent relative humidity.
- b. For testing purposes under this article, the following distinction is made between neoprene and natural rubber:
 - 1) Natural rubber: Elastomers containing more than 50% natural rubber.
 - 2) Neoprene: Elastomers containing 50% or more neoprene.
- c. General test requirements for all elastomer materials

<u>Test</u>	<u>ASTM Designation</u>	<u>Requirements</u>
Durometer hardness (Shore A)	D2240	50 plus or minus 5
Ultimate elongation	D412	350 percent minimum
Compression set at minus 50 degrees F. for 70 hours to determine per- cent compression set 30 minus after release of test load	D1229	60 percent maximum

Resistance of ozone cracking of specimens prepared in accordance with Procedures A of ASTM D518 and subjected to 104 degrees F for 100 hours in 50 ppm ozone concentration	D1149	No cracking
<u>Test</u>	<u>ASTM Designation</u>	<u>Requirements</u>
Change in Durometer hardness	D573	10 points maximum
Adhesion of metal test	D429 Method B	Elastomer tears before
Flame propagation index (Is)	E162	Acceptance criteria not specified but report test results to Engineer. Allowable drippings: none
Smoke generation	NFPA No. 258-T	Acceptance criteria not specified, but report test results to Engineer.

d. Neoprene elastomer, additional test requirements

High temperature compression set after 22 hours at 212 degrees F	D395 Method B	35 percent maximum
Tensile strength	D412	10340 KPa minimum
Accelerated aging after 70 hours at 212 degrees F		
Decrease in tensile strength	D573	15 percent maximum
Decrease in ultimate	D573	40 percent

elongation Oil absorption test at 212 degrees F for 70 hours ASTM Oil No. 3	D471	maximum 100 percent maximum
ASTM Oil No. 1	D471	Minus 10 percent plus 20 percent

e. Natural rubber elastomer, additional test requirements

<u>Test</u>	<u>ASTM Designation</u>	<u>Requirements</u>
High temperature compression set after 22 hours at 158 degrees F	D395 Method B	25 percent maximum
Tensile strength	D412	15800kPa minimum
Accelerated aging 70 hours at 212 degrees F		
Decrease in tensile strength	D573	25 percent maximum
Ultimate elongation	D573	25 percent maximum
Change in hardness, measured on the Duro-meter A Scale		10 points maximum
Oil absorption volume change at 212 degrees F for 70 hours		
ASTM No. 3 Oil	D471	100 percent
ASTM No. 1 Oil	D471	Minus 10 percent plus 20 percent

- E. Production and production testing: Upon Engineer approval of qualification testing as specified in Article 1.07D, Contractor shall begin production of the fasteners. Contractor shall provide qualification tests which were completed no more than ten years before this Contract date. Contractor shall certify that all rail fasteners

produced were manufactured in the same manner as the rail fasteners subjected to the Qualification Testing and that the manufacturing process used for producing each rail fastener is the same.

The Contractor shall perform production testing on two randomly selected fasteners from the first 50 fasteners produced and each 2,000 fasteners, or fraction of, produced thereafter as follows:

1. Static tests: Articles 1.07D.10 through 1.07D.16 of this Section.

F. Identification: Subsequential lot number, Contractor's name or trademark, and consecutive numbers on each size of rail fastener shall be marked in a permanent manner.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. The standard Direct Fixation Rail Fastener shall be a Model F20R0 by L.B. Foster, Transit Products Division or an approved equal that complies with this Section
- B. Special trackwork direct fixation fasteners shall be "H" Series Fasteners by L.B. Foster, Transit Products Division or an approved equal that complies with this specification.
- C. All Direct Fixation Rail Fasteners bodies shall be of a molded, one piece design.
- D. Two (2) Pandrol e-2055 right hand rail clips shall be used to attach rail to fastener except at locations where joint bars, strap guard rail, bolts or other track elements interfere with the proper installation of the "e" clips. At such locations, "c" clips or other modified Pandrol clips shall be used on one or both sides of the rail as required. All rail clips shall be fully galvanized.
- E. Special trackwork rail braces shall be adjustable, bolt-down type, installed on special trackwork direct fixation fasteners. Rail braces shall be used at all locations shown in the AREMA Base Plans for Split Switches.

ARTICLE 3 EXECUTION

3.01 MANUFACTURE, TEST, AND DELIVER RAIL FASTENER ASSEMBLIES

- A. As specified, and in accordance with the accepted Shop Drawings.
- C. The Contractor shall review the typical concrete plinth sizes for tangent track, curved track, and special trackwork shown on the Contract Drawings. Should the

concrete plinths require adjustments in size due to the design size of the direct fixation fasteners, the Contractor shall provide the plinth sizes, layout and necessary reinforcing required at no additional cost to the Authority. Show any size deviations on the Shop Drawings.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

**SECTION 02464
SPECIAL TRACKWORK**

ARTICLE 1 GENERAL

1.07 SUMMARY

- A. The Work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for special trackwork, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Manufacturing, testing, shop assembly and delivery to the Worksite of special trackwork and spare parts.
- C. The Contract Documents provide the performance parameters and design criteria to complete the Special Trackwork portion of the Work. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 02450, "General Track Construction."
- B. Section 02452, "Direct Fixation Track Construction."
- C. Section 02453, "Special Trackwork Construction."
- D. Section 02462, "Direct Fixation Rail Fasteners."
- E. Section 02466, "Steel Rail."
- F. Section 02468, "Rail Welding."
- G. Section 02456, "Track Appurtenances and other Track Material."
- H. Section 02471, "Track-to-Earth Resistance Testing."
- I. Section 13574, "Wayside Signal Equipment."

1.03 REFERENCE STANDARDS

- A. American Railway Engineering and Maintenance Association (AREMA) Latest Edition, Manual for Railway Engineering and the AREA Portfolio of Trackwork Plans.

- B. American National Standards Institute (ANSI).
 - 1. B18.22.1, Plain Washers.
- C. American Society for Testing and Materials (ASTM).
 - 1. A36 Structural Steel.
 - 2. A148, High-Strength Steel Castings for Structural Purposes.
 - 3. A307, Carbon Steel Externally Threaded Standard Fasteners.
 - 4. A325, High-Strength Bolts for Structural Steel Joints.
- D. National Electrical Manufacturer's Association (NEMA): LI-1, Industrial Laminated Thermosetting Products
- E. Association of American Railroad (AAR).

1.04 SUBMITTALS

- A. Shop Drawings, Product Data, and Samples: Contractor shall submit the following:
 - 1. Shop Drawings showing:
 - a. Insulated curved split switch section including stock rails for both right and left hand switches (including house top guarded switch points, manganese switch point inserts, and floating heel blocks)
 - b. Railbound manganese steel frogs.
 - c. Solid Manganese Steel Frogs
 - d. Closure rails.
 - e. Crossover connecting rails.
 - f. Tangent offset tables.
 - g. Strap guard rails.
 - h. Layout and details of direct fixation fasteners including concrete plinth locations and sizes, rail braces, gauge plates, rail fasteners clips and miscellaneous parts for both right and left hand switches, turnouts, crossovers and crossings.
 - i. All switch point details, plates, castings, floating heel blocks, rails, switch rods and miscellaneous parts.
 - j. Complete layouts and details for all types of right hand turnouts, left hand turnouts, single crossovers and double crossovers, including switch machines, switch rods, and lugs.
 - k. Contractor shall determine all special trackwork rail lengths and show on shop drawing.
 - l. The Contractor's design drawings shall be sealed by a Professional Engineer registered in the State of Pennsylvania.
 - 2. Product Data: Submit the procedure to be used in the depth hardening of frog castings.
- B. Certificates and Reports: Contractor shall submit the following:
 - 1. Certificates of material compliance required by AREMA and this Specification.

2. Test reports of chemical analyses, Brinell hardness, electrical insulation and other tests required by AREMA and the Contract Documents.
3. Frog depth hardening results.

1.05 DEFINITIONS

(NOT REQUIRED)

1.06 ENVIRONMENTAL REQUIREMENTS

(NOT REQUIRED)

1.07 QUALITY ASSURANCE

- A. Quality Assurance Program: Contractor shall refer to Section 02450 "General Track Construction" and conform to the requirement of the Quality Assurance Program.
- B. Special Trackwork shall conform to the AREMA "Specifications for Special Trackwork" and the Contract Documents.
- C. Rail: Conforming with Section 02466, "Steel Rail" except as noted in this Section.
- D. Tolerances: Conform with the AREMA "Portfolio of Trackwork Plan No's. 1010 and 1011, Permissible Variations in Completed Frogs and Switches," respectively.
- E. Source Quality Control: Test insulated gauge plates and switch rods in accordance with AAR Manual, Part 116 Signal Section, "Assembly and Test of Insulated Track Fittings."
- F. Pre-assembly
 1. Shop assemble, test and operate, all Special Trackwork units for inspection by Engineer prior to site delivery. Shop assembly to include all trackwork components, as well as all switch machines and switch rods. Switch machines shall be adjusted and manually thrown to show correct switch point throw in both the normal and reverse positions.
 2. Use specified joint bars to connect rail joints. Install 3/16" end post shim where insulated joint bars are shown in the Contract Documents. Do not apply adhesives during this process.
 3. No bracing will be permitted to hold components to proper gauge.

1.08 REFERENCE STANDARDS

- A. AREMA, Latest edition, "Portfolio of Trackwork Plans" and "Manual For Railway Engineering"

ARTICLE 2 PRODUCTS

2.01 SWITCH AND STOCK RAILS

A. General Requirements

- a. Curved split switches: Length as shown, double reinforced switch point, in accordance with AREMA Plan No's. 122, 124 and 221 and as modified by the Contract Documents. Switches to incorporate house top guarded switch points, manganese switch point inserts, and floating heel blocks)
 - b. Strap guard rail shall be fabricated and attached to the running rail as indicated by the Contract Documents.
- B. Materials: All rails to conform to 115 RE head hardened, high strength rail as per Section 02466, "Steel Rail" except that rail shall be fully heat treated for switch points and stockrails, all other rails shall be heat treated, head hardened.
- C. Strap Guard Rail: Section 02450, "General Track Construction"
- D. Manufacture
1. Switch points and stockrails may be machined initially and subsequently fully heat treated to achieve the requirements of Paragraph 2.01B.
 2. Drill switch points, rails, strap guard rails, reinforcing bars, floating heel block assembly, switch rods, standard joints and insulated joints in accordance with the Contract Documents and AREMA Specifications for "Rail Drilling, Bar Punching, and Track Bolts." Perform all drilling of special trackwork rails in the shop. Field drilling of these products is not acceptable.
 3. Bevel all switch and stock rail ends in accordance with AREMA Plan No. 1005.
 4. Remove rail brands in reinforcing bar area and within 20" of the rail end.
- E. Identification
1. Stencil paint mark each component prior to shipment. Use white alkyd -based paint on a background of permanent black paint suitable for steel.
 2. Place markings in an area that will not subsequently be covered by joint bars.
 3. Identification markings for switch and stock rails to provide:
 - a. Component location.
 - b. Component part name.
 - c. Turnout number.
 - d. Turnout hand.

2.02 TURNOUT AND DIAMOND FROGS

A. General Requirements

1. Turnout, center, and end frogs shall be medium wall railbound manganese steel or self-guarded, solid manganese steel frogs in accordance with the Contract

- Documents and general conformance with AREMA Plan No's. 600A, 600B, 621, 622, 671, 700, 750, and 761 except as indicated in Contract documents.
2. Flangeway profile for flange bearing frogs, used within double crossovers only, will be provided by Authority during shop drawing process.
 3. All castings shall be designed for 115 RE rail section.
 4. Drill frogs for standard or insulated joints in accordance with the Contract Documents, and AREMA, Specifications for "Rail Drilling, Bar Punching, and Track Bolts."

B. Materials

1. Rail used in the manufacture of frog components shall conform to 115 RE high strength head hardened rail as per Section 02466, "Steel Rail."
2. The castings for frogs and frog inserts shall be manganese steel.

C. Manufacture

1. Depth harden the impact areas of the manganese steel castings for turnout and diamond frogs by explosive press, or hammer hardening procedure in accordance with AREMA "Specifications for Special Trackwork, Manganese Steel Castings, Section M2.7, Depth Hardening." Section M2.7.5 shall not apply.
2. Drill frog rails for standard or insulated joints in accordance with the Contract Documents and AREMA Specifications for "Rail Drilling, Bar Punching, and Track Bolts." Perform all drilling in the shop. Field drilling is not acceptable.
3. Bevel all rail ends in accordance with AREMA Plan No. 1005.
4. Remove rail brands in reinforcing bar area and within 20" of the rail end.

D. Identification

1. Stencil paint mark each frog prior to shipment. Use white alkyd-based paint on a background of permanent black paint suitable for steel.
2. Place markings in an AREMA that will not subsequently be covered by joint bars.
3. Identification marking for frogs to provide:
 - a. Frog location.
 - b. Either frog number or frog type with angle or radius.
 - c. Frog hand, if applicable.
4. Stamp location of $\frac{1}{2}$ inch point of frog on casting.

2.03 SPECIAL TRACKWORK RAILS

A. General Requirements

1. Provide Special Trackwork rails, such as the closure, stock and crossover connecting rails.
2. Drill Special Trackwork rail, for standard joints and strap guard rail bonded insulated joints as shown in accordance with AREMA.

- B. Materials: All rails within turnouts and crossover connecting rails shall be high strength, head hardened rail, see article 2.01B.
- C. Manufacture
 - 1. Drill and cut Special Trackwork rails in the shop. Field cutting and drilling of these products is not acceptable.
 - 2. Bevel Special Trackwork rail ends in accordance with AREMA Plan No. 1005.
 - 3. Remove rail brands within 20" of the rail end.
 - 4. Rail lengths shown in Contract Document may be modified to eliminate joints as long as the locations of Insulated joints does not change.

2.04 ADJUSTABLE RAIL BRACES

- A. Direct fixation fastener with adjustable rail brace assembly, H series, as manufactured by L. B. Foster Company, or approved equal, see Section 02462, "Direct Fixation Rail Fasteners."

2.05 GAUGE PLATES

- A. Direct fixation fastener with insulated gauge plate and adjustable rail brace assemblies, H series, as manufactured by L. B. Foster Company, or approved equal, see Section 02462, "Direct Fixation Rail Fasteners."

2.06 LEAD CURVE AND FROG GUARD RAILS

- A. Guard rails shall be bolted, strap guard. Contractor shall drill, bend and install the guard rail as required.

2.07 SWITCH FLOATING HEEL BLOCK ASSEMBLY

- A. General Requirements
 - 1. All switches to have a floating heel block as shown on the typical details in the Contract Documents. Switch sets shown in Contract Documents to be as necessary to incorporate floating heel blocks.

2.07 SWITCH RODS

- A. Switch Rods and Clips of Vertical Design, Type MJS, insulated and adjustable construction.
- B. Contractor shall test in accordance with Association of American Railroad's requirements.
- C. Length: As shown.

- D. Switch rods must be capable of at least 1" plus/minus adjustment after the initial throws, as shown, have been set.
- E. Contractor's Shop Drawings shall provide the required spread measurement for each switch rod which are needed to support the specified throw.
- F. Identification: Assembled switch rods shall be stamped No. 1, No. 2 and No. 3 as required.

ARTICLE 3 EXECUTION

3.01 MANUFACTURE OF SPECIAL TRACKWORK

- A. As specified on Contract Documents and detailed on approved Shop Drawings.

3.02 DELIVERY OF SPECIAL TRACKWORK

- A. For delivery of special trackwork, see Section 02450, "General Track Construction."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

**SECTION 02466
STEEL RAIL**

PART 1 GENERAL

1.01 SUMMARY

- A. The Work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for Steel Rail, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Furnishing, testing, delivering and handling of running rail.

1.02 RELATED SECTIONS

- A. Section 02450, "General Track Construction."
- B. Section 02452, "Direct Fixation Track Construction."
- C. Section 02453, "Special Trackwork Construction."
- D. Section 02464, "Special Trackwork."
- E. Section 02468, "Rail Welding."
- F. Section 02471, "Track-to-Earth Resistance Testing."

1.03 REFERENCE STANDARDS

- A. American Railway Engineering and Maintenance Association (AREMA) Latest Edition, Manual for Railway Engineering, Chapter 4, Part 1, Section 1.1 and Part 2, Section 2.1.

1.04 SUBMITTALS

- A. Contractor shall submit mill certificates, chemical analysis and the results of all sampling and materials test required by the AREMA Manual for Railway Engineering.

1.05 DEFINITIONS

(NOT REQUIRED)

1.06 ENVIRONMENTAL REQUIREMENTS

(NOT REQUIRED)

1.07 QUALITY ASSURANCE

- A. Quality assurance program shall conform to the Contract Documents and the manufacturer's established internal quality control procedures

PART 2 PRODUCTS

2.01 STANDARD RAIL

- A. Not to be used.

2.02 HIGH-STRENGTH RAIL

- A. New 115RE section rail conforming to AREMA Chapter 4, Part 1, Section 1.1 and Part 2, Section 2.1, except as follows:
 - 1. Steel shall be cast using the continuous process method.
 - 2. Hydrogen removal shall be by vacuum degassing.
 - 3. Rail shall be heat-treated, head hardened, except rail for switch points and stock rails which shall be fully heat treated after machining. Alloy rail is not acceptable.

PART 3 EXECUTION

3.01 MANUFACTURER, TEST AND SHIP RAIL

- A. As specified in this Specification.

PART 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

**SECTION 02468
RAIL WELDING**

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The Work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for Rail Welding, in accordance with the Contract Documents.
- B. The Work of this Section includes, but is not limited, the following activities:
 - 1. Welding and testing of welds for continuous welded rail (CWR), and includes welds made by both the thermite (exothermic) and pressure welding (electric-flash butt welding) processes. Rail shall be initially welded into strings not less than 820' in length by the pressure welding process. Final welding of the rail strings, into CWR, may be made by pressure welding or thermite welding.

1.02 RELATED SECTIONS

- A. Section 02450, "General Track Construction."
- B. Section 02452, "Direct Fixation Track Construction."
- C. Section 02453, "Special Trackwork Construction."
- D. Section 02464, "Special Trackwork."
- E. Section 02466, "Steel Rail."

1.03 REFERENCE STANDARDS

- A. American Railway Engineering and Maintenance Association (AREMA), Latest Edition, and Manual for Railway Engineering, Latest Edition.
- B. ASTM

1.04 SUBMITTALS

- A. Proposed layout of CWR strings (which will result in there being either no or the least field welds in curved track).
- B. Proposed Method, Procedures and Equipment for:
 - 1. Pressure welding rails.

2. Transporting, handling and loading rail and CWR strings.
 3. Thermite welding.
 4. Rail weld testing
 - a. Ultrasonic.
 - b. Dynamic.
 - c. Hardness.
 - d. Magnetic particle.
 5. Rail grinding.
- C. Proposed Location and Layout for:
1. Pressure welding plant, if applicable
 2. Rail storage area
- D. Welding Records
1. Records of all thermite welds by weld numbers and their locations.
 2. Records of all pressure welds by weld number and their locations as well as a record of machine performance for each weld.
 3. The following weld test reports:
 - a. Ultrasonic inspection reports.
 - b. Dynamic test reports.
 - c. Hardness test reports.
 - d. Magnetic particle test reports.
- E. Sample Welds
1. Sample welds for pressure welds and thermite welds.
 2. Test results on sample welds.
- F. Certification: Manufacturer's certification that all furnished products meet specified requirements.
- G. Qualifications
1. Proposed supervisor and crew qualifications.
 2. Proposed testing firm qualifications and agreement.

1.05 DEFINITIONS

(NOT REQUIRED)

1.06 ENVIRONMENTAL REQUIREMENTS

(NOT REQUIRED)

1.07 QUALITY ASSURANCE

- A. Rail welding shall be performed in accordance with the AREMA "Specification for Fabrication of continuous Welded Rail" and "Thermite Welding - Rail Joints," except as augmented or modified herein.
- B. Rail welding shall be performed under the direct supervision of a qualified supervisor with five years minimum experience in the welding of rail for the welding process being preformed. Contractor shall engage qualified technicians for welding crews with at least one year of experience.
- C. Sample Welds
 1. Produce a minimum of two sample welds, produced by the equipment to be used on this project, in accordance with the approved rail welding procedure and test them as indicated herein. Provide separate sets of sample welds from each welding crew to be used on this project.
 2. Test sample welds as specified in Paragraph 1.03D. Equipment and welding crew shall be considered qualified upon acceptance of all sample welding.
 3. If welding equipment, welding crews, welding materials or welding procedures are changed during the progress of the rail welding work, new sample welds and testing shall be performed at Contractor's expense and submitted to the Engineer for approval. Contractor shall not proceed with production welding until Engineer's approval has been obtained.
- D. Inspection and Testing
 1. Testing laboratory services: Employ an independent testing laboratory to perform all indicated weld testing.
 2. Testing technician: The testing shall be performed by a technician certified to have met ASNT procedure SNT-TC-1A, Level II or III qualifications.
 3. Visually inspect each weld at the completion of finish grinding. Surface cracks visible to the unaided eye shall be cause for rejection of the weld.
 4. Ultrasonic inspection
 - a. Use the following equipment for ultrasonic testing:
 - b. Calibrated paper tape recording attachments to record accurately the CRT screen indications when a non-complying weld is located
 - c. 2.25 MHz angle beam transducers $\frac{1}{2}$ " by 1" at 70 degrees and 45 degrees
 - d. Suitable high viscosity couplings of good wetting characteristics
 - e. Standard IIW calibration blocks of rail steel for primary reference response and to construct distance amplitude correction curve, and distance and sensitivity calibration blocks of rail steel for calibration checks.
 - f. Provide a 115lb, head hardened calibration rail mock-up acceptable to the Engineer for daily calibration of ultrasonic test equipment
 - g. Perform ultrasonic inspection of welds in accordance with ASTM E 164, incorporating the following:
 1. Scanning level shall be plus 20 Db minimum.
 2. Scan the rail in a zigzag pattern twisting probe, on one side of the weld only, at a rate not exceeding 6" per second, so that the full weld is

- scanned. Each pass will overlap a minimum 10 percent and the scanning is carried out longitudinally to the rail.
3. Calibrate the equipment at the start and end of each day's work, and at least every four hours during examination, and hourly checks with DSC blocks. If any point on the distance-amplitude curve has been changed by more than 20 percent, all results since last calibration check shall be void and all welds re-examined. If the curve has moved on the sweep line by more than five percent, all non-complying welds since last calibration check shall be re-examined.
 4. When a reflection of greater amplitude than the acceptance criteria is found, scan around the full perimeter of the weld from both sides, to ensure full weld coverage and determination of size, type and location of discontinuity.
 5. Make permanent trace recording of discontinuity indications.
 6. Paint the rail web on both sides, across the weld, to denote weld not conforming to acceptance criteria.
 - h. Acceptance criteria: All welds shall be free from defect or flaw, giving a reflected display of greater than 20 percent of distance-amplitude correction curve at calibration level, or will be as listed in the table below. In addition, the criteria stated in Paragraph 3.04.C herein shall apply.

Minimum Acceptance Levels (Decibels)

Transducer Angle	
Reflector	
	115 RE
Severity	70 degrees
Large Reflectors	+8
Small Reflector	+9
Minor Reflector	+10

- i. Inspection reports: Welds inspected by ultrasonic test shall be recorded on the appropriate test report form. The form shall include the location of the weld in track; the results of the ultrasonic inspection including size of defects found in the head, web, or base of rail; shape identity and location of all reflections; trace record; the results of the visual inspection; name of inspector; and other information as needed.
5. Radiographic inspection
 - a. Radiography shall be conducted in accordance with ASTM E142 using short wave length radiation. Examination of welds shall be performed only by or under the supervision of a person of proven experience and ability, operating under a proper license.
 - b. Film shall be capable of producing sharp images, and be free of processing and mechanical defects. High speed, coarse-grained film is prohibited. Fine films shall b used covering head, web and each side of base as shown. Identify

each film by contract number, rail identification, date of test, name of testing agency and the view.

- c. Acceptance of the weld shall be based on the weld having full penetration, complete fusion and being free of flaws. A letter shall accompany each film plate bearing information given on the film, certifying compliance with ASTM E142 and stating whether or not the weld satisfies specified requirements.
- d. Radiograph plates shall be compared to ultrasonic scans to determine the ability of ultrasonic equipment to identify inclusions or other weld defects. If necessary, compare radiograph plates with ultrasonic scans using the ultrasonic reference blocks. Results of this comparison shall be made in a separate report and included recommended ultrasonic equipment to be used and sensitivity requirements.

6. Dynamic testing

a. Repeated load test

- 1. Procedures: The test weld shall be supported on 36" centers with the weld located between supports. See AREMA Engineering Manual, Chapter 4, Figure 2-56, Rolling Load Test. Repeated loads shall be applied with two hydraulic rams. Loads shall be applied to the rail alternatively at Points A and B. Each load shall vary from zero to 44,400lbs in the approximate shape of a sine curve. Loads shall be applied for two million cycles. Application of load at Point A and then at Point B shall constitute one cycle. Measure rail deflection every 500,000 load cycles at Point A and record to the nearest 1/1000".
- 2. Acceptance criteria
 - a) Maximum deflection of the weld during testing shall not exceed 1/16".
 - a) Visual, radiographic, and ultrasonic inspection subsequent to the test shall not reveal the generation of fatigue cracks or other unacceptable conditions.

b. Slow bend test of sample welds

- 1. Procedure: Subject one of each type sample weld which has passed the ultrasonic test to the slow bend tests described in the Proceedings of the AREMA, Volume 68, pages 384 and 385.
- 2. Acceptance Criteria
 - a) Minimum deflection: 5/8".
 - a) Modulus of rupture: 125,000PSI minimum.

7. Hardness test

- a. Procedure: Measure weld and adjoining rail hardness on the center of the head of the rail at the center of the weld and at points 6" from the weld, in accordance with ASTM G 10.
- b. Acceptance Criteria: The hardness of the weld shall be equal to the average Brinell hardness of the two joined rails with the following tolerances:

Average Rail Brinell Hardness Tolerance

300 to 340	+/- 20 Brinell Pts.
341 to 360	+/- 40 Brinell Pts.

8. Magnetic particle testing
- a. General: Magnetic particle testing will not be accepted as a final indication of the acceptability of a rail weld, however, its use as a part of the Contractor's pressure welding Quality Program is required.
 - b. Procedure: Conduct magnetic particle testing in accordance with ASTM E 709 with the weld temperature below 800 degrees F.
 - c. Acceptance Criteria: If the weld is acceptable, the particles should form a regular longitudinal pattern indicating homogeneity and freedom from defects, surface irregularities, and internal discontinuities. Welds not giving favorable results during magnetic particle testing shall be cut out and the rails rewelded. Final determination of the acceptability of welds giving a positive indication during magnetic particle testing will be based on the results of ultrasonic testing performed once the rail has been laid in a final position on the completed track.

ARTICLE 2 PRODUCTS

2.01 THERMITE RAIL WELDING KITS

- A. Contractor shall furnish one of the following brands:
 - 1. Calorite: Limited preheat as manufactured by Calorite, Inc., Addison, IL.
 - 2. Thermit: Self-preheat as manufactured by Orgo-Thermit, Inc., Lakehurst, NJ.
 - 3. Boutet: As distributed by DuWel steel Products Company, Chicago, IL.
 - 4. Approved equal.
- B. The rail welding kits shall conform to the manufacturer's recommended standard for welding heat-treated rail
- C. The thermite welding kits shall be stored per manufacturers instructions and directions, safe from atmospheric weather conditions that would affect the performance of the weld kit.

2.02 PRESSURE WELDING EQUIPMENT

- A. Equipment for pressure welding shall be one or both of the following:
 - 1. Holland Company, Model GASSF80 Porta Plant or approved equal.
 - 2. Holland Company, Model K355H Mobile Welder or approved equal.

ARTICLE 3 EXECUTION

3.01 GENERAL

A. Rail welding shall be conducted in strict accordance with the approved procedures and Working Drawings.

B. Bolt holes shall not be made in the ends of the rail to be welded.

3.02 THERMITE WELDING

A. Rail strings shall be joined in the field by thermite welding.

B. Thermite welds shall not be located within the following locations:

1. Within 13' of a field weld in the same rail.
2. Within 13' from the center or any bolted or glued joint.
3. Within 10' of a direct fixation track bridge abutment, nor within 49' of a ballasted deck bridge abutment.

C. Preparation of Rail Ends: Rail ends shall be either sawcut or ground at right angles to the rail to provide a smooth and clean surface. The surface of the rails for a length of approximately 6" from the end of the rails shall be cleaned by grinding to remove all grease, dirt loose oxide, oxidized metal, scale and moisture. All burrs and lipped metal, which interfere with the fit of the mold, shall be removed.

D. Weld Gap: At the time of field thermite welding, the rails shall have the rail gap recommended by the manufacturer of the weld kit and shall be aligned to produce a weld which, with respect to alignment, shall comply with the AREMA Specifications. If the rail gap is larger than the manufacturer's recommended gap after the rails have been adjusted for zero thermal stress, then sufficient rail shall be removed from one or both rails to permit insertion of a rail not less than 19' long which shall provide the recommended gaps at each end of a field welding. At a location where the rail gap is smaller than the manufacturer's recommended gap, the recommended gap shall be obtained by sawing a piece from one rail.

E. Thermite Weld Preheating: The rail ends shall be preheated prior to welding to a sufficient temperature and for sufficient time as indicated in the approved welding procedure to ensure full fusion of the weld metal to the rail ends without cracking of the rail or weld.

F. Thermite Weld Postheating: The molds shall be left in place after tapping for sufficient time to permit complete solidification of the molten metal and proper cooling to prevent cracking and provide a complete weld with proper hardness and ductility.

G. Weld Finish: Trimming and grinding of the weld shall result in the weld being within the following tolerances:

1. The weld at the top and sides of rail head shall be finished to within plus 0.010" or minus 0.000" of the parent section. The top, bottom and sides of the rail base shall be finished to within plus 1/8" or minus 0.00" of the parent section.

2. The remainder of the rail weld shall be finished to within plus 1/8" or minus 0.000" of the parent section. Finishing shall eliminate cracks visible to the unaided eye.
 3. Notches created by offset conditions shall be eliminated by grinding to blend variations. Protrusions and gouges in the welded area shall be removed, and the weld area shall be blended into the rail contour by grinding in a manner, which will eliminate fatigue crack origins. Defects visible to the unaided eye shall be removed by grinding, except that if removal by grinding cannot be accomplished without damaging the rail, the weld shall be removed. Grinding pressure, which overheats the rail, shall not be permitted.
 4. Heavy grinding of the weld shall be completed while the weld is still hot from welding or by a rail shearing device approved by the Engineer. Finish grinding shall be performed after the weld has cooled to ambient temperature.
 5. When welding new rail to existing rail, transition the new rail into the profile of the existing rail over a distance of 3'.
- H. Welding Numbering: A semi-permanent weld number shall be marked on the rail immediately adjacent to the weld using a quality paint marker at the time the weld is made. Engineer will provide Contractor an initial weld number, and welds shall be numbered sequentially in the order in which they are made. Defective welds which are replaced shall be assigned a new sequential number by adding a letter to the defective weld number (i.e. defective weld 437 would be replaced by 437A).
- I. Welding Record: A welding record shall be prepared on copies of a form similar to Figure 02468-1. Forms shall be completely filled out in the field coincident with the rail welding and shall not be transcribed onto clean sheets back in the office. The original welding record forms bearing the initials and signatures of the field personnel witnessing the welding shall be submitted to the Engineer as a Project Record Document.

3.03 PRESSURE WELDING

- A. Pressure welded rail into strings not less than 820'.
- B. Preparation of Rail Ends: Rail ends shall be at right angles to the rail. The surface of the rails for a length of approximately 6" from the end of the rails shall be free from grease, dirt, loose oxide, oxidized metal, scale and moisture.
- C. At the time of welding, the rails shall be aligned to produce a weld which complies with the AREMA Specifications.
- D. Weld Finish: Trimming and grinding of the weld shall result in the weld being within the following tolerances:
 1. The weld at the top and sides of rail head shall be finished to within plus 0.010" or minus 0.000" of the parent section. The top, bottom and sides of the rail base shall be furnished to within plus 0.010" or minus 0.000" of the parent section.

2. The remainder of the rail weld shall be finished to within plus 1/8" or minus 0.000" of the parent section. Finishing shall eliminate cracks visible to the unaided eye.
 3. Protrusions and gouges in the welded area shall be removed, and the weld area shall be blended into the rail contour by grinding in a manner, which will eliminate fatigue crack origins. Defects visible to the unaided eye shall be removed by grinding, except that if removal by grinding cannot be accomplished without damaging the rail, the weld shall be removed. Grinding pressure, which overheats the rail, shall not be permitted.
 4. Heavy grinding of the weld shall be completed while the weld is still hot from welding or by a rail shearing device approved by the Engineer.
- E. Welding Numbering: A semi-permanent weld number shall be marked on the rail immediately adjacent to the weld using a quality paint marker at the time the weld is made. Engineer will provide Contractor an initial weld number, and welds shall be numbered sequentially in the order in which they are made. Defective welds which are replaced shall be assigned a new sequential number by adding a letter to the defective weld number (i.e. defective weld 437 would be replaced by 437A).
- F. Welding Record: A welding record shall be prepared on copies of a form similar to Figure 02468-1. Forms shall be completely filled out in the field coincident with the rail welding and shall be transcribed onto clean sheets back in the office. The original welding record forms bearing the initials and signatures of the field personnel witnessing the welding shall be submitted to the Engineer as a Project Record Document.

3.04 PRODUCTION WELD INSPECTION

- A. A chart recorder shall be used to monitor all significant pressure welding parameters and to identify each weld in each string. In addition, each rail shall be numbered at both ends with paint and this number shall be included on the recording to indicate the beginning and ending of each rail. Each recorder employed shall be calibrated daily. Recordings shall become the property of Authority at the time the welded rail is released for installation.
- B. All welds shall be inspected at the time of welding by the dry powder magnetic particle method in accordance with ASTM E 709.
- C. All rail welds shall be visually inspected at the time of weld finishing and ultrasonically tested prior to Final Acceptance, but after the rail has been laid in final position in track and all lining, surfacing, thermal adjustment, and anchoring work has been completed.
 1. Weld quality, finish, and alignment shall be in accordance with the standards cited herein.
 2. Welds showing a response at any level that is identified as a crack or lack of fusion shall not be acceptable.

3. Welds showing a response that is less than 50 percent of the primary reference level shall be acceptable.
4. Welds showing a response greater than 50 percent but that do not exceed the primary reference level are acceptable, provided that all of the following apply:
 - a. The defects are evaluated as slag or porosity.
 - b. The largest defect does not exceed 3/16" in its largest dimension.
 - c. The total area of the defects does not exceed 0.25in².
 - d. The sum of the greatest dimension of defects in a line does not exceed 3/8".
5. Welds showing a response that exceeds the primary reference level shall not be acceptable.

D. Hardness Tests of Welds

1. Procedure: Measure weld and adjoining rail hardness on the center of the head of the rail in the center of the weld and at points 6" from the weld. Test one weld out of each ten, as selected by Engineer, for each type of weld. If failure rate exceeds 10%, Engineer may require more tests.
 2. Acceptance Criteria: The hardness of the weld shall be equal to the average Brinell hardness of the two joined rails as specified in Paragraph 1.03D.7.
- E. Weld testing shall be carried out by an independent testing laboratory at the expense of the Contractor. The testing service and their testing program and procedures are subject to approval by the Engineer as specified in Paragraph 1.03D of this Section.
- F. The testing service shall certify whether or not each weld meets the quality criteria detailed and shall submit reports directly to the Engineer within three working days of testing a weld. The Engineer will forward copies to Contractor. At the time of testing, the testing service shall mark their findings as to acceptability or rejection on the weld itself.

3.05 REPAIR OF DEFECTIVE WELDS

- A. Welds found defective by hardness test, ultrasonic test, magnetic particle test, or visual inspection shall be replaced at no additional cost to Authority. Electric flash butt welds in rail rejected during inspection or testing shall be repaired in accordance with AREMA Manual, Chapter 4, "Recommended Field Repairs to Pressure Butt Weld Failures" and as modified herein.
- B. Pressure welds in rail rejected during inspection or testing shall be cut out and rewelded if possible, or replaced with at least a 19'-6" rail welded in its place by two thermite welds.
- C. Thermite welds in rail rejected during inspection or testing shall be cut out and rewelded if possible or replaced with at least a 19'-6" rail welded in place by two thermite welds in accordance with this Specification.
- D. Defective welds shall be rewelded and replacement welds shall be tested at no additional cost to Authority.

- E. Special Thermite Welds: Should a defective thermite weld replacement using an inserted piece of rail and two welds not be practical because of limitations due to adjacent special trackwork parts or for other reasons, the defective weld shall be cut out and replaced with a special wide thermite weld as approved by the engineer. Prior to use in track, the special thermite weld shall be tested and accepted as specified in Article 1.03D.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

FIGURE 02468-1
THERMITE WELD RECORD

Date of Welding: _____ Time Weld Completed: _____

Welding Kit Manufacturer and Part Number: _____
Manufacturer's Recommended Weld Gap (Q*): _____ mm

Weather Conditions: _____

Ambient Temperature: _____ Degree F Rail Temperature (T^*): _____ Degrees F

Length of Rail Being Welded (L^*): $L =$ _____ ft. + _____ ft. = _____ ft.

Required Rail Gap (G^*): _____ in.

Actual Rail Gap: _____ in.

Method of Obtaining Required Gap (If by artificial means, describe below):

Print Names of Crew Members Below:

Crew Chief's Statement of fact:

The weld described above has been completed in accordance with the Contract Documents.

Crew Chief _____
Signature

Print Name

Date: _____
Must Be Signed at time
Weld is Completed

* Note: See TECHNICAL PROVISIONS OF CONTRACT DOCUMENTS, SECTION 02450, GENERAL TRACK CONSTRUCTION, PART 3, Article 3.03 E.

Left and Right are determined by facing in the direction in which stations increase

END OF SECTION

SECTION 02471

TRACK-TO-EARTH RESISTANCE TESTING

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for track-to-earth resistance testing, in accordance with the contract documents.

1.02 RELATED SECTIONS

- A. Section 02451, "Ballasted Track Construction."
- B. Section 02452, "Direct Fixation Track Construction."
- C. Section 02453, "Special Track Construction."

1.03 SUBMITTALS

- A. Qualifications of the proposed testing firm and supervisor in accordance with Paragraphs 1.05A and 1.05B herein.
- B. A detailed written description of the proposed testing plan and procedures, including proposed documentation of test results.
- C. Types, models, serial numbers, and dates of calibration of all test instruments.
- D. Certified test reports for each test conducted including data obtained during specified test procedures, in approved format.

1.04 GENERAL NOTES

- A. The purpose of this testing is to verify compliance with the requirements set forth in this Section.
- B. The procedures for the measurement of track-to-earth resistance presented in this Section are general guidelines to be used as construction progresses and may require modification to suit actual field conditions

1.05 QUALITY ASSURANCE

- A. Contractor shall engage an independent firm specializing in the work documented in this Section, with at least five years documented experience to perform all indicated

- testing.
- B. The supervisor assigned to perform this work shall have a minimum certification level of Senior Corrosion Technologist from NACE International. The supervisor shall have a minimum 5 years of documented experience in the performance of track-to-earth resistance testing on dc electrified rail transit systems. The supervisor shall be on site, and direct all testing.
 - C. Instrument Calibration: Test instruments shall be calibrated within six months prior to use on this Project.

ARTICLE 2 PRODUCTS

2.01 TEST EQUIPMENT

- A. Multi-Combination Voltmeter/Ammeter
 - 1. Analog Instrument
 - a. DC Voltmeter: Multi-scale (1 mV to 10 volt, or 2 mV to 20 volt), center zero or 10 percent upscale, accurate to within 0.5 percent of full scale. Electronic voltmeter circuit shall provide a minimum input resistance of 10 megohms for ranges above 20 mV.
 - b. DC Ammeter: Multi-scale (1mA to 10 amp, or 2 mA to 20 amp), center zero or 10 percent upscale, accurate to within 0.5 percent of full scale.
 - 2. Electronic Instrument (Digital Readout)
 - a. DC Voltmeter: Multi-scale (20 mV to 20 volt), accurate to within 1 percent of reading \pm 1 digit, minimum input resistance of 10 megohms for ranges above 20 mV.
 - b. DC Ammeter: Multi-scale (20 mA to 20 amp), accurate to within 1 percent of reading \pm 1 digit.
- B. DC Power Source: 12 volt, sealed, rechargeable battery with a minimum 6.5-ampere/hour capacity. For tests requiring additional current magnitudes, Contractor shall use two or more batteries in series.
- C. Test Wires: Insulated, single conductor stranded copper test leads of various sizes and lengths, and with appropriate connectors to suite test conditions. At least two hand reels with approximately 500 feet of insulated, stranded copper wire (16 AWG minimum).
- D. Cu-CuSO₄ Reference Electrode: 1 $\frac{1}{4}$ inch diameter, 6 inches long with solid copper rod contacting a saturated solution of copper sulfate, with porous plug allowing electrical contact with the soil.

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. Contractor shall test discrete, electrically isolated sections of track as required for quality assurance of the track installation. Construction progress testing shall be performed for embedded and tie and ballast construction at no greater interval than 1000 feet.
- B. The track section to be tested shall be visually inspected to ensure there is no debris, water, or other conductive material in electrical contact with the metallic track components, which could result in low effective track-to-earth resistance.

3.02 TEST PROCEDURES

- A. Contractor shall ensure electrical continuity between the rails of the track section being tested by using existing cables or by installing temporary wire connections between the rails at each end of the track section.
- B. Contractor shall establish a current circuit (I_1) between the rails and a low resistance earth contact, and a rail-to-earth voltage measuring circuit (E_1) using a Cu-CuSO₄ reference electrode.
- C. With the current circuit (I_1) closed, meter ranges of both the current and voltage circuits shall be reduced until the lowest readable scales are reached and record the "on" values for the current (I_1) and voltage (E_1) circuits.
- D. Contractor shall open the current circuit (I_1) shall be opened and immediately record the "off" values for the current and voltage circuits. Repeat at least three times for accuracy.
- E. The change in current (ΔI_1) and the change in potential (ΔE_1) shall be calculated and recorded for each reading ($\Delta I_1 = I_{\text{on}} - I_{\text{off}}$ etc).
- F. The effective track-to-earth resistance shall be calculated and recorded by dividing the summation of the change in potential by the summation of the change in current ($R_{1-1} = \sum \Delta E_1 / \sum \Delta I_1$).
- G. Contractor shall obtain track-to-earth data at the opposite end of the track section under test ($R_{2-1} = \sum \Delta E_2 / \sum \Delta I_1$).
- H. R_{1-1} shall be compared with R_{2-1} . A difference of greater than 5 percent could indicate attenuation resulting from the relationship of the track section's longitudinal resistance and the track-to-earth resistance. A significant variation between R_{1-1} and R_{2-1} can be expected if the track-to-earth resistance falls below acceptable levels.
- I. The average resistance-to-earth of the test section [$R_{\text{avg}} = (R_{1-1} + R_{2-1}) / 2$] shall be calculated and recorded.

- J. Contractor shall calculate and record the resistance-to-earth per 1000 feet of track [$R_T=R_{avg}(L)/1000$ =ohms per 1000 feet, where L = length of track in test section (in feet)].

3.03 ACCEPTANCE CRITERIA

- A. The minimum acceptable in-service track-to-earth resistance values for direct fixation track construction is 1000 ohms per 1000 feet of single track.
- B. The minimum acceptable in-service track-to-earth resistance values for tie and ballast track construction is 500 ohms per 1000 feet of single track.
- C. The minimum acceptable in-service track-to-earth resistance values for embedded track construction, including grade crossing track, is 100 ohms per 1000 feet of track.
- D. If the test results show that any section of trackwork fails to meet the acceptance criteria, Contractor shall inspect the section under test for installation deficiencies, and correct any problems detected. Following this procedure, tests shall be repeated. If the test section fails again to meet the acceptance criteria, Contractor shall investigate and correct the cause for failure and repeat testing until satisfactory results are obtained. All retesting and corrective measures taken shall be performed at no additional cost to Authority.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 02581

DUQUESNE LIGHT COMPANY SWITCH PADS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for construction of Duquesne Light Company switch pads, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Excavation.
 - 2. Grounding system installation.
 - 3. Conduit installation.
 - 4. Backfill and compaction.
 - 5. Switch pad installation.

1.02 RELATED SECTIONS

- A. Section 02316, "Excavation."
- B. Section 02320, "Backfill."
- C. Section 03211, "Reinforcement Bars and Dowels."
- D. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- E. Section 16111, "Conduit."
- F. Section 16060, "Grounding and Bonding."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. UL.
- C. NEMA.
- D. Commonwealth of Pennsylvania, Underground Utility Line Protection Act, Act 181 of 2006.

1.04 REQUIREMENTS OF REGULATORY AGENCIES

- A. Contractor shall notify Duquesne Light Company ten (10) working days prior to the start of switch pad work.

- B. No backfilling of electrical installation shall occur until the installation has been inspected by Duquesne Light Company.

ARTICLE 2 PRODUCTS

- A. Class AAA Concrete in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- B. Steel Reinforcement in accordance with Section 03211, "Reinforcement Bars and Dowels."
- C. Ground Wire Conduits: 1 1/2" Virgin Polyvinyl Chloride (PVC) Schedule 40 in accordance with ASTM F 512. Duct and fittings shall be UL Approved and Listed and rate for wire temperatures of 90 Degrees Celsius.
- D. No. 57 Coarse Aggregate in accordance with Section 02320, "Backfill."
- E. Conduit in accordance with Section 16111, "Conduit" and according to the Contract Drawings.
- F. Conduit Radius: 5" ID, 90°, 36" Radius Galvanized Steel Bend Coated with a 40 mil PVC Jacket, in accordance with UL-6A (Electrical Rigid Metal Conduit) and NEMA RN-1 (Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit).
- G. Grounding System
 - 1. Ground Bus: 1/4" x 3" x 30" copper bar.
 - 2. Ground Bus Connector: #4/0 AWG Soft Drawn Stranded Copper Wire.
 - 3. Ground Rod: 3/4" x 10' Copper Clad Ground Rod free of nonconductive coatings, such as paint or enamel.
 - 4. Ground Grid: 4/0 Soft Drawn Solid Copper Wire.
 - 5. Potential Ground Grid: #4 AWG Soft Drawn Solid Copper Wire
- H. Pullcords shall consist of 18 gauge nylon cord and have a minimum breaking strength of 170 pounds.
- I. Anchoring Hardware in accordance with PENNDOT 408, Section 1101.04.

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. Construct switch pads in accordance with the Contract Drawings.
- B. The Contractor shall coordinate with Duquesne Light Company prior to beginning installation of the switch pads. Do not begin any part of the installation until Duquesne Light's concurrence is received.

- C. Excavate pad foundation to the depth required on the Contract Drawings.
- D. All below grade grounding connections must be exothermically welded.
- E. Install conduits as shown on the Contract Drawings, including connection to conduits previously installed in Contract NSC-006 and continuing to the Duquesne Light Company Switch Pads and ending at the substation building..
- F. The Contractor shall install a pullcord in the conduits.
- G. Backfill grounding grid and pad area with AASHTO No. 57 coarse aggregate as shown on the Contract Drawings.
- H. The concrete pads must be allowed a minimum of seven days curing time prior to the installation of Duquesne Light Company equipment.
- I. Prior to requesting installation of Duquesne Light Company equipment, an unobstructed access way capable of withstanding a 72,000 pound truck loading must be provided and maintained by the Contractor.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02581.001 – Duquesne Light Company Switch Pads shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

Item 02581.001 – Duquesne Light Company Switch Pads will be paid at the lump sum price and shall include the cost of all work specified in this Section.

SECTION 02627

PIPE UNDERDRAIN, PAVEMENT BASE DRAIN AND SUBSURFACE DRAIN OUTLETS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for pipe underdrain, pavement base drain and subsurface drain outlets, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Base drain and installation including all fittings
 - 2. Connection to existing base drain or inlet
 - 3. Geotextile
 - 4. Aggregate backfill and compaction.
 - 5. Excavation

1.02 RELATED SECTIONS

- A. Section 02320, "Backfill."
- B. Section 02353, "Geotextile."
- C. [NOT USED]
- D. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures".
- E. Section 02316, "Excavation."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication #72.
- C. PENNDOT Publication 19.
- D. PENNDOT Publication 35 (Bulletin 15).
- E. ASTM.
- F. AASHTO.
- G. Geosynthetic Research Institute, Drexel University.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Pavement Base Drain in accordance with PENNDOT 408, Section 610.2, except as modified herein:
 - 1. Section 610.2(a)9.b and 610.2(b)1 and 2: Modify reference to Section 703.1 to Section 02320, "Backfill."
 - 2. Section 610.2(a)9.i: Modify Section 615.2 to Article 2.01C of this Section.
 - 3. Delete Section 610.2(e).
- B. Pavement Base Drain and Pipe Underdrain: Provide pipe material identical to existing pavement base drain and pipe underdrain which is disturbed by construction.
- C. [NOT USED]
- D. Pavement Base Drain, Modified
 - 1. Pipe in accordance with Article 2.01A of this Section.
 - 2. AASHTO #57 Coarse Aggregate in accordance with Section 02320, "Backfill."
 - 3. Geotextile in accordance with Section 02353, "Geotextile."
 - 4. Mortar, if necessary, for connection to existing drainage structures in accordance with Article 2.01A of this Section.
- E. Perforated Pipe Underdrain
 - 1. Pipe in accordance with PENNDOT 408, Section 610.2.
 - 2. Wrap pipe with Geotextile Class 2, Type A.

ARTICLE 3 EXECUTION

3.01 INSTALLATION

- A. Construct Pavement Base Drain in accordance with PENNDOT 408, Section 610.3, except as follows:
 - 1. Section 610.3(c)5: Modify reference to 615.3 to Article 3.01F of this Section.
- B. Construct Pavement Base Drain, Special in accordance with the Contract Drawings.
- C. [NOT USED]
- D. Connect pavement base drain and pipe underdrain to existing pavement base drain and pipe underdrain system. Provide a watertight connection between existing pipe and newly installed pipe using suitable couplings and fittings or special connectors.
- E. During construction, cap the exposed ends of the existing pavement base drain and pipe underdrain with geotextile to ensure no construction debris gets into the pipe. Make sure the existing pipe end is free of debris before connecting new pipe.

- F. No subsurface drain outlets are permitted for the pavement base drain installation. All roadway pavement base drains shall be tied into drainage facilities. When reinstalling pavement base drain, ensure that all existing and new pavement base drain is connected to a drainage system.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]
- H. [NOT USED]
- I. Item 02627.009 – 6” Pavement Base Drain, Modified will be measured per linear foot, complete in place

4.02 PAYMENT

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]
- H. [NOT USED]
- I. Item 02627.009 – 6” Pavement Base Drain, Modified will be paid at the unit price and shall include the cost of all related work specified in this Section.

END OF SECTION

NSC-009

02627-4

April 21, 2008

Pipe Underdrain, Pavement Base Drain and Subsurface Drain Outlets

SECTION 02721

SUBBASE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for subbase, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Aggregate.
 - 2. Placement and Compaction.

1.02 RELATED SECTIONS

- A. Section 02320, "Backfill."
- B. Section 02340, "Subgrade."
- C. Section 02740, "Bituminous Pavement and Sidewalk."
- D. [NOT USED]
- E. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication #72.
- C. PENNDOT Publication 19.
- D. AASHTO.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Coarse Aggregate: Indicated Depth: In accordance with Section 02320, "Backfill."

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION OF SUBBASE

- A. Construct subbase on prepared subgrade in accordance with PENNDOT 408, Section 350.3, except as modified herein:
 1. Modify reference to "Standard Drawings" to "Contract Drawings."
 2. Delete Section 350.3(d), Paragraph 2.
 3. Section 350.3(d), Paragraph 3: Delete "Flexible."
 4. Delete Section 350.3(h).
 5. Do not allow traffic, including construction traffic, prior to placement of finished surface.
 6. If subbase is exposed to weather in excess of 30 days prior to placing finished surface, re-test in-place material in accordance with PENNDOT 408, Section 350.3(f) and (g).

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. [NOT USED]
- B. [NOT USED]
- C. Item 02721.003 – Subbase, 6" Depth (No. 2A) shall be measured per square yard, complete in place.

4.02 PAYMENT

- A. [NOT USED]
- B. [NOT USED]
- C. Item 02721.003 – Subbase, 6" Depth (No. 2A) will be paid at the unit price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 02740

BITUMINOUS PAVEMENT AND SIDEWALK

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for bituminous pavement and sidewalk, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Bituminous base, binder, and wearing course materials.
 - 2. Compaction of bituminous courses.
 - 3. All asphalt sealers.

1.02 RELATED SECTIONS

- A. Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricade."
- B. [NOT USED]
- C. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication #19.
- C. ASTM.
- D. PENNDOT Publication 35, Bulletin #15.

1.04 SUBMITTALS

- A. Quality Assurance/Control Submittals
 - 1. Submit the design data and calculations and proposed job-mix formula, for approval by the Engineer. Contractor shall prepare a quality control plan and submit design data and calculations and the proposed job-mix formula for review to the Engineer for acceptance before starting the work. Work shall not commence until the Engineer has reviewed and accepted the quality control plan and the job-mix formula.

ARTICLE 2 PRODUCTS

2.01 BASE COURSE MATERIALS

- A. In accordance with PENNDOT 408, Section 305.2 except as modified herein:
 - 1. Modify Section 305.2(b).1 to include "excluding slag."
 - 2. Modify Section 305.2(b).2 to include "excluding slag."

2.02 WEARING COURSE MATERIALS

- A. In accordance with PENNDOT 408, Section 420.2 except as modified herein:
 - 1. Modify Section 420.2(b).1 and 2 to include "excluding slag."
- B. Bituminous Sealer shall be an Asphalt Rubber Sealing Compound in accordance with PENNDOT 408, Section 469.2(a).

2.03 BINDER COURSE MATERIALS

- A. In accordance with PENNDOT 408, Section 421.2 except as modified herein:
 - 1. Modify reference to Section 420.2(b).1 and 2 to include "excluding slag."

2.04 [NOT USED]

2.05 [NOT USED]

2.06 [NOT USED]

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION OF BITUMINOUS CONCRETE BASE COURSE

- A. In accordance with PENNDOT 408, Section 305.3.

3.02 CONSTRUCTION OF BITUMINOUS WEARING COURSE, ID-2

- A. In accordance with PENNDOT 408, Section 420.3.

3.03 CONSTRUCTION OF BITUMINOUS BINDER COURSE, ID-2

- A. In accordance with PENNDOT 408, Section 421.3.

3.04 MILLING OF BITUMINOUS PAVEMENT SURFACE

- A. In accordance with PENNDOT 408, Section 491.3.

3.05 [NOT USED]

3.06 [NOT USED]

3.07 [NOT USED]

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02740.001 - Bituminous Binder Course, ID-2, 2" Depth shall be measured per square yard, complete in place.
- B. Item 02740.002 - Bituminous Wearing Course, ID-2, 1- 1/2" Depth, SRL-L shall be measured per square yard, complete in place.
- C. [NOT USED]
- D. [NOT USED]
- E. Item 02740.005 – Bituminous Concrete Base Course, 4" Depth shall be measured per square yard, complete in place.
- F. Item 02740.006 – Bituminous Concrete Base Course, 2-½" Depth shall be measured per square yard, complete in place.
- G. Item 02740.007 – Milling of Bituminous Pavement Surface, 1 - 1/2" Depth shall be measured per square yard, complete in place.
- H. [NOT USED]
- I. [NOT USED]

4.02 PAYMENT

- A. Item 02740.001 - Bituminous Binder Course, ID-2, 2" Depth will be paid at the unit price and shall include the cost of all related work specified in this Section.
- B. Item 02740.002 - Bituminous Wearing Course, ID-2, 1- 1/2" Depth, SRL-L will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. [NOT USED]
- D. [NOT USED]
- E. Item 02740.005 – Bituminous Concrete Base Course, 4" Depth will be paid at the unit price and shall include the cost of all related work specified in this Section.

- F. Item 02740.006 – Bituminous Concrete Base Course, 2 ½" Depth will be paid at the unit price and shall include the cost of all related work specified in this Section.
- G. Item 02740.007 – Milling of Bituminous Pavement Surface, 1 - 1/2" Depth will be paid at the unit price and shall include the cost of all related work specified in this Section.
- H. [NOT USED]
- I. [NOT USED]

END OF SECTION

SECTION 02741
BITUMINOUS TACK COAT

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for bituminous tack coat, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. [NOT USED]
- B. Section 02740, "Bituminous Pavement and Sidewalk."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication #19.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. In accordance with PENNDOT 408, Section 460.2 except as follows:
 - 1. Delete reference in 703.1(a).2 to "air-cooled blast furnace slag" and "air-cooled steel slag." Only natural sand or manufactured sand made of crushed rock will be accepted for use in blotting.

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION OF BITUMINOUS TACK COAT

- A. In accordance with PENNDOT 408, Section 460.3.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02741.001 - Bituminous Tack Coat shall be measured per square yard unit, complete in place.
- B. [NOT USED]

4.02 PAYMENT

- A. Item 02741.001 - Bituminous Tack Coat will be paid at the unit price and shall include the cost of all related work specified in this Section.
- B. [NOT USED]

END OF SECTION

SECTION 02751

DRIVEWAYS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for driveways, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Construction and removal of any necessary forms.
 - 2. Furnishing and placing cement concrete.
 - 3. Furnishing and placement of welded wire fabric.
 - 4. Vibration of freshly placed concrete.
 - 5. Finishing of cement concrete surfaces.
 - 6. Curing compounds and procedures.
 - 7. Any necessary joint saw-cutting.
 - 8. Furnishing and placement of expansion joint material and caulking.
 - 9. Apply Protective Coatings
 - 10. Furnish and placement of subbase material

1.02 RELATED SECTIONS

- A. Section 02340, "Subgrade."
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. Section 03211, "Reinforcement Bars and Dowels."
- F. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- G. Section 09900, "Protective Coating for Concrete Surfaces."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication #72.
- C. ASTM.

1.04 SUBMITTALS

- A. Submit the details of all joints required for approval by the Engineer. Existing pavement joint pattern shall be matched when abutting existing pavements and sidewalks, where possible. Contractor shall provide details of all joints required and detailed layout of joints in accordance with the Contract Drawings. Include all manholes, valve boxes and junction boxes, and other installations on joint layout detail if located within the driveway. Engineer's acceptance shall be obtained before beginning work.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. In accordance with PENNDOT 408, Section 676.2 except as modified herein:
 1. Class P Concrete in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
 2. Subbase, 6" Depth (No. 2A) in accordance with PENNDOT 408, Section 350.2.
 3. Welded wire fabric as shown in the Contract Drawings in accordance with Section 03211, "Reinforcement Bars and Dowels."
 4. Caulking in accordance with PENNDOT 408, Section 705.8 (b).
 5. Pre-molded Expansion Joint Material in accordance with PENNDOT 408, Section 705.1.
 6. Boiled Linseed Oil in accordance with Section 09900, "Protective Coating for Concrete Surfaces."

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION OF DRIVEWAY

- A. In accordance with PENNDOT 408, Section 676.3 except as modified herein:
 1. Excavate, as required, and form the foundation at a depth 14 inches parallel with the finished surface of the driveway.
 2. Prepare Subgrade in accordance with Section 02340 "Subgrade" at a depth of 14 in. below and parallel to the finished driveway surface.
 3. Saw cut joints shall be $\frac{1}{2}$ " wide and $\frac{1}{4}$ the depth of the slab. Space joint as indicated on Contract Drawings.
 4. Modify Section 676.3 (d) from 4 inches of concrete to Reinforced Cement Concrete Pavement, 8" Depth as per the Contract Documents.
 5. Apply Boiled Linseed Oil in accordance with Section 09900, "Protective Coating for Concrete Surfaces."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02751.001 – Concrete Driveway shall be measured per square yard, complete in place.

4.02 PAYMENT

- A. Item 02751.001 – Concrete Driveway will be paid at the unit price and shall include the cost of all work specified in this Section.

END OF SECTION

SECTION 02761
PAINTING TRAFFIC LINES AND MARKINGS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor materials, tools, equipment and incidentals necessary for painting traffic lines and markings, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Application of pavement markings.
 - 2. Surface preparation and cleaning.
 - 3. Protection of application.

1.02 RELATED SECTIONS

- A. Section 01780, "Maintenance and Protection of Traffic."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication 212 .
- C. PENNDOT Publication 35 (Bulletin 15)
- D. AASHTO
- E. MUTCD.
- F. Federal Standard No. 595a ASTM
- G. PENNDOT Publication 111 (TC-8700 Series)
- H. PENNDOT TC-8600 Series Traffic Control Standards

1.04 SUBMITTALS

- A. At least 21 days prior to beginning work, the Contractor shall provide the Engineer with a list of materials, including paint formulations, and a schedule of painting operations.
- B. The Contractor shall provide Engineer with the manufacturer's instructions for the mixing ratios for the materials, application temperatures, proper mixing techniques and any other data on proper installation.

1.05 ENVIRONMENTAL REQUIREMENTS

- A. Paint shall be applied during dry weather with a minimum ambient temperature and dry pavement surface temperature per the manufacturer's recommendation for paint application. The Engineer will make the final determination of the proper atmospheric and pavement surface conditions to produce satisfactory results.
- B. Volatile Organic Content (VOC): The EPA maximum VOC for traffic paint shall not be exceeded.

ARTICLE 2 PRODUCTS

2.01 MANUFACTURERS

- A. Epoxy traffic paints shall be manufactured by a supplier listed in PENNDOT Bulletin 15.

2.02 EQUIPMENT

- A. For Line Application: Contractor shall be in accordance with PENNDOT 408, Section 962.3(b)1.
- B. Provide application equipment with a system capable of spraying epoxy material mixed in the proper formulation to the manufacturer's requirements and also capable of:
 1. Applying symbol markings and longitudinal lines with the specified glass bead application.
 2. Heating Epoxy Part A to 170°F maximum.
 3. Heating Epoxy Part B to 160°F maximum.
 4. Mix Part A to Part B in 2:1 plus or minus 5% ratio by volume.
 5. Delivering the mixed epoxy at a minimum pressure of 200 psi through the static mixer.

2.03 MATERIALS

A. Epoxy Resin Material

1. Composition – Percentage by Weight

White

Titanium Dioxide 20% plus or minus 2 (ASTM D476 Type III)

Epoxy Resins 80% plus or minus 2

Yellow

Chrome Yellow 25% plus or minus 2 (ASTM D211 Type III)

Epoxy Resins 75% plus or minus 2

2. Color: Color chip 17778 for white and 13538 for yellow of Federal Standard No. 595a when the material is placed in a Type EH weatherometer for a period of 500 hours and weathered according to ASTM-E 42.

3. Drying Cure Time: Dry to a no tack condition in 10-15 minutes or less when installed at the temperatures above 50°F at a thickness of 15 mils.
4. Glass Beads: Reflectorize with glass beads per AASHTO - M247.

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION

- A. Contractor shall store and handle paint in accordance with PENNDOT 408, Section 962.2(c).
- B. Epoxy Paint shall be applied in accordance with the Traffic Signal Plans, the Traffic Control Plan, and PENNDOT Publication 68, Subchapter K.
- C. Contractor shall clean and dry roadway surface prior to painting to the Engineer's satisfaction. The surface shall be blown or swept free of loose dirt and other debris immediately prior to application of the epoxy.
- D. Contractor shall uniformly apply the epoxy resin markings with a minimum cross section of 15 mils. A tolerance of $\frac{1}{2}$ inch plus or minus from the specified width will be allowed provided the variation is gradual and does not detract from the general appearance. Apply glass beads immediately after application of the epoxy resin at a minimum 25 lbs. per gallon of epoxy. Uniformly distribute glass beads on the painted surface.
- E. Contractor shall provide satisfactory protection for center lines, lane lines, and edge lines until the paint is dry and track free from vehicular traffic. Conduct epoxy installations only when the road surface temperature is 50°F or higher. Marked or damaged areas shall be repainted as directed by the Engineer. Barrier cones are considered as satisfactory protection for materials requiring more than two (2) minutes dry time.
- F. Markings, which after application and curing the Engineer determines to be defective, shall be repaired.
 1. Major problem areas and method of repair include the following:
 - a. Incorrect location: Satisfactorily remove and replace incorrectly placed patterns as directed by the Engineer.
 - b. Insufficient thickness, line width, glass bead coverage or retention: Prepare defective material by acceptably grinding or blast cleaning to remove a substantial amount of beads to roughen the marking surface. Remove loose particles and debris by blasting with compressed air. Restripe the cleaned surface in accordance with this Section.
 - c. Uncured or discolored material, insufficient bonding: Remove defective markings and clean pavement surface one (1) foot beyond the affected area. Restripe the marking on the cleaned surface in accordance with this Section.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. [NOT USED]
- B. Item 02761.002 – Epoxy Resin Paint, 4" White Edge Line shall be measured per linear foot, complete in place.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]
- H. Item 02761.008 – Epoxy Resin Paint, 6" Broken White Skip Line shall be measured per linear foot, complete in place.
- I. [NOT USED]
- J. [NOT USED]
- K. [NOT USED]
- L. [NOT USED]
- M. [NOT USED]
- N. [NOT USED]
- O. [NOT USED]
- P. [NOT USED]
- Q. [NOT USED]
- R. [NOT USED]
- S. [NOT USED]
- T. [NOT USED]

4.02 PAYMENT

- A. [NOT USED]

- B. Item 02761.002 – Epoxy Resin Paint, 4" White Edge Line will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]
- H. Item 02761.008 – Epoxy Resin Paint, 6" Broken White Skip Line will be paid at the unit price and shall include the cost of all related work specified in this Section.
- I. [NOT USED]
- J. [NOT USED]
- K. [NOT USED]
- L. [NOT USED]
- M. [NOT USED]
- N. [NOT USED]
- O. [NOT USED]
- P. [NOT USED]
- Q. [NOT USED]
- R. [NOT USED]
- S. [NOT USED]
- T. [NOT USED]

END OF SECTION

SECTION 02781

CONCRETE CURB

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for concrete curb, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. The construction and removal of any necessary forms.
 - 2. The furnishing, placing, and compaction of aggregate backfill.
 - 3. The furnishing, placement, and vibration of cement concrete.
 - 4. The furnishing and placement of re-enforcement.
 - 5. Furnishing and placing of joint material and caulking.
 - 6. Curing compounds and procedures.

1.02 RELATED SECTIONS

- A. Section 02320, "Backfill."
- B. Section 03211, "Reinforcement Bars and Dowels."
- C. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- D. Section 09900, "Protective Coating for Concrete Surfaces."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication #72.
- C. ASTM.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. [NOT USED]
- B. City of Pittsburgh Concrete Curb: in accordance with PENNDOT 408, Section 630.2 except as follows:
 - 1. Concrete: use Class P in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

2. Re-enforcement: ASTM-A684 Size #4 rebar.

C. [NOT USED]

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION

A. [NOT USED]

B. City of Pittsburgh Concrete Curb: in accordance with PENNDOT 408, Section 630.3, except as modified herein:

1. Construct to the dimensions indicated on the City of Pittsburgh Concrete Curb detail in the Contract Drawings.

C. [NOT USED]

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. [NOT USED]

B. Item 02781.002 - City of Pittsburgh Concrete Curb shall be measured per linear foot, complete in place.

C. [NOT USED]

4.02 PAYMENT

A. [NOT USED]

B. Item 02781.002 – City of Pittsburgh Concrete Curb will be paid at the unit price and shall include the cost of all related work specified in this Section.

C. [NOT USED]

END OF SECTION

SECTION 02785
CONCRETE SIDEWALKS AND STAIRS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for concrete sidewalks and stairs, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Construction and removal of any necessary forms
 - 2. Furnishing, placing and compaction of base materials
 - 3. Furnishing and placing cement concrete
 - 4. Furnishing and placement of welded wire fabric or reinforcement
 - 5. Vibration of freshly placed concrete
 - 6. Finishing of cement concrete surfaces
 - 7. Curing compounds and procedures
 - 8. Any necessary joint saw-cutting
 - 9. Furnishing and placement of expansion joint material and caulking
 - 10. Construction of sidewalk ramps and detectable warning devices.
 - 11. [NOT USED]
 - 12. Applying Protective Coatings

1.02 RELATED SECTIONS

- A. Section 02316, "Excavation."
- B. Section 02320, "Backfill."
- C. [NOT USED]
- D. Section 03211, "Reinforcement Bars and Dowels."
- E. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- F. Section 09900, "Protective Coating for Concrete Surfaces."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.

1.04 SUBMITTALS

- A. Submit the details of all joints required and locations of handicapped ramps for approval by the Engineer. Existing pavement joint pattern shall be matched when abutting existing pavement, where possible. Contractor shall provide details of all joints required and detailed layout of joints in accordance with the Contract Drawings. Include all manholes, valve boxes and junction boxes, and other installations on joint layout detail. Engineer's acceptance shall be obtained before beginning work.

ARTICLE 2 PRODUCTS

2.01 REINFORCED CONCRETE SIDEWALK AND STAIRS

- A. In accordance with PENNDOT 408, Section 676.2 except as modified herein:
- B. Concrete Mix: Class P Concrete in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
 1. Use a black color additive in the concrete mix for the sidewalk ramps that are constructed adjacent to reinforced concrete sidewalk.
- C. Reinforcement: Use welded wire fabric as shown in the Contract Drawings and in accordance with Section 03211, "Reinforcement Bars and Dowels", in the sidewalk and sidewalk ramps.
- D. AASHTO No. 57 Coarse Aggregate in accordance with the Contract Documents and Section 02320, "Backfill."
- E. Detectable Warnings: Detectable warnings shall consist of raised truncated domes with a diameter of nominal 0.9 in., a height of nominal 0.2 in. arranged in an offset pattern with a center-to-center spacing of nominal 1.66 in. and shall contrast visually with adjoining surfaces.
- F. [NOT USED]

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION

- A. In accordance with PENNDOT 408, Section 676.3 except as modified herein:
 1. Sidewalk ramp construction is incidental to the reinforced concrete sidewalk construction. This includes the sidewalk ramps that are constructed adjacent to reinforced concrete sidewalk.
 2. Detectable Warnings shall be placed on sidewalk ramps as shown in the Contract Drawings.
 3. [NOT USED]
 4. In accordance with PENNDOT 408, Section 676.3(a) Preparation of Foundation except as follows: The Contractor shall form the foundation at a depth as shown

on the Contract Drawings and parallel with the finished surface of the sidewalk. The Contractor shall thoroughly compact the foundation. Contractor shall finish to a firm, even surface; moisten if required. Refer to Section 02320, "Backfill," for compaction requirements.

5. In accordance with PENNDOT 408, Section 676.3(b) Placing Aggregate for Bed.
 - B. [NOT USED]
 - C. [NOT USED]

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASURMENT

- A. [NOT USED]
- B. Item 02785.002 –Reinforced Concrete Sidewalk, 6" Depth shall be measured per square yard, complete in place.
- C. [NOT USED]

4.02 PAYMENT

- A. [NOT USED]
- B. Item 02785.002 – Reinforced Concrete Sidewalk, 6" Depth will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. [NOT USED]

END OF SECTION

SECTION 02825

SECURITY FENCE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for security fence, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Install factory finished security fence where shown on Contract Documents.
 - 2. Install factory finished security swing fence gates including, but not limited to, all posts, pales, rails, locking mechanisms, and hardware where shown on Contract Documents.

1.02 RELATED SECTIONS

- A. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

1.03 REFERENCE STANDARDS

- A. ASTM A653/A653M- Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
- B. ASTM A924/A924M- Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
- C. ASTM A1011/A1011M- Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength and High Strength Low-Alloy with Improved Formability.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product Data, mounting details, and installation instructions for security fencing, gates, and accessories.
- B. Shop Drawings: Submit Shop Drawings showing extent of security fence and gates.
- C. Fence Manufacturer and Installers Qualifications

1.05 QUALITY ASSURANCE

- A. Fence Manufacturer Qualifications: A company with a minimum of five years experience in producing security fencing similar to that indicated for this Project

- and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- B. Installers Qualifications: The security fence installer shall provide laborers and supervisors who are thoroughly familiar with the type of fence installation involved and the materials and techniques required by the manufacturer to install a warranted fence.

1.06 PRODUCT HANDLING AND STORAGE

- A. Upon receipt at the Worksite, all materials shall be checked to ensure that no damage occurred during shipping or handling.
- B. Materials shall be stored in such a manner to ensure proper ventilation and drainage, and protect against damage, weather, vandalism and theft.

ARTICLE 2 PRODUCTS

2.01 MANUFACTURER

- A. The steel corrugated pale fence system shall conform to Ameristar Impasse Gauntlet three rail style manufactured by Ameristar Fence Products, Inc. in Tulsa Oklahoma or approved equal. NSC-003/006 contract will install security fence on the open boat. Contractor shall coordinate with the Engineer to provide similar if not same security fence product.
1. Swing gate shall be Ameristar Impasse Trident five rail style, or approved equal.
 2. Install swing gate so Gauntlet fixtures do not interfere with the opening of the gate.
- B. The entire fence system, the associated gates(s), accessories, fittings and fasteners shall be obtained from a single source.

2.02 MATERIAL

- A. Steel material for fence framework, including corrugated pales, rails, and posts, shall be galvanized prior to forming in accordance with the requirements of ASTM A924/A924M, with minimum yield strength of 50,000 psi. The steel shall be hot-dip galvanized to meet the minimum requirements of ASTM A653/A653M with a minimum zinc coating of 0.90 oz/ft², Coating Designation G-90
- B. The manufactured galvanized framework shall be subjected to a thermal stratification coating process (high-temperature, in-line, multi-stage, multi-layer) including, as a minimum, a six-stage pretreatment/wash with zinc phosphate, an electrostatic spray application of an epoxy base, and a separate electrostatic spray application of polyester finish. The base coat shall be a zinc-rich thermosetting

epoxy powder coating (gray in color) with a minimum thickness of 2 mils. The topcoat shall be a “no-mar” TGIC polyester powder coat finish with a minimum coat thickness of 2 mils. The color shall be black. The stratification-coated framework shall be capable of meeting the performance requirements for each quality characteristic shown in Table 02825-1 Stratification – Coated Performance Requirements

TABLE 02825-1 Stratification – Coated Performance Requirements

Quality Characteristics	ASTM Test Method	Performance Requirements
Adhesion	D3389- Method B	Adhesion (retention of coating) over 90% of test area (tape and knife test).
Corrosion Resistance	B117 & D1654	Corrosion resistance over 3500 hours (scribed per D1645; failure mode is accumulation of 1/8" coating loss from scribe or medium #8 blisters).
Impact Resistance	D2794	Impact resistance over 60 inch lb. (forward impact using 0.625" ball)
Weathering Resistance	D822, D2244, D523 (60 Degree Method)	Weathering resistance over 1,000 hours (failure mode is 60% loss of gloss or color variance of more than 3 delta-E color units).

- C. Material for corrugated pales shall have a nominal thickness of 0.075 inches and shall be 2 ¾" wide. The cross-sectional shape of the rails shall be similar or equal to Ameristar's Impasse rail design with a nominal thickness of 0.100 inches. Pre-drilled holes in the rail shall be spaced 6" o.c. Tamperproof fasteners shall be used to fasten each pale to each rail. Posts shall similar or equal to Ameristar's Impasse double wall I-Beam design with a nominal membrane thickness of 0.100 inches (0.200" effective wall thickness).
- D. Material, dimensions and spacings for gate pales shall be the same as that used for fence panels. Gate ends and gate rails shall be 2" square x 11 ga. galvanized steel.

2.03 FABRICATION

- A. Pales, rails, and posts shall be pre-cut to specified lengths. Rails shall be pre-punched to accept the tamperproof security fasteners.
- B. Completed panels shall be capable of supporting 400 lb. load (applied at midspan) without permanent deformation. Panels shall be biasable to a 30 degree change in grade.

- C. Gates shall be fabricated using the fence pales. All gate rail and gate end intersections shall be joined by welding. All fence pale and gate rail intersections shall be joined by welding. Gates shall swing as shown in the Contract Documents. Provide locking mechanism including lock keys (4) to the Engineer prior to completion of the Work. Locking system may consist of a manufacturer's system, however the lock shall be a pad lock of sturdy construction. The lock shall be located so that emergency services shall be able to unlock the gate by cutting the lock with bolt cutters.
 - 1. Completed gates shall be capable of supporting a 600 lb. load applied at midspan without permanent deformation (prior to mounting gates to posts).

2.04 CONCRETE

- A. Concrete for installing fence posts shall be Class P Concrete in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures." .

ARTICLE 3 EXECUTION

3.01 PREPARATION

- A. All new installation shall be laid out by the Contractor in accordance with the Contract Documents.
- B. Contractor shall confirm dimensions of the gate and driveway prior to fabrication.

3.02 INSTALLATION

- A. Fence posts for eight (8) foot nominal spans shall be set 96" O.C. plus or minus 1/2". Gate posts shall be spaced according to the gate openings shown on the Contract Documents. The posts shall extend 3'-0" into the ground and shall be embedded with Class P concrete as shown on the Contract Documents.
- B. Panels shall be attached to posts using mounting brackets and tamperproof security fasteners supplied by the manufacturer.
- C. Post installations shall be vertical with the tops of the posts, rails and pales level.
- D. Install gates as shown on the Contract Documents.

3.03 CLEANING

- A. Contractor shall remove all excess material from the jobsite and clean all fence framework to remove any mud, grout, or other extraneous material before final approval.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASURMENT

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. Item 02825.004 – Security Fence, 10' Height, shall be measured per linear foot, complete in place.
- E. Item 02825.005 – Security Gate, 10' Height, 12' Width, shall be measured per each, complete in place.
- F. Item 02825.006 – Security Gate, 10' Height, 16' Width, shall be measured per each, complete in place.

4.02 PAYMENT

- A. [NOT USED]
- B. [NOT USED]
- C. [NOT USED]
- D. Item 02825.004 – Security Fence, 10' Height, will be paid at the unit price and shall include the cost of all related work specified in this Section.
- E. Item 02825.005 – Security Gate, 10' Height, 12' Width, will be paid at the unit price and shall include the cost of all related work specified in this Section.
- F. Item 02825.006 – Security Gate, 10' Height, 16' Width, will be paid at the unit price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 02840

GUIDE RAIL

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for guide rail, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Removal and disposal of existing guide rail.
 - 2. Furnishing and placement of guide rail components include posts, rail element, terminal sections, end treatments, and all other hardware associated.
 - 3. All connections to existing guide rail elements.

1.02 RELATED SECTIONS

- A. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication #72.
- C. ASTM.
- D. AASHTO.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Guide Rail in accordance with PENNDOT 408, Section 620.2 except as follows:
 - 1. Delete "Section 1119" from Section 620.2(a).
 - 2. Delete Section 620.2(b).
 - 3. Section 1109.01, modify Standard Drawings to Contract Drawings.
 - 4. Section 1109.02, modify Standard Drawings to Contract Drawings.
 - 5. Delete Section 1109.02 (b) and (c).
 - 6. Delete Section 1109.03 (a), (d), and (e).
 - 7. Delete Section 1109.04 (b).
 - 8. Section 1109.05, modify Standard Drawings to Contract Drawings.

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION OF GUIDE RAIL

- A. In accordance with PENNDOT 408, Section 620.3 except as follows:
 - 1. Modify Section 620.3 from Standard Drawings to Contract Drawings.
 - 2. Delete Section 620.3(a).4.
 - 3. Delete Section 620.3(a).6.
 - 4. Delete Section 620.3(a).7.
 - 5. Delete Section 620.3(b).
 - 6. Modify Section 620.3(c) to read "Remove existing guide rail from locations indicated, at which time the guide rail becomes Contractor's property. The transport and disposal of removed guide rail material is solely the responsibility of the Contractor.
 - 7. Delete Section 620.3 (d) and (e).

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 02840.001 – Type 2-S Guide Rail shall be measured per linear foot, complete in place.
- B. Item 02840.002 – Terminal Section shall be measured per each, complete in place.
- C. [NOT USED]
- D. [NOT USED]
- E. Item 02840.005 – Remove Existing Guide Rail (Contractor's Property) shall be measured per linear foot, complete in place.

4.02 PAYMENT

- A. Item 02840.001 – Type 2-S Guide Rail will be paid at the unit price and shall include the cost of all related work specified in this Section.
- B. Item 02840.002 – Terminal Section will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. [NOT USED]
- D. [NOT USED]
- E. Item 02840.005 – Remove Existing Guide Rail (Contractor's Property) will be paid at the unit price and shall include the cost of all related work specified in this Section.

END OF SECTION

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02840-3

April 21, 2008

Guide Rail

SECTION 02843

BOLLARDS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, material, tools, equipment, and incidentals necessary for bollards, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Excavation.
 - 2. Furnishing and placement of metal bollards, including any necessary hardware.
 - 3. Placement and compaction of base aggregate material.
 - 4. Placement and vibration of cement concrete.
 - 5. Furnishing and placement of expansion joint material and caulking.
 - 6. Painting.
 - 7. Expansion joint and caulk.

1.02 RELATED SECTIONS

- A. Section 02316, "Excavation."
- B. Section 02320, "Backfill."
- C. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- D. Section 09902, "Painting."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication 72.

ARTICLE 2 PRODUCTS

2.01 METAL BOLLARDS

- A. Metal bollards shall be as specified in the Contract Documents. The Contractor shall submit the bollard product data to the Engineer for approval.
- B. Class P Cement Concrete in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- C. AASHTO No. 57 Coarse Aggregate in accordance with Section 02320, "Backfill."

- D. Pre-molded Expansion Joint Material in accordance with PENNDOT 408, Section 705.1.
- E. Caulking in accordance with PENNDOT 408, Section 705.8 (b)
- F. Exterior paint (color to be determined by the Engineer) in accordance with Section 09902, "Paint."
- G. Padlock- Safety Lockout Padlock with a 1 3/4" laminated steel body or approved equal (1 padlock per entrance).
- H. Chain shall be 3/8" diameter hot galvanized proof coil chain (grade 30) with a minimum working load limit of 2650 pounds.
- I. All bollards shall match the size, shape, color and appearance of the existing bollards being replaced.
 - 1. Fixed bollards where indicated on the drawings shall be mental bollards manufactured by URBACO, UK.

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION

- A. The Contractor shall install bollards in accordance with the Contract Documents.
- B. The installation of the bollards shall be at the locations noted in the Contract Documents or as directed by the Engineer. The location of all bollards shall be approved by the Engineer before reinstallation.
- C. The installation shall include excavation for the bollard, furnishing the bollard, the connection hardware (eyebolt or approved equal), chain, the padlock, the concrete fill and the foundation supporting the bollard. Chain and connection hardware are constructed at parking lot driveway entrances only.
- D. Apply paint to all exposed portions of the bollard. Do not paint hardware and chains. Paint color to be determined by the Engineer.
- E. The Contractor shall furnish the keys for the padlocks to the Engineer at the completion of this item of work.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASURMENT

- A. Item 02843.001 –Bollards shall be measured per each, complete in place.

4.02 PAYMENT

- A. Item 02843.001 – Bollards will be paid at the unit price and shall include the cost of all work specified in this Section.**

END OF SECTION

SECTION 02891
TRAFFIC SIGNING

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor materials, tools, equipment and incidentals necessary for traffic signing, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Sign posts with a breakaway base.
 - 2. Post mounted signs.
 - 3. Sign brackets.
 - 4. Structure mounted extruded aluminum channel signs.
 - 5. [NOT USED]
 - 6. [NOT USED]
 - 7. [NOT USED]
 - 8. Excavation.
 - 9. Backfill.
 - 10. [NOT USED]
 - 11. [NOT USED]
 - 12. [NOT USED]
 - 13. [NOT USED]
 - 14. Installation and relocation of overhead clearance bars.

1.02 RELATED SECTIONS

- A. Section 01870, "Maintenance and Protection of Traffic."
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. Section 02316, "Excavation."
- F. Section 02320, "Backfill."
- G. Section 03211, "Reinforcement Bars and Dowels."
- H. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- I. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408.
- B. PENNDOT Publication 35 (Bulletin 15).
- C. PENNDOT Publication 236M.
- D. PENNDOT Publication 219 (BC-700 Series).
- E. AASHTO
- F. MUTCD.
- G. Standard Drawing Package (North Shore Connector, Supplemental Construction Details for the City of Pittsburgh).
- H. PENNDOT Publication 111M, (TC-8600 and TC-8700 Series)
- I. PENNDOT Publication 148

1.04 SUBMITTALS

- A. Submit sign fabrication Shop Drawings to the Engineer for approval prior to fabrication.
- B. Submit catalog cut and / or shop drawing for overhead clearance bar device, installation components, and installation locations.

ARTICLE 2 PRODUCTS

2.01 MANUFACTURERS

- A. Flat Sheet Signs in accordance with PENNDOT Bulletin 15.
- B. Breakaway Steel Posts in accordance with PENNDOT Bulletin 15.
- C. Extruded Aluminum Signs in accordance with PENNDOT Bulletin 15.

2.02 MATERIALS

- A. [NOT USED]
- B. Post Mounted Signs, Type B Modified in accordance with PENNDOT 408, Section 931.2.
- C. [NOT USED]
- D. [NOT USED]

- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]
- H. [NOT USED]
- I. [NOT USED]
- J. [NOT USED]
- K. [NOT USED]
- L. [NOT USED]
- M. Overhead clearance bar as shown on the Contract Drawings and as manufactured by Ideal Shield 2525 Clark Street Detroit, MI 48209 (1-866-825-8659). Provide clearance bars as follows:
 - 1. 7.5 inch diameter x 9'-2" long, lo-density polyethylene pipe with round end caps and withstands temperatures from -40 to 210 degrees F.
 - 2. The pipe material is safety yellow in color and has the message "CLEARANCE 7'-6" painted on the front surface.
 - 3. Two (2) stainless steel eye bolts are provide for the connection of the hanging chains.
 - 4. Hanging chain consisting of 316L stainless steel standard chain link with 3/16" size links. Provide lengths as necessary to install clearance bars at temporary and final locations.
 - 5. Provide stainless steel hardware as necessary to attach hanging chain to clearance bar and to bridge structure.
 - 6. Provide $\frac{1}{4}$ " stainless steel mechanical anchors to attach hanging chain to outside edge of bridge for the permanent anchorage.

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION

- A. [NOT USED]
- B. Post Mounted Signs, Type B Modified in accordance with PENNDOT 408, Section 931.3.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]

- F. [NOT USED]
- G. [NOT USED]
- H. [NOT USED]
- I. [NOT USED]
- J. [NOT USED]
- K. [NOT USED]
- L. [NOT USED]
- M. [NOT USED]
- N. [NOT USED]
- O. Temporary Traffic Signing is considered part of the work of Section 01870, "Maintenance and Protection of Traffic."
- P. Four (4)- overhead clearance bars shall be installed at the existing locations adjacent to Reedsdale Street after the permanent access road into Parking Lot 1 has been completed. Two (2)- Overhead clearance bars shall be installed at locations identified by the Contractor and approved by the Engineer (over the exit lanes on the permanent access road out of Parking Lot 1), submit the mounting locations for review and approval. Locate these two (2) clearance bars on the outside of the concrete bridge deck using $\frac{1}{4}$ " stainless steel mechanical anchors. The Contractor is to have the clearance bar and anchor locations approved by the Engineer prior to relocating these bars.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. [NOT USED]
- B. Item 02891.002 – Post Mounted Signs, Type B Modified shall be measured per square foot, complete in place.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]

- G. [NOT USED]
- H. [NOT USED]
- I. [NOT USED]
- J. [NOT USED]
- K. [NOT USED]
- L. [NOT USED]
- M. [NOT USED]
- N. [NOT USED]
- O. [NOT USED]
- P. [NOT USED]
- Q. No separate measurement shall be made for the Temporary Traffic Signing portion of the work of this Section.
- R. Item 02891.020 – Overhead Clearance Bar shall be measured per each, complete in place.

4.02 PAYMENT

- A. [NOT USED]
- B. Item 02891.002 – Post Mounted Signs, Type B Modified will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. [NOT USED]
- H. [NOT USED]
- I. [NOT USED]
- J. [NOT USED]

- K. [NOT USED]
- L. [NOT USED]
- M. [NOT USED]
- N. [NOT USED]
- O. [NOT USED]
- P. [NOT USED]
- Q. No separate payment will be made for the Temporary Traffic Signing portion of the work of this Section. Payment for such portion(s) of the work shall be included in the payment for related portions of the Work.
- R. Item 02891.020 – Overhead Clearance Bar will be paid at the unit price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 03211

REINFORCEMENT BARS AND DOWELS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for reinforcement bars and dowels, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Furnishing and placing plain or epoxy coated reinforcement bars, welded wire fabric, threaded dowel bar splicers and mechanical connections.
 - 2. Supply dowels to be grouted in place for cement concrete construction.
 - 3. [NOT USED]

1.02 RELATED SECTIONS

- A. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- B. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408
- B. PENNDOT Publication 35 (Bulletin 15).
- C. ASTM
- D. AASHTO
- E. ACI
- F. AWS, Section 1.4

1.04 SUBMITTALS

- A. The Contractor shall submit the following to the Engineer for review:
 - 1. Shop Drawings. Show reinforcing steel details in conformance with ACI 315, including material size, cutting and bending dimensions, placement plans and details, and marking for each reinforcement item. Show proposed lap splices and method of support.
 - a. If not shown on the Contract Drawings, lap splice lengths shall be supplied as an AASHTO, Class C splice.

2. Reinforcing Bar Lists. Submit bar schedules giving the weight for each bar, the total weight for each bar size, and the total weight of all the bars on the list. Bar weights will be based on theoretical unit weights shown in ASTM A615.
 3. Splice Devices: Submit technical data and two samples of each splice device proposed for use.
 4. Accessories and alternative reinforcement support choices.
- B. The Contractor shall submit the following certificates to the Engineer for review:
1. Submit copies of Certified Mill Test Reports (CMTR's), and Certificates of Compliance (C of C's), for the frequency of testing specified in AASHTO M31, Section 13. Random samples for verification will be obtained at the job site by the Engineer when deemed necessary. Such random samples will not exceed two pieces 30 inches long for Number 11 bar size and smaller and one piece 30 inches long for Numbers 14 and 18 bar sizes, per year, per supplier. Additional samples may be required if a nonconformity is encountered.
 2. Welding procedures and welding certificates complying with AWS D1.4.

1.05 QUALITY ASSURANCE

- A. Tolerances:
1. Fabrication tolerances for reinforcing bars, as listed below, shall be inspected and approved by the fabricator prior to shipping:
 - a. Sheared length: Plus or minus 1 inch.
 - b. Overall dimensions of stirrups, ties, and spirals: Plus or minus 1/2 inch.
 - c. All other bends: Plus or minus 1 inch.
 2. Placement tolerances for reinforcing bars, as listed below, shall be inspected and approved by the Engineer prior to placement of the concrete:
 - a. Clear distance to formed surfaces: plus or minus 1/4".
 - b. Minimum spacing between bars: minus 1/4".
 - c. Top bars in slabs and beams:
 - 1) Members 8" deep or less: plus or minus 1/4".
 - 2) Members greater than 8", but less than 2 ft deep: plus or minus 1/2".
 - 3) Members 2 feet or more deep: plus or minus 1".
- B. Reinforcing bars may be moved up to 1 inch to avoid interferences with embedded items.
- C. The minimum specified protective cover shall apply after all tolerances are taken into consideration.

1.06 PRODUCT DELIVERY, HANDLING, AND STORAGE

- A. After fabrication, bundle and tag reinforcing steel for identification at the job site. Provide readable tags identifying the steel by reinforcement item marking shown on approved shop drawings and giving quantity of such items contained in the bundle.

- B. Deliver reinforcing steel in bundles, limited to one size, grade, and length of bar, securely tied, and identified with plastic tags in an exposed position identifying the mill, the melt or heat number, and the grade and size of bars.
- C. Use reinforcing steel and wire fabric free from mud, grease, other foreign matter, and conditions causing rust or damage, in accordance with PENNDOT 408, Section 1002.3(a), first and second paragraphs.
- D. Reinforcement shall be stored above ground in a clean and dry condition on a platform in an orderly manner, plainly marked to facilitate inspection, in accordance with PENNDOT 408, Section 1002.3(b).

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Deformed Billet-steel Reinforcement Bars including dowels, spirals, and column ties shall be in accordance with PENNDOT 408, Section 709.1(a)2, AASHTO M31, (ASTM A615, Grade 60) and shall be epoxy coated where indicated on the Contract Drawings in accordance with PENNDOT 408, Section 709.1(c).
 - 1. Number 14 and number 18 bars shall not be lap spliced.
- B. Low alloy steel used when welding of reinforcing is required shall be in accordance with PENNDOT 408, Section 709.1(d), for ASTM A706 Grade 60.
- C. Annealed Iron Wire shall be in accordance with ASTM A684.
- D. Deformed Welded Wire Fabric shall be in accordance with PENNDOT 408, Section 709.4, AASHTO M221 (ASTM A497).
- E. Steel Welded Wire Fabric shall be in accordance with PENNDOT 408, Section 709.3, AASHTO M55 (ASTM A185).
- F. [NOT USED]
- G. Supports: Provide non-corrosive supports, such as chairs, bolsters, spacers, blocks, hangers, and other devices to support and position reinforcement, of adequate strength and approved design to prevent displacement of reinforcement. Supports shall be made of mortar, plastic, or metal. All parts of metal supports and accessories left in place within 1 1/2 inches of an exposed concrete surface shall be non-rusting metal or epoxy coated. Only plastic coated supports shall be used for architectural finished concrete.

ARTICLE 3 EXECUTION

3.01 PLACEMENT

- A. Place all reinforcement bars, welded wire fabric, mechanical connectors, and supply dowels to be grouted in place for cement concrete construction in accordance with PENNDOT 408, Sections 709 and 1002.3, and the Contract Documents. If one or more parameters conflict, use the more stringent.

3.02 PLACEMENT OF REINFORCING BARS AND WELDED WIRE FABRIC

- A. Contractor shall make field adjustments in accordance with PENNDOT 408, Section 1002.3(c).
- B. Contractor shall place and fasten bars and welded wire fabric in accordance with PENNDOT 408, Section 1002.3(d).
- C. Lap splicing of bars shall be in accordance with PENNDOT 408, Section 1002.3 (e).

3.03 PLACING AND FASTENING REINFORCING STEEL

- A. When placed in the Work, reinforcing steel shall be clean and free of dirt, heavy scale, paint, oil, grease, and other foreign matter that may reduce bond.
- B. Arrange and place reinforcement as shown on the Contract Drawings, approved Shop Drawings, and in accordance with the tolerances specified herein.
- C. Support and secure reinforcement as required in accordance with the following:
 1. Prevent displacement beyond the tolerances specified in accordance with Article 2.01G of this Section.
 2. Steel reinforcing shall be firmly secured against displacement by ties at every other intersection point with a maximum of 12 inches between tied joints. In addition, steel reinforcing mats (top and bottom) shall be securely connected together so that uniform vertical spacing can be maintained throughout. This connection may be accomplished with coated tie wires or other secure means. Connections shall be placed no farther apart than 4 feet. Support devices may be utilized for this purpose.
 3. Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shape and dimensions as approved by the Engineer. Blocks for spacing reinforcing bars shall also be precast mortar blocks of approved design and short enough to permit their ends to be adequately covered with concrete. The precast mortar blocks shall be made from the same materials and have the same or greater strength and the same proportions of sand and cement as that of the concrete in which they are to be used. They shall be cast and properly cured before use and shall have a wire of copper or other non-rusting metal or other device cast into each block so that the block can be securely fastened to the reinforcement. Layers of bars shall be separated by such blocks, which may be reinforced, and which shall have slots or other means to receive the

bars and hold them in place. All parts of metal supports that are left in place within 3 inches of an exposed surface of the concrete shall be non-rusting metal, epoxy coated, or galvanized. Galvanizing of such parts will be approved provided the weight of the zinc coating per square foot of actual surface shall average not less than 2 ounces, and no individual specimen shall show less than 1.8 ounces. Galvanizing shall not be used in locations where they will touch uncoated bars or ties. The use of pebbles, pieces of broken stone, metal pipe, or wooden blocks shall not be permitted.

- D. Do not field bend bars where piping, inserts, sleeves, or other such items interfere with placing of reinforcement. Obtain the Engineer's approval with the necessary adjustments to the reinforcement before placing concrete.
- E. Furnish and place dowels in accordance with the Contract Drawings.
- F. Rust Protection
 - 1. Wrap reinforcement with impervious tape or other accepted protective materials, where there is danger of rust staining adjacent surfaces. Remove protective materials and clean reinforcement as required before proceeding with concrete placement.
 - 2. On reinforcement that is partially embedded in the structure, and which may be exposed for more than three weeks before being enclosed in concrete, provide a light coat of neat cement grout on the surfaces of the exposed reinforcement to prevent staining of the exposed concrete surface.
- G. Welding: Welded reinforcement connections shall be placed where indicated on the Contract Drawings as part of the prescribed work. Use welding procedures in accordance with AWS D1.4. Only ASTM A706, Grade 60 reinforcement shall be welded.
 - 1. The Contractor may not use welded reinforcement connections in other locations without approval from the Engineer.
- H. Dowels shall be fully developed and shall be installed in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structure.", Article 1.04F.
- I. Mechanical splices shall be placed where indicated on the Contract Drawings as part of the prescribed work. The Contractor may use mechanical splices in other locations as he deems necessary at no additional cost to Authority.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 03305

CAST-IN-PLACE CONCRETE AND CEMENT CONCRETE STRUCTURES

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for cast-in-place concrete and cement concrete structures, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Preparing concrete mix designs
 - 2. Preparing concrete placement plans
 - 3. Providing concrete formwork
 - 4. Placing concrete.
 - 5. Curing of concrete
 - 6. Removal of formwork
 - 7. Supply and placement of embedment anchors, sealants, and expansion joints
 - 8. Penetrating Sealer
 - 9. Concrete testing
 - 10. All reinforcement: reinforcing bars, dowels, wire mesh, splices, epoxy coated reinforcing, threaded dowel bar splicers, and all welded reinforcement connections.

1.02 RELATED SECTIONS

- A. Section 01775, "Testing Laboratory Services."
- B. Section 02320, "Backfill."
- C. Section 02353, "Geotextile"
- D. [NOT USED]
- E. Section 03211, "Reinforcing Bars and Dowels"
- F. Section 09900, "Protective Coating for Concrete Surfaces"
- G. Section 16060, "Grounding and Bonding"
- H. [NOT USED]

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408

- B. PENNDOT Publication 34 (Bulletin 14)
- C. PENNDOT Publication 35 (Bulletin 15)
- D. PENNDOT PTM No. 611
- E. National Ready Mixed Concrete Association
- F. ASTM
- G. AASHTO
- H. ACI; Including ACI 224R-01 Chapters 3, 4, and 8 concerning crack control of the plinth concrete
- I. PENNDOT Publication 19 (PTM)

1.04 SUBMITTALS

- A. Contractor shall prepare and submit Shop Drawings for reinforcement bars, formwork anchor bolts, and conduits.
- B. Contractor shall prepare and submit Working Drawings and calculations signed and sealed by a Professional Engineer to supplement the Contract Documents for falsework, field sketches, joint layout and other details as necessary to construct the work, for review and approval by the Engineer. Include details of typical form systems, typical location of form joints, form ties, construction joints and embedments. Show all proposed placement sequences. Include technical data on proposed commercial form systems and forming accessories.
- C. Concrete Design Mixes: Contractor shall submit design mixes for review and approval for each class and type of concrete applicable to the areas of Work as shown in the Contract Documents. Include test data for proposed trial mixes or statistical data from previous Authority, PENNDOT, or City of Pittsburgh contracts in accordance with ACI 318, Article 5.3
- D. At least thirty (30) days before work is started, Contractor shall submit, for review and approval, a description of the proposed method, equipment and sequence (including schedule) for batching, mixing, transporting and placing concrete including any methods for protection from rain, snow, or freezing temperatures.
- E. At least thirty (30) days before work is started, Contractor shall submit for review and approval, a description of the mix plant recording methods and a sample report provided by the system. Include a legend identifying codes used to designate mix designs, batch weights and admixtures.
- F. Concrete Placement Plans
 - 1. If cold weather or hot weather concreting is anticipated or required, Contractor shall submit concrete placement and protection plan to Engineer and receive approval by the Engineer prior to placing concrete in cold or hot weather.

2. Contractor shall hold a concrete placement meeting and present details of the placement to the Engineer. Concrete placement shall not begin until the following have been accepted:
 - a. Placement plan,
 - b. Concrete mix design,
 - c. Inspection plan,
 - d. Concrete sampling plan.
 4. Submit materials data in accordance with Section 01300, Table 01300-1 for all accessory materials, for review and approval such as sealers, curing compounds, bond coats, and joint materials.
- G. Furnish test and verification data called for elsewhere in this Section, including:
1. Quality control program, test results, and quality control charts.
 2. Concrete batch printouts .
 3. Concrete strength data for form and falsework removal.
- H. [NOT USED]
- I. Submit resume of Engineer specified in Article 1.07.A of this Section for approval by the Engineer.
- J. Submit resume of the Contractor specified in Article 1.07.A of this Section for approval by the Engineer.
- K. Submit evidence of certification specified in Article 1.07.B for approval by the Engineer.

1.05 DEFINITIONS

- A. "New concrete construction," and "fresh concrete", Concrete work performed under this Contract.
- B. Air Temperature: The measured temperature, in the shade, not in direct rays of sun, or near artificial heat.
- C. Curing Temperature: The temperature of the air immediately adjacent to concrete. Where concrete is not covered by forms or other protective coverings, or where protective coverings are considered inadequate, the curing temperature will be considered as being not more than the air temperature.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Mixing Conditions in accordance with PENNDOT 408, Section 704.1 (f).
- B. No materials shall be used if they contain volatile organic compounds (VOC's) without prior written approval of the Engineer.

1.07 QUALITY ASSURANCE

- A. A qualified and experienced Contractor, who has completed concrete work similar in material, design and extent to that indicated for this Contract on at least three similar projects and whose work has resulted in construction with a record of successful in-service performance.
 - 1. A Professional Engineer, who is experienced in providing engineering services of the kind indicated, shall be employed by Contractor.
- B. A Contractor experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
 - 1. Manufacturer must be certified according to the National Ready Mixed Concrete Association's Certification of Ready Mixed Concrete Production Facilities or shall be an actively producing plant certified by PENNDOT.
- C. An independent testing agency shall be engaged by the Contractor to conduct field and laboratory testing as specified in this Section and Section 01775, "Testing Laboratory Services."
- D. Contractor shall obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source and each admixture from the same manufacturer.

ARTICLE 2 PRODUCTS

2.01 MANUFACTURERS

- A. PENNDOT approved materials in accordance with the following:
 - 1. PENNDOT Publication 35 (Bulletin 15)
 - a. Products: Premixed nonstaining, nonshrink grout; concrete admixtures; premixed nonshrink grout; epoxy bonding compound; anchor bolts, nuts and washers; cement; expansion joint filler; and protective coating.
 - 2. PENNDOT Publication 34 (Bulletin 14)
 - a. Product: Aggregate.

2.02 MATERIALS

- A. Cement Concrete: In accordance with PENNDOT 408, Section 704, indicated class, Portland Type II, Type IS or equivalent truck-mixed design cement for all concrete. High early-strength concrete shall not be used unless specified in other Sections.
 - 1. Class AAA Concrete: All traction power substation slabs and beams.
 - a. Submit all relevant data shown in PENNDOT 408, Section 704, Table A, for both the trial mix and placement mix to the Engineer for review and approval.
 - 2. Class P concrete – Primarily used for drainage structures, fence foundations, concrete paving and concrete sidewalks. City of Pittsburgh Class P concrete mix as approved by the City of Pittsburgh.

- B. Aggregates**
 - 1. Coarse and fine aggregates to be used in all classes of concrete shall be in accordance with PENNDOT 408, Section 703.1 and 703.2, limestone only.
- C. Concrete Curing Material and Admixtures**
 - 1. Curing and protecting covers in accordance with PENNDOT 408, Section 711.1.
 - 2. Curing compounds in accordance with PENNDOT 408, Section 711.2 (a) (clear compound only) and (c), compatible with protective coating, if any.
 - 3. Concrete admixtures in accordance with PENNDOT 408, Section 711.3.
- D. Nonstaining, Nonshrinking Grout** in accordance with PENNDOT 408, Section 1001.2(d).
- E. Nonshrink Grout for Studs, Dowels, and Anchor Bolts:** A PENNDOT Bulletin 15 approved premixed, nonshrink grout or PENNDOT 408, Section 1080.2(c), except use Type C Fine Aggregate.
 - 1. Contractor may use premixed nonshrink grout that passes a No. 8 sieve. Mix according to the manufacturer's instructions.
- F. Forms**
 - 1. Temporary in accordance with PENNDOT 408, Section 1001.2 (h) 1.
- G. Other Material**
 - 1. Premolded expansion joint filler in accordance with PENNDOT 408, Section 705.1.
 - 2. Joint sealing material in accordance with PENNDOT 408, Section 705.4(d).
 - 3. Reinforcement bars and welded and deformed fabric in accordance with Section 03211, "Reinforcing Bars and Dowels."
 - 4. Anchor bolts in accordance with PENNDOT 408, Section 1105.02(c)2, unless modified in the Contract Documents.
 - 5. Epoxy bonding compound in accordance with ASTM C881.
 - 6. Vapor barrier in accordance with 6 mil polyethylene film.
- H. Penetrating Concrete Sealer** in accordance with Section 09900, "Protective Coating for Concrete Surfaces."
- I. No materials shall be used if they contain volatile organic compounds (VOC's)** without prior written approval of the Engineer.

2.03 MIXES

- A. Proportioning and Mixing Concrete**
 - 1. In accordance with PENNDOT 408, Section 704 and Article 2.02, for proportioning and mixing all classes of concrete except for architectural concrete and silica-fume concrete as noted below.

- B. The Contractor shall use an independent testing agency for preparing and testing all proposed mix designs for the laboratory trial mix designs, and provide all results to Engineer for review and approval.

ARTICLE 3 EXECUTION

3.01 CONSTRUCTION

- A. Contractor shall construct in accordance with PENNDOT Standard Drawings and the Contract Documents.
- B. Forms and Centering
1. In general, Contractor shall support, pre-clean, brace, tie, and coat forms in accordance with PENNDOT 408, Section 1001.3 (a) 1.
- C. Reinforcement
1. Contractor shall place reinforcement in accordance with Section 03211, "Reinforcement Bars and Dowels"
- D. Contractor shall place pipes and conduits in the structure concrete, as indicated, including pipes and conduits furnished and delivered by others, in accordance with PENNDOT 408, Section 1001.3.(e). Existing pipes and conduits shall be maintained where indicated. For protection, Contractor shall wrap pipes with bituminous paper unless otherwise noted in the Contract Documents.
- E. Contractor shall place anchor bolts, and material of similar nature as indicated, including those supplied by others, in accordance with PENNDOT 408, Section 1001.3.(f). Projecting portions of anchor bolts shall be painted in accordance with PENNDOT 408, Section 1060.3 as soon as practical after the anchor bolts have been set, but not until the surrounding concrete or grout has hardened sufficiently to preclude damage from the painting operation. Threads shall be coated with grease after painting.
- F. Placing and Finishing Concrete
1. General requirements in accordance with PENNDOT 408, Section 1001.3 (k) 1.
 2. Contractor shall vibrate concrete in accordance with PENNDOT 408, Section 1001.3 (k) 2.
 3. Final Finishes:
 - a. Conventional finish shall be in accordance with PENNDOT 408, Section 1001.3 (k) 9.a.
 - b. For slabs receiving an architectural finish, supply the recommended finish required for the topping material.
 - c. All remaining slabs not included above shall receive a light broom finish.
 4. Patching shall be in accordance with PENNDOT 408, Section 1001.3(k)10.
 5. Water shall not be added to concrete during delivery, at Worksite, or during placement.
 - a. Do not add water to concrete after adding high-range water-reducing admixtures to mix.

- G. Joints shall be constructed in accordance with PENNDOT 408, Section 1001.3 (n).
- H. Curing and protection of concrete in accordance with PENNDOT 408, Section 1001.3 (p).
- I. Removal of falsework and forms and application of external loads to concrete in accordance with PENNDOT 408, Section 1001.3 (q).

3.02 FIELD QUALITY CONTROL

- A. Concrete shall be field tested in accordance with PENNDOT 408, Section 704.
- B. Prior to the removal of forms for cement concrete construction, Contractor shall determine the minimum compressive strength, using equipment in accordance with ASTM C39 on previously molded cylinder specimens. Test cylinders shall be cured in accordance with PENNDOT PTM No. 611.

3.03 JOINTS, BONDING, AND EMBEDDED ITEMS

- A. Construction Joints
 - 1. Make construction joints straight and as inconspicuous as possible (where exposed to view), and in accurate vertical and horizontal alignment. Grind down exposed surface irregularities and protrusions that could cause voids.
 - 2. Thoroughly clean the surface of the concrete at construction joints by water blasting, green cutting, or other effective method prior to placing adjoining concrete. As an allowance for initial shrinkage, do not place concrete against the hardened side of a construction joint for at least 36 hours.
 - 3. Reinforcement shall be continuous across construction joints. Provide keys and dowels in accordance with the Contract Drawings.
 - 4. Locations of construction joints shall be shown on submittals, except in case of emergency as specified below. The locations shall be in accordance with those shown on the Contract Drawings. If not shown on the Contract Drawings, the maximum spacing shall be 30 feet.
 - 5. When the work of placing concrete is unexpectedly interrupted by breakdowns, storms, or other causes, and the concrete as placed would produce an improper construction joint, the Contractor shall form a construction joint approved by the Engineer. When such a joint occurs at a section on which there is a shearing stress, the Contractor shall provide an adequate mechanical bond across the joint by forming a key, inserting reinforcing steel, or some other satisfactory means, which will prevent a plane of weakness.
- B. Expansion and Contraction Joints
 - 1. Construct joints in accordance with the Contract Drawings. Carefully inspect joints and ensure that they are free of concrete, grout, and debris. The outer edges of the joint shall be straight, parallel, and neat in appearance.
 - 2. Reinforcement and other embedded metal items bonded in the concrete shall not extend through the joint, unless shown on the Contract Drawings for corrosion control bonding or other purpose.
- C. Embedded Items

1. Clean items to be embedded in concrete of oil or foreign matter that would weaken the bond of the concrete to these items.
2. Install in the form work required inserts, anchors, sleeves, and other items furnished in the Contract Documents. Install anchor bolts, anchor systems, and continuous dovetail anchor slots, where shown. Secure all items in place to prevent movement during placement and compaction of concrete.
 - a. Use plastic sleeves on all anchor bolts to facilitate installation of bolted items. Once the bolted item is in place, grout the sleeve with non-shrink grout prior to grouting of any base plates or steel frames.
 - b. For anchor bolts, follow substation supplier's drawings and instructions.
3. Close ends of conduits, piping, and sleeves embedded in concrete with caps or plugs.
4. Complete tests on piping and other items which are required to be tested before starting concrete placement.
5. Before depositing concrete, check the location and support of piping, electrical conduits, and other items which are to be wholly or partially embedded.

3.04 CONCRETE SEALER

- A. Apply concrete penetrating sealer to all exposed concrete in accordance with the manufacturer's specifications.
- B. The concrete sealer shall be used as supplied by the manufacturer and not altered in any way. The sealer shall be applied onto the concrete surfaces at the manufacturer's recommended rate of coverage.
- C. Prevent the concrete sealer from coming in contact with open joints that have not yet been filled with joint sealant, so as to prevent any possible loss of bond of the joint sealant.

3.05 CONCRETE CRACK SEALING

- A. Cracks through slabs shall be sealed with a bead of polyurethane sealant. This applies only to cracks between 0.008 and 0.06 inch wide of the type that penetrate through the concrete slab and that result from inadequate control of shrinkage or temperature stresses during curing. Cracks of structural concern shall be repaired by other methods approved by the Engineer. Shallow cracks and craze cracking do not need to be sealed by the methods in this Article.
- B. Cracks shall be sealed after construction movement is substantially stable and before the cracked surface is covered by waterproofing, pavement, or other construction.
- C. Crack sealing materials shall be applied by skilled applicators under a supervisor or contractor with proven successful experience in applications of scope similar to this Contract. Crack sealing materials shall be applied when the concrete and the ambient air temperature are above 40 degrees F. If a heated enclosure is used to accomplish this, the heating device shall not be one that exhausts products of combustion within the enclosure, nor shall a combustion type be located within any tunnel or boat section.

- D. Before containers of sealing materials are opened, the labels shall be checked and the label information documented. If multi-component systems are used, mixing shall be completed prior to application. Manufacturers' instructions shall be followed.
- E. For all types, an initial demonstration application shall be satisfactorily made in the presence of the Engineer and approved before the application is allowed to continued.
- F. Cracks shall be sealed:
 1. On the top surface of slabs.
- G. Before application of the sealant, the crack shall be routed full length to form a V-shaped notch with a depth of between 1/4 inch and 3/8 inch and a width of between 3/16 inch and 3/8 inch. The routed crack shall be cleaned with an air jet and a wire brush to remove dust and loose particles.
- H. The routed crack shall be filled with sealant by trowel or pressure gun. The sealant shall be tooled to ensure intimate contact with the joint sides and removal of trapped air and voids, and brought flush and consistent with the concrete face.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 03305.001 - Traction Power Substation Pad and Transformer Pads shall be measured as a lump sum, complete in place.

4.02 PAYMENT

- A. Item 03305.001 - Traction Power Substation Pad and Transformer Pads will be paid at the lump sum price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 03630
PLINTH ANCHORING SYSTEM

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for the plinth anchoring system, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Plinth anchorage hole layout and locating trackbed deck reinforcement.
 - 2. Concrete drilling of plinth anchor holes as specified.
 - 3. Furnishing and placing plinth anchor reinforcement bars and the bonding epoxy.
 - 4. Testing plinth anchor placements.
 - 5. Repair of trackbed concrete damage caused by plinth anchoring activities including incomplete drilled holes.

1.02 RELATED SECTIONS

- A. Section 02450, "General Track Construction."
- B. Section 02452, "Direct Fixation Track Construction."
- C. Section 02453, "Special Track Construction."
- D. Section 03211, "Reinforcement Bars and Dowels."
- E. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408
- B. PENNDOT Publication 35 (Bulletin 15).
- C. ASTM
- D. AASHTO
- E. ACI

1.04 SUBMITTALS

- A. The Contractor shall submit the following certificates to the Engineer for review:
 - 1. Submit copies of Certified Mill Test Reports (CMTR's), and Certificates of Compliance (C of C's), for the frequency of testing specified in AASHTO M31, Section 13. Random samples for verification will be obtained at the Worksite by the Engineer when deemed necessary. Such random samples will not exceed two pieces per supplier. Additional samples may be required if a nonconformity is encountered.
- B. The Contractor shall submit the material technical data sheets for the bonding epoxy.
- C. The Contractor shall submit an installation procedure, including the proposed rebar location procedure, concrete repair procedures for damaged concrete as a result of the plinth anchor drilling activities, and successfully install six (6) demonstration anchors. The demonstration anchors may be in production locations.

1.05 QUALITY ASSURANCE

- A. Tolerances:
 - 1. The plinth drilled anchor hole locations shall not exceed 3" in any direction from the plan locations. The Contractor is responsible for ensuring that the plinth anchor location shall meet all stated clearance and concrete cover requirements.
 - 2. The Contractor shall perform a confined pull test (ASTM E488 and E1512) on each of the six (6) demonstration plinth anchors. The minimum pull-out strength required shall be 3000 lbs.
 - a. Production plinth anchors, perform confined pull-out tests at a frequency of four (4) tests in the first one hundred (100) installed anchors and four (4) tests for every three thousand (3000) subsequent plinth anchors.
 - 3. Placement tolerances for reinforcing bars, as listed below, shall be inspected and approved by the Engineer prior to placement of the plinth concrete:
- B. Anchor holes must be relocated a minimum of 3 inches if track slab rebar or other obstruction is encountered during the drilling process to meet the minimum edge distance for each hole. The abandoned hole shall be filled with a non-shrink grout.
- C. The minimum specified protective cover shall apply after all tolerances are taken into consideration.
- D. The field drilling procedure shall provide a positive stopping measure on the drill to prevent any over-drilling and to demonstrate the 6" depth is met.

1.06 PRODUCT DELIVERY, HANDLING, AND STORAGE

- A. Deliver, store, bundle and tag rebar in accordance with Section 03211 "Reinforcement Bars and Dowels" requirements.
- B. Store and protect the bonding epoxy material according to the manufacturer's recommendations.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. #4 Reinforcement bar; refer to Section 03211 "Reinforcement Bars and Dowels".
- B. Epoxy shall be a two part hybrid adhesive mortar combining urethane methacrylate resin, hardener, cement and water with a fast curing time similar or equal to Hilti HIT HY 150 MAX Adhesive Anchor or approved equal. The epoxy shall be delivered through a mixing nozzle or equal. Base material application temperature range shall be between 14° F and 104° F.

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. Layout the hole locations as per the typical sections and layout requirements shown in the Contract Drawings. Adjust the individual hole locations within the tolerances stated in these Specifications and the drawings to avoid existing rebar or other interferences.
- B. Drill the holes, place the reinforcement bars, and place the epoxy system in accordance with PENNDOT 408, Section 1002.3, the manufacturer's installation instructions and the Contract Documents. If one or more parameters conflict, use the more stringent parameter.

3.02 PLACEMENT OF REINFORCING BARS

- A. Contractor shall make field adjustments in accordance with PENNDOT 408, Section 1002.3(c).

3.03 PLACING AND FASTENING REINFORCING STEEL

- A. When placed in the Work, reinforcing steel shall be clean and free of dirt, heavy scale, paint, oil, grease, and other foreign matter that may reduce bond.
- B. Arrange and place reinforcement as shown on the Contract Drawings, approved Shop Drawings, and in accordance with the tolerances specified herein.
- C. Furnish and place the plinth anchor reinforcement bars in accordance with the Contract Drawings.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 03630.001 – Plinth Anchorage shall be measured per track-foot, complete-in-place. For measurement purposes, the following set payment dimensions shall apply:

The No. 4 Special Crossover shall be an equivalent of 214 track-feet. The Left and Right Track portions of the Crossover shall be measured as track feet.

The No. 6 Double Crossover shall be an equivalent of 100 track-feet.

The No. 8 Special Crossover shall be an equivalent of 180 track-feet. The Left and Right Track portions of the Crossover shall be measured as track feet.

4.02 PAYMENT

- A. Item 03630.001 - Plinth Anchorage will be paid at the unit price and shall include the cost of all work specified in this Section.

END OF SECTION

SECTION 04200
UNIT MASONRY

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for unit masonry, in accordance with the Contract Documents.
- B. The work of this Section includes, but is limited to, the following activities:
 1. Concrete unit masonry.
 2. Reinforced concrete unit masonry.
 3. Cleaning masonry.
 4. Installation of fire-safing material.
 5. Miscellaneous metalwork
 6. Design, construct, and maintenance of the Temporary Tunnel Closure Wall
 7. Installation of concrete masonry units under Gateway Station platform to close two access openings
- C. The Contract Documents provide the performance parameters and design criteria to complete the temporary tunnel closure wall portion of the Work. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricade."
- B. Section 02220, "Demolition."
- C. Section 03211, "Reinforcement Bars and Dowels."
- D. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- E. Section 05520, "Miscellaneous Metalwork."
- F. Section 08110, "Steel Doors and Frames."
- G. Section 08710, "Finish Hardware."

1.03 REFERENCE STANDARDS

- A. ACI

- B. ASCE
- C. ASTM
- D. ANSI
- E. NBS
- F. Brick Industry Association (BIA)
- G. NFPA

1.04 PERFORMANCE REQUIREMENTS

- A. Provide unit masonry that develops the following net-area compressive strengths (f_m) at 28 days. Determine compressive strength of masonry from net area compressive strengths of masonry units and mortar types according to ACI 530.1 / ASCE 6 / TMS 602.
- B. Provide unit masonry that develops the following installed compressive strengths (f_m) at 28 days.
 1. For Concrete Unit Masonry: As follows, based on net area:
 - a. $f_m = 1500$ psi, unless otherwise indicated.

1.05 SUBMITTALS

- A. Product Data for each different masonry unit, accessory, and other manufactured product specified. Submit color samples for the ground face block to be used at the TPSS site to the Engineer for color coordination with the NSC-011 headhouse block color. Engineer will approve color of ground face block prior to ordering block for installation.
- B. Shop Drawings for reinforcing detailing fabrication, bending, and placement of unit masonry reinforcing bars. Comply with ACI 315 "Details and Detailing of Concrete Reinforcement" showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of masonry reinforcement.
- C. Samples for verification of the following:
 1. Five full-size units for each different masonry unit required.
 2. Accessories embedded in the masonry.
 3. Weep holes/vents in color to match mortar color.
- D. Material certificates for the following, signed by manufacturer and Contractor, certifying that each material complies with requirements.

1. Each different cement product required for mortar and grout, including name of manufacturer, brand, type, and weight slips at time of delivery.
 2. Each material and grade indicated for reinforcing bars.
 3. Each type and size of joint reinforcement.
 4. Each type and size of anchors, ties, and metal accessories.
- E. Material test reports from a qualified independent testing agency, employed and paid by Contractor or manufacturer, indicating and interpreting test results relative to compliance of the following proposed masonry materials with requirements indicated.
1. Mortar complying with property requirements of ASTM C270.
 2. Grout mixes. Include description of type and proportions of grout ingredients.
 3. Masonry units.
- F. Shop Drawings for the design and construction of the Temporary Tunnel Closure Wall including design calculations (sealed by a Professional Engineer). Shop Drawings shall show all necessary elements including, but not limited to, location and design of the wall, emergency exit doors, signage, lighting, and pedestrian cross passage.

1.06 QUALITY ASSURANCE

- A. Referenced Standards: Masonry assemblies shall comply with ACI 530/ASCE 5, "Building Code Requirements for Masonry Structures", and ACI 530.1/ASCE 6, "Specifications for Masonry Structures".
- B. Masonry Testing Service: Contractor shall engage a testing laboratory, acceptable to the Engineer to test mortar and grout compositions, properties, and strengths.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store masonry units on elevated platforms, under cover, and in a dry location to prevent their deterioration or damage due to moisture, temperature changes, contaminants, corrosion, and other cause. If units become wet, do not install until they are in an air-dried condition.
- B. Store cementitious materials in their original containers on elevated platforms, under cover, and in a dry location. Do not use cementitious materials in broken containers or in containers showing water marks or other evidence of damage or contamination.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

- D. Store masonry accessories including metal items, to prevent corrosion and accumulation of dirt and oil.

1.08 PROJECT CONDITIONS

- A. Protection of Masonry: During erection, cover tops of walls with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
1. Extend cover a minimum of 24 inches down both sides and hold cover securely in place.
- B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least 3 days after building masonry walls or columns.
- C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed. Immediately remove grout, mortar, and soil that come in contact with such masonry.
- D. Cold-Weather Construction: When the ambient temperature is within the limits indicated, use the following procedures:
1. 40 to 32 deg F: Heat mixing water or sand to produce mortar temperatures between 40 and 120 deg F.
 2. If the tunnel temperature should fall below 32 degrees F at any time during the day or night, it shall be the responsibility of the Contractor to provide a temporary enclosure to maintain a temperature of 40 degrees F throughout the entire work area. heat both sides of walls under construction. Maintain 40 degrees F. within the enclosure for minimum 48 hours after construction.
 3. Do not build upon substrate having a temperature less than 40 degrees.
- E. Hot-Weather Requirements: Protect unit masonry work when temperature and humidity conditions produce excessive evaporation of water from mortar and grout. Provide artificial shade and wind breaks and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 deg. F and above.

ARTICLE 2 PRODUCTS

2.01 CONCRETE MASONRY UNITS (CMU) MATERIALS

- A. Size: Manufacturer's standard size plain CMU with nominal face dimensions of 10 inches x 16 inches. Thickness of units as indicated on the Contract Drawings.
- B. Special Shapes: Provide where required for lintels, corners, jambs, sash, control joints, headers, bonding conduit sleeves, and other special conditions.
1. Provide square-edged units for outside corners.
- C. Hollow non-load bearing CMU - ASTM C 129, Type I, moisture controlled, normal weight; interior only; not for exterior walls.

- D. CMU shall be manufactured with a waterproofing admixture. Possible products and suppliers include:
 - 1. DRY BLOCK as manufactured by W. R. Grace
 - 2. Master Seal SL as manufactured by Master Builders, Inc.
 - 3. or approved equal.
- E. All CMU shall be sound and free from cracks or other defects that would interfere with the proper placing of the units or impair the strength and appearance.
- F. Cure CMU in a moisture-controlled atmosphere or in an autoclave at normal pressure and temperature to comply with ASTM C 90, Type I.
- G. Limit moisture absorption during delivery and until time of installation to the maximum percentage specified for Type I units.
- H. Ground Face Block shall be provided by New Holland Concrete, block color G1028 (Adobe), or approved equal. Coordinate final block color with TPSS finish color and with the NSC-011 headhouse block color. Coordination with the NSC-011 block shall be through the Engineer.

2.02 MORTAR MATERIALS

- A. Portland cement lime mortar.
- B. Portland Cement: ASTM C 150, Type I, except Type III may be used for cold weather construction. Low-alkali, nonstaining cement.
- C. Hydrated Lime: ASTM C 207, Type S.
- D. Aggregate for Mortar: ASTM C144.
- E. Admixture for Mortar: water proofing as required to match masonry admixture.
- F. Water: Clean and potable.

2.03 JOINT REINFORCEMENT

- A. Horizontal Joint Reinforcing: Provide welded wire units prefabricated in straight lengths of not less than 10 ft., with match corner ("L") and intersecting ("T") units. Fabricate from cold-drawn steel wire complying with ASTM A 82, with deformed continuous side rods and plain cross rods, into units with widths of approximately 2 inches less than nominal width of walls and partitions as required to position side rods for full embedment in mortar with mortar coverage of not less than 5/8 inch on joint faces exposed to exterior and not less than 1/2 inch elsewhere. Provide the following type of joint reinforcing, unless otherwise indicated.
 - 1. Truss type with diagonal cross rods, unless otherwise indicated.
 - a. Prefabricated corners and tees.
- B. Number of Side Rods: Single pair for single wythe masonry and as indicated for

multi-wythe masonry, or if not otherwise indicated, one side rod for each brick wythe and one side rod for each face shell of each concrete masonry wythe.

- C. Wire Sizes: Fabricate with 9-gage side and cross rods, unless otherwise indicated.
- D. Wire Finish: For exterior and interior walls provide hot-dip galvanize joint reinforcing to comply with ASTM A 153, Class B-2 coating (1.5 oz. per sq. ft.).

2.04 ANCHORS AND TIES

- A. Provide straps, bars, bolts, and rods fabricated from not less than 16 gage sheet metal or 1/4" inch diameter rod stock, unless otherwise indicated. In accordance with the Contract Documents

2.05 FLASHING MATERIALS

- A. In accordance with Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricades, Article 2.06

2.06 MISCELLANEOUS MASONRY ACCESSORIES

- A. Expansion Joint Compressible Filler: see Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."
- B. Control Joints Sealers: see Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

2.07 MORTAR AND GROUT MIXES

- A. Do not lower the freezing point of mortar by use of admixtures or anti-freeze agents.
- B. Do not use calcium chloride in mortar or grout.
- C. Mortar for Unit Masonry: Comply with ASTM C270, Proportion Specification, for types of mortar required, unless otherwise indicated.
 - 1. The method of measuring materials for the mortar used in construction shall be either volume or weight. Measurement of sand and other mortar materials by shovel is not permitted.
- D. Waterproofing admixture in all mortar shall be Dry Block as manufactured by W. R. Grace, Masterseal SL as manufactured by Master Builders, Inc. or approved equal. The Contractor shall adherence to manufacturer's requirements. Admixture shall be guaranteed not to affect strength and color or cause efflorescence at joints.
- E. Grout for Unit Masonry: Comply with ASTM C 476 grout for use in construction of reinforced and non-reinforced unit masonry. Grout shall be of consistency

indicated or if not otherwise indicated, of consistency (fine or coarse) at time of placement which will completely fill all spaces intended to receive grout.

1. Coarse concrete grout mix with pea gravel (maximum 3/8 inch stone).
2. Minimum 3000 psi..

- F. Grout color for Ground Face block wall at TPSS shall be coordinated to match Ground Face block color as determined in Article 2.01.H of this Section.

2.08 REINFORCEMENT

- A. Reinforcement Bars and welded and deformed fabric shall be in accordance with Section 03211, "Reinforcing Bars and Dowels."
- B. Shop fabricated reinforcement which is shown to be bent or hooked.
- C. Steel Angles or other steel items, in accordance with Section 05502, "Miscellaneous Metalwork."

2.09 LINTELS

- A. Block Lintels: Fabricate from standard lintel-type concrete masonry units of the same material and texture as the units in the adjoining work, steel bar reinforced as indicated and filled with Class A concrete, use 3/8 inch aggregate.

2.10 MASONRY CLEANING MATERIALS

- A. Detergent Masonry Cleaner: General purpose cleaner for final cleaning of new masonry. Blend of organic and inorganic acids and wetting agents similar to "Sure Klean 600 Detergent" as manufactured by ProSoCo, Inc. or approved equal.

2.11 TEMPORARY TUNNEL CLOSURE WALL

- A. Doors, Frames, and Hardware in accordance with Section 08110, "Steel Doors and Frames." Section 08710, "Finish Hardware."
- B. Temporary pedestrian cross passage between emergency walkways in accordance with Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricade." Provide steps at either end if there is a difference in elevation between the cross passage and the emergency walkway. Provide temporary hand railing along the passage.
- C. Temporary lighting for emergency egress and pedestrian cross passage in accordance with Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricade."
- D. Temporary emergency exit signage
- E. Temporary Access Gate: Optional, Contractor's choice to suite it's needs. Materials are the Contractor's choice but shall be considered solid in nature due to the requirements provided in Article 3.10 of this Section.

F. Temporary tunnel closure wall: 10" CMU wall in accordance with this Section

G. Flashing and penetrations in accordance with the Contract Documents.

ARTICLE 3 EXECUTION

3.01 INSTALLATION, GENERAL

- A. Thickness: Build walls and other masonry construction to the full thickness of the masonry units, using units of thickness indicated.
- B. Build openings and recesses to accommodate items including overhead catenary, plinths and rail, railroad utilities, drainage channel, and emergency walkways.
- C. Cut masonry units with motor-driven saws designed to cut masonry with clean, sharp, unchipped edges. Cut units as required to provide pattern shown and to fit adjoining work neatly. Use full units without cutting wherever possible. Use dry cutting saws to cut concrete masonry units.
- D. Do not wet concrete masonry units.
- E. Construction Tolerances: Variation from Plumb: For vertical lines and surfaces do not exceed $\frac{1}{4}$ inch in any story, nor $\frac{1}{2}$ inch in 40 feet or more.
 - 1. Variation from Level: For bed joints and lines of exposed lintels, sills, and horizontal grooves, do not exceed $\frac{1}{4}$ inch in 20 feet, nor $\frac{1}{2}$ inch in 40 feet or more.
 - 2. Variation of Linear Building Line: For position shown in plan and related portion of columns, walls and partitions, do not exceed $\frac{1}{2}$ inch in 20 feet, nor $\frac{3}{4}$ inch in 40 feet or more.
 - 3. Variation in Mortar Joint Thickness: Do not exceed bed joint thickness plus or minus $\frac{1}{8}$ inch.
- F. Pattern Bond: Lay exposed masonry in the bond pattern in running bond vertical joint in each course centered on units in courses above and below. Lay concealed masonry with all units in a wythe bonded by lapping not less than 2 inches. Bond and interlock each course of each wythe at corners, unless otherwise shown.
- G. Layout walls in advance for accurate spacing of surface bond patterns, with uniform joint widths and to properly locate openings, movement-type joints, returns and offsets. Avoid the use of less than half size units at corners, jambs and wherever possible at other locations.
- H. Lay up walls plumb and with courses level, accurately spaced and coordinated with other work.
- I. Stopping and Resuming Work: Rack back $\frac{1}{2}$ masonry unit length in each course; do not tooth. Clean exposed surfaces of set masonry, wet units lightly (if specified to be wetted), and remove loose masonry units and mortar prior to laying fresh masonry.
- J. Built-In Work: As the work progresses, build in items specified in the Contract Documents. Fill in solidly with masonry around built-in items.

1. Fill space between hollow metal frames and masonry solidly with grout.
2. [NOT USED]
3. Fill CMU cores with grout 3 courses (24 inches) under lintels and similar conditions.
4. Provide support system which spans the 3' wide drainage trough located in the trackbed within the Gateway Station Loop. Span shall be provided for the weight of the block way to be constructed on top of the span.

3.02 MORTAR BEDDING AND JOINTING

- A. Batch Control: Measure and batch materials by volume or weight, such that required proportions for mortar can be accurately controlled and maintained. Measurement exclusively by shovel will not be permitted.
- B. Lay hollow concrete masonry units as follows:
 1. With full mortar coverage on horizontal and vertical face shells.
 2. Bed webs in mortar starting course on footings and in all courses where adjacent to cells or cavities to be filled with grout.
- C. Joints: Maintain joint widths shown, except for minor variations required to maintain bond alignment. If not otherwise indicated, lay walls with 3/8 inch joints. Cut joints flush for masonry walls which are to be concealed or to be covered by other materials. Tool exposed joints slightly concave using a jointer larger than joint thickness. Rake out mortar in preparation for application of caulking or sealants where shown.
- D. Remove masonry units disturbed after laying; clean and relay in fresh mortar. Do not pound corners at jambs to fit stretcher units which have been set in position. If adjustments are required, remove units, clean off mortar, and reset in fresh mortar.

3.03 HORIZONTAL JOINT REINFORCING

- A. Provide continuous horizontal joint reinforcing as shown and specified. Fully embed longitudinal side rods in mortar for their entire length with a minimum cover of 1/2 inch. Lap reinforcement a minimum of 6 inches. Do not bridge control and expansion joints with reinforcing, unless otherwise indicated. Provide continuity at corners and wall intersections by use of prefabricated "L" and "T" sections. Cut and bend units as directed by manufacturer for continuity at returns, offsets, pipe enclosures and other special conditions.
- B. Space continuous horizontal reinforcing as follows:
 1. For multi-wythe walls (solid or cavity) where continuous horizontal reinforcing acts as structural bond or tie between wythes, space reinforcing as required by code but not less than 16 inches o.c. vertically.
 2. For single-wythe walls, space reinforcing at 16 inches o.c. vertically, unless otherwise indicated.
- C. Reinforce masonry openings greater than 12 inches wide, with horizontal joint reinforcing placed in two horizontal joints approximately 8 inches apart, both immediately above lintels and below sills. Extend reinforcing a minimum of 24 inches beyond jambs of the opening.

3.04 ANCHORING MASONRY WORK

- A. Provide anchoring devices of the type indicated. If not indicated, provide standard type for facing and backup involved.
- B. Anchor masonry to structural members where masonry abuts or faces such members to comply with the following:
 1. Anchor masonry to structural members with metal ties embedded in masonry joints and attached to structure.
 2. Space anchors 24 inches o.c. vertically and 36 inches o.c. horizontally, unless otherwise indicated.
- C. Provide steel angles and shapes as shown on the Contract Drawings and in accordance with Section 05502, Miscellaneous Metalwork.”

3.05 CONTROL AND EXPANSION JOINTS

- A. Install control and expansion joints in unit masonry where indicated; if not indicated, maximum 30 feet on center. Build-in related items as the masonry progresses. Do not form a continuous span through joints unless provisions are made to prevent in-plane restraint of wall or partition movement.
- B. Form control joints in concrete masonry as follows:
 1. Install preformed control joint gaskets designed to fit standard sash block.
 2. Form joint of width indicated, but not less than 3/8 inch for installation of sealant and backer rod. Maintain joint free and clear of mortar.

3.06 LINTELS

- A. Provide minimum bearing at each jamb for whichever is greater, 8 inches or 1 inch per foot of masonry opening and in accordance with the Contract Drawings.

3.07 REINFORCED CONCRETE UNIT MASONRY

- A. Construct low-lift masonry by placing reinforcement, laying masonry units and pouring grout as the work progresses.
- B. Place vertical reinforcement bars and supports prior to laying of masonry units. Extend above elevation of maximum pour height as required to allow for splicing. Horizontal reinforcement bars may be placed progressively with laying of masonry units.
 1. Support vertical reinforcing in position at vertical intervals not exceeding 192 bar diameters nor 10 feet.
- C. Limit grout pours as required to prevent displacement of masonry by grout pressures (blowout), but do not exceed 48 inches pour height.
- D. Pour grout using container with spout and consolidate immediately by rodding or puddling; do not use trowels. Place grout continuously; do not interrupt pouring of grout for more than one hour. If poured in lifts, place from center-to-center of masonry courses. Terminate pour 1-1/2 inches below top of highest course in pour.

- E. When more than one pour is required to complete a given section of masonry, extend reinforcement beyond masonry as required for splicing. Pour grout to within 1½ inches below top course of each pour. After grouted masonry is cured, lay masonry units and place reinforcement for second pour section before grouting. Repeat sequence if more pours are required.

3.08 REPAIR, POINTING AND CLEANING

- A. Repair: Remove and replace masonry units which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in fresh mortar or grout, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge any voids or holes, except weep holes, and completely fill with mortar. Point-up all joints at corners, openings and adjacent work to provide a neat, uniform appearance, properly prepared for application of caulking or sealant compounds.
- C. Cleaning: Clean exposed brick masonry surfaces by the bucket and brush hand cleaning method. Comply with requirements of BIA Technical Notes No. 20 "Cleaning Brickwork."
 1. Use commercial cleaning agents in accordance with manufacturer's instructions, if approved by Engineer.
 2. Clean expose CMU masonry by dry brushing at the end of each day's work and after final pointing to remove mortar spots and droppings. Comply with recommendations of masonry cleaning materials manufacturer.

3.09 QUALITY CONTROL

- A. The Contractor shall employ and pay all costs for a testing laboratory to perform quality control testing during construction, including a certified technician to obtain samples at the Worksite.
- B. Testing Frequency: Tests and evaluations listed in this Article will be performed during construction of each wall
- C. Evaluate mortar composition and properties; ASTM C780.
- D. Test mortar properties; ASTM C270.
- E. Test grout used in masonry construction; ASTM C1019.
- F. Evaluation of Quality Control Tests: In absence of other indications of noncompliance with requirements, masonry will be considered satisfactory if results from construction quality control tests comply with minimum requirements indicated.
- G. The results will be reported in writing to Engineer on same day that tests are made.

3.10 TEMPORARY TUNNEL CLOSURE WALL

- A. Construct temporary tunnel closure wall immediately after the Wood Street turnback operations have been instituted by the Contractor and Authority. Ensure that all necessary Authority facilities have been decommissioned, specifically the overhead catenary system (OCS) prior to work associated with the wall. Do not disable existing Gateway Station emergency ventilation systems until the temporary tunnel closure wall has been completed and accepted by the Engineer.
- B. Provide all necessary facility framing. The Contract Documents show various facilities including OCS, drainage channel, standpipes, emergency walkways, plinths and rail. Provide sleeves for existing conduit and cables and relocated conduit including the relocated 23 kv feeder cables and emergency ventilation fans EM-9 and EM-10 power and control cabling. Provided blockouts for any other necessary facilities as required.
- C. Provide flashing in areas of blockout to provide an environmental and secure wall closure.
- D. Contractor may wish to install a gate for access between the construction zone and Authority operating tunnel. The gate should be sized to accommodate contractor's equipment should it wish to transport construction vehicles in and out of the tunnel. The gate, if installed will be located on the inbound (left track) side. The gate shall be constructed of a material which is solid so when it is closed, the wall acts to provide a solid cut off of the tunnel. If a gate is installed, the gate shall be equipped with a locking mechanism. Supply the Engineer with a means to unlock the gate.
- E. Provide emergency exit doors in accordance with Section 08110, "Steel Doors and Frames. Provide "Panic Hardware" on the Wood Street Station side, and standard door mechanism on the Gateway side to allow two way access through the wall. Doors need to have automatic closing hardware so that they remain closed unless in use. Do not prop open doors. These doors need to remain closed to provide for proper functioning of the emergency ventilation fan operation
- F. Install a temporary pedestrian cross passage on the Gateway Station side of the temporary tunnel closure wall. Install steps on both sides if there is a difference in elevation between the emergency walkways and the temporary pedestrian cross passage. If the Contractor chooses to install a gate for construction vehicle access, provide for a removable portion of the pedestrian cross passage to facilitate this traffic. Do not remove the removable cross passage section until the vehicle traffic is at the gate and ready to travel through the area. Replace the removable cross passage section immediately after the vehicle has passed through the gate. This cross passage is required to be in service at all times should an emergency occur.
- G. Provide emergency exit signage above both exit doors on both sides of the wall. Provide Emergency Exit directional signage at the pedestrian cross passage. The route of emergency exit will require people located on the emergency walkway left track

(inbound) side to cross over to the right track (outbound) side to continue to evacuate to the emergency egress located at the end of the existing Gateway Station platform.

- H. Provide temporary lighting including but not limited to electrical supply, conduit, and wiring for the pedestrian cross passage and closure wall in accordance with Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricades."
- I. The temporary tunnel closure wall separates the fire zone for Wood St from the construction on the Gateway side. The temporary tunnel closure wall shall deter air from being pulled down from the Gateway construction. All temporary tunnel closure wall elements shall resist 0.5 psi wind load.
- J. Maintain temporary tunnel closure wall throughout the Work. Remove the temporary tunnel closure wall at the conclusion of the work in accordance with Section 02220, "Demolition." The wall shall remain in service until the new tunnel ventilation equipment is installed and commissioned. Do not begin demolition of temporary tunnel closure wall until receipt of written approval from the Engineer.

3.11 8" CONCRETE MASONRY UNITS AT NEW GATEWAY STATION

- A. Install 8" concrete masonry units in two 3'-4" high by 8'-0" long access openings under the platform at Gateway Station. The right track opening is furthest north in the station. The left track opening is furthest south in the station. Masonry block will be provided by the NSC-010 contractor.

3.12 EXISTING VENTILATION FAN DAMPER CLOSURE

- A. After removal of the existing ventilation fan dampers located within the existing Gateway Loop, Contractor shall construct concrete block walls, 10" CMU within the damper opening to close off the void in the wall. Construct walls at locations shown in the Contract Documents.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 04200.001 – Temporary Tunnel Closure Wall shall be measured as a lump sum unit, complete in place.
- B. Item 04200.002 – Concrete Ground Face Block Wall, 10" CMU shall be measured as a square foot unit, complete in place.
- C. Item 04200.003 – Concrete Block Wall, 10" CMU shall be measured as a square foot unit, complete in place.

- D. No measurement shall be made for the installation of the 8" Concrete Masonry Units at Gateway Station portion of the work of this Section.

4.02 PAYMENT

- A. Item 04200.001 – Temporary Tunnel Closure Wall will be paid at the lump sum price and shall include the cost of all work specified in this Section.
- B. Item 04200.002 – Concrete Ground Face Block Wall, 10" CMU will be paid at the unit price and shall include the cost of all work specified in this Section.
- C. Item 04200.003 – Concrete Block Wall, 10" CMU will be paid at the unit price and shall include the cost of all work specified in this Section.
- D. No separate payment will be made for the 8" Concrete Masonry Units at Gateway Station portion of the work of this Section. Payment for portion(s) of the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 05120

STRUCTURAL STEEL

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for structural steel, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. Section 15400, "Tunnel Services Scope of Work"
- B. Section 15887, "Tunnel Ventilation and Balancing Dampers"
- C. Section 15888, "Tunnel Ventilation Noise Attenuators"
- D. Section 15889, "Tunnel Ventilation Fans"
- E. Section 15889, "Tunnel Ventilation Jet Fans"

1.03 REFERENCE STANDARDS

- A. AASHTO
- B. AISC
- C. ANSI
- D. ASTM
- E. AWS
- F. Industrial Fasteners Institute (IFI)
- G. PENNDOT, Publication 408
- H. PENNDOT, Publication 19 (PTM)
- I. SSPC

1.04 SUBMITTALS

- A. Shop Drawings, Working Drawings, and erection drawings shall be provided in accordance with PENNDOT 408, Section 1105.01(c) and (d).

- B. Mill Orders and Shipping Statements shall be provided in accordance with PENNDOT 408, Section 1105.01(e)6, except as modified herein:
 - 1. Revise Department's shop inspector to Contractor's testing agency / shop inspector.
- C. DTI Certificates shall be provided in accordance with PENNDOT 408, Section 1105.02(d) and (d)6.
- D. High Strength Bolt Certificates shall be provided in accordance with PENNDOT 408, Section 1105.02(d) and (d)3.
- E. Bolts, Nuts, and Washers documentation shall be provided in accordance with PENNDOT 408, Section 1105.02(d), (d)8, (d)8.a, (d)8.b, and (d)8.c.
- F. Welded Stud Shear Connector certificates shall be provided in accordance with PENNDOT 408, Section 1105.02(e)4.
- G. Furnish certification that the requirements pertaining to shop painting have been performed as specified in Section 09910, "Inorganic Zinc-Rich Paint System for Structural Steel-Shop Application.", prior to beginning any shop painting.

1.05 DEFINITIONS

- A. Direct Tension Indicator (DTI): A hardened washer with protrusions on one face that are flattened as the bolt is tensioned. Correct bolt tension is then determined by examining the gap between the washer and bolt head remaining after tightening.

1.06 QUALITY ASSURANCE

- A. Prequalification shall be provided in accordance with PENNDOT 408, Section 1105.01(a).

1.07 DELIVERY, STORAGE AND HANDLING

- A. Storage of Materials shall be provided in accordance with PENNDOT 408, Section 1105.01(f).
- B. Materials shall be handled and stored per manufacturer's recommendations. Each lot shall be shipped in protective containers with type, lot number, quantity, and total lot size.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Structural Steel shall be provided in accordance with PENNDOT 408, Section 1105.02(a).
- B. [NOT USED]

- C. Bolts, Nuts, and Washers shall be provided in accordance with PENNDOT 408, Section 1105.02(c).
- D. High-Strength Bolts shall be provided in accordance with PENNDOT 408, Section 1105.02(d).
- E. Welded Stud Shear Connectors shall be provided in accordance with PENNDOT 408, Section 1105.02(e).
- F. Steel Pipe shall be provided in accordance with PENNDOT 408, Section 1105.02(j).
- G. [NOT USED]
- H. Welding Material shall be provided in accordance with PENNDOT 408, Section 1105.02(t).
- I. [NOT USED]
- J. [NOT USED]

ARTICLE 3 EXECUTION

3.01 FABRICATION

- A. Straightening Material and Curving Rolled Beams and Welded Girders shall be in accordance with PENNDOT 408, Section 1105.03(a).
- B. Finish shall be in accordance with PENNDOT 408, Section 1105.03(b).
- C. Bolt Holes shall be in accordance with PENNDOT 408, Section 1105.03(c).
- D. Preparation of Field Connections shall be in accordance with PENNDOT 408, Section 1105.03(d).
- E. Accuracy of Hole Group shall be in accordance with PENNDOT 408, Section 1105.03(e).
- F. Bolting shall be in accordance with PENNDOT 408, Section 1105.03(f).
- G. Preassembly of Field Connections shall be in accordance with PENNDOT 408, Section 1105.03(g).
- H. Match-Marking shall be in accordance with PENNDOT 408, Section 1105.03(h).
- I. Connections Using Unfinished or Turned Bolts shall be in accordance with PENNDOT 408, Section 1105.03(i).
- J. Connections Using High Strength Bolts shall be in accordance with PENNDOT 408, Section 1105.03(j).

- K. Plate Cut Edges shall be in accordance with PENNDOT 408, Section 1105.03(k).
- L. Welding shall be in accordance with PENNDOT 408, Section 1105.03(m).
- M. Oxygen and Air Plasma Arc Cutting shall be in accordance with PENNDOT 408, Section 1105.03(p).
- N. Facing of Bearing Surfaces shall be in accordance with PENNDOT 408, Section 1105.03(q).
- O. Abutting Joints shall be in accordance with PENNDOT 408, Section 1105.03(r).
- P. Plates: Direction of Rolling, Fabrication of Members shall be in accordance with PENNDOT 408, Section 1105.03(s).
- Q. Bent Plates shall be in accordance with PENNDOT 408, Section 1105.03(t).
- R. Fit of Stiffeners shall be in accordance with PENNDOT 408, Section 1105.03(u).
- S. Annealing and Stress Relieving shall be in accordance with PENNDOT 408, Section 1105.03(w).
- T. Threads for Bolts and Pins shall be in accordance with PENNDOT 408, Section 1105.03(z).
- U. Marking and Shipping shall be in accordance with PENNDOT 408, Section 1105.03(bb).
- V. Painting shall be in accordance with PENNDOT 408, Section 1105.03(cc).
- W. Identification of Steel During Fabrication shall be in accordance with PENNDOT 408, Section 1105.03(dd).
- X. Welded Connections shall be in accordance with PENNDOT 408, Section 1105.03(ee).
- Y. Numerically-controlled Drilled Field Connections shall be in accordance with PENNDOT 408, Section 1105.03(ff).
- Z. Facing of Bolted Surfaces shall be in accordance with PENNDOT 408, Section 1105.03(gg).
- AA. Determination of Surface Flatness shall be in accordance with PENNDOT 408, Section 1105.03(hh).

3.02 SHOP FINISHING

- A. [NOT USED]

3.03 SOURCE QUALITY CONTROL

- A. Quality Control shall be in accordance with PENNDOT 408, Section 1105.01(g).
- B. Supplemental Requirements for Notch Toughness shall be in accordance with PENNDOT 408, Section 1105.02(a)4, except as modified herein:
 - 1. All indicated testing is to be provided by the Contractor's testing laboratory.
- C. High Strength Bolts, Nuts, and Washers shall be in accordance with PENNDOT 408, Section 1105.02(d)7.
- D. Galvanizing shall be in accordance with PENNDOT 408, Section 1105.02(s).
- E. Full Size Tests shall be in accordance with PENNDOT 408, Section 1105.03(aa).
- F. Welds: shall be in accordance with PENNDOT 408, Section 1105.03(m)8.
- G. Inspection shall be in accordance with PENNDOT 408, Section 1105.01(e), except as modified herein:
 - 1. Inspection will be provided by the Contractor's testing laboratory.

3.04 ERECTION

- A. Handling and Storing Materials shall be in accordance with PENNDOT 408, Section 1050.03(c)1.
- B. Falsework Design and Construction shall be in accordance with PENNDOT 408, Section 1050.03(c)2.
- C. Erection Procedure shall be in accordance with PENNDOT 408, Section 1050.03(c)3.
- D. Bearings and Anchorage shall be in accordance with PENNDOT 408, Section 1050.03(c)4.
- E. Straightening Material shall be in accordance with PENNDOT 408, Section 1050.03(c)5.
- F. Field Assembly shall be in accordance with PENNDOT 408, Section 1050.03(c)6. Perform and inspect all field welds in accordance with AWS D1.5 and for tubular sections AWS D1.1.
- G. Connections Using High Strength Bolts shall be in accordance with PENNDOT 408, Section 1050.03(c)7.
- H. Misfits shall be addressed in accordance with PENNDOT 408, Section 1050.03(c)9.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 05505

METAL OCS POLES

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for metal OCS poles, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following:
 - 1. Termination Portals
 - 2. OCS Support Poles
 - 3. Headspan Poles
 - 4. Cross-span Poles
 - 5. Small Part Steelwork

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 09910, "Painting OCS Poles."
- C. Section 16602, "General Requirements Overhead Contact System."

1.03 REFERENCE STANDARDS

- A. ASTM
 - 1. A36 Structural Steel
 - 2. A53 Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless
 - 3. A283 Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars
 - 4. A325 High Strength Bolts for Structural Steel Joints, Including Suitable Nuts and Plain Hardened Washers
 - 5. A370 Methods and Definitions for Mechanical Testing of Steel Products
 - 6. A449 Quenched and Tempered Steel Bolts and Studs
 - 7. A563 Carbon and Alloy Steel Nuts
 - 8. A588 High-Strength Low-Alloy Structural Steel with 50 KSI Minimum Yield Point to 4 inch Thick
 - 9. A595 Steel Tubes, Low-Carbon, Tapered for Structural Use
 - 10. A687 High-Strength Non-headed Steel Bolts and Studs
 - 11. A871 High-Strength Low-Alloy Structural Steel Plate with Atmospheric Corrosion Resistance
 - 12. E269 Standard Definitions of Terms Relating to Magnetic Particle Examination
 - 13. E709 Standard Recommend Practice for Magnetic Particle Examination

14. F436 Hardened Steel Washers
 15. F593 Stainless Steel Bolts, Hex Cap Screws, and Studs
- B. AISC
1. S326 Specifications for the Design, Fabrication and Design of Structural Steel for Buildings.
 2. S302 Code of Standard Practice for Steel Buildings and Bridges.
- C. AWS
1. D1.1 Structural Welding Code

1.04 SUBMITTALS

- A. Contractor shall submit the manufacturer's specifications and installation instructions for approval for all components in this Section.
- B. Contractor shall submit Shop Drawings for approval showing details and dimensions of all pole types, together with complete specifications of materials and supporting calculations.
 1. Prepare Shop Drawings under seal of a Professional Engineer.
 2. Indicate welded connections using standard AWS welding symbols. Indicate net weld lengths.
- C. Certificates of compliance shall be submitted for all components in this Section.
 1. Certification: Before commencing fabrication furnish a certification verifying that the materials have been designed, manufactured, inspected, and tested in accordance with the applicable portion of the reference standards and this Section.
 2. Test Reports: Furnish copies of reports of all factory tests as required by this Section and referenced standards.
- D. Submit certificates of qualifications for welders and welding inspectors.
 1. Provide certifications that welders employed have satisfactorily passed AWS qualification tests within the previous 12 months.
 2. If re-certification of welders is required, re-testing will be at the expense of the Contractor.
 3. Approval of the Welding Inspector shall be obtained from the Engineer.
- E. Samples: Contractor shall submit an authentic sample of any component which was accepted or conditionally accepted by the Engineer (as indicated on Shop Drawing reviews) when so requested by the Engineer, or as required by this Section. All samples shall be identified with a tag label of desirable material, wired to the sample.

1.05 QUALITY ASSURANCE

- A. Qualifications for Welding Work
 - 1. Quality of welding processes and welding operations shall be in accordance with AWS D1.1.
- B. Source Quality Control
 - 1. Material and fabrication procedures are subject to inspection and tests in the mill, shop, and field. These inspections and tests shall not relieve Contractor of the responsibility for providing materials and fabrication procedures, which are in compliance with the requirements.
- C. Field Measurements: Take all field measurements prior to preparation of Shop Drawings and fabrication.
- D. Shop Assembly: Pre-assemble components in the shop to the maximum extent possible, to minimize field splicing and assembly of units at the Worksite. Disassemble units only to the extent necessary for shipping and handling. Clearly mark components for easy assembly at Worksite.
- E. Material Testing: The chemical compositions and appropriate mechanical properties shall be determined for all materials used, either by obtaining manufacturer's certificates of compliance or by laboratory testing at a facility acceptable to the Authority.
- F. Weld Testing
 - 1. The services of an AWS Certified Welding Inspector shall be provided by the fabricator to perform specified fabrication and verification inspection of welding procedures, and to perform weld tests as specified herein.
 - 2. A visual inspection of all welds shall be performed in conformance with the AWS Code.
 - 3. Weld testing shall be performed on a sample number of poles selected at random by the Engineer, comprising 5 percent of the total number of poles.
 - 4. Equipment, procedures and personnel for weld testing, and test reports, shall conform to the requirements of AWS D1.1, Section 6 Inspection.
 - 5. Weld testing shall consist of:
 - a. Ultrasonic and radiographic testing conforming to the requirements of AWS D1.1, Section 6; and
 - b. Magnetic particle testing conforming to the requirements of ASTM E709.
 - 6. All poles selected for testing shall be tested by the ultrasonic and magnetic particle methods. In addition, one-quarter of these poles, or a minimum of 2 poles, selected at random by the Engineer, shall also be tested by the radiographic method.
 - 7. Ultrasonic or radiographic testing shall be performed on the complete penetration welds between the pole shaft and pole base, and on any circumferential welds in the pole shaft at splice location (if any), for each pole being tested. Magnetic

- particle testing shall be performed on all other welds including longitudinal seam welds, welds at handholes, cable outlets, etc.
8. For each tested pole that is found to be unacceptable, weld testing shall be performed on a further sample of two poles, selected at random by the Engineer.
 9. Results of weld testing shall be deemed acceptable or unacceptable in accordance with AWS D1.1, Sections 8, 9 or 10.
 10. Welds found to be unacceptable shall be repaired in accordance with AWS D1.1, Section 3, and re-tested at the Contractor's expense.
- G. Impact Testing: Structural steel materials for base plates and pole shafts shall be tested for impact toughness in accordance with the Charpy V-notch test as specified in ASTM A370. The minimum energy value shall be 15 ft-lbs at 0 degrees F.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Contractor shall ensure that all materials furnished are suitably packaged and protected against damage during delivery and transportation.
- B. Contractor shall store all products in accordance with the manufacturer's instructions, to ensure that all material is protected from damage.
- C. Contractor shall handle and otherwise use the guys and anchors in accordance with the manufacturer's instructions, so as to ensure that the products are not damaged or misused prior to or during installation.
- D. Any damage to the equipment and material shall be Contractor's responsibility and all repairs and replacements shall be accomplished by Contractor in accordance with the manufacturer's instructions, at Contractor's expense.
- E. Poles and portal cross-beam shall be prepared and shipped in a manner to prevent damage to the painted or weathering surfaces.
- F. Poles and portal cross-beam shall be delivered to site to ensure uninterrupted work progress.
- G. Poles, portal cross-beams and base plates shall be delivered complete with associated fittings and accessories, properly packed and protected against damage and loss of parts.
- H. Only limited quantities of various components may be stored at one time; however, sufficient stocks of items shall be in continuous storage on site to permit the Engineer to inspect on a regular basis all components prior to their inclusion in the erected Overhead Contact System. OCS poles, portal cross-beam and small part steelwork shall not be stored in direct contact with the ground. All steel, which becomes soiled

or damaged by improper storage methods will be repaired and returned to a like-new condition at the Contractor's expense.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. General: Painted steel poles will be installed at all locations.
 - 1. The poles shall be tapered tubular steel that conforms to the general size requirements shown on the Contract Drawings.
 - 2. The square tube portal poles and cross-beam shall conform to the requirements shown on the Contract Drawings.
 - 3. Metal fabrications and small part steelwork to be erected for the Overhead Contact System shall be designed, furnished and installed by Contractor following the guidelines in Articles 2.01B through 2.01L of this Section.
- B. Poles and Portal
 - 1. Pole shafts and portal cross-beam shall be fabricated from one piece (no splicing) and from one structural steel material type conforming to the ASTM A871 Grade 60.
 - 2. Subject to the Engineer's approval, other materials and fabrication methods may be used for the poles and portal cross-beam. For tapered tubular poles, consideration will be given to press-formed poles (minimum 18 sides) provided that a visually round section is obtained. Wide-flange type poles will not be considered.
 - 3. Poles shall not exceed a maximum deflection due to operating loads of 2 inches at contact wire level. The maximum total deflection measured at the pole top shall not exceed 2.5 percent of the total pole length due to both static and live loads combined. Poles shall not exhibit any permanent deflection or damage as a result of the defined system operating or non-operating loads.
- C. Base Plates: Base plates shall be fabricated from structural steel conforming to the ASTM Specification A588.
- D. Nuts shall comply with ASTM A563, hot-dip galvanized, overtapped threads in accordance with AISC requirements for UNC series.
- E. Washers shall comply with ASTM F436, hot dip galvanized.
- F. Twin cantilever mounting brackets shall be fabricated from steel conforming to ASTM A36 and should match to pole finish. Handholes shall be fabricated from steel of the same type as the pole shafts as specified.
- G. Pole caps shall be fabricated from steel compatible with the pole shaft, fitted with a minimum of three stainless steel set screws.

- H. Feeder Risers: Feeder riser spouts or nipples shall be standard steel pipe conforming to ASTM A53, Type S, Grade A or B.
- I. Grounding Assembly: Nuts shall be heavy square 5/8 inch x 11 NC welded to base plate. Ground connector shall be stainless steel or bronze.
- J. Handhole Cover Screws: Handhole cover screws shall be stainless steel hex head screws.
- K. Weld Filler: Weld filler metal shall conform to AWS D1.1.
- L. Pole and Portal Cross-beam Finish: Poles, portal cross-beam and attachments shall be as specified in Section 09910, "Painting OCS Poles."
- M. Track stationing identification signs shall be fabricated and installed on OCS poles, as shown on the Contract Drawings, at approximate 500 feet intervals. Signs shall be mounted so they can be easily viewed by the operator of an oncoming LRV in the predominant direction of travel.

2.02 FABRICATION

- A. General: Poles, portal cross-beam, fittings, accessories and base plates shall be fabricated to the dimensions indicated in the approved Shop Drawings.
- B. Methods and Tolerances: Poles, portal cross-beam, fittings, accessories and base plates shall be fabricated by methods and within tolerances conforming to the AISC Specifications, except as specified herein.
- C. Tolerances
 - 1. Pole Diameter: Pole diameter shall be within $\pm 1/16$ inch of the design diameter. Round poles shall be concentric and round to within $\pm 1/8$ inch of full indicator reading.
 - 2. Pole and Portal Cross-beam Wall Thickness: Wall thickness exclusive of the weld area shall be within plus 10 percent or minus 5 percent of the design thickness.
 - 3. Pole Taper: Pole taper shall be between 0.075 inch and 0.145 inch change in diameter per 1 foot of length and constant for the length of the pole.
 - 4. Pole Straightness: Pole straightness shall be within 1/8 inch per 5 feet of pole length (1:480).
 - 5. Tolerances for base plates shall be as follows:
 - a. Bolt Circle $+1/16$ inch, -0 inch.
 - b. Hole Diameter $+1/16$ inch, -0 inch.
 - c. Location of Holes $\pm 1/32$ inch in each direction.
- D. Welding Procedures: Welding procedures, welders, welding operations and tackers shall conform to the provisions of AWS D1.1, Section 2, Design of Welded Connections; Section 3, Workmanship; Section 4, Technique; and Section 8, 9 or 10.

- E. Weld Repair: Welds found to be unacceptable shall be repaired in conformance with the provisions of AWS D1.1, Section 3, Workmanship.
- F. Contractor shall provide spare nuts and washers for OCS pole anchor bolts which comply with this Section. The spare nuts and washers shall consist in quantity of two percent (2%) of the amount installed of each size, rounded higher to the next full number of nuts or washers. These spare nuts and washers shall be delivered to the Engineer at a location specified by the Engineer.
- G. Pole Identification Plate: A stainless steel pole identification plate shall be attached to the base plate of each pole. The plate shall show the pole type and pole stationing. The plate design, style of lettering and method of attachment shall be equal to the identification plate of the existing Stage I and Stage II systems. The plate design shall be submitted to the Engineer for approval.

ARTICLE 3 EXECUTION

3.01 INSTALLATION/ERECTION

- A. Erect structural steel in accordance with AISC Specification for structural steel erection or in accordance with manufacturer's recommended instructions.
- B. All OCS poles shall be raked and/or adjusted to a plumb condition to compensate for the static dead load deflection induced by all wire and equipment. The final erected pole plumb (perpendicular) position shall not exceed 1 in 50 of true vertical with pole fully loaded, measured within 8 feet of its base. This measurement shall account for the taper of the tapered tubular poles. Adjustments shall be as directed by the Engineer.
- C. Field Assembly: Set structural frames accurately to the lines and elevations indicated. Align and adjust the various members forming a part of a complete frame or structure before permanently fastening. Clean bearing surfaces and other surfaces which will be in permanent contact before assembly. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
- D. Poles: OCS poles shall be erected on various structures using anchor bolts which have been cast into concrete. The OCS pole erection crew shall maintain a quantity of leveling nuts, washers and lock nuts in the required sizes so that each pole erected will have the proper number of nuts and washers. Anchor bolts, nuts and washers are galvanized steel, and the Contractor shall take care to avoid damaging all galvanized surfaces. When poles have been erected to their final rake and alignment, the leveling nuts shall be in full contact with the base- plate washers, and their locknuts shall be tightened according to the "turn-of-nut" method. Topside washers, anchor nuts and locknuts shall be placed to secure the pole. Locknuts shall be tightened according to the "turn-of-nut" method. Immediately after tightening all nuts, touch-up all

compression points on the nuts with zinc-rich paint formulated for field application on galvanized metals.

- E. Pole Fittings: Contractor shall install all fittings required for the specific installation, including, but not limited to, the following items:
 1. Handholes.
 2. Feeder outlets or spouts.
 3. Pole caps.
 4. Twin cantilever mounting brackets.
- F. Feeder Poles: Traction Power feeder poles installed with the spout oriented towards the track where the feeder cables will be connected.
- G. Grounding and Bonding: All steel poles installed by Contractor shall be bonded to the foundation as shown on the Contract Drawings.
- H. Additional Requirements
 1. Pole caps shall be installed on all poles prior to setting of the pole.
 2. Contractor shall exercise care during erection of poles and portal to prevent subjection of the poles and portal to abuse and disfigurement. All imperfections on the steel poles and portal cross-beam shall be repaired by Contractor as necessary to restore pole to condition acceptable by the Engineer.
 3. Caution is mandated during steel pole and portal erection to prevent contact with other overhead lines, and possible energized utilities.
 4. Feeder poles shall be fitted with cable supports and terminating bushings at the cable entrance hubs. The terminating bushings shall be weather-proof, of compression seal type.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 05510

WARNING SIGNS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for warning signs, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following:
 - 1. "Danger High Voltage" signs shall be placed on all OCS poles that are directly adjacent to overhead structures, and poles and tunnel walls adjacent to or within station platforms. They shall be placed on all poles and tunnel walls with balance-weight anchors, OCS disconnect switches and traction power feeders and, in addition, shall be placed on OCS poles and along tunnel walls such that spacing between signs shall be not greater than 1000 feet.
 - 2. "Danger Live Wire" signs shall be placed on all overhead structure barriers (if required).
 - 3. Warning "Power-Off" signs for Section Insulators shall be placed at all section insulator locations (2 per section insulator). These signs shall be similar size, type and quality as those that currently exist on the Stage I and Stage II Systems.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 16602, "General Requirements Overhead Contact System."

1.03 SUBMITTALS

- A. Submit samples of signs for information and approval prior to final order and fabrication.

1.04 DELIVERY, STORAGE AND HANDLING

- A. All signs and materials shall be delivered, stored and handled in such a manner to avoid damage.

1.05 WARRANTY

- A. All signs shall be manufactured for outdoor use. Contractor shall certify that no appreciable discoloration, cracking, blistering or dimensional change will occur for a period of not less than 10 years.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. All "Danger Live Wire," "Danger High Voltage" and Section Insulator signs shall be made with a 0.08 in thick rigid aluminum backing plate. All sharp edges shall be rounded and deburred.
- B. All "Danger Live Wire," signs should be permanently attached with power driven nails capable of holding signs and anchoring into the backing or base material.
- C. All "Danger High Voltage" signs shall be permanently attached to the OCS poles with stainless steel strapping, capable of holding the signs securely in place. The backing plate shall be rolled (curved), to fit flush against the pole face.

2.02 FABRICATION

- A. All letters and numbers shall be on the front of the sign only.
- B. Signs shall be manufactured in a dry, temperature controlled area.
- C. All painted and adhering surfaces shall be prepared and made free from dirt, oil, and grease or other substances that prevent bonding.
- D. All painting shall be in accordance with the sign manufacturer's standard practice and recommendations, and as approved by the Engineer.
- E. "Danger Live Wire" and "Danger High Voltage" and Section Insulator signs shall be painted, or silk-screened with the colors shown on the Contract Drawings.

ARTICLE 3 EXECUTION

3.01 PREPARATION

- A. Surfaces to which signs shall be attached shall be free of ice, dirt, or foreign objects.

3.02 INSTALLATION/APPLICATION/ERECITION

- A. "Danger Live Wire" signs shall be attached to the face of the protective barrier at the Tunnel Portal. Signs shall be permanently fixed to the barrier, with one sign positioned directly above each OCS wire.
- B. "Danger High Voltage" signs shall be attached to the OCS poles at a nominal height of 5 feet above high rail level. The sign shall be located on the pole face, away from the track, and the backing plate shall be curved (rolled) to fit flush against the round pole, as shown on the Contract Drawings.
- C. Warning signs for Section Insulators shall be installed at each section insulator

location. Method of installation shall be approved by the Engineer.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 05520
MISCELLANEOUS METALWORK

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for miscellaneous metalwork in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Supplying, fabricating, finishing, and installing miscellaneous steel items including embedded plates, assemblies, and angles.
 - 2. Elevator Casings including supplying, fabricating and finishing of casing pipe and end plate, and installation of casing including drilling and grouting.
 - 3. Grating
 - 4. Frames
 - 5. Safety nosings.
 - 6. Tunnel Emergency Walkways and Crossovers including, but not limited to: design, fabricate, construct, and coordinate the tunnel emergency walkways, crossovers, ladders, end barriers, stair assemblies, and railings.
- C. The Contract Documents provide the performance parameters and design criteria to complete the Tunnel Emergency Walkways and Crossovers portion of the Work. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures"
- B. Section 16060, "Grounding and Bonding."

1.03 REFERENCE STANDARDS

- A. PENNDOT Publication 408
- B. PENNDOT Publication 19, PTM
- C. PENNDOT Publication 35 (Bulletin 15)
- D. AASHTO
- E. ASTM

F. AISC

G. SSPC

1.04 SUBMITTALS

A. The following shall be submitted by the Contractor:

1. Shop Drawings of the proposed metalwork including:
 - a. Final design drawings and associated calculations, where required.
 - b. Drawings and calculations shall be sealed by a Professional Engineer.
 - c. Detail drawings giving plans, elevations and sections.
 - d. Installation drawings showing methods of backing, installation and fastening.
 - e. Tunnel Walkways and Crossovers design
2. Samples:
 - a. One (1), 18 inch square representative sample of each type of grating including a corner detail and any hold down hardware.
 - b. One (1), one foot long piece of grating frame including the anchor
 - c. One (1), one foot long piece of stair nosing including any latching (tie down) connections.
3. Schedule. Schedule of metalwork to be provided including types, general locations, sizes, construction details, latching provisions and any other data pertinent to installation.
4. [NOTUSED]

B. Manufacturer Qualifications

1. Evidence of manufacturer qualifications. PENNDOT 35 (Bulletin 15) listed.
2. Certifications of Compliance. Qualification in accordance with PENNDOT 408, Section 1105.01(a).

C. Tunnel Walkway Pre-construction Report of tunnel facilities for manufacture of tunnel emergency walkways and crossovers.

1.05 COORDINATION

- A. Walkway design interfaces with other facilities including, but not limited to, duct banks, stand pipes, plinths, train signals, and tunnel structure finished floor elevations. The Contractor shall coordinate its design, fabrication, and install with these and all other facilities.

1.06 DESIGN CRITERIA

- A. All handrail, barrier rail and guards shall comply with the requirements of ANSI/ASCE 7-95 as referenced in the BOCA National Building Code and the requirements of ANSI A117.1 and ADAAG.

- B. Handrail, barrier rail and guard assemblies shall resist a single concentrated load of 50 lbs/ft. applied in any direction at any point along the top, and have attachment devices and supporting structure to transfer this loading to the base structure.
- C. [NOT USED]
- D. Handrail, barrier rail and guard assemblies shall resist the forces indicated above without damage or permanent set to any component of the assembly.
- E. Handrail, barrier rail and guard assemblies shall be fabricated and installed to allow for thermal movement resulting from temperatures between -20 degrees F to 100 degrees F. Fabrication and installation shall allow sufficient movement to prevent buckling, opening of joint, overstressing of components and connections, and other detrimental effects.
- F. Metals shall be insulated from other incompatible metals or materials to prevent galvanic action or other forms of corrosion.
- G. [NOT USED]
- H. Walkways, cross overs, and stand alone walkways shall be designed for their own dead weight, including all components, with a load factor of 1.4 and a 100 psf grating live load with a load factor of 1.6 and shall comply with thermal requirements given in Section 1.06E.
- I. Ladders shall be designed for an individual rung load of 375 pounds to be applied simultaneously with a lateral load of 50 pounds with a safety factor of 1.6.
- J. Walkways shall be designed for an individual hanger attachment of 50 pounds for utilities with a safety factor of 1.6 and only one attachment is allowed per span. No utility shall be anchored to the walkway, all anchorages shall be to the adjacent concrete superstructure. Any attachment larger than 50 pounds requires approval from the Engineer.

ARTICLE 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers to be PENNDOT Publication 35 (Bulletin 15) listed and provide information in accordance with Article 1.04 B of this Section.

2.02 MATERIALS

- A. Ferrous Metal Materials shall be in accordance with the following:
 1. Structural Steel Plates, Shapes and Bars in accordance with ASTM A709 (AASHTO M270) Grade 50 or in accordance with the Contract Drawings.
 2. Steel Tubing in accordance with ASTM A500 or A501 as indicated on the Contract Drawings.

3. Steel Pipe, in accordance with ASTM A53 seamless pipe, standard weight Grade B, unless another weight is indicated on the Contract Drawings or required by structural loads.
4. Anchor bolts in concrete used for miscellaneous metalwork connections shall be in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures".
5. [NOT USED]
6. Galvanizing shall be provided in accordance with PENNDOT 408, Section 1105.02(s).
7. [NOT USED]
8. Grout for leveling of base plates shall be in accordance with Section 03305, "Cast in Place Concrete and Cement Concrete Structures".
9. [NOT USED]
10. [NOT USED]

B. Grounding Materials in accordance with Section 16060, "Grounding and Bonding."

ARTICLE 3 EXECUTION

3.01 FABRICATION

- A. Metalwork shall be fabricated and installed in accordance with the applicable provisions of the AISC Code and AISC Specification.
- B. Fabrication shall include all operations such as shearing, punching, bending and forming necessary to complete the work. Metals shall be sheared and punched cleanly and accurately and burrs are to be removed.
- C. Corners and seams shall be welded continuously. Materials and methods should be used that minimize distortion and any effects on the strength and corrosion resistance of the base metals.
- D. Joints that will be exposed to weather shall be fabricated to exclude water.
- E. Joints shall be located where they are least conspicuous. Fasteners shall be concealed where practicable.
- F. Products shall have sufficient strength and stiffness to prevent distortion during shipping, handling, installing and under severe service conditions.
- G. Items shall be fabricated in a manner that shall provide for expansion and contraction, prevent shearing of fasteners, ensure rigidity, and to provide close fitting of sections.
- H. Exposed edges of items shall be dressed smooth, without sharp edges and with corners slightly rounded.

3.02 FINISHING

A. Galvanizing

1. All items to be hot dipped galvanized in accordance with ASTM A123, or ASTM A153. Provide 2.35 oz. per s.f. coating.
2. Prepare un-coated ferrous metal surfaces in accordance with SSPC-SP 3, "Power Tool Cleaning". Apply zinc rich primer.
3. Fabricated items shall be galvanized complete, or in largest possible sections.
4. Galvanized items that are to be painted shall be wash primed within 6 hours of galvanizing.
5. Touch up galvanized items with zinc rich paint as required by the Engineer. This should be in accordance with ASTM A780-01 "Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coating".

B. Paint

- A. To be inorganic zinc rich paint formulated for the cathodic protection of ferrous metals against corrosion. This shall be used as a primer to non-galvanized steel or in conjunction with hot-dip galvanized surfaces to protect uncoated damaged sections. Closed cell units shall have vent holes placed in inconspicuous areas.
- B. Paint shall be applied in accordance with manufacturer instruction.
- C. Paint shall be in accordance with SSPC Paint 20.

3.03 CONSTRUCTION REQUIREMENTS

A Examination

1. Areas to receive work shall be examined to verify that the setting conditions and dimensions are correct to receive the items.
2. Work shall not be started until unsatisfactory conditions have been corrected.
3. Metalwork shall be installed in accordance with Shop Drawings and Contract Drawings and manufacturers installation instructions.
4. Items shall be accurately fitted, plumb and level, and free from distortion or defects.
5. Sufficient temporary support shall be provided during erection to counter erection loads and maintain true alignment. Items to be built into concrete or masonry shall be sufficiently supported.
6. Welding shall only be carried out where indicated on the Shop Drawings and Contract Drawings.
7. Prior to making any adjustments, which are not scheduled, the Contractor must seek the approval of the Engineer.
8. Anchors and fasteners as indicated on the Shop Drawings and Contract Drawings shall be provided and as necessary to hold the work rigidly in place.
9. Work shall be fastened tightly to prevent rattle or vibration except where expansion or contraction tolerances are required.
10. Non-shrink grout mixed in accordance with manufacturer instructions shall be used in setting frames, plates, bolts and other similar items.
11. Metalwork shall be protected from damage to surface, profile and shape.

3.04 ADJUSTMENT AND CLEANING

- A. It is the responsibility of the Contractor to ensure that scratches or disfigurements caused in the shipping or handling of the product are properly cleaned and repaired.
- B. All metalwork should be inspected on delivery for damage. Minor damage is to be repaired as outlined below as long as this is acceptable to the Engineer.
- C. To minimize damage, on site metalwork should be stored safely under cover.
- D. Touch up Surfaces and Finishes
 - 1. Galvanized surfaces. Clean fillet welds, bolted connections, and abraded areas and repair galvanizing in accordance with ASTM A780.
 - 2. Painted Surfaces: Clean fillet welds, bolted connections, and abraded areas and touch up paint with the same material as used for shop painting.
- E. Cleaning
 - 1. Metalwork shall be cleaned to remove weld splatter, excess sealant, dirt and any other foreign material.
 - 2. Cleaning shall be undertaken using materials and methods that will not damage the finish, as recommended by the material manufacturer.
- F. Adjustment
 - 1. Metalwork fabrications shall be adjusted as necessary to provide proper clearances and prevent binding and interference between parts.

3.05 [NOT USED]

3.06 [NOT USED]

3.07 TUNNEL EMERGENCY WALKWAY INSTALLATION

- A. A pre-construction walk through is required for each linear foot of walkway to be installed. The Contractor shall create a Tunnel Walkway Pre-Construction Report for use in fabrication and installation of walkways. The Tunnel Walking Pre-Construction Report shall record as a minimum: the condition of the base slab, the condition of the wall, the existence of super elevated track rail, the existence of any super structure expansion joints, the presence of all appurtenances on the wall or base slab, and the approximate stationing of each occurrence. The Tunnel Walking Pre-Construction Report information is only required in the area of the walkway.
- B. Install walkway in accordance with the Contract Drawings maintaining a constant height above the track rail. The track height above the base slab will vary in accordance with its super elevation.

- C. Do not span expansion joints of the super structure. Plan the walkway layout such that there is a one inch gap in the vicinity above the super structure expansion joint.
- D. The base slab is generally sloped beneath the foot of the walkway. The walkway base plate must fully bear on the base slab. The use of 1/2 inch grout beneath the base plate is allowed to provide full bearing. Shims may be used for installation where the base plate is to be grouted and shall have a minimum of one inch grout cover. The Contractor may dry pack grout under the base plate filling the entire void. The edge of grout, where used, shall have a 45 degree bevel. Grout strength shall be 4,000 psi minimum.
- E. The walkway may have a utility support attached to the under side by use of a hanger assembly no closer than 8 feet on center. The maximum allowable load shall be 50 pounds in the vertical direction only. The use of utility anchorages attaching to the walkway is prohibited unless specifically designed, modified as necessary, and furnished by the supplier of that utility.
- F. In the area of the bored tunnel or in areas along the running tunnels where there is a gap larger than 2 inches between the wall and the back edge of the walkway grating supply wire mesh, D20 minimum.
- G. The walkway edge along the track side shall maintain all clearance envelopes issued in the Contract Documents. See TK Series drawings for outline of train clearances.
- H. Metal work shall be grounded, see Article 3.11 below. End banding shall be used at all discontinuities and adjacent metalwork shall be individually supported and shall not share a common base plate or support frame.

3.08 EMERGENCY WALKWAY CROSSOVER INSTALLATION

- A. A pre-construction walk through is required for each linear foot of crossover to be installed. The Contractor shall incorporate findings into the Tunnel Walkway Pre-Construction Report for use in fabrication and installation of crossovers. The Tunnel Walkway Pre-Construction Report shall record as a minimum: the condition of the base slab, the condition of the adjacent wall, the existence of super elevated track rail, the presence of all appurtenances on the lower wall or base slab, and the approximate stationing of each occurrence. The Tunnel Walkway Pre-Construction Report information is only required in the area of the crossover footprint.
- B. Install crossover in accordance with the Contract Drawings maintaining a constant height, level with the track rail. The base slab generally varies in accordance with the super structure cross slope.
- C. The crossover base plate must fully bear on the base slab. The use of 1/2 inch grout beneath the base plate is allowed to provide full bearing. Shims may be used for installation where the base plate is to be grouted and shall have a minimum of one inch

grout cover. The Contractor may dry pack grout under the base plate filling the entire void. The edge of grout, where used, shall have a 45 degree bevel. Grout strength shall be 4,000 psi minimum.

- D. Verify the minimum clearance distance of 3 inches with the Port Authority Operations prior to installation. Any adjustments shall be submitted for approval utilizing the standard Shop Drawing process.
- E. End barriers shall be placed at the dead end of each crossover and shall be considered as part of the crossover assembly and shall maintain all clearance envelopes issued in the Contract Documents. End barriers above the cable trough shall be attached to a common plate at the termination of the handrail for grounding purposes.
- F. Metal work shall be grounded, see Article 3.11 below. End banding shall be used at all discontinuities and adjacent metalwork shall be individually supported and shall not share a common base plate or support frame. Cross overs may not share a common ground with any adjacent walkway and should be directly tied to the ground wire.

3.09 LADDER INSTALLATION

- A. A pre-construction walk through is required for each location where a ladder is to be installed. The Contractor shall incorporate findings into the Tunnel Walkway Pre-Construction Report for use in fabrication and installation of ladders. The Tunnel Walkway Pre-Construction Report shall record as a minimum: the condition of the base slab, the existence of super elevated track rail, the existence of any super structure expansion joints, the presence of all appurtenances on the base slab, and the approximate stationing of each occurrence. The Tunnel Walkway Pre-Construction Report information is only required in the area of each ladder.
- B. Install ladders in accordance with the Contract Drawings maintaining a constant height above the track rail. The track height above the base slab will vary in accordance with its super elevation.
- C. Do not span expansion joints of the super structure. Plan the ladder layout such that there is no ladder in the vicinity above super structure expansion joints.
- D. The base slab is generally sloped beneath the foot of the ladder. The ladder base plate must fully bear on the base slab. The use of 1/2 inch grout beneath the base plate is allowed to provide full bearing. Shims may be used for installation where the base plate is to be grouted and shall have a minimum of one inch grout cover. The Contractor may dry pack grout under the base plate filling the entire void. The edge of grout, where used, shall have a 45 degree bevel. Grout strength shall be 4,000 psi minimum.

- E. An abrasive nosing shall be installed where each ladder meets the top of the walkway and shall be considered as part of the walkway assembly. Coordinate the placement of all ladders within the walkway layout plan.
- F. All ladders along the track shall maintain all clearance envelopes issued in the Contract Documents. See TK Series drawings for outline of train clearances.
- G. Metal work shall be grounded, see Article 3.11 below. Ladders share a common ground with the walkway it is attached to.

3.10 STAIR AND RAILING INSTALLATION

- A. A pre-construction walk through is required for each location where a stair is to be installed. The Contractor shall incorporate findings into the Tunnel Walkway Pre-Construction Report for use in fabrication and installation of stairs. The Tunnel Walkway Pre-Construction Report shall record as a minimum: the condition of the base slab and wall, the existence of super elevated track rail, the presence of all appurtenances on the base slab, and the approximate stationing of each occurrence. The Tunnel Walkway Pre-Construction Report information is only required in the area of each stair.
- B. Install stairs in accordance with the Contract Drawings. The stairs are to be flush with the walkway at the top and all steps shall be evenly spaced.
- C. An abrasive nosing shall be installed for each riser of the stair assembly and shall be considered as part of the stair assembly.
- D. All stairs along the track side shall maintain all clearance envelopes issued in the Contract Documents.
- E. Install Railing at the existing Gateway Station platform areas, cut during the NSC-004R demolition activities to provide protection for the remaining platform areas as shown on the Contract Documents.
- F. Metalwork shall be grounded, see Article 3.11 below. Stairs share a common ground with the walkway it is attached to. If the stairs become discontinuous from adjacent metalwork for any reason it shall be individually grounded.

3.11 GROUNDING

- A. All metalwork within the tunnels and stations shall be grounded. No metalwork fabrication shall be continuous for more than 500 feet. This includes but is not limited to all walkways, cross overs, ladders, stairs, and handrails or any combination thereof. These items shall be separated using approved isolation materials such that no bolt, grate, frame, plate or any other adjacent metal item can transfer current. Each segment of metalwork shall be grounded in accordance with Section 16060, "Grounding and Bonding".

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 05520.001- Miscellaneous Fabricated Steel Items shall be measured per pound, complete in place.
- B. Item 05520.002 - Grating shall be measured per square foot, complete in place.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. Item 05520.007 – Emergency Walkways shall be measured per linear foot, complete in place.
- H. Item 05520.008 – Emergency Walkway Crossovers shall be measured per linear foot, complete in place.
- I. Item 05520.009 – Ladders shall be measured per each, complete in place
- J. Item 05520.010 – Stairs shall be measured per each, complete in place
- K. Item 05520.011 – 12 Foot Crossover Platform shall be measured per square foot, complete in place.
- L. Item 05520.012 - Emergency Stand Alone Walkways shall be measured per linear foot, complete in place.

PAYMENT

- A. Item 05520.001- Miscellaneous Fabricated Steel Items will be paid at the unit price and shall include the cost of all related work specified in this Section.
- B. Item 05520.002 - Grating will be paid at the unit price and shall include the cost of all related work specified in this Section.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]

- G. Item 05520.007 – Emergency Walkways will be paid at the unit price, and shall include the cost of all related work specified in this Section.
- H. Item 05520.008 – Emergency Walkway Crossovers will be paid at the unit price, and shall include the cost of all related work specified in this Section.
- I. Item 05520.009 – Ladders will be paid at the unit price, and shall include the cost of all related work specified in this Section.
- J. Item 05520.010 – Stairs will be paid at the unit price, and shall include the cost of all related work specified in this Section.
- K. Item 05520.011 – 12 Foot Crossover Platform will be paid at the unit price, and shall include the cost of all related work specified in this Section.
- L. Item 05520.012 – Emergency Stand Alone Walkways will be paid at the unit price, and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 07841

FIRE STOP AND BARRIER SYSTEMS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor materials, tool, equipment, and incidentals necessary for fire stop and barrier systems, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Fire stop materials
 - 2. Fire barrier systems
 - 3. Accessories

1.02 RELATED SECTIONS

- A. Section 15400, "Tunnel Services Scope of Work"
- B. Section 15885, "Mechanical Tunnel Fire Protection Systems"
- C. Section 15887, "Tunnel Ventilation and Balancing Dampers"
- D. Section 15888, "Tunnel Ventilation Noise Attenuators"
- E. Section 16890, "Tunnel Services Electrical Requirements of Mechanical Equipment"

1.03 REFERENCE STANDARDS

- A. ASTM
- B. FMG
- C. UL

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each through-penetration fire stop and barrier system, show each type of construction condition penetrated, relationships to adjoining construction, and type of penetrating item. Include fire stop and barrier design designation of qualified testing and inspecting agency that evidences compliance with requirements for each condition indicated.

1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop and barrier system configuration for construction and penetrating items.
 2. Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular through-penetration firestop and barrier condition, submit illustration, with modifications marked, approved by through-penetration fire stop and barrier system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.
- C. Through-penetration fire stop and barrier system schedule: Indicate locations of each through-penetration firestop and barrier system, along with the following information:
1. Types of penetrating items.
 2. Types of constructions penetrated, including fire-resistance ratings and, where applicable, thicknesses of construction penetrated.
 3. Through-penetration fire stop and barrier systems for each location identified by firestop and barrier design designation of qualified testing and inspecting agency.
- D. Qualification Data: For Installer.
- E. Product Certificates: For through-penetration fire stop and barrier system products, signed by product manufacturer.
- F. Product Test Reports: From a qualified testing agency indicating through-penetration fire stop and barrier system complies with requirements, based on comprehensive testing of current products.

1.05 PERFORMANCE REQUIREMENTS

- A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration fire stop and barrier systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.
1. Fire-resistance-rated wall/ceiling assemblies including fire barriers and smoke barriers.
- B. For through-penetration fire stop and barrier systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.
1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration fire stop and barrier systems.
 2. For floor penetrations with annular spaces exceeding 4 inches in width and exposed to possible loading and traffic, provide fire stop and barrier systems capable of supporting floor loads involved, either by installing floor plates or by other means.

3. For penetrations involving insulated piping, provide through-penetration fire stop and barrier systems not requiring removal of insulation.
- C. For through-penetration firestop and barrier systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: A firm that has been approved by FMG according to FMG 4991, "Approval of fire stop and barrier contractors."
- B. Installer Qualifications: A firm experienced in installing through-penetration firestop and barrier systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements.
Manufacturer's willingness to sell its through-penetration fire stop and barrier system products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.
- C. Installation Responsibility: Assign installation of through-penetration fire stop and barrier systems in Project to a single qualified installer.
- D. Source Limitations: Obtain through-penetration fire stop and barrier systems, for each kind of penetration and construction condition indicated, through one source from a single manufacturer.
- E. Fire-Test-Response Characteristics: Provide through-penetration firestop and barrier systems that comply with the following requirements and those specified in Article 1.05 of this Section:
 1. Firestop and barrier tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is UL or another agency performing testing and follow-up inspection services for fire stop and barrier systems acceptable to authorities having jurisdiction.
 2. Provide rated systems complying with the following requirements:
 - a. Through-penetration firestop and barrier system products bear classification marking of qualified testing and inspecting agency.
 - b. Through-penetration firestop and barrier systems correspond to those indicated by reference to through-penetration firestop and barrier system designations listed by the following:
 - 1) UL in its "Fire Resistance Directory."
- F. Preinstallation Conference: Conduct conference at Worksite.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver through-penetration firestop and barrier system products to Worksite in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, lot number, shelf life if applicable, qualified testing and inspecting agency's classification marking applicable to Project, curing time, and mixing instructions for multicomponent materials.
- B. Store and handle materials for through-penetration firestop and barrier systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.08 PROJECT CONDITIONS

- A. Environmental Limitations: Do not install through-penetration firestop and barrier systems when ambient or substrate temperatures are outside limits permitted by through-penetration fire stop and barrier system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.
- B. Ventilate through-penetration fire stop and barrier systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.09 COORDINATION

- A. Coordinate construction of openings and penetrating items to ensure that through-penetration fire stop and barrier systems are installed according to specified requirements.
- B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration fire stop and barrier systems.
- C. Notify Owner's inspecting agency at least seven days in advance of through-penetration fire stop and barrier system installations; confirm dates and times on days preceding each series of installations.
- D. Do not cover up through-penetration firestop and barrier system installations that will become concealed behind other construction until each installation has been examined by Owner's inspecting agency and building inspector, if required by authorities having jurisdiction.

ARTICLE 2 PRODUCTS

2.01 MANUFACTURERS

- A. Promat International.
- B. A/D Fire Protection Systems Inc.

- C. 3M; Fire Protection Products Division.
- D. Or approved equal.

2.02 FIRESTOP AND BARRIER, GENERAL

- A. Compatibility: Provide through-penetration firestop and barrier systems that are compatible with one another; with the substrates forming openings; and with the items, if any, penetrating through-penetration firestop and barrier systems, under conditions of service and application, as demonstrated by through-penetration firestop and barrier system manufacturer based on testing and field experience.
- B. Accessories: Provide components for each through-penetration firestop and barrier system that are needed to install fill materials and to comply with Article 1.05 of this Section. Use only components specified by through-penetration firestop and barrier system manufacturer and approved by qualified testing and inspecting agency for firestop and barrier systems indicated. Accessories include, but are not limited to, the following items:
 1. Permanent forming/damming/backing materials, including the following:
 - a. Slag-/rock-wool-fiber insulation.
 - b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
 - c. Fire-rated form board.
 - d. Fillers for sealants.
 2. Temporary forming materials.
 3. Substrate primers.
 4. Collars.
 5. Steel sleeves.

2.03 FILL MATERIALS

- A. Cast-in-Place Firestop and Barrier Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.
- B. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture.
- C. Firestop and Barrier Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.
- D. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.
- E. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.

- F. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.
- G. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Worksite to form a nonshrinking, homogeneous mortar.
- H. Pillows/Bags: Reusable heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents, and fire-retardant additives.
- I. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
- J. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces, and nonsag formulation for openings in vertical and other surfaces requiring a nonslumping, gunnable sealant, unless indicated firestop and barrier system limits use to nonsag grade for both opening conditions.
 - 2. Grade for Horizontal Surfaces: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces.
 - 3. Grade for Vertical Surfaces: Nonsag formulation for openings in vertical and other surfaces.

ARTICLE 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of work.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop and barrier systems to comply with firestop and barrier system manufacturer's written instructions and with the following requirements:
 - 1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop and barrier systems.
 - 2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop and barrier systems. Remove loose particles remaining from cleaning operation.
 - 3. Remove laitance and form-release agents from concrete.

- B. Priming: Prime substrates where recommended in writing by fire-resistive joint system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.
- C. Masking Tape: Use masking tape to prevent through-penetration firestop and barrier systems from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestop and barrier system materials. Remove tape as soon as possible without disturbing firestop and barrier system's seal with substrates.

3.03 THROUGH-PENETRATION FIRESTOP AND BARRIER SYSTEM

- A. General: Install through-penetration firestop and barrier systems to comply with Article 1.05 of this Section and with firestop and barrier system manufacturer's written installation instructions and published drawings for products and applications indicated.
- B. Install forming/damming/backing materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
 1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestop and barrier systems.
- C. Install fill materials for firestop and barrier systems by proven techniques to produce the following results:
 1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
 2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
 3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.04 IDENTIFICATION

- A. Identify through-penetration firestop and barrier systems with preprinted metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches of edge of the firestop and barrier systems so that labels will be visible to anyone seeking to remove penetrating items or firestop and barrier systems. Use mechanical fasteners for metal labels. For plastic labels, use self-adhering type with adhesives capable of permanently bonding labels to surfaces on which labels are placed and, in combination with label material, will result in partial destruction of label if removal is attempted. Include the following information on labels:
 1. The words "Warning - Through-Penetration Firestop and Barrier System - Do Not Disturb. Notify Building Management of Any Damage."

2. Contractor's name, address, and phone number.
3. Through-penetration firestop and barrier system designation of applicable testing and inspecting agency.
4. Date of installation.
5. Through-penetration firestop and barrier system manufacturer's name.
6. Installer's name.

3.05 FIELD QUALITY CONTROL

- A. Where deficiencies are found, repair or replace through-penetration firestop and barrier systems so they comply with requirements, at not additional cost to Authority.
- B. Proceed with enclosing through-penetration firestop and barrier systems with other construction only after inspection reports are issued and firestop and barrier installations comply with requirements.

3.06 CLEANING AND PROTECTING

- A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop and barrier system manufacturers and that do not damage materials in which openings occur.
- B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop and barrier systems are without damage or deterioration at time of issuance of Certificate of Acceptance of Final Inspection. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop and barrier systems immediately and install new materials to produce systems complying with specified requirements.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 08110
STEEL DOORS AND FRAMES

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for steel doors and frames, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Fabricate and install frames
 - 2. Fabricate and install doors
 - 3. Grout
 - 4. Coatings and finishes
 - 5. Fasteners
 - 6. Hardware preparation
 - 7. Door hardware
 - 8. Cleaning and touchup

1.02 RELATED SECTIONS

- A. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures"
- B. [NOT USED]
- C. Section 08710, "Finish Hardware."
- D. Section 09902, "Painting."
- E. [NOT USED]

1.03 REFERENCE STANDARDS

- A. ASTM
- B. ANSI
- C. NFPA
- D. Steel Door Institute (SDI)
- E. Door and Hardware Institute (DHI)
- F. BOCA

1.04 SUBMITTALS

- A. Product Data for each type of door frame specified, including details of construction, materials, dimensions, hardware preparation, core, label compliance, sound ratings, profiles, and finishes shall be submitted to the Engineer for review and approval.
- B. Shop Drawings showing fabrication and installation of steel doors and frames, including details of the door, elevations of door design types, conditions at openings, details of construction, location and installation requirements of door and frame hardware and reinforcements, details of joints and connections shall be submitted to the Engineer for review and approval. Show anchorage, and accessory items.

1.05 DEFINITIONS

- A. Steel Sheet Thicknesses: Thickness dimensions, including those referenced in ANSI A250.8, are minimums in accordance with ASTM standards for both uncoated steel sheet and the uncoated base metal of metallic-coated steel sheets.

1.06 QUALITY ASSURANCE

- A. Steel Door and Frame Standard in accordance with ANSI A250.8, unless more stringent requirements are indicated.
- B. Fire-Rated Door Assemblies: Assemblies in accordance with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing in accordance with NFPA 252.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver doors and frames cardboard-wrapped or crated to provide protection during transit and job storage. Provide additional protection to prevent damage to finish of factory-finished doors and frames.
- B. Inspect doors and frames on delivery for damage. Minor damages may be repaired provided refinished items match new work and are approved by the Engineer; otherwise, remove and replace damaged items as directed.
- C. Store doors and frames at construction site under cover. Place units on minimum 4-inch high wood blocking. Avoid using non-vented plastic or canvas shelters that could create a humidity chamber. If cardboard wrappers on doors become wet, remove cartons immediately. Provide minimum 1/4-inch spaces between stacked doors to promote air circulation.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Cold-Rolled Steel Sheets in accordance with ASTM A 366, Commercial Steel (CS), or ASTM A 620, Drawing Steel (DS), Type B; stretcher-leveled standard of flatness.
- B. Galvanized Steel Sheets: The steel shall be hot-dip galvanized so as to provide a ductile coating, tightly adherent to the base steel. The zinc coating shall be an A60 coating in accordance with ASTM A924. The zinc coating shall be minimum spangle and shall be treated for paint adhesion.
 - 1. Zinc coating shall be not less the 0.6 oz. per square foot of steel, total coverage.
 - 2. Coating shall be applied to both sides of steel.
 - 3. Exterior units and interior units shall be hot-dip galvanized steel.
- C. Grout: in accordance with Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures". Hollow metal frames shall be fully grouted, unless otherwise indicated.
 - 1. Frames receiving grout shall have the inside of frames coated with bituminous paint.
- D. Bituminous Coating in accordance with SSPC-Paint 12, Solvent Type Bituminous Mastic, compounded for 15 mil dry film thickness per coat.

2.02 DOORS

- A. Provide door of sizes, thickness, and designs indicated; if door thickness is not indicated, provide 1-3/4 inch thick doors.
- B. Doors: Provide doors in accordance with requirements indicated below by referencing ANSI A250.8 for level and model and ANSI A250.4 for physical-endurance level:
 - 1. Level 4, Physical Performance Level A (extra heavy duty), Model 1 (full flush), galvanized steel sheets. Minimum steel face thickness indicated below is uncoated steel.
 - a. Minimum 0.053 inch thick cold-rolled steel sheet faces. (16 gage)
 - 2. [NOT USED].

2.03 FRAMES

- A. General: Provide steel frames for doors in accordance with ANSI A250.8 and with details indicated for type and profile. Conceal fastening, unless otherwise indicated.
 - 1. Fabricate frames from 0.067-inch (14 gage) thick uncoated steel sheet, galvanized both sides.
- B. Door Silencers: Except on weatherstripped frames, drill stops to receive 3 silencers on strike jambs of single-door frames.

- C. [NOT USED]
- D. Supports and Anchors: Fabricated from not less than 0.042-inch thick, electrolytic zinc-coated or metallic-coated steel sheet.
 - 1. [NOT USED]
- E. Inserts, Bolts and Fasteners: Manufacturer's standard units. Where zinc-coated items are to be built into exterior walls and interior walls, in accordance with ASTM A 153, Class C or D as applicable.
- F. Profiles shall be submitted for approval by the Engineer and coordinated with Shop Drawings prior to installation.

2.04 FABRICATION

- A. General: Fabricate steel door and frame units in accordance with ANSI A250.8 and to be rigid, neat in appearance, and free from defects including warp and buckle. Where practical, fit and assemble units in manufacturer's plant. Clearly identify work that cannot be permanently factory assembled before shipment, to assure proper assembly at the Worksite.
- B. Door Construction: For all locations, fabricate doors, panels, and frames from galvanized steel sheet. Close top and bottom edges of doors flush as an integral part of door construction or by addition of 0.053-inch thick, galvanized steel channels with channel webs placed even with top and bottom edges.
- C. Core Construction: Manufacturer's standard core construction that produces a door in accordance with SDI standards.
 - 1. Doors: Resin-impregnated kraft/paper honeycomb.
- D. [NOT USED]
- E. Clearances for Fire-Rated Doors in accordance with NFPA 80.
- F. Tolerances in accordance with SDI 117, "Manufacturing Tolerances for Standard Steel Door and Frames."
- G. Fabricate concealed stiffeners, reinforcement, edge channels, louvers, and moldings from either cold or hot rolled steel sheet.
- H. Exposed Fasteners: Unless otherwise indicated, provide countersunk flat or oval heads for exposed screws and bolts.
- I. [NOT USED]
- J. Hardware Preparation: Prepare doors and frames to receive mortised and concealed hardware according to final door hardware schedule and templates provided by

hardware supplier. Door and frame preparation for hardware shall be in accordance with ANSI A250.6 and ANSI A115 Series specifications.

1. [NOT USED]
- K. Frame Construction: fabricate frames to shapes approved.
 1. Fabricate frames with mitered or coped and continuously welded corners and seamless face joints.
 2. Provide welded frames with temporary spreader bars.
 3. Frames shall be hot dip galvanized after corners are welded.
- L. Reinforce doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied hardware may be done at the Worksite.
- M. Locate hardware as indicated on Shop Drawings or, if not indicated, in accordance with ANSI A250.8.

2.05 FINISHES

- A. [NOT USED]
- B. Prime Finish: Factory-applied coat of rust-inhibiting primer in accordance with ANSI A250.10 for acceptance criteria and compatible with paint finish in accordance with Section 09902, "Painting."

ARTICLE 3 EXECUTION

3.01 INSTALLATION

- A. General: Install steel doors, frames, and accessories in accordance with Shop Drawings, manufacturer's data, and as specified.
- B. Place frames in accordance with SDI 105, unless otherwise indicated. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is completed, remove temporary braces and spreaders, leaving surfaces smooth and undamaged.
 1. [NOT USED]
 2. Install fire-rated frames in accordance with NFPA 80.
 3. [NOT USED]
 4. Hollow metal frames shall be fully grouted, unless otherwise indicated. Coordinate grout material with Engineer.
 - a. Frames receiving grout shall have the inside of frames coated with bituminous paint.
- C. Install doors in accordance with ANSI A250.8. Fit hollow-metal doors accurately in frames, within clearances specified in ANSI A250.8. Shim as necessary in accordance with SDI 122 and ANSI/DHI A115.1G.

1. Fire-Rated Doors: Install within clearances of NFPA 80.

3.02 FINISHING AND CLEANING

- A. Prime Coat Touchup: Immediately after erection, sand smooth any rusted or damaged areas of prime coat and apply touchup of compatible air-drying primer.
- B. Install door hardware after paint is dry in accordance with Section 08710, "Finish Hardware."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 08710

FINISH HARDWARE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals for finish hardware, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. Section 08110, "Steel Doors and Frames."

1.03 REFERENCE SECTIONS

- A. UL

1.04 SUBMITTALS

- A. Completely itemized hardware schedule with catalog cuts of each piece of hardware to be provided. Coordinate with the schedule in Article 3 of this Section.
- B. Standard manufacturer warranties for each piece of hardware to be provided.
- C. [NOTUSED]
- D. Paper templates, approved hardware schedule, and when required, actual hardware shall be sent to frame and door manufacturers in sufficient time for those manufacturers to prepare for hardware and to incorporate hardware into their products if required.
- E. All hardware schedules submitted for approval must be in vertical format. Hardware schedules submitted in a horizontal format are unacceptable and will be returned unchecked.

1.05 QUALITY ASSURANCE

A. Qualification of Manufacturers:

1. Hardware numbers in Article 3.03 Schedule of Hardware are taken from the catalogs of:
 - a. Butts: McKinney Manufacturing Company.
 - b. Continuous Gear Hinges: Hager Companies "Hager's Roton Continuous Hinge."
 - c. Locksets: BEST Lock Corporation.
 - d. Exit Devices: Sargent Manufacturing Company.
 - e. Door Closers: Sargent Manufacturing Company.

- f. Door Trim: Rockwood Manufacturing Company.
 - g. Overhead Stops and Holders: Sargent Manufacturing Company.
 - h. Thresholds and Gaskets: Pemko Manufacturing Company.
 - i. Flush Bolts, Door Stops and Bumpers: Rockwood Manufacturing Co.
 - j. Cylinders: BEST Lock Corporation.
2. Other Manufacturers: Hardware of the same types, weights and functions approved by the Engineer and as manufactured by the following manufactures may be bid:
 - a. Butts: Stanley, Hager.
 - b. Continuous Gear Hinge: No Substitution.
 - c. Locksets: No Substitution.
 - d. Exit Devices: Von Duprin, Inc.
 - e. Door Closers: LCN, Inc.
 - f. Door Trim: Quality Hardware Manufacturing.
 - g. Overhead Stop and Holders: Rixson-Firemark Division.
 - h. Threshold and Gaskets: National Guard Products.
 - i. Flush bolts, Door Stops and Bumpers: Quality Hardware Manufacturing.
 - j. Cylinders: No Substitution.
3. Substitutions: Proposed substitutions shall be equal to the specified material with respect to size, quality, function and finish. The supplier proposing to bid on substitute material shall request permission to do so from the Engineer not less than ten (10) days prior to bid date. If the substitution is allowed, it shall be so noted by addendum. Deviation from this procedure will be cause for rejection of substitution request.

B. Qualifications of Supplier:

1. Architectural Hardware Consultant (AHC) shall properly schedule and service hardware requirements.

C. Requirements of Regulatory Agencies:

1. All exit devices must be listed under "Panic Hardware" in accident equipment list of UL. Doors at the temporary tunnel closure wall are used as emergency exits, they must be equipped with labeled fire exit hardware.
2. Code Requirements: Hardware shall meet or exceed the requirements of City of Pittsburgh Bureau of Building Inspection.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Pack hardware in boxes. Plainly mark each box with the identification of the opening for which hardware is intended, including packaging list, showing each item enclosed, proper screws, bolts, accessories, and similar items in each box.
- B. Check hardware on receipt at the project to ensure that each set is complete and operative.

Store hardware in a manner which will prevent damage and which will ensure that no items are removed from any set before installation.

ARTICLE 2 PRODUCTS

2.01 REQUIREMENTS

- A. Sizes, weights and quality specified are minimum acceptable.
- B. Should item of hardware not specified be required for completion of the Work, furnish such items of types and quantities suitable for the service required and comparable to adjacent or similar hardware.
- C. Should it be determined that specified hardware for any location, because of detail or size of member to which the hardware is to be applied, is unsuitable, provide hardware of the proper type. Such hardware shall be similar in operation to types specified and not of lesser quality.
- D. Locks shall have keepers. Catches shall have strikes. Provide required escutcheons and plates.
- E. Screws: Phillips head screws, finish to match surrounding hardware.
- F. Finishes: Except where specified otherwise, finishes shall be dull chrome (US26D). Exposed portions of door closers shall have a sprayed finish to match adjacent hardware. Push plates, pull plates, and kickplates shall be stainless steel (US32D). Aluminum threshold and weatherstrip shall have a natural aluminum finish.

2.02 MATERIALS

- A. Butts:
 - 1. Furnish butts in types, weights, and sizes shown.
 - 2. Furnish two (2) butts for each door 5'-0" or less in height plus one butt for each additional 2'-6" in height or fraction thereof.
 - 3. Base and finish of butts to be stainless steel.
 - 4. Furnish with non-removable pins (NRP) on all out-swinging exterior doors.
- B. [NOT USED]
- C. Door Closers:
 - 1. All door closers shall be the product of one manufacturer. Closers shall be of full rack and pinion construction with separate valves for adjusting closing and latching speeds and hydraulic backcheck, adjustable spring providing closer sizes 1 through 6 compliant with ADA, and removable non-ferrous covers such as Sargent's 351 Series and LCN's 4041 Series with equivalent features or approved equal. Extra duty arms are to be provided where specified.
 - 2. Mounting applications to be standard or parallel with proper arm brackets. Closer location is subject to practicality and approval.
 - 3. Closer shall allow for maximum swing of door. Avoid door opening against closer arm.

D. Locksets:

1. Furnish heavy-duty type locksets and latchsets with 2-3/4 inch back set, minimum 9/26 inch throw latchbolt such as BEST 93K7-15D and ANSI (1-14 inch x 4-7/8 inch) strike in the functions specified, unless otherwise indicated.

E. Panic Hardware:

1. All exit devices shall be the product of one manufacturer and must be listed under "Panic Hardware" in the Accident Equipment List of UL. Where devices are required on labeled doors, devices shall bear a "UL" label indicating "Fire Exit Hardware" such as Sargent's 80 Series or approved equal in types and functions specified and with "ETL" Series outside trim or Von Duprin 90 Series with 992L - 06 lever trim or approved equal.

F. Door Pull and Push Plates:

1. Furnish pull plates and push plates as specified.
2. Pull plates shall have grip attached to the plates at the factory.

G. Protection Plates:

1. Kickplates shall be 18 gauge (.050) by 8 inches high by 2 inches less than the nominal width of single doors and 1 inch less than the nominal width of double doors and installed on the stop (push) side.

H. Door Stops:

1. Furnish some type of stop for each door opening, complete with fasteners as required by detail. Do not use closer arm as a stop unless specified.
2. Doors at the temporary tunnel closure wall shall open away from the tunnel wall and stop parallel with the emergency walkway so that there is no gap between the door and the walkway. This is to prevent individuals from stepping between the walkway and the door, into the trackway below.
3. Furnish overhead stops and holders where specified:
 - a. O.H. Stop 590S.

I. Door Silencers:

1. Furnish rubber door silencers for all hollow metal frames; three (3) per single and two (2) per pair of doors.

J. [NOT USED]

K. Thresholds and Gasketing:

1. Thresholds shall be of the type specified under the hardware sets, furnish full length of opening with lead expansion shields for anchoring. All thresholds shall be set in full bed of mastic.
2. Weatherstripping shall be of the type specified under the hardware sets, furnish for both jambs and head.

L. [NOT USED]

2.03 KEYING

- A. If the Contractor chooses to add a locking mechanism to the temporary tunnel closure wall doors, provide keying as prescribed. Furnish copies (2) of keys to all temporary doors to the Engineer.
- B. All locksets and cylinders shall be set to the existing BEST Lock Corporation master key system. No substitutions.
- C. Contractor shall install all cylinders.
- D. Field keying during construction will use construction cores supplied by BEST.
- E. Contractor shall provide for the following:
 - 1. Key blanks – two (2) per cylinder.
 - 2. Cores – One (1) per cylinder.

ARTICLE 3 EXECUTION

3.01 INSTALLATION

- A. Apply and install hardware in accordance with the best trade practice.
- B. Secure bumpers to walls with toggle bolts or expansion shields as required by wall or partition construction.

3.02 CLEAN AND ADJUST

- A. Adjust hardware so that it functions smoothly.
- B. Take care not to mark or damage adjacent work. Repair or replace work to the Engineer's satisfaction.

3.03 SCHEDULE OF HARDWARE

- A. The following schedule is included as a guide in establishing the quality, type and function of hardware required for each opening and is not to be construed as all inclusive. Quantities listed under each hardware set are for each opening. Product numbers used are from the manufacturers listed in Article 1.05A.1 of this section.
- B. Typical door hardware:
 - 1. 1.5 Pr. Butt Hinges TA2314-4-1/2 x 4-1/2 x US32D x NRP
 - 2. 1.0 Ea. Exit Device 12-S8300F ETL x US32D
 - 3. 1.0 Ea. Door Closer 351 O SRI EN
 - 4. 1.0 Ea. Wall Stop as designed by Contractor

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work of this Section shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 09900

PROTECTIVE COATING FOR CONCRETE SURFACES

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for protective coatings for concrete surfaces, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. Section 01791, "Remove, Store and Re-Erect Existing Components."
- B. [NOT USED]
- C. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. Section 02751, "Driveways"
- F. Section 02785, "Concrete Sidewalks and Stairs."
- G. [NOT USED]
- H. [NOT USED]
- I. Section 03305, "Cast-in-Place Concrete and Cement Concrete Structures."

1.03 REFERENCE STANDARDS

- A. PENNDOT, Publication 408.
- B. PENNDOT, Publication 35, Bulletin 15.
- C. AASHTO.

1.04 SUBMITTALS

- A. [NOT USED]
- B. Certifications in accordance with PENNDOT 408, Section 503.2 and 1006.03(b)3

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. Boiled Linseed Oil: In accordance with PENNDOT 408, Section 503.2 and Section 1019.2(a).
- B. [NOT USED]
- C. Penetrating Sealer:
 - 1. Horizontal Surfaces - Penetrating Sealer for horizontal surfaces shall be Hydrozo 100 as manufactured by BASF Building Systems (889 Valley Park Drive, Shakopee, MN 55379) or approved equal.
 - 2. Vertical Surfaces - Penetrating Sealer for vertical surfaces shall be Hydrozo Silane 40 VOC as manufactured by BASF Building Systems (889 Valley Park Drive, Shakopee, MN 55379) or approved equal.
- D. [NOT USED]

ARTICLE 3 EXECUTION

3.01 PROTECTION OF CONCRETE PAVEMENTS, SIDEWALKS AND CURB

- A. Contractor shall protect by application of boiled linseed oil in accordance with PENNDOT 408, Section 503.3 and Section 1019.3(a).

3.02 [NOT USED]

3.03 [NOT USED].

3.04 [NOT USED]

3.05 [NOT USED]

3.06 PROTECTION OF BRIDGE SUPERSTRUCTURE AND RETAINED FILL AREA CONCRETE SURFACES

- A. Contractor shall protect by application of penetrating sealer in accordance with the Contract Drawings, Section 2.01.C, following the manufacturer's directions, and as directed by the Engineer.
- B. The penetrating sealer in these areas will be applied by the NSC-009 Contractor after concrete plinth construction is complete.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. [NOT USED]
- B. [NOT USED]
- C. Item 09900.003 – Penetrating Sealer shall be measured per square yard, complete in place.
- D. No separate measurement shall be made for the Boiled Linseed Oil portion of the work of this Section.

4.02 PAYMENT

- A. [NOT USED]
- B. [NOT USED]
- C. Item 09900.003 – Penetrating Sealer will be paid at the unit price and shall include the cost of all related work specified in this Section.
- D. No separate payment will be made for the Boiled Linseed Oil portion of the work of this Section. Payment for such portion(s) of the work shall be included in payment for the related portions of the work.

END OF SECTION

SECTION 09902

PAINTING

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for painting, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Supply, application, protection and cleanup for exterior and interior painted items.

1.02 RELATED SECTIONS

- A. Section 01784, "Temporary Pedestrian Accommodations, Fence and Barricades."
- B. [NOT USED]
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]

1.03 DEFINITIONS

- A. "Paint" as used herein means all coating systems materials, including primers, emulsions, enamels, stains, sealers and fillers, and other applied materials whether used as a prime, intermediate or finish coats.

1.04 SUBMITTALS

- A. Product Data: For each paint system specified.
 - 1. Material List: Provide an inclusive list of required coating materials. Indicate each material and cross-reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.
 - 2. Manufacturer's Information: Provide manufacturer's Product Data sheets, Volatile Organic Compounds (VOC) levels, MSDS sheets and written application instructions including handling, storing, mixing requirements, specified thinners, thinner amounts, and application equipment recommendations for each coating material proposed for use.

- B. Samples for Initial Selection: Contractor shall submit manufacturer's color charts showing the full range of colors available for each type of finish-coat material indicated.
- C. Prior to beginning related work, Engineer will furnish a color schedule and color chips for surfaces to be painted. Contractor shall submit samples of selected colors for review of color using appropriate paint type (s). Provide a listing of material and application for each coat of each finish sample.
 - 1. Furnish Engineer "Drawdowns", 8-1/2 inch x 11 inch samples of each color used on project; identified with project name, date, color, and formula.
- D. Application Qualifications in accordance with Article 1.05 of this Section.

1.05 QUALITY ASSURANCE

- A. Applicator Qualifications: Engage an experienced applicator who has a minimum of 7 years of successful in-service commercial experience with painting system applications similar in material and extent to that indicated for this Project.
- B. Source Limitations: Obtain primers and undercoat materials for each coating system from the same manufacturer as the finish coats.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the Worksite in manufacturer's original, unopened packages and containers bearing manufacturer's name and label.
- B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45° F. Protect materials from freezing.

1.07 JOB/SITE CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted, surrounding air temperatures (50° F to 95° F), and humidity dew points meet paint manufacturer's printed instructions.

ARTICLE 2 PRODUCTS

2.01 MANUFACTURERS

- A. Possible paint manufacturers:
 - 1. PPG Architectural Finishes, Inc.
 - 2. Sherwin-Williams Company
 - 3. Tnemec Company Inc.
 - 4. or Approved Equal

- B. All paint manufacturer's paint systems must meet or exceed paint requirements in accordance with Articles 3.09 of this Section to be approved.

2.02 COLORS

- A. Refer to drawing or Contract Drawing notes on items to be painted. If not included, colors will be selected from approved paint manufacturer's color charts and in accordance with the Contract Documents.

2.03 MATERIALS

- A. General: Provide best commercial quality grade types of coatings as regularly manufactured by accepted paint manufacturers and meeting Paint Schedule requirements. Materials not displaying manufacturer's identification as a standard, best-grade product will not be acceptable. Provide undercoat paint products by same manufacturer as finish coats. Use only thinners approved by paint manufacturer, and use only within recommended limits.
- B. Paint Coordination: Provide finish coats which are compatible with prime paints used. Review the Contract Documents in which prime paints are to be provided to ensure compatibility of total coating system for various substrates. Upon request from other trades, furnish information on characteristics of finish materials proposed for use, to ensure compatible prime coats are used. Provide barrier coats over incompatible primers or remove and re-prime as required. Notify Engineer in writing of any anticipated problems using specified coating systems with substrates primed by others.

ARTICLE 3 EXECUTION

3.01 [NOT USED]

3.02 ITEMS NOT TO BE PAINTED OR FINISHED

- A. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.
- B. [NOT USED]
- C. [NOT USED]

3.03 SURFACE PREPARATION

- A. Perform preparation and cleaning procedures in accordance with paint manufacturer's instructions and as herein specified, for each particular substrate condition.
- B. [NOT USED]

- C. Clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease prior to mechanical cleaning. Program cleaning and painting so that contaminants from cleaning process will not fall onto wet, newly-painted surfaces.
- D. [NOT USED]
- E. [NOT USED]
- F. Ferrous Metals: Clean ferrous surfaces, which are not galvanized or shop-coated, of oil, grease, dirt, loose mill scale, and other foreign substances as recommended by paint manufacturer specified. Touch-up shop-applied prime coats wherever damaged or bare, where required by other Sections of these Technical Provisions.
- G. [NOT USED]
- H. [NOT USED]

3.04 MATERIALS PREPARATION

- A. Mix and prepare painting materials in accordance with manufacturer's directions.

3.05 APPLICATION

- A. General: Apply paint in accordance with manufacturer's directions. Use applicators and techniques best suited for substrate and type of material being applied.
- B. Apply additional coats when undercoats or other conditions show through final coat of paint, until paint film is of uniform finish, color and appearance. Give special attention to ensure that surfaces, including edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.
- C. [NOT USED]
- D. [NOT USED]
- E. [NOT USED]
- F. [NOT USED]
- G. Omit first coat primer on metal surfaces which have been shop-primed and touch-up painted, unless otherwise indicated.
- H. Minimum Coating Thickness: Apply prime coat of material which is required to be painted or finished, and which has not been prime-coated by others.
 - 1. Recoat primed and sealed surfaces where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn-through or other defects due to insufficient sealing.

- I. Smooth Finish: Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling such as laps, irregularity in texture, skid marks, or other surface imperfections.
- J. Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface or uniform finish, color, appearance and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness or other surface imperfections will not be acceptable.
- K. Completed work: Match approved samples for color, texture and coverage. Remove, refinish, or repaint work that is not in compliance with specified requirements equal to the approved sample.

3.06 CLEAN-UP

- A. Clean-Up: During progress of work, remove from Worksite discarded paint materials, rubbish, cans and rags at end of each work day.
- B. Upon completion of painting work, clean window glass and other paint-spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch or otherwise damage finished surfaces.

3.07 PROTECTION

- A. Protect work of other trades, whether to be painted or not, against damage by painting and finishing work. Correct any damage by cleaning, repairing or replacing, and repainting.
- B. Provide "Wet Paint" signs as required to protect newly-painted finishes. Remove temporary protective wrappings provided by others for protection of their work, after completion of painting operations.
- C. At the completion of work of other trades, touch-up and restore all damaged or defaced painted surfaces.

3.08 [NOT USED]

3.09 EXTERIOR PAINT SCHEDULE

- A. Exterior Ferrous Metal: Semi-gloss aliphatic acrylic polyurethane;
 - 1. One (1) coat of polyamide epoxy. DFT – 4.0 mils (Tnemec, Hi-Build Epoxoline, Series 66 or approved equal.)
 - 2. Two (2) coats of aliphatic acrylic polyurethane. DFT – 3.0 mils/coat (Tnemec, Endura-Shield II, Series 1075 or approved equal.)
 - 3. One (1) coat of clear satin aliphatic acrylic polyurethane. DFT – 2.0 mils (Tnemec, Endura-Clear, Series 76 or approved equal.)

4. First coat not required if factory primed – spot prime abraded areas only with polyamide epoxy primer.

B. [NOT USED]

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 09910

PAINTING OCS POLES

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment, and incidentals necessary for painting OCS poles, in accordance with the Contract Documents.
- B. This Section includes, but is not limited to the following:
 - 1. Painted OCS poles and attachments as supplied from the manufacturer in a finished condition and/or items requiring field painting.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 005505, "Metal OCS Poles"
- C. Section 16602, "General Requirements Overhead Contact System."

1.03 REFERENCE STANDARDS

- A. ANSI Standard Z55.1

1.04 SUBMITTALS

- A. Color samples shall be submitted for approval.
- B. Paint data as specified shall be submitted.
- C. Paint shop application methods shall be submitted for all poles and steelwork, including preparation methods, application procedures, and special curing practices used.
- D. Warranty of paint shall be submitted for approval.

1.05 DELIVERY, STORAGE AND HANDLING

- A. All painted equipment and material shall be handled and stored by Contractor so as to not damage or otherwise deter the paint or coating from protecting the coated item.
- B. The storage of paint and its associated mixes shall be in accordance with the paint manufacturer's written instructions and shall not cause damage to or alter the composition of the paint such that its qualities are altered or otherwise lost.

- C. Contractor shall store all flammable paints and solvents in an acceptable manner and place.

1.06 WARRANTY

- A. The finished coating shall be guaranteed to last a minimum of 10 years, with no major paint peeling, blistering, cracking or surface corrosion occurring within that period.

1.07 DEFINITIONS

- A. The term "paint" as used herein, includes coatings, emulsions, enamels, varnishes, paints and other protective sealers, whether used as a prime, intermediate or finish coat.

ARTICLE 2 PRODUCTS

2.01 MATERIALS

- A. The type of paint approved for use on OCS poles are as follows:
1. Primer paint to be an inorganic zinc-rich coating applied over blast-cleaned surfaces, two-component systems. Minimum dry film thickness shall be 3 mils.
 2. Intermediate coating shall be high bond epoxy. Minimum film thickness shall be 5 mils.
 3. Top coating shall be urethane capable of resistance to weather, abrasion and salt solution, having a wide selection of available colors. Minimum film thickness shall be 1.5 mils.
- B. All paint products and coatings shall be selected, purchased and used on the basis of a normal exterior exposure in a rural, medium industrial area capable of withstanding a moist, salt laden, environment.
- C. Paints intended for use in the field shall be stored in sealed containers that legibly show the designated name, formula, batch number, color, quantity, date of manufacture, manufacturer's number and directions including storage, special precautions and warnings.
- D. Contractor shall provide the following information for all paint used:
1. The paint manufacturer and key number.
 2. Manufacture lot number.
 3. Color.
 4. Directions and instructions for storage and application.
- E. Color: For all painted poles and steelwork the color shall be Pittsburgh Paint Color 247-7, Bright Cerulean.
1. Pittsburgh Paint Color 247-7, Bright Cerulean.

ARTICLE 3 EXECUTION

3.01 INSPECTION

- A.** All paint and its application shall be subject to inspection by the Engineer.

3.02 INSTALLATION

- A.** Painted surfaces shall have a minimum 3 coat application. Each coat shall be of a different color or shading so as to be readily distinguishable from the other coats. The coating shall consist of a primer, intermediate and finish layer and shall be applied in accordance with the paint manufacturer's instructions.
- B.** Unless otherwise recommended by the paint manufacturer, all paint applications shall be performed when the ambient temperature is between 45 degrees F and 95 degrees F. All paints shall be applied only to surfaces that are completely dry and free of surface moisture, clean and free of dirt, oil, mill scale, and detrimental coatings which will cause the paint to lose its bonding properties, and as recommended by the paint manufacturer. In no case shall paint be applied to surfaces on which there is visible water, frost, ice or snow.
- C.** Items not to be painted, which are in contact with or adjacent to surfaces scheduled for painting, shall be removed or protected prior to surface preparation and painting operations. All masking and protective tapes shall be totally removed, without leaving residue, upon completion of the painting operations.
- D.** Surface preparation shall comply with the manufacturer's recommendations, including blast cleaning and removal of mill scale. Oil, grease, and dirt shall be removed with clean cloths and acceptable solvents prior to mechanical cleaning and preparation. After brushing, sanding, and mechanical cleaning, all loose scale and dirt shall be completely removed prior to painting.
- E. Prime Coat**
 - 1.** Primers shall be capable of remaining in satisfactory condition for 6 months without the protection of a finish coat, for all field painting applications.
 - 2.** Primers shall have sufficient penetrating and wetting properties to insure good coating regardless of the presence of light scale, or light rust on the surface to be painted.
- F. Intermediate Coat**
 - 1.** The intermediate coat shall be compatible with the final finish coat, as recommended by the paint manufacturer.

G. Finish Coat

1. The finish coat shall be a coating suitable for protecting the surfaces to which it is applied. It shall completely hide the primer and intermediate coats and shall have no visible streaks, blisters, or obvious color or surface imperfections.
2. Drying time to a tack free condition shall not be more than 24 hours.

3.03 APPLICATION

- A. Paint shall be applied by brush, roller, spray, or electro-coating except as herein specified. At the time of application, all paint mixes shall show no signs of deterioration.
- B. Paints of different manufacturers shall not be mixed together. Thinning is acceptable prior to application where necessary to suit conditions of surface, temperature, weather, and method of application with not more than one pint of approved thinner per gallon of paint or as per the paint manufacturer's instructions.
- C. Paint shall be applied so the final finished surfaces shall be free of visible runs, drops, brush marks and variation of color, texture and finish.
- D. Each coat shall be applied as a film of uniform thickness, not less than thickness as specified. Special attention shall be given to insure that all surfaces including edges, corners, crevices, welds and fasteners receive a film thickness equivalent to that of adjacent painted surfaces.
- E. Sufficient time shall elapse between successive coats to permit proper drying. The application of another coat shall not cause the lifting or loss of adhesion of the undercoat.

3.04 FIELD QUALITY CONTROL

- A. All painting activities shall be in accordance with this Section, and are subject to inspection by the Engineer at any time.
- B. All paint, which is unacceptable, as applied, shall be removed, or repaired in accordance with the paint manufacturer's instructions, and corrected to the Engineer's satisfaction at the Contractors expense.
- C. Poles and steelwork, which have paint damage due to mishandling, poor erection and/or storage practices and Contractor and/or manufacturer procedures, shall be repaired at no additional cost to Authority. Paint repairs shall be accomplished in the field or returned to shop, in accordance with the paint manufacturer's instructions.

ARTICLE 4 EASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13570
SIGNAL SYSTEM REQUIREMENTS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for signal system requirements, in accordance with the Contract Documents.
- B. The work of this section includes, but is not limited to, the following activities:
 - 1. The Contractor shall install interlocking and wayside signal systems equipment according to the layout and equipment locations shown on the Contract Drawings.
 - 2. Additional modifications required by the Contractor's design must be approved by the Engineer.
 - 3. The Contractor shall install interlocking and wayside signal system equipment per the Contractor's approved design at five locations for the Project:
 - a. New Allegheny Avenue Interlocking and Terminal Relay Room
 - b. New North Side Station Relay Room
 - c. New Gateway Station Relay Room
 - d. Existing Gateway Interlocking Relay Room
 - e. Existing Wood Street Interlocking Relay Room
 - 4. The work shall include modification to existing relay-based interlockings, modifications to entrance/exit type local control panel and logic, all wayside ground equipment including, but not limited to wayside signals, automatic train stops, and electric switch machines, non-vital interlocking software modifications, control center modifications, any ancillary systems, and all equipment, hardware and software necessary to provide a complete, and working system.
 - 5. The Contractor shall provide all submittals required by Section 01300, "Administrative Requirements" and Section 13579, "Design Requirements."
 - 6. The Contractor shall perform all factory and field-testing as is described within Section 13595, "Signal System Test and Inspection."
 - 7. The Contractor shall modify the existing local control panels as specified within the Contract Documents for the reconfigured Wood Street and Gateway Interlocking.
 - 8. The Contractor shall provide new local control panels as specified within the Contract Documents for new Allegheny Interlocking.
 - 9. The Contractor shall modify the Operations Control Center (OCC) to accommodate the new and existing interlockings and relay rooms. The Contractor shall properly interface all new controls and indications with the OCC, and shall implement and support all testing for this interface as is required by the Contract Documents.
 - 10. The Contractor shall revise existing Wood Street Interlocking to convert it from an existing single crossover arrangement to a double crossover (scissors)

arrangement. This work is necessary to implement a turn back operation on the line that will facilitate the tunnel boring operation. As part of this work, the existing single crossover arrangement at the interlocking shall be retired and replaced with a newly constructed scissors crossover arrangement. The existing relay based circuitry at the Wood Street Interlocking Relay Room shall be modified by the Contractor to support the new interlocking arrangement as shown on the Contract Drawings. The Contractor shall perform the following work at Wood Street Interlocking associated with these changes:

- a. The Contractor shall provide all field wiring necessary to revise the control circuits for Wood Street Interlocking to convert it to its new arrangement. The work also includes modifications to the existing relay room at Wood Street Interlocking, the provisioning of newly wired relay racks within the existing relay room, installation of new relays within existing relay racks, site preparations, and all permits necessary to install the signal system equipment.
- b. Four new, US&S Model SLP M-3 (low profile) electric switch machine layouts, complete with all rods, plates and attachments for the new scissors crossover arrangement are to be provided by others as part of the Authority Advanced Rail System Procurement – Wood Street Double Crossover Track Material Contract. It is necessary to replace the existing M23B dual control switch machines with this specific switch machine arrangement as the switch machines are to be installed on the normally closed point, and there is insufficient room in-between the tracks to install dual control switch machines adjacent to each other.
- c. The Contractor shall provide all interface with the Authority Advanced Rail System Procurement – Wood Street Double Crossover Track Material Contract as is necessary to ensure that the power operated switch layout arrangement is properly coordinated with the installation of the special track work. Coordination shall include but not be limited to the following:
 - 1) The Contractor shall attend the final inspection of the pre-assembled double crossover arrangement with the Authority at the Advance Track Procurement Contractor's fabrication shop for the purpose of determining that the four new US&S Model SLP M-3 (low profile) electric switch machine layouts are properly installed on the layout and that there will be no installation or maintenance problems that arise once the new layouts are installed in the field.
- d. All existing control circuitry located within the Wood Street Interlocking Relay Room, not described here-in as being modified, shall remain in service within the existing rack locations.
- e. The Contractor shall modify the existing local Genisys non-vital microprocessors, their application logic and all related circuitry to provide for the new arrangement of Wood Street Interlocking.
- f. The Contractor shall modify the existing remote Genisys non-vital microprocessor, application logic and all related circuitry to provide for the new arrangement of Wood Street Interlocking.
- g. The Authority shall provide the existing circuit drawings for Wood Street

Interlocking to the Contractor. CADD files are not available. The Authority will provide electronic image files of the circuits in "tiff" format. The Contractor shall convert the tiff images to Autocad and shall mark the CADD files, (X=out, O=in) to portray the changes required to the circuitry as described here in. All detail wiring diagrams, power loops, rack layouts, terminal boards, fuse panels, plug connector and intra rack cable details, entrance rack arrangements, relay rack arrangements, and relay room layout drawings shall also be marked to indicate the changes. All final As-built drawings shall be provided to the Authority in CADD format as specified. The Contractor shall redraw and convert all existing drawings as is required to conform to these specifications.

11. The Contract Drawings represent required circuit modifications for the existing Gateway Interlocking Relay Room. Existing Gateway Station is to be taken out of service during the demolition of the loop and the construction of the new Gateway Station. The Contractor shall design and implement circuit and logic modifications to the existing Gateway Interlocking Relay room necessary to implement the signal routes and aspects indicated within the Contract Drawings.
 - a. The work includes modifications to the existing relay room at Gateway Interlocking, the installation of new relays within existing relay racks, site preparations, and all permits necessary to install the signal system equipment.
 - b. The Contractor shall provide all field wiring necessary to revise the control circuits for Gateway Interlocking to convert it to its new arrangement.
 - c. The Contractor shall modify the existing local Genisys non-vital microprocessors, their application logic and all related circuitry to provide for the new arrangement of Gateway Interlocking.
 - d. The Contractor shall modify the existing remote Genisys non-vital microprocessor, application logic and all related circuitry to provide for the new arrangement of Gateway Interlocking.
 - e. The Contractor shall properly interface all new or modified controls and indications with the Operations Control Center, and shall implement and support all testing for this interface as is required by these Specifications.
 - f. The Authority shall provide the existing circuit drawings for Gateway Interlocking to the Contractor. CADD files are not available. The Authority will provide electronic image files of the circuits in "tiff" format. The Contractor shall convert the tiff images to Autocad and shall mark the CADD files, (X=out, O=in) to portray the changes required to the circuitry as described here in. All detail wiring diagrams, power loops, rack layouts, terminal boards, fuse panels, plug connector and intra rack cable details, entrance rack arrangements, relay rack arrangements, and relay room layout drawings shall also be marked to indicate the changes. All final As-built drawings shall be provided to the Authority in CADD format as specified. The Contractor shall redraw and convert all existing drawings as is required to conform to these specifications.
12. New Gateway Station Relay Room:
 - a. The Contractor shall install a new Vital and Non-Vital Microprocessor

Controller, any extender modules, vital and non-vital relays, TWC system equipment, track circuits and equipment and all other equipment described within these Contract Documents, installed within pre-wired racks, to provide control for, and interface to all new automatic signals, automatic train stops and new track circuits for the new track alignment as shown on the Contract Drawings. The limits of what devices are controlled from the existing Gateway Relay Room and the new Gateway Relay Room are indicated within the Contract Drawings.

- b. The Contractor shall provide all field wiring necessary to interface the newly provided vital microprocessor controller in the new Gateway Relay Room to the existing relay based signal circuits in the existing Gateway Relay Room.
 - c. All existing track circuits located within the existing Gateway Relay Room, not removed as part of the loop demolition, shall remain in service within the existing rack locations. The Contractor shall provide all field wiring between the existing Gateway Interlocking Relay Room and the new Gateway Station Relay Room necessary to directly input the track circuits, traffic circuit information, route locking circuit information and any other signaling circuits that may be required, into the new vital microprocessor controller in the new Gateway Relay Room, as may be necessary to control the new automatic signals.
 - d. The Contractor is responsible to provide all required vital software to interface between the existing system as modified and the new system as indicated on Contract Documents.
13. New North Side Station Relay Room:
- a. The Contractor shall install a new Vital and Non-Vital Microprocessor Controller, any extender modules, vital and non-vital relays, TWC system equipment, track circuits and equipment and all other equipment described within these Specifications and indicated within the Contract Drawings, installed within pre-wired racks, to provide control for, and interface to all new automatic signals, automatic train stops and new track circuits for the new track alignment as shown on the Contract Drawings. The limits of what devices are controlled from the new North Side Station Relay Room are indicated within the Contract Drawings.
 - b. The Contractor is responsible to provide all required vital and non-vital software to interface to the new system as indicated on Contract Drawings and Specifications.
14. New Allegheny Station Interlocking Relay Room:
- a. The Contractor shall install a new Vital and Non-Vital Microprocessor Controller, any extender modules, vital and non-vital relays, TWC system equipment, track circuits and equipment and all other equipment described within these Contract Documents, installed within pre-wired racks, to provide control for, and interface to all new controlled signals, power operated switch machines, automatic train stops and new track circuits for the new track alignment as shown on the Contract Drawings. The limits of what devices are controlled from the new Allegheny Station Interlocking Relay Room are

- indicated within the Contract Drawings.
- b. The Contractor is responsible to provide all required vital and non-vital software to interface to the new system as indicated in the Contract Documents.
15. Equipment to be supplied by the Contractor includes but is not limited to the following:
- a. Local vital and non-vital logic processors.
 - b. Non-vital processors/interface to OCC.
 - c. The non-vital processor used to interface to OCC may also be used to process the local non-vital logic.
 - d. Controlled Interlocking signals.
 - e. Automatic Block Signals.
 - f. Automatic Train Stops.
 - g. Switch Machines and Switch Layouts.
 - h. Snow Melter Control Cases and Snow Melter Layouts (at Allegheny).
 - i. Track circuits and track circuit equipment including impedance bonds.
 - j. Traction return and signal track bonding
 - k. Traction return crossbonding.
 - l. New TWC equipment as shown on the Contract Drawings.
 - m. Train Protection Strobe Light System.
16. Train to Wayside Communications System (TWC)
- a. The Contractor shall install new TWC equipment as shown on the Contract Drawings and described in Section 13580, "Train to Wayside Communications (TWC)."
 - b. The Contractor shall also provide all new application logic programming in existing Microlok Vital Microprocessor control systems and Genisys Non-Vital Microprocessor control systems necessary to implement the new TWC Routes to be provided by this Project. These requirements are further defined within Section 13580, "Train to Wayside Communications (TWC)."
17. Exterior Cable:
- a. The Contractor shall furnish and install all cables and interconnect wiring. These requirements are detailed in Section 13587, "Wire and Cable."
 - b. All cable shall be installed in conduit, cable trough, or duct bank. Direct burial cable is not permitted without the approval of the Engineer.
 - c. Spare conductors shall be provided as specified in Section 13587, "Wire and Cable", and shall terminate at all junction boxes.
 - d. Conduit:
 - 1) The Contractor shall furnish and install conduits and associated hardware required for cable installation as shown on the Contract Drawings.
 - e. Cable Trough:
 - 1) The Contractor shall furnish and install cable trough and associated hardware required for cable installation as shown on the Contract Drawings. The Contractor shall design, furnish, and install the connections between conduit, cable trough, and the pullboxes/manholes that are required for signal cables. The Contractor shall review the

- Contract Drawings to determine types and quantities. The requirements for these connections are detailed in Section 13585, Installation.
- 18. The Contractor shall remove any existing signal equipment in order to implement the Contractor's design or as directed by the Engineer.
 - 19. The Contractor shall bond around existing insulated joints that are no longer required.
- C. The Contract Documents provide the performance parameters and design criteria to complete the signal system requirements. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 00200, "Instructions to Bidders."
- B. Section 01300, "Administrative Requirements."
- C. Section 01910, "Operations, Maintenance and Repair Data."
- D. Section 13574, "Wayside Signal Equipment."
- E. Section 13576, "Circuit Requirements."
- F. Section 13577, "Solid State Equipment."
- G. Section 13579, "Design Requirements."
- H. Section 13580, "Train to Wayside Communications."
- I. Section 13581, "Local Control Panels."
- J. Section 13582, "Safety and Systems Assurance."
- K. Section 13585, "Installation Requirements"
- L. Section 13587, "Wire and Cable."
- M. Section 13588, "Relays and Plugboards."
- N. Section 13589, "Electrical and Electronic Components."
- O. Section 13590, "Housings and Housing Equipment."
- P. Section 13591, "Tags, Locks and Keys."
- Q. Section 13593, "Signal Power Distribution."
- R. Section 13595, "Signal System Test and Inspection."

1.03 REFERENCE STANDARDS

- A. AREMA Communications and Signals Manual of Recommended Practices
- B. Port Authority of Allegheny County Standard Operating Procedures Manual, March 16, 2007 Revision

1.04 SUBMITTALS

- A. Submittals shall be provided as described within each of the Specification Sections described above within Article 1.02, Related Sections. All equipment, materials and products provided under this Contract shall require approval of the Engineer.
- B. The Contractor shall submit the resume of the Signal Engineer responsible for the engineering, design and application engineering and development of the signal systems. The Signal Engineer shall be assigned permanently for the duration of this Project and shall be approved by the Engineer. The Signal Engineer shall have a minimum of ten (10) years experience in development of hardware for rapid transit wayside signal projects. This shall include, but not be limited to, engineering, designing, testing, installing, configuring, debugging and documenting of all necessary hardware and applications.
- C. The Contractor's design drawings shall be sealed by a Professional Engineer registered in the State of Pennsylvania.

1.05 QUALIFICATIONS

- A. The Contractor shall provide a Signal Engineer on-site for the duration of the work. The Contractor shall also provide all necessary Engineering support for pre-revenue service operations in accordance with this Section. The Signal Engineer shall have a minimum of 10 years experience in projects of similar nature, size and complexity to this Project.
- B. The Signal Engineer shall be authorized to direct the Contractor's personnel so the design can proceed without delay. The Signal Engineer shall have experience in related signal projects of comparable size and complexity.

1.06 EXISTING CONDITIONS

- A. The information presented in this Section shall be used by the Contractor to familiarize itself with the type of services that Authority currently provides and the type of service Authority anticipates providing in the future. The Contractor shall verify this information as needed to accomplish its work.
- B. Authority owns and operates the LRT System that serves the South Hill communities and the City of Pittsburgh. The LRT System was placed into service in 1987 under the designation of Stage I. The Stage I LRT System in 1987 included a new vehicle

maintenance building, the OCC and 55 LRV's. Service in the downtown subway area, known as the Central Business District (CBD), Penn Park Spur, Allentown Line, Library Line, and the line from the CBD to South Hills Village via Beechview continues.

- C. The Stage I LRT Program did not bring the Drake, Library and Overbrook lines up to light rail standards. The Overbrook Line was taken out of service in 1993. The Drake Line was taken out of service in 1999.
- D. Authority has made improvements to the Stage I LRT System. These improvements were known as the Stage II LRT Program and consisted of modifications to existing Stage I systems and/or components, as well as the addition of new systems and components. The Overbrook Line was completely rebuilt and put back in service under the Stage II LRT Program.
- E. The existing LRT System's fleet consists of 83 LRV's. Two-car trains shall be operated during peak periods in the CBD, on the Beechview Line and the Overbrook Line and one-car trains during non-peak periods,
- F. During calendar year 1997, the LRT System carried more than 28,000 rides on an average weekday. It is currently anticipated that ridership will increase to more than 41,000 during an average weekday in 2005, and to 49,500 in 2015.
- G. Existing station/stops include: Gateway Center, Wood Street, Steel Plaza, Penn Park, Station Square, South Hills Junction, Fallowfield, Potomac, Dormont Junction, Mt Lebanon, Castle Shannon, Washington Junction, South Hills Village, Boggs, Bon Air, Denise, South Bank, McNeilly, Killarney, Memorial Hall and Willow. Additional stations were built in the CBD at First Avenue, at Castle Shannon Junction on the South Hills Village Line, and at Library.
- H. The existing LRT System includes 21 signal control locations, each with a corresponding local control panel located along the right-of-way. Penn Park, Gateway, Wood Street, Steel Plaza (Midtown), Fourth Avenue, Panhandle Bridge, Station Square (Carson Street), South Hills Junction, Dawn, Dormont Junction (McFarland), Mt. Lebanon, Castle Shannon, Overbrook Junction, Washington Junction, Bethel Village, Dorchester, South Hill Village, Boggs, Denise, Glenbury, and Pine.
- I. The rails are continuous welded rail, with the occasional bolted joint found at special trackwork.

1.07 CONTRACT DRAWINGS AND SPECIFICATIONS

- A. The Contract Drawings represent logic equations and circuits for the system as shown in "typical" format, except the "Block Layout" and "Control Line Drawings", which are definitive and final as presented. Not all required circuits and equations are shown. The Contractor shall provide complete final circuits using the Contract Drawings and Specifications as a guide for methodology, not content.

1.08 GENERAL SYSTEM REQUIREMENTS

- A. North Shore Connector, Contract Package NSC-009;
 - 1. The Contractor shall provide a complete, safe, reliable, operable and maintainable signal system. The signal system to be provided by the Contractor is an extension to Authority's existing signal system, as described in the Contract Documents. This portion of Authority's Signal System will be known as the North Shore Connector (NSC) Signal System.
 - a. The NSC Signal System shall be a track circuit based system that employs double rail power frequency track circuits in between interlockings and single rail power frequency based track circuits within interlocking limits for the purpose of train detection. Wayside automatic and controlled block signals shall be provided to govern movement within the signal blocks in accordance with Authority's Standard Operating Procedures Manual. Automatic train stops shall also be provided for speed enforcement.
 - 2. In order to simplify the text, use of the words "design," "furnish," "provide", "replace," "install," or "commission" shall all mean design, manufacture, furnish, install and test to an operational status.
 - 3. The Contractor shall furnish all labor, material, equipment, supervision, transportation, and miscellaneous services, whether or not explicitly identified herein, to provide a completely tested and fully operational signal system.
 - 4. The Contractor shall be responsible for determining by field inspection and analysis of Authority supplied drawings and the Contract Drawings, the exact location and condition of existing equipment and circuits that must be removed and replaced with new equipment, and to which changes are to be made. If the existing equipment or circuitry requires interfacing with the new equipment, the Contractor shall provide necessary revisions and equipment required to make the system fully operational. The Contractor shall verify the as-in-service condition of all existing circuitry and equipment prior to making any circuit revisions and wiring changes.
 - 5. The Contractor's work shall include all Train to Wayside Communications (TWC), Automatic Block Signal (ABS), new vital microprocessor-based and modification to existing relay-based interlockings, entrance/exit type local control panels logic, all wayside ground equipment including, but not limited to wayside signals, automatic train stops, and electric switch machines, non-vital interlocking system material, control center modifications, any ancillary systems, and all equipment, hardware and software necessary to provide a complete and working system.
 - 6. All equipment supplied shall be of the most modern design and meet the highest standard of industry and all applicable requirements of the AREMA Communications and Signals Manual of Recommended Practices.
 - 7. The Contractor shall supply all documentation, training, and spare parts, as indicated in the Contract Documents.
 - 8. The Contractor shall become familiar with Authority's existing LRT System.
 - 9. The Contractor shall review the Contract Documents in their entirety to determine

their relationship.

10. The Contractor shall bear total system responsibility for all work and for specified additions and changes to Authority systems. The Contractor has the responsibility to integrate all elements of the work to meet overall Contract Document requirements.
11. All Contractor provided systems, equipment and services shall perform and be suitable for their intended purpose, be provided in accordance with best commercial practices, and be in compliance with all applicable Contract Document requirements.
12. The Contractor shall assume total responsibility for the configuration of equipment, parts interconnecting wiring, software, and other materials and services furnished. Any modifications to approved system designs shall be subject to prior approval by the Engineer.
13. The Contractor shall assume total responsibility for the correction of any degradation in the performance of existing Authority system or equipment, which results from any system or requirement interface installed by the Contractor.
14. Although the Engineer will review the Contractor's design and component configuration and products selected, the Contractor retains responsibility to comply with all Contract requirements.
15. The Contractor shall provide sufficient personnel and equipment to support Authority's integrated testing program and pre-revenue service operations to verify that the completed system operates properly.
16. The Contractor shall pretest all systems and subsystems prior to placing them in service. The Contractor is responsible for all costs associated with these tests as well as any re-work and retest that may occur as a result of the tests.
17. Integrated testing includes the testing with the use of a LRV in accordance with Section 13595, "Signal System Test and Inspection," the traction power substations, overhead contact system, communications and signals, in operating and emergency simulation modes. The Contractor shall support these tests and maintain full operation of the signal system during performance of the tests. In the event of any malfunctions in the signal system, the Contractor shall immediately identify the problem and repair, adjust or replace necessary items or equipment to correct the malfunction.
18. The Contractor shall provide pre-revenue service operations to include but not be limited to the training of Authority's Operations and Maintenance personnel as described within Section 1910, "Operations, Maintenance and Repair Data." All types of operational and emergency situations will be simulated. The Contractor shall support these tests and maintain the Signal System at full performance.
19. From the first sixty calendar days following acceptance of the signaling system by the Authority, the Contractor, through its Signal Engineer, shall provide technical assistance in troubleshooting, repair and maintenance. The Contractor shall observe Authority's maintenance personnel and provide advice and assistance so as to achieve a high quality maintenance program.
20. Any use of materials not covered under the Contract Documents, shall be submitted to the Engineer for approval prior to use and installation.

21. The maintenance of Authority operations shall be given the highest priority. Any plan for disruption of service for installation of equipment and/or in-service testing of interim or final signaling system modifications must be approved by the Engineer. The Contractor is responsible for the planning, design, installation, staging and testing of the work in a manner so as to avoid disruption of passenger service. Work shall not be permitted to conflict with operations unless specific authority is granted by the Authority. The Contractor is responsible to return operations to their normal state after all work outages.

ARTICLE 2 PRODUCTS

[NOT USED]

ARTICLE 3 EXECUTION

3.01 COORDINATION WITH OTHERS

- A. The Contractor shall design and develop all interfaces between Contractor-furnished equipment and equipment furnished by others.
- B. The Contractor shall provide all interface with the early procurement of the Wood Street Double Crossover, Contract No. 3002, FTA Project PA-03-0315, as is necessary to ensure that the power operated switch layout arrangement is properly coordinated with the installation of the special track work. Coordination shall include but not be limited to the following:
 1. The Contractor shall attend the final inspection of the pre-assembled double crossover arrangement at the Advance Track Procurement Contractor's fabrication shop for the purpose of determining that the four new US&S Model SLP M-3 (low profile) electric switch machine layouts are properly installed on the layout, that there will be no installation or maintenance problems that arise once the new layouts are installed in the field, and that the switch machine motors and mechanisms operate properly. The Contractor shall electrically test the switch machine installation as detailed within Section 13595, "Signal System Test and Inspection."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 13570.001 - Allegheny Avenue Station Interlocking and the Associated Automatic Block Signal System shall be measured as a lump sum unit, complete in place.
- B. Item 13570.002 - North Side Station Automatic Block Signal System shall be measured as a lump sum unit, complete in place.

- C. Item 13570.003 - Modified Gateway Interlocking and the Associated Automatic Block Signal System shall be measured as a lump sum unit, complete in place.
- D. Item 13570.004 - Modified Wood Street Interlocking shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. Item 13570.001 - Allegheny Avenue Station Interlocking and the Associated Automatic Block Signal System will be paid at the Lump Sum Price and shall include the cost of all related work specified in this Section.
- B. Item 13570.002 – North Side Station Automatic Block Signal System will be paid at the Lump Sum Price and shall include the cost of all related work specified in this Section.
- C. Item 13570.003 - Modified Gateway Interlocking and the associated Automatic Block Signal System will be paid at the Lump Sum Price and shall include cost of all related work specified in this Section.
- D. Item 13570.004 - Modified Wood Street Interlocking will be paid at the Lump Sum Price and shall include cost of all related work specified in this Section.

END OF SECTION

SECTION 13574
WAYSIDE SIGNAL EQUIPMENT

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for wayside signal equipment, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Power switch layouts
 - 2. Wayside signals
 - 3. Automatic train stops
 - 4. Wayside junction boxes
 - 5. Signal mounting
 - 6. Track circuits, power frequency
 - 7. Impedance bonds
 - 8. Rail connections and bonds
 - 9. Snow melters
 - 10. Signs
 - 11. TWC loops
 - 12. Train Protection Strobe Light Warning System
- C. The Contract Documents provide the performance parameters and design criteria to complete the wayside signal equipment. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements."
- B. Section 01910, "Operations, Maintenance and Repair Data."
- C. Section 02456, "Track Appurtenances and Other Track Material"
- D. Section 13570, "Signal System Requirements."
- E. Section 13580, "Train to Wayside Communications (TWC)."
- F. Section 13585, "Installation Requirements"
- G. Section 13587, "Wire and Cable."
- H. Section 13591, "Tags, Locks and Keys."

1.03 REFERENCE STANDARDS

- A. AISI Standard C-1035.
- B. AREMA Communications and Signals Manual of Recommended Practices.
- C. ASTM Standards A27-65, A47-68, A236-67, A236-69, A283-70, and A311-64.
- D. NEMA.
- E. UL.

1.04 SUBMITTALS

- A. Submit the following to the Engineer for approval prior to manufacture of the equipment:
 - 1. Shop Drawings for assembly of the switch machines, wayside signals, automatic train stops, impedance bonds, snow melter equipment, snow melter cases, and TWC loops. Shop Drawings shall include a complete bill of materials listing all components and hardware.
 - 2. Installation Shop Drawings of each electric switch and lock movement layout showing all switch and lock mounting details, connections to the track switch points, and layout as applicable. A separate installation Shop Drawing shall be provided for each switch point where an electric switch machine will be installed.
 - 3. Factory test procedures for approval by Engineer prior to the factory testing of the switch machine mechanisms.
 - 4. Complete field installation Shop Drawings for all material specified within this section. This shall include detailed installation drawings showing specific installation requirements for each location as follows;
 - a. Any special civil features required such as drainage or other civil improvements
 - b. Any concrete or structural steel modifications required for the installation
 - c. Concrete plinth spacing and mounting arrangement of all cables and conduits in relation to the placement and spacing of the plinths
 - d. Concrete plinth spacing, details for attachment to wall or structure, mounting arrangements, fastening details, and complete assembly Shop Drawings for all material specified within this Section.
 - 5. Product data, Shop Drawings, and specifications for all wayside signal equipment.
 - 6. Impedance Bond test data.
 - 7. All field and factory test data, documents, and results specified within Section 13595, "Signal System Test and Inspection."

1.05 DELIVERY, STORAGE AND HANDLING

- A. The Contractor shall deliver, handle, and store materials in accordance with manufacturer's instructions. All damage incurred in transit and/or caused by mishandling or improper storage shall be the Contractor's responsibility.

- B. Prior to shipment, coat with petroleum jelly or other approved preservative all parts of switch machines which are not painted or made of non-corroding material. Plug or cap all unused threaded outlets. During storage and after installation, switch machine movements shall be properly greased, lubricated and maintained by Contractor until Acceptance of Final Inspection.
- C. Ship lamps separately from signal heads.
- D. Junction boxes and all component parts shall be properly protected at the point of manufacture to prevent damage during shipment. All exterior openings shall be sealed during shipment.

ARTICLE 2 PRODUCTS

2.01 POWER SWITCH LAYOUTS

- A. Power operated electric switch machine layouts shall include dual control, powered mainline switch machines, and all other hardware necessary to mechanically couple the switch machine to the track switch. Also included are risers, junction boxes, and cable as specified in Section 13587, "Wire and Cable", and electrical fittings to interconnect the power operated electric switch machine to the relay room. All power operated electric switch machines shall have 15-watt, 110 VAC heaters in both the circuit controller and motor compartments. Power operated electric switch machine layouts shall be provided at locations indicated on the Contract Drawings.
- B. Mainline Track Switch Machines
 - 1. The Contractor shall provide electric powered switch machines of the 110 VDC type, shall use a three wire control circuit and shall conform to the AREMA Communications and Signals Manual of Recommended Practices, Part 12.2.1, except as otherwise specified herein.
 - 2. When track switch points are in full normal or full reverse position, the mechanical locking equipment shall prevent track switch point movement by vibration or any other means other than the control circuits, or manual lever.
 - 3. The switch circuit controller shall indicate track switch points have moved and are locked in the full normal or full reverse position. Circuit controller contacts shall also control connections to the motor.
 - 4. Point detector shall provide an indication that track switch points are in full normal or reverse position.
 - 5. Track switch machines shall have separate rods for movement of track switch points, locking, and point detection.
 - 6. Dual control machines shall be provided with a separate lever to select power or hand-throw mode of operation. When this lever is moved from the power position, power from any source, for operation of the switch machine shall be cut off. Means shall be provided to require the hand-throw lever to be brought into correspondence with switch position before the switch can be moved by the hand-throw lever. Provide latches and padlocks to fasten and lock the hand-throw lever

- in both extreme positions as specified in Section 13591, "Tags, Locks and Keys."
7. Operating Characteristics;
 - a. Electric switch machines shall be rated for operation at 110 VDC nominal, and shall be capable of repeated successful operation, without damage, at voltages between 90 and 130 VDC. The operating voltage shall be measured at the motor while the track switch is moving.
 - b. Operating Time;
 - 1) The track switch operating time shall be measured from the closure of the front contacts on the track switch operating relay to the input of a switch indication at the vital processor, or pick-up of the switch correspondence relay when the track switch machine is operating at load as indicated within the AREMA Communications and Signals Manual of Recommended Practices, Part 12.2.1.
 - 2) Track switch machine operating times shall not exceed five seconds as specified in AREMA Communications and Signals Manual of Recommended Practices, Part 12.2.1.
 - a) Operation by the hand throw lever shall give the same mechanism stroke, including full lock rod protection as operation by power.
 8. A representative type of dual control, power operated electric switch machine is the Model M23-A furnished by Union Switch & Signal Inc. (US&S) as shown in the Contract Drawings. The Contractor shall provide US&S M23-A switch machines or an approved equal.
- C. Painting and Identification
1. Malleable metal letters, painted white, not less than 3 inches high, shall be securely fastened to the first concrete plinth adjacent to each switch point.
 2. Two letters, "N" and "R" made of malleable metal, painted white, shall be used to denote normal and reverse position of the track switch points. Letters shall be drilled to provide means to attach them to the plinth.
 3. Except as otherwise specified, all components of power switch layouts shall be finished in accordance with AREMA Communications and Signals Manual of Recommended Practices, Part 1.5.10. The finish color shall be black.
- D. Rods and Hardware
1. Power switch layout shall include swivel front rods, lock rods, lock rod lugs, point detector rods, throw rods, throw rod brackets, point detector rod lugs, and all other required rods, screws, bolts, washers, gauge plates, and hardware necessary to mount track switch machines and connect them to the points.
 2. Switch rods and hardware shall meet the following requirements:
 - a. Lock Rods: ASTM Specification A236-69, Class G for Carbon Steel Forgings for Railroad Use.
 - b. Front Rods: Feet shall meet specification for Carbon Steel forgings for Railway use. Use ASTM A236-67, Class B.
- E. Lugs shall be malleable Iron ASTM A47-68 Grade 3508 or quenched and tempered medium strength steel castings ASTM A27-65 Grade 65-35.

- F. Bars shall be stress relief annealed cold-drawn Carbon Steel meeting ASTM A311- 64, Grade 1144.
- G. Plates shall meet Specification ASTM A-283-70 Grade A.
 - 1. Throw Rods: Throw rods having a set of 1 inch or more shall be heat treated to give a minimum tensile strength of 85,000PSI.
 - 2. Rods shall be open hearth AISI C-1035 Steel.
 - a. Hardware: All hardware shall conform to AREMA Communications and Signals Manual of Recommended Practices requirements.
 - 3. Power operated electric switch layouts shall be insulated from the running rails and shall be provided with insulated rods and gauge plates to electrically insulate one running rail from the other.
- H. Electrical Fittings: Power switch operating layouts shall include necessary electrical fittings to permit interconnection of the track switch machine with control and indication circuitry located in the relay room or instrument house. This material shall include junction boxes, mounting brackets, conduits, hoses, tubing, terminals, and hardware. Terminal blocks mounted in junction boxes shall conform to AREMA Communications and Signals Manual of Recommended Practices, Part 14.1.5.
- I. Accessories
 - 1. Each power switch machine shall be equipped with three padlocks. One padlock shall restrict entry to inside of the switch machine; the second padlock to restrict entry into the switch motor compartment; the third padlock will lock the hand throw lever.
 - 2. Padlocks for hand-throw lever, power switch machine and switch motor compartments shall be keyed as specified by the keying plan in Section 13591, "Tags, Locks and Keys."
 - 3. Extended gauge plate and fiberglass insulation shall be provided as shown on the Contract Drawings.

2.02 WAYSIDE SIGNALS

- A. Mainline Signals
 - 1. Long range railroad type signal layouts shall include a double lens type signal head, brackets, background, visors, electrical fittings, junction boxes, terminals, conduit, flexible hose, and all hardware required for proper installation, including mast, and foundations.
 - 2. Signal backgrounds shall be made of sheet aluminum not less than 0.125 inches thick, and of sufficient strength and rigidity. Outer edges shall not be closer than 12 inches to the center of the lens units.
 - 3. All signals shall be continuously illuminated and shall display the proper aspect.
- B. Tunnel Signals
 - 1. Signal layouts for tunnel section and when mounted in between the tracks shall include a double lens type signal head, brackets, electrical fittings, junction boxes,

- terminals, conduit, flexible hose, and all hardware required for proper installation.
2. Signals in the tunnel section and when mounted in between the tracks shall be provided by the Contractor as needed and shall be of the type specified in the Contract Drawings.

C. Signal Heads

1. Signal heads shall conform to AREMA Communications and Signals Manual of Recommended Practices, Part 7.1.1, except as otherwise specified herein.
2. Each signal head shall include a cast iron or cast aluminum housing, a hinged back door, double lens arrangement with outer diameter of 8.375 inches and inner 5.5 inches diameter lens, and a reflex-reflecting sheet number plate. Signals shall be adaptable for mounting on columns, concrete walls, or pedestals as required.
3. All signals shall be completely equipped with lamps, lamp receptacles, lenses, transformers, terminals, terminal boards, and number plates. Signals shall be internally wired at the factory.
4. Each signal head shall be ventilated by two openings in the door covered by a fine mesh brass or copper screen and hood to prevent entrance of moisture. Locking arrangement of doors shall be such that the door cannot be locked until fully closed. Doors shall have a stop to prevent them from swinging into the path of trains. Signal doors shall be designed to open all signal compartments at the same time.
5. Each signal housing shall contain lamp compartments separated by partitions to prevent the passage of light. Compartment shall provide ample space for lamps, lamp receptacles, transformers, and adjusting devices as required.
6. Lens shall be of high impact plastic and provide full high intensity indications.
7. Signal lenses shall be secured to the signal head so that their removal will not affect adjustment of the lamp receptacles. When viewed from a height of 7 feet above the top of rails, the lenses shall give a distinct and unmistakable aspect under the most adverse operating conditions at a distance of 500 feet.
8. Signals shall be equipped with back lights approximately 0.25 inches in diameter. The backlights shall be placed opposite the respective lens and shall be green, yellow, red, or lunar white.
9. Two lamps or dual-filament lamps shall be mounted behind each lens. Current for the signal lamps shall be taken from individual transformers for each lamp compartment. Signal lamps shall be manufacturer's designation RLS, 28 watt, 10 volt, S-11 bulb, SC-base, CC-6 shape with a light center length of 1.25 inches and a tolerance of 0.0156 inches. Lamp shall have a life of at least 7,000 hours at the rated voltage. Lamp shall be derated in operation at least 10 percent.
10. Receptacle shall readily permit establishment and maintenance of proper relation of lamps to lenses. Receptacles shall prevent lamps from coming loose due to vibration or other causes.
11. A screen lens protector shall be provided for each signal lens to be installed on aerial structure. The screen shall protect signals from vandalism and not obscure signal aspects.
12. Each signal door shall be equipped with one padlock and keyed as specified by the

keying plan in Section 13591, "Tags, Locks and Keys."

- D. Signal Number Plates, Speed Limit Signs and Yard Limit Signs:
 - 1. Provide a signal number plate for each wayside signal.
 - 2. Provide a speed limit sign on wayside signals where indicated on the Contract Drawings.
 - 3. Signal number plates, speed limit signs, and yard limit signs shall conform to AREMA Communications and Signals Manual of Recommended Practices, Part 14.6.1, except as otherwise specified herein.
 - 4. Signal number plates, speed limit signs, and yard limit signs shall be constructed of sheet steel or aluminum with black reflex-reflecting lettering on a white synthetic enamel background. Design of the number plate and size of the lettering shall permit the plate to be read, under all conditions, at a distance of at least 50 feet from the signal while the plate is illuminated by transit vehicle headlights. Lettering for signal number plates and signs shall be minimum four inches high and shall be in conformance with the AREMA Communications and Signals Manual of Recommended Practices, Part 14.6.3.
 - 5. For all signals, two lines of lettering shall be provided on each number plate. The top line shall be the designation or name of the interlocking from which the signal is controlled. The bottom line shall be the signal number.
 - 6. Yard limit signs shall be mounted adjacent to Signals 10N and 12N at Allegheny Interlocking as indicated on the Contract Drawings.
- E. Mast and Base: 5 inches aluminum or steel pipe post equipped at the top to accommodate signal units, and with a base at the bottom mounted directly to the concrete structure. Mast mounted signals shall be provided with a junction box base.
- F. Cable shall be provided in accordance with Section 13587, "Wire and Cable."
- G. All signal housings shall be weatherproof.
- H. Wayside signals shall be provided at locations indicated on the Contract Drawings.

2.03 AUTOMATIC TRAIN STOPS (ATS)

- A. The Contractor shall provide and install ATS equipment at all signal locations.
 - 1. ATS will be compatible with existing inductive train-stop equipment now in service.
- B. The wayside coils will be active at all times, unless the signal governing movements over the coils displays a permissive aspect.

2.04 WAYSIDE JUNCTION BOXES

- A. Wayside junction boxes shall be:
 - 1. Stainless steel, construction in accordance with NEMA, UL standards, or as approved by the Engineer. Enclosures shall be made from 12 gauge, 316 stainless

- steel with a NEMA 4X rating at a minimum.
- 2. Equipped for terminating or busing signal cables, with all wiring accessible from the front.
- 3. Interior painted white or gray.
- 4. Locking device on cover to prevent locking unless door is completely closed.
- 5. Covers and other openings gasketed to provide dustproof and weatherproof enclosure.
- 6. Size as needed to provide sufficient terminals, with all terminals accessible from the front, and to accommodate minimum bending radius of wires and cables.
- 7. Container inside for storage of wiring diagram.
- 8. Door or cover hinged with stops to prevent opening into path of trains. Hinges shall be replaceable castings with bronze pins.
- 9. Hasp to accept a padlock. Padlocks keyed as specified by keying plan in Section 13591, "Tags, Locks and Keys."
- 10. Provide a minimum of 20 percent spare terminals in each wayside junction box.

2.05 SIGNAL MOUNTING

- A. Wayside signal units shall be directly attached to the tunnel wall with mounting brackets. Mast mounted wayside signals shall be provided with a junction box base which shall be bolted to the aerial structure and concrete deck slab. Refer to the Contract Drawings for signal mounting arrangements.

2.06 TRACK CIRCUITS, POWER FREQUENCY

- A. Track circuits shall perform the function of train detection.
- B. General Performance Requirements
 - 1. Track circuit equipment shall either detect the failure of an insulated joint or protect against it causing any unsafe condition.
 - 2. Track circuits shall be compatible with the traction power negative return, and not be affected by traction power return current imbalances.
 - 3. Track circuit equipment shall have fixed transmitter and receiver locations for accurate track circuit definition.
 - 4. Restoration of power after a power failure shall automatically restore track circuits to normal operation.
 - 5. Reset of deenergized track circuits shall not be based on adjacent track circuit occupancy.
 - 6. Track circuits shall function properly in an uncontrolled temperature environment from -40 to 160 degrees F.
 - 7. Track circuit resistors shall comply with the heat requirements of AREMA Communications and Signals Manual of Recommended Practices Part, 14.2.15.
 - 8. Power frequency track circuits shall use 60 Hz vane relays.
- C. Detection Requirements
 - 1. Track circuits shall detect a shunt anywhere within track circuit boundaries.

Shunting sensitivity for all track circuits shall be 0.2 ohm impedance with a rail-to-rail leakage impedance of 3 ohms minimum per 1000 feet of track at the operating frequency, and under the following conditions:

- a. Train moving or stopped.
- b. Traction power on or off.
- c. All rail conditions for operation on any track.
2. Track circuits shall provide for double rail broken rail detection when circuit is applied as a double rail track circuit. Where single rail track circuits are used, broken rail detection shall be provided for the signal rail.
3. Failure of track circuit components shall not permit shunting sensitivity to fall below that specified after the track circuit has been properly adjusted.

D. Track Circuit Requirements

1. Contractor shall provide power frequency track circuits with the following requirements:
 - a. Shall be 60 Hz, and of the matching transformer or balancing impedance type. Feed voltage shall be adjusted through a transformer, and resistor network. Receiving end shall route the 60 Hz current from the track through a transformer to an AC vane type relay where it will be compared to a reference voltage for relay pickup. Current limiting resistors and properly sized fuses shall be provided on both the feed end and receiving end. Local reference voltage shall be fused and fed through an RC phase shifter to the track relay.
 - b. Contractor shall use single rail power frequency (PF) track circuits within interlocking limits. All other track circuits shall be double rail power frequency (PF) type.

E. Hardware Requirements

1. Track devices
 - a. Contractor shall provide and install insulated joints that are required for its design.
 - b. Such insulated joints shall be installed in accordance with Section 02456, "Track Appurtenances and Other Track Material"
2. Track leads: Contractor shall provide relay and transformer leads for connections to the rails, and all other material and apparatus including track and jumper bonds, as required for a complete track circuit installation in accordance with these Contract Documents.
3. Negative rail connections: Separate negative rail connections shall be provided for track relays and transformers, and shall be located opposite the insulated joint.

2.07 IMPEDANCE BONDS

- A. Contractor shall provide, install, and test all impedance bonds required for the signal system. Include all mounting hardware, connectors, cables and other appurtenances.
 1. The bonds shall operate properly with a continuous capacity of 1500 amperes per rail, and an intermittent rating of three times continuously for one minute, repeated every ten minutes.

2. The bonds shall have a minimum impedance of 0.5ohms at 60Hz.
3. The impedance bonds shall not require tuning (untuned).
4. The bonds shall have a minimum traction power current unbalance of 10 percent.
5. Rail-to-rail DC resistance of the bond and its cable and connector assembly shall not exceed 0.00057 ohms.
6. The bonds shall be interchangeable with the existing US&S bonds.

2.08 RAIL CONNECTIONS AND BONDS

A. Power Bonds

1. All non-insulated joints in single or double rail track circuit territory including guard-rail joints in curved track areas shall use 250 kcmil size, 10 inches long bonds, two for each joint, as manufactured by Erico Products, Inc., Dwight and Wilson Co., United States Steel, or an approved equal.
2. Power bonds for frog and switch fouling connections and expansion joints shall be two 500 kcmil extra flexible.

B. Signal Rail Bonds

1. Signal bonds in single rail negative return areas shall be railhead type manufactured bonds prepared for welding. The bonds shall be 7/32 inches by 6 1/2 inches and of necessary length, as shown in the Contract Drawings , two (2) for each joint, as manufactured by Erico Products, Inc., Dwight and Wilson Co., United States Steel, or approved equal.
2. These bonds shall be manufacturer bonds prepared for welding by the exothermic process. Bonds, bonding materials, and types of molds shall be as approved by the Engineer.
3. Frog and switch jumpers and end of storage track cross bonds shall be installed and welded to the base of the rail as approved by the Engineer. The cable for frog and switch jumpers and end of storage track cross bonds shall be 500 kcmil extra flexible.

2.09 SNOW MELTERS

- A. General: Contractor shall provide switch heater assemblies to keep the switch layouts at Allegheny Interlocking free and clear of snow and ice and permit operation under all adverse weather conditions. Switch Heaters shall be of the Calrod type, or approved equivalent, designed to operate from a nominal 650 VDC plus spikes with 300 watts per 1 foot uniform heating throughout the length of the heater. Snowmelter point heaters, crib heaters, contactors, contactor enclosures, controllers and miscellaneous snowmelter components shall be provided and shall be as manufactured by the Rails Co., Unitrac System, Mineral Insulated Component Systems, Inc., Chromolox Co., Fabricated Metals Corporation or approved equal.

B. Point Heaters

1. The heater shall be composed of an active heating element as shown on the Contract Drawings.

2. The element shall have an additional 12-inch inactive length at each end; and a non-separable terminal with a 10 feet power lead.
3. Each connection lead shall consist of a single conductor, No. 6 AWG; seven strand (minimum) tinned copper wire with 2000 volt insulation.
4. Wire insulation construction shall be of a heat-resistant rubber compound type, flexible with an oil-resistant neoprene jacket overall.
5. The total wire construction shall be suitable for use in wet or dry outdoor locations, conduits, underground ducts, open air or direct burial applications.

C. Crib Heaters

1. The heater shall be composed of an active heating element formed in a "U" shape.
2. The element shall have no more than 2 inches of inactive material at each end.
3. Each end shall have a non-separable terminal attached.
4. Each connection lead shall consist of a single conductor No. 6 AWG, 7 strands (minimum) tinned copper wire with 2000-volt insulation; one lead shall be 3 feet minimum, the other 15 feet minimum.
5. Wire insulation construction shall be of a heat-resistant rubber compound type, flexible with an oil-resistant neoprene jacket overall.
6. The total wire construction shall be suitable for use in wet or dry outdoor locations, conduits, underground ducts, open air or direct burial applications.
7. The crib heaters shall be configured to provide adequate heat to areas where snow and ice would interfere with operating and indication rods.
8. Two crib heaters shall be installed for each power operated switch layout; one shall be located under the throw rod, and one under the lock rod.

D. Terminals

1. The terminal shall be permanently sealed and non-separable with a stainless steel sleeve.
2. The terminal shall be insulated as shown on the Contract Drawings with a mechanically sturdy moisture-resistant compound of epoxy or equivalent compound.

E. Transients: Heaters shall be capable of withstanding spikes of 4,500 volts peak and 50 milliseconds duration, while nominal 650 VDC power is applied during power operation.

F. Controls

1. Contactors and fuses shall be enclosed in a NEMA 4X construction box made of stainless steel or aluminum.

G. Power Wiring: Controlled power wires for the heaters shall be run in ducts and conduits and stubbed up at the heater with bootlegs.

H. Conduits: Contractor shall install flexible armored conduit for wire or cable runs underneath the switch layout in between plinths as shown on the Contract Drawings.

- I. Contactors
 - 1. Contractor shall provide contactors for controlling 650 VDC to the switch heaters.
 - 2. Each contactor shall have contacts rated for the current load of the heater it controls.
 - 3. Contactors shall be installed in such a manner that they may be removed or replaced without removing the mounting panel.
 - 4. Contactors shall be heavy-duty, double-pole (normally open, series wired) rated at 35 amperes minimum at 1000 VDC. Contactors shall be capable of switching a circuit load of 22,500 watts, through an ambient temperature range of -20 degrees F to 140 degrees F.
 - 5. Contactors shall have contact terminals with self-locking nuts and quick-disconnect type coil terminals. Coil actuation voltage shall be 120 VAC. The coil shall be treated to resist shorts, ground, and electrolysis action under humid conditions. The frame and auxiliary hardware shall be cadmium plated. The contactor shall be supplied with an arc chute assembly and a panel-mounting bracket. The contactors shall be similar to Powerswitch #911125 or an approved equal.
- J. Contactor Enclosures:
 - 1. The Contractor shall furnish pre-cast foundation mounted switch heater contactor enclosures which are rigid, weatherproof, and constructed of stainless steel, aluminum, or Cor-Ten steel suitable for use in highly corrosive atmospheres.
 - 2. Design shall conform in general to NEMA Type 4X construction.
 - 3. Enclosure size shall be 125 percent of that which is sufficient to encase the equipment required, allowing the addition of future control equipment.
 - 4. Sizes are to be determined by the Contractor and submitted to the Engineer for approval.
 - 5. The enclosure shall have a single door. The enclosure design shall include complete hinge concealment when door is closed. The door shall be capable of opening through a 90 degree swing, and equipped with a removable stop to prevent it from opening further. Door design shall be tamperproof.
 - 6. The main box portion of the enclosure shall be of one-piece construction with smooth rounded corners, all seams sealed, and no holes or knockouts. There shall be no gasketed joints except for a neoprene door gasket, to assure a tight seal.
 - 7. Each enclosure shall have automatic, corrosion-proof, stainless steel condensation drain plugs installed in the bottom. Plugs shall be of a tamperproof design, with stainless steel screening.
 - 8. The enclosure shall be provided with a 3/8 inch Fiberglass laminate interior mounting panel, which conforms to NEMA GPO-2 construction and meets UL 94V-0 rating for highly flame-resistant material. The panel shall be attached to the inside of box by stainless steel washers and locknuts, attached to integral 3/8 inch No. 16 stainless steel collar studs embedded in main box interior. A vertically mounted barrier of similar construction shall be mounted on the sub-panel to separate high and low voltage items. Mounting hardware shall be coated with a plastic material; no metal shall be exposed on either side of the barrier.

9. Each enclosure shall have a print pocket attached inside the door.
10. The enclosure door shall have a stainless steel three-point door lock fitting for padlocking the enclosure. The latch shall have a 5/8 inch diameter opening for accepting a lock shackle.
11. Each enclosure shall have a drip shield installed to protect door hardware from dripping water, ice/snow build-ups, and settling dust.
12. The enclosure interior and mounting panel shall be finished in flat white enamel.

K. Power Fuses

1. Contractor shall provide power fuses for all switch heater circuits.
2. Fuse type shall be time-delay, current limiting, non-indicating and non-renewable.
3. High-voltage fuses shall have a minimum voltage rating of 1000 VDC, as manufactured by Fusetek, #23070, or approved equal.
4. DC fuse block shall be phenolic base, one pole, Class R, rated 1000 VDC, 0 to 30 amps, Powerswitch #911022A or approved equal.

L. DC Fused Disconnect Switch, 650 VDC

1. A fused disconnect switch shall be provided by Contractor to terminate the cable connection from the 650 VDC catenary to each switch heater case.
2. The fuse disconnect switch shall have a hot stick operated disconnect switch to disconnect the feed to the switch heater contactor.
3. The maximum loading for the contactors through a fused disconnect switch shall not exceed 60 amps.
4. The fused disconnect switch shall be of fire-resistant, non-metallic construction and rated for a minimum loading at 100 amps at 900 VDC.
5. The fused disconnect switch shall be a Powerswitch #950616 or approved equal.
6. Fused disconnect switches shall be painted red and be labeled "danger, high voltage."

M. Control Voltage Fused Disconnect Box.

1. Contractor shall mount a fused disconnect box on the outside of the heater contactor enclosure to disconnect the control power from the enclosure.
2. The fused disconnect box shall be a Siemens / ITE #NR321 or approved equal.

2.10 SIGNS

A. Material: Wayside signs shall be constructed of sheet aluminum.

B. Mounting

1. Adapter clamps shall be constructed of cast aluminum conforming to AREMA Communications and Signals Manual of Recommended Practices, Part 3.2.80 and shall be used to attach the sign to the mast.
2. The sign shall be attached to the adapter clamp by stainless steel or cadmium plated steel bolts, nuts and washers to prevent electrolytic action between dissimilar metals.

- C. Surface Preparation: The aluminum sheet shall be cleaned and etched or coated with wash primer prior to application of reflex-reflective sheeting in accordance with manufacturer recommendations for applying such sheeting.
- D. Type of lettering and nomenclature shall be as indicated on the Contract Drawings.
- E. Reflex-reflecting Sheet Finish
 - 1. Reflex-reflecting material shall be used for background only.
 - 2. The reflex-reflecting sheet shall be in accordance with AREMA Communications and Signals Manual of Recommended Practices, Part 15.2.20 and shall be cut with square corners for application to the entire front surface of the front plate except for a space of approximately, but not less than, 1/16 inch from the edges.
 - 3. The adhesive backing shall be activated by the prescribed solvent or by heat. The sheeting shall then be applied by hand roller, squeeze roller or vacuum applicator to form a durable bond, not closer than 1/16 inch to any edge of the plate. The sheet shall then be edge sealed in accordance with manufacturer recommendations.
 - 4. Letters or striping shall then be applied over the reflex sheeting by use of heavy black paste enamel applied with a silk screen process.
 - 5. All letters, numerals, and striping shall be true as to edge and form.
 - 6. Backs of signs shall be painted flat black in accordance with AREMA Communications and Signals Manual of Recommended Practices, Part 1.5.10. .

2.11 TWC LOOPS

- A. TWC loops shall be installed at locations shown on the Contract Drawings and shall be as specified in Section 13580, "Train to Wayside Communications (TWC)."

2.12 TRAIN PROTECTION STROBE LIGHT WARNING SYSTEM

- A. The Contractor shall provide a complete Train Protection Strobe Light Warning system assembly for each location shown on the Contract Drawings. Each individual strobe light shall be wired to a control contact operating from an output of the Non Vital Processor located in the appropriate signal relay room. Operation of the strobe lights is performed from the OCC via a control sent to the non vital microprocessor in the relay room. The Contactor shall modify the OCC to accommodate the control for the new Train Protection Strobe Light Warning system. The Contractor shall properly interface all new controls and indications with the OCC, and shall implement and support all testing for this interface as is required by the Contract Documents.
- B. The strobe warning light shall operate from 120V AC 50/60Hz power and the strobe shall have a minimum operating life of 10,000 hours at the rated voltage. The strobe light shall be UL Listed and CSA certified for outdoor use and shall include a watertight, dust-tight, corrosion resistant type 4X, IP66 enclosure. The strobe light shall include a white or clear dome to simulate a "white" strobe lighting effect of 1,000,000 candlepower and an effective candlepower rating of 300.

- C. Contractor shall provide all necessary hardware and conduit to mount strobe light assembly on walls as indicated on the Contract Drawings. Strobe lights shall be mounted to the wall using a mounting bracket that is heavy-duty, constructed of durable cast aluminum, and sealed with powder coat paint. The mounting shall accommodate a watertight sealed connector for conduit to be attached to the base of the mounting to provide a concealed and protected wire access to the strobe light assembly.
- D. The strobe light shall be Federal Signal Corporation, Fireball Strobe Warning Light Model FB2PST 120VAC 50/60Hz with clear dome and Wall Mounting Bracket Kit Model LWMB2 or approved equal.

ARTICLE 3 EXECUTION

3.01 GENERAL EQUIPMENT

- A. Contractor shall install at locations as shown on Contract Drawings, and in accordance with Section 13585, "Installation Requirements."

3.02 WAYSIDE JUNCTION BOXES

- A. Boxes shall be mounted in such a manner that no part, including doors in the open position, will project into the LRV clearance envelope.
- B. All wire and cable shall be terminated on internal terminal blocks, with 20% spare terminals provided.
- C. The exterior of the door shall be stenciled to identify location.
- D. Copy of the external wiring diagram shall be placed in container provided.
- E. Cable supports shall be used inside cases to avoid straining terminations and to maintain an orderly installation.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13576
CIRCUIT REQUIREMENTS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for circuit requirements, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. This Section provides general requirements for the Contractor's signal design.
 - 2. The Contractor shall be required to field verify all existing signal circuitry at Wood Street and Gateway Interlocking Relay Rooms prior to the on-set of the detailed design at these locations.
- C. The Contract Documents provide the performance parameters and design criteria to complete the circuit requirements. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 13570, "Signal System Requirements."
- B. Section 13577, "Solid State Equipment."
- C. Section 13580, "Train to Wayside Communications (TWC)."
- D. Section 13588, "Relays and Plugboards."
- E. Section 13589, "Electrical and Electronic Components."
- F. Section 13595, "Signal System Test and Inspection."

1.03 REFERENCE STANDARDS

- A. AREMA Communication and Signal Manual of Recommended Practices.

1.04 SUBMITTALS

- A. The Contractor shall submit a nomenclature list based on the Contract Drawings to the Engineer for approval. The Contractor shall then follow approved nomenclature in the design of logic and circuit drawings.
- B. The Contractor shall submit logic and circuit typicals for approval of the Engineer.

- C. The Contractor shall submit the following information on track circuits:
 - 1. Complete circuit diagrams of track circuits.
 - 2. Explanation of operation of track circuits.
 - 3. Frequency and Electro-Magnetic Interference (EMI) analysis of track circuits.
 - 4. Engineering data on signal strength, shunting sensitivity at various operating and ballast conditions.
- D. The Contractor shall submit wiring diagrams showing the exact routing and termination of all wires and cables in relay rooms and wayside equipment cases, and junction boxes.
- E. The Contractor shall prepare and submit as-built circuit drawings that accurately depict actual circuit conditions in service, as specified in the Contract Documents.
 - 1. As-built drawings at any location shall contain all circuits from any adjacent locations to which there is any type of interface, such as line circuits or traffic circuits.
- F. The Contractor shall submit a complete lightning/surge protection plan.
 - 1. The plan shall specify all devices and circuitry to be protected.
 - 2. Include all protection devices and the methodology in application and installation of each.
 - 3. Include product literature and theory/application manuals for all such protective devices.
 - 4. Include electrical Shop Drawings of each device/circuit to be protected exhibiting application of the protective devices.
- G. The Contractor shall submit a detailed design for Gateway Interlocking modifications as described within Section 13570, "Signal System Requirements" and as shown within the Contract Drawings. Circuit submittals shall be organized within a circuit book for each location that includes all circuitry controlled out of the location. The circuit book shall include all temporary circuit changes associated with the staging of the Work. The Contractor shall provide all additional material and design associated with the construction staging. The Contractor shall submit wiring diagrams showing the exact routing and termination of all wires and cables in the existing Gateway Interlocking Relay Room. The Contractor shall include within the circuit book, a Code and Function Assignment sheet for each relay room.
- H. The Contractor shall submit a detailed design for Wood Street Interlocking modifications as described within Section 13570, "Signal System Requirements" and as shown within the Contract Drawings. Circuit submittals shall be organized within a circuit book for each location that includes all circuitry controlled out of the location. The circuit book shall include all temporary circuit changes associated with the staging of the Work. The Contractor shall provide all additional material and design associated with the construction staging. The Contractor shall submit wiring diagrams showing the exact routing and termination of all wires and cables in the existing Wood Street Interlocking Relay Room. The Contractor shall include within the circuit book,

- a Code and Function Assignment sheet for each relay room.
- I. The Contractor shall submit a detailed design for all signaling equipment installed within the North Side Station Relay Room as described within Section 13570, "Signal System Requirements" and as shown within the Contract Drawings. Circuit submittals shall be organized within a circuit book for each location that includes all circuitry controlled out of the location. The Contractor shall submit wiring diagrams showing the exact routing and termination of all wires and cables in the North Side Station Relay Room. The Contractor shall include within the circuit book, a Code and Function Assignment sheet for each relay room.
 - J. The Contractor shall submit a detailed design for all signaling equipment installed within the North Side Station Relay Room as described within Section 13570, "Signal System Requirements" and as shown within the Contract Drawings. Circuit submittals shall be organized within a circuit book for each location that includes all circuitry controlled out of the location. The Contractor shall submit wiring diagrams showing the exact routing and termination of all wires and cables in the new North Side Station Relay Room. The Contractor shall include within the circuit book, a Code and Function Assignment sheet for each relay room.
 - K. The Contractor shall submit a detailed design for Allegheny Interlocking as described within Section 13570, "Signal System Requirements" and as shown within the Contract Drawings. Circuit submittals shall be organized within a circuit book for each location that includes all circuitry controlled out of the location. The circuit book shall include any temporary circuit changes associated with the staging of the Work. The Contractor shall provide all additional material and design associated with the construction staging. The Contractor shall submit wiring diagrams showing the exact routing and termination of all wires and cables in the new Allegheny Interlocking Relay Room. The Contractor shall include within the circuit book, a Code and Function Assignment sheet for each relay room.

1.05 DEFINITIONS

- A. the terms "restrictive" and "permissive" are used in connection with the binary outputs of two-position components or subsystems and denote such alternatives as: a lower speed and a higher speed; deceleration and acceleration; brakes applied and brakes released; actuation of alarm and no actuation of alarm; etc., respectively.

ARTICLE 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Circuit Design Requirements:

- 1. Train safety shall be the prime consideration in the design of the NSC Signal System and in the selection of its components including vital processors, relays and other

- devices with moving parts, insulated wire, wire terminals, binding posts, housings, conduits, resistors, capacitors, transformers, inductors and other similar items.
2. Circuit design shall conform to the AREMA Communication and Signal Manual of Recommended Practices and the Authority design practices. Signal system nomenclature shall be interpreted as shown on the Contract Drawings.
 3. The following requirements shall govern the design of the portions of the system or a subsystem which effect train safety:
 - a. Only components which have high reliability and predictable failure modes and rates and which have been proven in conditions similar to the projected service shall be utilized.
 - b. Components shall be combined in a manner that a restrictive rather than a permissive condition will result from component failure.
 - c. All circuits which are not confined to one housing, and which affect safety shall be double-wire, double-break, except signal lighting circuits.
 - d. The design shall be based on closed circuit principles. Broken wires, broken rails, dirty contacts, a relay failing to respond when energized or a loss of power supply energy shall not result in unsafe conditions.
 - e. Component or system failures shall cause a more restrictive signal indication than permitted with no failure.
 - f. System safety design shall be such that any number of simultaneous component or system failures attributable to the same cause or related causes shall not cause unsafe conditions. Failures that are not independent (those failures which in turn always cause others), shall be considered in combination as a single failure and shall not cause an unsafe condition. Any non-detectable failure in combination with any other failure shall not permit an unsafe condition to occur.
 - g. Electronic circuit design shall ensure that the following types of component failures have a restrictive rather than a permissive effect:
 - (1) Two terminal devices: open, short, partial open or partial opens and/or partial shorts.
 - (2) Multi-terminal devices: combination of opens, shorts, partial opens and/or partial shorts.
 - h. Wherever possible, built-in checks shall be included that impose a restriction and/or actuate an alarm whenever a device fails to assume its most restrictive position and conditions require that it should.
 - i. Redundant design by itself shall not be considered an acceptable method of assuring design safety.
 - j. Questions on design intent shall be directed to the Engineer and approved before commencement of design.
 - k. The vital application software shall define the operation of the vital interlocking system. Control logic to be incorporated in the vital application software is as specified in Section 13577, "Solid State Equipment."
 4. Service Proven Equipment and Design
 - a. The Contractor shall furnish signal equipment proven in similar North American transit service and shall make use of its experience to prepare a

- suitable and proven detail design for this Project.
- b. The Contractor shall be fully responsible for the safety of the new NSC Signal System, independent of any other requirements of this Specification.
 - c. Vital circuits shall be of fail-safe design, based on closed loop circuit principles, and meet AREMA Communications and Signals Manual of Recommended Practices requirements for use of vital relays.
 - d. Vital logic shall be implemented using vital microprocessors. Vital plug-in relays may be used for specific applications. When any interlocking relay network is interfaced with, or operates in conjunction with, any electronic circuit, the electronic circuit shall perform as required by the Contract Documents for such network with relays.
5. Contractor shall provide Circuit Books for each location as follows:
- a. Draw conventional circuits and logic as shown in the Contract Drawings, with sufficient information to reflect the actual wiring of each circuit and location of each component.
 - b. Each wire connecting from point to point shall have a unique nomenclature. Nomenclature shall be assigned based on circuit function.
 - c. When the wire transgresses a point, the nomenclature shall remain the same if the function remains the same. Numerically stepped prefixes or suffixes shall not be used.
 - d. Each component or terminal shall have a unique location code.
 - e. Each circuit book shall have drawings which contain a listing of the relays used, the sheet number where each relay is located, which contacts are used and which are spare for each relay, and the sheet number where each used contact is located.
 - f. Each circuit book shall also have drawings which depict rack and sideboard layouts showing component arrangement and location, multiconductor connectors showing used and spare pin connectors with all used pin connectors marked with the page number of the drawing on which the pin connectors can be found.
 - g. Each relay and relay contact shall have a coordinate designation, which corresponds to its location on the rack or mounting bars.
 - h. Arrange drawings for easy reading – not crowded or cluttered. Show circuits with a minimum of crossed or offset lines.
 - i. Define nomenclature and symbols on a separate drawing or drawings. Use nomenclature and symbols as shown in the Contract Drawings.
6. In addition to the relays that are required for specific application by the Contract Documents, repeater relays and other necessary relays shall be supplied as needed to meet all system performance requirements, the cost of which shall be borne by the Contractor.
- B. All vital circuits that energize a relay located outside of a relay room, instrument house or case and all circuits which energize a vital relay located inside a house or case but which contain contacts outside of the house or case, shall be two-wire double break circuits, energized from an ungrounded DC power supply.

1. Adjacent relay rooms, houses and/or cases interconnected by a vandal proof, weathertight enclosure above ground shall be considered as one house or case.
 2. The cable way between these houses and/or cases shall be limited to 50 percent fill limit.
 3. Vital circuits that do not go outside of the house or case shall be positive energy, single-break circuits constructed in accordance with Section 13588, "Relays and Plugboards."
- C. Non-vital circuits shall generally be implemented with non-vital microprocessors, and non-vital relays in accordance with Section 13588, "Relays and Plugboards," electrical and electronic components as specified in Section 13589, "Electrical and Electronic Components," or with a combination of these devices.
- D. Failure Modes: The following failure modes of any circuit element shall not cause unsafe conditions:
1. Front contacts weld; back contacts weld; front, back and heel contacts of dependent contacts weld; or any combination of these events.
 2. Relay armature sticks in any position.
 3. Broken wires, damaged or dirty contacts, relays failing to respond when energized, or a loss of power supply energy.
 4. Other failure modes as specified elsewhere in the Contract Documents.
- E. Circuits controlled by the prime relay and its repeaters shall be coordinated so that unsafe conditions do not occur if any combination of repeater relays fails to energize.
- F. The Contractor shall provide surge suppressors, lightning arrestors for track circuits, power supplies, battery chargers, audio frequency transmitters and receivers and electronic circuit equipment to protect against damage caused by lightning and electrical transients.
1. Protection shall be provided on primary, secondary and tertiary levels.
 2. Arrestors shall be series high voltage arrestors, shunt low voltage arrestors, and AC line arrestors or combination as required.
 3. Arrestors used in vital circuits shall be self-clearing, except as otherwise specified.
- G. The AREMA Communication and Signal Manual of Recommended Practice shall serve as basic reference sources in selection and application of lightning and surge protection devices.
- H. The Contractor shall be required to field verify all existing signal circuitry at Wood Street and Gateway Interlocking Relay Rooms prior to the on-set of the detailed signal design at these locations.
- I. The Contractor shall modify the existing circuits for Wood Street Interlocking and Gateway Interlocking as follows:
1. Draw conventional circuits and logic as shown in the Contract Drawings, with

- sufficient information to reflect the actual wiring of each circuit and location of each component.
2. Each wire connecting from point to point shall have a unique nomenclature. Nomenclature shall be assigned based on circuit function.
 3. When the wire transgresses a point, the nomenclature shall remain the same if the function remains the same. Numerically stepped prefixes or suffixes shall not be used.
 4. Each component or terminal shall have a unique location code.
 5. The Contractor shall modify the existing rack and sideboard layouts showing revised component arrangement and location, multiconductor connectors showing used and spare pin connectors with all used pin connectors marked with the page number of the drawing on which the pin connectors can be found.
 6. Each relay and relay contact shall have a coordinate designation, which corresponds to its location on the rack or mounting bars.
 7. Arrange drawings for easy reading – not crowded or cluttered. Show circuits with a minimum of crossed or offset lines.
 8. Nomenclature and symbols shall match the existing circuits at Gateway Interlocking.
 9. In addition to the relays that are required for specific application by the Contract Documents, repeater relays and other necessary relays shall be supplied as needed to meet all system performance requirements, the cost of which shall be borne by the Contractor.

2.02 INTERLOCKING ROUTE SELECTION

- A. Route selection circuits select and establish the desired route through an interlocking.
- B. Routes shall be initiated by the following:
 1. Track circuit occupancy under automatic route selection: Some routes through interlockings shall be selected automatically via track circuit occupancy on the approach to the home signals. Routes shall be as shown on the Contract Drawings.
 2. Train to Wayside Communications (TWC) shall be used as follows:
 - a. Establish routes through the interlocking as shown on the Contract Drawings.
 - b. Cancel routes that were set automatically.
 - c. Reestablish the route after cancellation.
 3. Local Control Panel (LCP): Entrance/exit panel to control switches and signals.
 4. Operations Control Center (OCC): Via control consoles at OCC.
- C. TWC loops shall be installed as shown on the Contract Drawing, and be as specified in Section 13580, "Train to Wayside Communications (TWC)."
 1. To change the route at a signal via TWC control, if an automatic route has been set at that signal, the automatic route must first be cancelled, and the new route can then be initiated by TWC control.
- D. Loss of shunt protection circuits shall be provided for all track circuits used in the

initiation of route selection.

- E. Length of the approach for automatic route selection via track circuit occupancy shall be based on the authorized speed in the area such that the home signal will be cleared and not affect maximum train speed or performance.

2.03 SWITCH CONTROL AND INDICATION CIRCUITS

- A. Switch control and indication circuits request track switches to the required position, energize track switch machines, enable track switch machines to operate, indicate point position and correspondence.
- B. Each switch machine motor shall be energized by an individual full wave rectifier power supply. The power shall be removed when the switch has reached the requested position and is in correspondence with its requested position.
- C. Switch overload circuits shall protect each power switch machine by using a switch overload stick relay. One overload stick relay shall be provided for each switch machine if operating current rises above the desired maximum due to a stalled switch or other overload. Once the overload has occurred, energy shall remain off until switch is called to the opposite direction.
- D. Normal and reverse switch correspondence relays shall be energized only when the switches are mechanically locked in the normal or reverse position and in correspondence with the switch request. Normal switch correspondence relay shall be deenergized whenever the reverse position is called for, and vice versa.
- E. Instantaneous load for track switch operation shall be calculated to account for all switches moving simultaneously.

2.04 LOCKING CIRCUITS

- A. Locking circuits shall prevent unsafe switch operation and prevent clearing of signals for opposing or conflicting routes. Types of locking to be provided are as follows:
 1. Time or approach locking shall lock switches within a route governed by a cleared wayside signal to prevent clearing wayside signals for opposing or conflicting routes when the cleared wayside signal is set to stop. Set the adjustable timer so a train on the approach has sufficient time to come to a full safe braking distance stop. Time or approach locking for a wayside signal shall be released when one of the following has occurred:
 - a. A train passes a signal, the signal goes to stop, and two-track release is implemented.
 - b. Signal is set to stop and approach track circuits are unoccupied.
 - c. The predetermined time interval has elapsed after the signal is set to stop and when approach locking is used, the approach track circuits are occupied.
 2. Route locking shall lock the switches within a route after a signal has been cleared for train movement onto that route, and prevent clearing of opposing and

conflicting signals within the interlocking. Route locking shall be in effect when time or approach locking is in effect, and remain in effect until the train has cleared the interlocking. Sectional release of route locking shall be provided where shown in the Contract Drawings.

3. Detector locking shall lock switches to prevent operation of track switches or derails when detector track area over the switch is occupied.
4. Switch locking shall lock switches by time locking, route locking and detector locking. Loss of shunt protection shall also be incorporated into switch locking circuits. Switch locking shall only be released when approach locking, time locking, and route locking are released, and detector track circuits are unoccupied. Should a detector track circuit become de-energized while a track switch is moving, switch-locking circuits shall permit the track switch to complete its stroke.

2.05 SIGNAL CLEARING CIRCUITS

- A. One route check function shall be provided to initiate signal clearing for each interlocking signal. A route check function shall initiate wayside signal clearing only when track switch positions correspond to those required for the route.
- B. Signal control circuits clear wayside signals at interlockings. Signal clearing shall be effective when:
 1. Route check circuits indicate a route has been established.
 2. Time locking or approach locking for the signal is in effect.
 3. Time locking or approach locking for opposing signals is unlocked.
 4. Track switches within the route correspond with their requests and are locked.
 5. No opposing or conflicting routes are in progress, and route locking is in effect.
 6. Detector track circuits are unoccupied, and detector switch locking is not in effect.
 7. Traffic is established in the proper direction.

2.06 SIGNAL LIGHTING CIRCUITS

- A. Wayside interlocking signals when indicating a route is aligned and locked, shall display the following aspects:
 1. Green/Red: Proceed on straight route, track is clear to next signal, and next signal displays a proceed aspect.
 2. Yellow/Red: Proceed on straight route, track is clear to next signal.
 3. Yellow/Red/Lunar: Proceed on straight route approaching next signal at not exceeding posted speed in the block.
 4. Flashing Green/Red: Proceed on diverging route, track is clear to next signal, and next signal displays a proceed aspect.
 5. Flashing Yellow/Red: Proceed on diverging route, track clear to next signal.
 6. Flashing Yellow/Red/Lunar: Proceed on diverging route approaching next signal at not exceeding posted speed in the block.
 7. Flashing Red/Red: Restricting (call-on).

8. Red/Red: Stop and stay.
- B. Flasher check shall be provided to prevent improper upgrade of signal aspects.
- C. Signal lighting circuits shall prevent inadvertent flashes of inappropriate aspects when changing from one aspect to another.

2.07 TRAFFIC CIRCUITS

- A. Traffic locking shall prevent clearing opposing signals into a section of track. Traffic locking circuits shall be provided between interlockings on both tracks.
- B. Circuitry shall lock direction of traffic on a section of track when any track circuit within that section is occupied or when time or route locking is effective for a signal which had been cleared into that track section.
- C. The traffic circuit shall maintain the direction when traffic is not locked until a different alignment is called. Traffic direction shall be maintained through any solid-state equipment or communication failure. Traffic shall be implemented between interlockings on the North Shore extension using fiber optic modems and cables between vital microprocessor interlockings.

2.08 LINE CIRCUIT LOGIC

- A. Line circuit logic shall be provided to pass information from one location to the next. Line circuits may be dedicated, traffic reversed, or as necessary to provide complete information.
- B. The Contractor shall consider the implications of repeating information via serial port. The hazards shall be identified and eliminated from the logic.

2.09 REPEATER CIRCUITS

- A. Repeater circuits shall be series repeaters with the last repeater in the proper circuits to avoid unsafe conditions if a relay fails to energize. Use of larger vital relays to avoid repeater relays shall be permitted.

2.10 EXIT INHIBIT LOGIC

- A. The Contractor shall provide logic for Exit Inhibits for every signal at each interlocking.
- B. Exit Inhibits shall be capable of being imposed and reset from OCC or the Local Control Panel.
- C. Non-vital requests for imposing inhibits are permitted. However, once imposed, the inhibits shall only be reset by fail-safe means.

2.11 MAINTAINERS CALL

- A. The Contractor shall provide a means to activate a Maintainers Call device from OCC for each location.

2.12 SNOW MELTER CONTROL AND INDICATION

- A. The Contractor shall provide a means to activate the snow melter from OCC or the Local Control Panel at each location.

2.13 ALARMS AND STATUS INDICATIONS

- A. The Contractor shall provide the means for transmitting alarm indications to OCC and displaying the alarms on the LCP.
- B. The Contractor shall propose status and alarms required based on the system provided. These alarms shall include at a minimum:
 1. AC and DC power off indications.
 2. DC ground detection.
 3. Intrusion detection.
 4. Fire.
 5. Blown fuse.
 6. Maintainers call.

2.14 OCC CONTROLS AND INDICATIONS

- A. The Contractor shall submit for approval a Code and Function Assignment sheet for each location provided under this Contract.
- B. The assignment and design of these functions shall be coordinated with the OCC.
- C. The Contractor shall provide all functions required for the controls and indications transmitted serially from / to the OCC System.
- D. Existing and typical OCC controls and indications are shown on the Contract Drawings.
- E. Control mode selection between the OCC, Local Control and Automatic is as specified within Section 13581, "Local Control Panels."

2.15 OTHER CIRCUITS

- A. Other circuits shall be as shown on the Contract Drawings. Additional circuits necessary to meet system requirements and the Contractor's specific design requirements shall be designed and implemented by the Contractor as required.

ARTICLE 3 EXECUTION

3.01 INSTALLATION

- A. The Contractor shall install all circuits in relay houses/rooms or cases. Similar and related circuits shall be grouped together. All wiring revisions to existing circuits shall be point checked prior to final wiring.

3.02 TESTING

- A. All circuits shall be tested as specified in Section 13595, "Signal System Test and Inspection."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13577
SOLID-STATE EQUIPMENT

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for solid-state equipment, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 1. This Section provides general requirements for the Contractor's signal design.
- C. The Contract Documents provide the performance parameters and design criteria to complete the solid-state equipment. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 01739, "Quality and Configuration Management"
- C. Section 01840, "Spare Parts and Test Equipment"
- D. Section 01910, "Operations, Maintenance and Repair Data"
- E. Section 13570, "Signal System Requirements"
- F. Section 13576, "Circuit Requirements"
- G. Section 13580, "Train to Wayside Communications (TWC)"

1.03 REFERENCE STANDARDS

- A. AREMA Communications and Signals Manual of Recommended Practices
- B. Code of Federal Regulations, Title 49, Part 236, Rules, Standards, and Instructions Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices and Appliances (CFR, Title 49, Part 236)
- C. IEEE 730, "Standard for Software Quality Assurance Plans"
- D. IEEE 828, "Standard for Software Configuration Management Plans."
- E. IEEE 830, "Guide to Software Requirements Specifications"

- F. IEEE 1012, "Standard for Software Verification and Validation Plans"
- G. IEEE 1016, "Recommended Practice for Software Design Descriptions"
- H. NEMA, National Electrical Manufacturers Association

1.04 SUBMITTALS

- A. Product Data:
 - 1. The Contractor shall include in the submittals, manufacturer's descriptive literature, product specifications, published details, parts lists, maintenance manuals, performance/capacity rating schedules or charts and installation and Site Specific programming instructions.
 - 2. The Contractor shall submit detailed hardware design, shop and installation drawings and documentation, and installation test procedures of the vital microprocessor electronic equipment to the Engineer for approval, prior to ordering materials for manufacture and assembly. These drawings and test procedures shall show as a minimum:
 - a. Equipment and rack layout
 - b. Functional block diagram of vital processor interlocking systems
 - c. Clear demarcation and delineation of vital hardware from non-vital hardware shall be included in all schematics, drawings, and block diagrams. In addition demarcation and delineation of the Class I vital hardware from the Class II vital hardware shall be performed.
 - d. Site specific application programming instruction and operations
 - e. Executive and site specific software control procedures
 - f. Interface requirements with vital and non-vital equipment
 - g. Parts catalog for each type of vital electronic equipment
 - h. Factory test procedures for vital electronic equipment
 - i. Field test procedures for vital electronic equipment
 - 3. The Contractor shall submit operating and maintenance procedures for the vital electronic equipment in accordance with Section 01910, "Operations, Maintenance and Repair Data."
 - 4. Submit sample of typical Site Specific Application Logic (SSAL) program for approval.
- B. Program Data:
 - 1. The Contractor shall include in the submittals a list of all vital and non-vital software provided as part of this Contract. The list shall identify which software components have been developed for this Contract, which are existing products utilized as such on similar train control systems, which are modified existing products, and which are existing products which have not been employed on similar train control systems. An existing product is a standard product of the manufacturer that has been sold repeatedly for application in vital railway functions.
 - 2. System Development Documentation - The Contractor shall provide documentation for each phase of product development to enable the Engineer to verify that the

system meets all requirements of these specifications.

- a. Software Development Plan (SDP)
- b. The Contractor shall identify, adopt or develop and maintain clear and complete documented plans of standards and procedures that describe the performance of all development tasks. These standards and procedures shall not conflict with the Specification and shall be subject to approval of the Project Manager, and review by the Engineer, prior to the onset of software development.
- c. The SDP shall be used in the development of the software and therefore should be readily accessible to all developers. The set of standards and procedures shall cover as a minimum:
 - (1) Project Management - including milestones, development procedures, schedule, resource allocation, subcontractor control, and reporting structure.
 - (2) Design techniques - covering methodology selection, procedures and formats, restrictions in use, and tool usage.
 - (3) Code standards - including naming conventions, sizing restrictions, language usage, file structure, and tool and utility usage.
 - (4) Documentation standards - including format, content, and issues related to automatic generation or regeneration.
 - (5) Review procedures and standards - including the identification of participant roles at each review, format of review presentation information, standard guidelines for review conduct.

C. Software Requirements Specification (SRS)

1. This document shall provide a description of the requirements which shall be performed in software. The functional requirements shall be described in both a textual form and Data Flow Diagrams. The SRS shall identify and describe external software and hardware to which the software shall interface, processing and timing constraints, logic nomenclature, operating constraints, and hardware limitations. In addition the SRS shall describe all safety related concepts to which the system shall be designed and implemented to meet the safety requirements of these Specifications. This document shall be submitted for approval of the Engineer prior to the start of any SSAL programming. This document shall be in general conformance to the guidelines presented in the latest issue of IEEE 830, "Guide to Software Requirements Specifications" or other approved standard.

D. Design Documentation

1. This documentation shall provide a complete design description of the Project hardware and software. The document shall be submitted first as a high level description of the system design and then as a detailed description of the system design. This documentation shall be in general conformance to the latest issue of IEEE 1016, "Recommended Practice for Software Design Descriptions."
 - a) The high level description shall include:
 - (1) Identification of all major hardware and software components,

interfaces, databases, system architecture, and sizing and timing estimates. Operational timing under peak and maximum (including future) loading conditions shall be specifically addressed.

- (2) Functional descriptions of how the system design components shall work together as a system to fulfill the functional requirements. Matrixes or similar methods shall be used to demonstrate that all functional requirements are being met.
- (3) A description of the techniques which shall be utilized in the design to maintain the safety of the vital processing of the system.
- (4) A description of how vital SSAL shall be generated and implemented.
- (5) Sizing; i.e., processor and memory utilization, expansion capability/techniques and spare capacity, as well as the methods for how system sizing is determined.
- (6) The method of making modifications to the application software after operational testing. The Contractor shall have a vital method of verifying/testing modifications without requiring a complete retest of the operational testing, i.e., the Contractor shall have methodology to verify the elements of the application which change and which do not change when a modification is made. This methodology shall be explained.
- (7) The detailed submittal of the Design Documentation shall provide:
 - (a) A breakdown of all major system components down to the lowest level components.
 - (b) The functional descriptions shall be updated to describe in detail how the functional requirements of the system are to be implemented. These functional descriptions shall be provided using either a structured pseudo-coding language or design language and shall be augmented with graphical representations.
 - (c) Detailed data and database descriptions shall be included as a Data Dictionary describing the usage, formatting, and handling of each element.
 - (d) The detailed design document shall clearly identify which lowest level components and interfaces are vital and which are non-vital.
 - (e) Schematics and block diagrams of hardware design.
 - (f) SSAL expressed in a boolean form or equivalent, for each interlocking.

- E. The Contractor shall provide a complete and detailed program printout of all SSAL for each vital processor, both vital and non-vital. The program shall be modularized in a logical and easily understood manner. The software listings and block diagrams shall

clearly distinguish between vital and non-vital software modules and procedures. Each module of the program shall be fully documented with plain-English explanations of its purpose and the methods by which it accomplished that task, the modules and data to which it is related, the modules of which it is a part, as well as a revision log. Nesting circuits and other software documentation will be bracketed and indented.

- F. The Contractor shall provide all Verification and Validation Testing plans, procedures, and reports for approval. The Software Verification and Validation Plan (SVVP) documentation shall meet the requirements of the approved SVVP.
 - 1. The Contractor shall provide demonstrated assurance of safety of the vital functions of the signal system. This documentation shall include identification of all vital functions as an outcome of the safety hazards analysis performed as required elsewhere. In addition to the hazard analysis documentation the analysis of the vital hardware and software shall be provided.
 - 2. Definition of all literals should be provided. A tabulation shall be provided listing every equation each literal appears in, and every page in the program listing that each literal appears on. A functions list describing the operation and implementation of all functions shall be provided. Any special features and/or implementations of the function shall be included.
 - 3. A formal configuration control procedure shall be required and implemented. All Integrated Circuits (ICs), Printed Circuit Boards (PCBs), components, etc., which are subject to revision (such as EPROM's) shall have the revision level check sums and CRC values identified on the component and catalogued from factory to in-service testing.
- G. Prototypes shall be developed to demonstrate critical system performance areas such as failover, timing under peak loading and failure conditions, and operations performance. Prototypes shall be developed and approved by the Engineer, prior to manufacturing and integrating the system.
- H. Test Equipment:
 - 1. The Contractor shall provide test equipment and submit documentation of the equipment required to perform diagnostic, functional and operational testing of the vital electronic equipment and interlocking operation as listed in Part 2 of this specification.
- I. List of service-proven vital equipment locations.
- J. Modifications or upgrades
 - 1. Any modifications or upgrades to solid-state equipment provided by the Contractor or its suppliers shall also be made to equipment already delivered to the Authority. Such modifications or upgrades shall be made until the end of the guaranty period.

1.05 QUALITY ASSURANCE

- A. The standards of the AREMA Communications and Signals Manual of Recommended Practices, Part 2.2.12, NEMA, IEEE and the Authority shall be adhered to in every instance where such standards have been established for the general application of work, material or equipment to be installed, except where such requirements conflict with this Specification.
- B. The Contractor shall generate a Software Quality Assurance Plan (SQAP) as described within the Section 01739, Quality and Configuration Management. The SQAP shall be in conformance with the latest issue of IEEE Standard 730, "Standard for Software Quality Assurance Plans." The SQAP shall be submitted for approval prior to beginning the development of the vital and non-vital firmware for this Project. The Contractor shall develop all system and application firmware in accordance with the SQAP and shall furnish the necessary documentation for the Engineer to verify conformance. In addition the Contractor shall provide a Software Configuration Management Plan (SCMP) as described within the Section 01739, "Quality and Configuration Management," in accordance with the latest issue of IEEE Standard 828, "Standard for Software Configuration Management Plans."
- C. The Contractor shall submit a Software Verification and Validation Plan (SVVP) as described within the Section 01739, "Quality and Configuration Management," for approval of the Project Manager and review by the Engineer early in the development of the system and application firmware. The SVVP shall be in conformance with the latest issue of IEEE Standard 1012, "Standard for Software Verification and Validation Plans". The Contractor shall verify and validate all vital and non-vital firmware, including application firmware in accordance with the approved SVVP and shall provide the necessary documentation to demonstrate to the satisfaction of the Engineer, the plan's conformance. The SVVP shall provide a method to verify that changes made to the site-specific application dependant firmware were confined to the intended logic. This would preclude the need for a system test of the entire content of the application EEPROM whenever a change is made to the logic
- D. The Contractor will not be required to demonstrate that software which was not developed specifically for this program and which software is utilized in an unmodified form in this program was developed in accordance with the approved SQAP. However, modifications to such software shall not be exempt from this requirement.

1.06 DESIGN

- A. The solid state equipment to be supplied in the Contractor's design includes vital microprocessor interlockings, non-vital logic controllers, and train to wayside communications (TWC).

- B. The Contract Drawings are representative of the type of SSAL required to be programmed by the Contractor. The Contractor shall program this logic in the most efficient manner possible using the Contract Drawings as a guide for content. Subject to review by the Engineer, the Contractor may deviate from the Contract Drawings. Not all of the required logic is shown on the Contract Drawings. The Contractor shall provide all logic to implement a safe signal system in accordance with the Contract Documents.
- C. The Contractor shall designate vital hardware as hardware, which under failure, can adversely affect the safety of train movements; and/or adversely affects the delivery of service to Authority customers. Further, if the safe implementation of a vital function is dependent in whole or in part on the absence of failures in the hardware circuit or device, then that hardware is vital. Vital hardware is hardware whose failure modes and characteristics can be accurately identified, predicted and exhaustively tested. The occurrences of failure modes that could have unsafe consequences are eliminated, prevented, or otherwise accounted for by design.
- D. Hardware whose failure modes may adversely affect the safe implementation of a vital function but which is not designed as vital hardware shall be considered vital. Failure modes in this hardware are revealed or otherwise accounted for by means other than vital hardware design techniques. These means include but are not limited to, software checking and comparison of independent hardware circuits.
- E. Non-vital hardware is defined as all hardware which is not vital. Non-vital hardware shall be clearly delineated from vital hardware.
- F. Vital firmware is a combination of system executive and application firmware required for the implementation of vital functions. Vital firmware is software whose execution is required for the implementation of a vital function.
- G. Non-vital firmware is all software which is not vital. Since execution of an error in non-vital firmware operating in the same processor as vital firmware could affect implementation of a vital function, that non-vital firmware shall be subjected to the same requirements as vital firmware.
- H. A vital function is a system function of which the correct performance affects the safety of passengers, personnel, equipment, or environment. In addition, a system function of which the incorrect performance allows a hazardous situation to exist which may adversely affect safety of passengers, personnel, equipment, or environment either immediately or subsequently shall be considered a vital function.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Equipment furnished under this Section shall not be shipped until the factory test reports have been approved, in writing, by the Engineer.

- B. Each item of the vital microprocessor interlocking system shall be inspected by the Contractor and the Engineer for shipping damage prior to installation.
- C. Any equipment showing signs of damage shall be repaired or replaced, at the Engineer's option, without cost to the Authority.

ARTICLE 2 PRODUCTS

2.01 GENERAL EQUIPMENT REQUIREMENTS

- A. Design
 - 1. Solid-state equipment and processor-based equipment, where required in this section, shall be provided by the Contractor. Such equipment shall be of the most modern design and meet the highest standards of industry and all applicable specifications of the AREMA Communications and Signals Manual of Recommended Practices and requirements of FRA, Part 236.
 - 2. All terminations, cable materials, and methods shall be commercially available and meet all specifications for the purpose intended.
 - 3. All connections to external circuits shall be designed to interface to service proven signal equipment operating at normal voltages for the type of equipment.
 - 4. All parts for solid-state equipment shall be available for a minimum of ten years after Acceptance.
- B. Modularity
 - 1. The equipment shall be modular in design.
 - 2. Plug-in type printed circuit boards shall be used wherever possible. They shall be manufactured with mechanical keying which prevents a board from being installed in an improper slot and with rugged ejectors able to withstand the stress of multiple insertions and ejections.
- C. Environment
 - 1. Solid-state equipment shall meet the basic temperature requirements, without heating or cooling enhancements such as heating strips and fans.
 - 2. If any portion of the complete devices or any assembly has operating or storage temperature requirements that differ from the specified ranges, the Contractor shall submit the specifications to the Engineer for approval.
- D. Diagnostics
 - 1. The system shall incorporate self-checking features and diagnostic tests to ensure that the equipment and programs are functioning properly.
 - 2. An LED shall be provided on the input board for each input to indicate when the input is activated.
 - 3. An LED shall be provided on the output board for each output to indicate when the output is activated.

E. Mounting

1. Unless otherwise noted, the equipment shall be mounted complete with necessary accessories on standard 19 inch railroad signal racks as per AREMA Communications and Signals Manual of Recommended Practices, Part 2.2.12.

F. Grounding and Transient Voltage Surge Suppression (TVSS)

1. The Contractor shall provide grounding, bonding, and TVSS devices, materials and wiring, to avoid damage to equipment from atmospheric lightning strikes and conducted transient voltage spikes.
2. The equipment shall be provided complete with the necessary isolation and power regulation devices to ensure its performance and reliability. The equipment design and fabrication shall be such as to make it immune from noise and transients. Solid-state equipment shall be immune to electrostatic discharges to all devices and surfaces exposed to human touch during operation or servicing.

G. Executive and Application-dependent Firmware

1. The operating instructions for the vital and non-vital processor units shall be divided into executive and application-dependent portions.
 - a. "Executive" shall signify the operating instructions that govern the execution of a unit's base functions. Examples of executive instructions include, but are not necessarily limited to, system integrity evaluation, error logging, hardware interface, timing, data communications, application dependant firmware execution, and the application of power to the controller. Executive instructions can be the same from one processor unit to another, for its type (i.e. vital or non-vital).
 - b. "Application-dependent" shall signify the operating instructions that govern the execution of unit-specific functions. These are functions that are unique to an individual controller. An example of application-dependent instruction is autorouting control at a particular interlocking. Application-dependent instructions may differ from one processor unit to another.
2. Executive instructions shall be stored in Programmable Read Only Memory (PROM) devices or in flashable memory that is permanently mounted on the CPU pc board and shall be called the Executive Firmware.
3. Application-dependent instructions shall be stored in solid state Erasable Programmable Read Only Memory (EPROM) chips or in flashable memory that is permanently mounted on the CPU pc board and be called application-dependent Firmware.
4. The Contractor shall provide all manuals, software, and hardware necessary for the creation and modification of site-specific vital and non-vital application-dependent Firmware.
 - a. The materials to be provided to the Authority shall consist of all source codes and the software libraries used or necessary for the creation or design of the object code version, and operation of any application-dependent instructions, together with any editors, compilers, linkers, loaders, PROM burners or other utilities, software libraries, the written documentation used or prepared in connection therewith, which documentation shall be reasonably sufficient to

- enable the Authority to recreate the object code version of said software from such source codes, compilers, linkers, loaders and utilities, and anything else designated by the Engineer (collectively, the "Delivered Software Materials"). Thereafter, during the performance of the Contract and the warranty period, the Contractor shall supplement and replace the Delivered Software Materials, as necessary, such that the Delivered Software Materials collectively are consistent, at all such times, with the form of the software most recently provided or delivered by the Contractor to the Authority.
5. The Contractor shall provide a means for changing the logic in both the vital and non-vital processors such that Authority personnel are able to change the logic in order to accommodate future track changes, or other such eventualities.
 6. All application-specific logic in any signal-related equipment provided by the Contractor shall be capable of modification. The Contractor shall provide all manuals, software, and hardware necessary for the creation and modification of such application-specific logic.
 7. The Contractor shall provide the manuals for the software and hardware described within the Paragraph 2.01G separate from the tools and test equipment that the Authority purchases from the Contractor's Recommended Spare Parts List and for no additional payment from the predetermined amount described in Section 01830, "Spare Parts and Test Equipment."

2.02 FUNCTIONAL DESIGN AND IMPLEMENTATION REQUIREMENTS

A. Vital Interlocking Control System:

1. All vital microprocessor-based equipment that is proposed for this project shall be service-proven.
 - a. A system, subsystem, component, product, element or part will be deemed service-proven if it has been successfully used, as determined by the Engineer, on an electrified mainline, transit railway, or similar application in North America for a minimum of five years.
2. Each vital microprocessor-based system shall consist of microprocessors which use a closed loop feedback and independent system diagnostics to maintain vital integrity. System outputs shall be positively monitored with independent current/voltage sensors and compared to the requested value. A vital "kill" circuit shall be used to de-energize all outputs and shutdown the system when the outputs fail to correspond to the required state. All software programs shall be checked as a part of, and after power-up and continuously during operation for alterations to ensure no modifications or errors have taken place after being installed. The central processing unit shall be continually tested to ensure all instructions are being executed properly and that processor integrity is being maintained.
3. The vital processor system shall not use a multi-processor voting type scheme to evaluate the correctness of outputs.
4. The vital microprocessor-based system shall incorporate self-checking features and diagnostic tests to ensure that the equipment, and program where applicable, are functioning properly. These checks shall be integral parts of both the hardware and

software to provide for a secure system. Vital processors shall not allow falsely permissive information to be transmitted to external devices which may result in a hazardous condition; non-vital processors and carrier systems shall minimize the possibility of false information being transmitted to external devices. In no case may false permissive information persist long enough to allow an unsafe condition to occur. Transmission of false information from a non-vital to a vital subsystem shall in no way affect the safety of the interlocking or system. Non-vital visual indications, such as LED lamps, shall demonstrate that the system is functioning properly; similarly, failure and diagnostic indications shall be provided. Indications shall isolate a failure to a particular function, or to the interface between two functions.

5. PROMS and EPROMS used shall be checked, as part of program execution, during each cycle, to ensure they have been unaltered during processor execution. Benchmarks shall be created for blocks of memory to implement these tests.
6. Inputs shall be buffered and shall be immune to contact bouncing and shall be electrically and physically isolated from one another. Access to inputs must be unique in the sense that under failure, reading of the incorrect input circuit will not result in a falsely permissive input being utilized in vital processing. Processor communication with each input shall vitally assure that the proper input and input state (on or off) is read. A non-vital visual indication, such as an LED lamp, shall be provided for each input on the input boards to indicate when the input is activated.
7. A falsely permissive non-vital input shall not adversely affect the safety of the vital function processing.
8. Outputs shall be electrically and physically isolated from one another. A vital means of verifying the proper state of the output shall be provided. Access to the outputs shall be unique in the sense that under failure, writing to the wrong output circuit will not result in a falsely permissive output being generated. Processor communication with each output shall vitally assure that the proper output is in the proper state (on or off). A non-vital visual indication, such as an LED lamp, shall be provided on the output boards for each output to indicate when the output is activated.
9. The output states of the processor shall be verified every 50ms to ensure correspondence between the actual and requested values. The system shall shutdown in the event that an output that should be off is on.
10. Communications (serial and/or parallel) between processors implementing vital functions shall be vital. Security protocol, including handshaking and error detection, shall be used to ensure the validity of data. Data shall default to the most restrictive state unless a valid transmission is received. Serially transmitted data between subsystems shall be updated every second to ensure the integrity of the communications link. Propagation time shall not exceed two seconds. Vital logic executing in each processor shall detect corrupted or inconsistent data received. Multiple pieces of partial products or raw data shall be used to provide a sufficient data base to detect inconsistencies.
11. Non-vital serial links shall either use CRC (minimum CRC-16) or check sum

- methods to provide a high level of assurance that invalid data is not accepted.
- 12. Inputs shall be reevaluated a minimum of once every second: evaluation shall use a double scan to ensure a permissive input is valid. If two successive scans do not result in the same permissive state, the data shall be treated as false. Input refresh will vitally erase the memory location to ensure the input is fresh. Diagnostic checks shall be included in the processing of inputs to ensure the database has not been corrupted in any fashion. Checks shall be included to ensure the independence of inputs from one another.
 - 13. The user interface for programming application dependant firmware shall be easy to use and shall only require knowledge of the interlocking design and the Boolean or ladder logic equivalents of the circuits to configure or reconfigure an interlocking.
 - 14. The SSAL shall define the operation of the vital interlocking system, and shall include, but not be limited to those functions described within Section 13576, Circuit Requirements and logic indicated within the Contract drawings.
 - a. Vital timing functions for interlocking locking requirements shall be field settable and adjustable, without the need to burn another SSAL EPROM, or download another program to the processor. Vital Timer Relays shall be used if required for this purpose unless the manufacturer has an approved software revision validation process that negates the need to perform system testing of the interlocking once a new application software EPROM has been installed or downloaded.
 - b. Start-up
 - (1) Upon start-up of the Vital Processor System, switches may be out of correspondence due to a lapse in communications, and corresponding loss of switch requests from the non-vital code system.
 - (2) Therefore, for a time duration of five seconds following a vital processor start-up, the field switch indication input shall set and stick the corresponding non-vital switch control request.
 - (3) When communications are restored, if the office or local panel switch request does not match the switch request in the field, the office display or local panel auxiliary switch light shall flash until the switch is requested to the same position as what is set in the field or until the switch is thrown to the other position.

B. Vital Software:

- 1. Software is inherently a non-vital implementation of logic. A microprocessor is inherently a non-vital implementation of hardware. Only through special application of hardware and software in which the failure modes and effects can be revealed and proven to meet defined values of probability of occurrence and outcome can a microprocessor be classified as a vital device.
- 2. System software of two types shall be function dependent upon each other to perform all vital and non-vital microprocessor logic.
 - a. Executive system software shall be provided by the Contractor that performs all functions necessary to provide for the proper and safe operation of the

microprocessor unit as specified, not to include site-specific logic processing and control.

- b. Application software shall be user-defined for site-specific application and interfacing with all necessary subsystems.
3. Diagnostic checks and vital processing shall only utilize data in its nonrestrictive state which has been stored in the machine for less than two machine cycles or 1 second, whichever is less. Memory locations used to determine the proper states of inputs and outputs shall be vitally cleared or destroyed prior to being reused during each cycle to ensure the integrity of the data.
4. Background diagnostics shall continuously monitor the execution of software. Synchronized tasks shall execute properly, and asynchronous tasks shall execute in the proper order. Checks shall be included to shutdown the system in the event of a processor overload or a processor stuck in a non-terminating program or task.
5. The system software shall recognize a secure distinction between the executive firmware and the application software such that it shall be impossible through the implementation of the application software to subvert in any manner the vital safety functions of the executive software.
6. There shall be no data contained within executive firmware that will limit or prevent the microprocessor system from being reconfigured for alternative site configurations by modification of application software. Modifications or changes to application software shall not require modification or recompilation of executive software.
7. Application dependant firmware implementing non-vital functions shall be kept separate and distinct from application dependant firmware implementing vital functions. Changes to non-vital application dependant firmware shall be performed without requiring re-verification and revalidation of the vital application dependant firmware.
8. Executive firmware shall be maintained in non-volatile memory that cannot be altered by any operation of any component of the microprocessor system during in-service operation. The executive firmware data storage shall include a check sum or CRC to provide a method of determining data validity. Diagnostic checks shall be incorporated which verify the integrity of the executive firmware during operation.
9. Application software shall be maintained in non-volatile memory that cannot be altered by any operation of any component of the microprocessor system during in-service operation. The application software data storage shall include a check sum or CRC to provide a method of determining data validity and verification of the software in use. Diagnostic checks shall be incorporated which verify the integrity of the application software during operation. The application dependant firmware shall be safe in and of itself without reliance on features of the executive software. If executed correctly, the logic shall not assume an unsafe state.
10. Nomenclature shall be consistent with PAAC practices, shall be as indicated within the Contract Drawings and consistent throughout the application, i.e., within all locations in which the system is applied. Nomenclature should distinguish I/O from internal variables. Inputs should be distinguished from outputs and the I/O nomenclature shall reference the logical unit on the other side of the interface, i.e.,

the input or output device. Variables of vital functions shall be distinguished from those of non-vital functions. New or special function designators shall be as simple as possible, but not conflict or lead to confusion with established function designations.

11. Changes in the application dependant firmware shall not require recompilation, verification and/or validation of the executive software.
12. The logic shall be as simple as possible, expressed in a high-level, structured and easily understood form.
13. Organization and adequate commenting are an inherent quality of the safety of the logic, i.e., the readability/understandability of the logic and logic organization are integral to the long-term safe operation and maintenance of the system. Therefore, comments shall be applied liberally throughout the software.
14. General organization of the application programming logic, in the order appearing in the program listing shall be:
 - a. Table and description of variable names
 - b. Program administration: version level, programmer, checker, etc.
 - c. Machine specific requirements in the programming (e.g., compiler switches)
 - d. General remarks, comments, special features, etc.
 - e. Inputs
 - f. Logic equations
 - g. Outputs
15. As a minimum, specific approval of the Engineer shall be required for each instance in which the Contractor wishes to "nest" logic more than 3 levels unless additional "intermediate" bits are required to perform the same function.
16. Where specific vital functions need to be verified, the logic shall be organized to avoid masking of the vital function with non-vital or other logic, and a vital means of validating the logic states shall be provided. For example, switch request and request storage prevention logic shall be provided independent of switch locking, and a means shall be provided for validating the state of the locking such as provision of a vital output or read only access to the contents of the memory location.
17. A non-asserted input is not equal to a back contact of a relay, but rather an open front contact. Vital logic requiring a non-asserted input to set an internal variable shall require an inverted input to be used in setting the internal variable. Where the relay equivalent function of a back-check is determined to be required and applied in more than one equation, the logic shall be arranged such that the back-check need only be checked once. For example, the application of a ~RWC literal in the setting of a NWC variable obviates the need for ~RWC literals in signal clearing and other equations (where the NWC is used). For logic determined internal to the machine, extraneous "back checking" of logic to replicate relay logic shall be avoided. For example, the requirement to "back-check" an AS state in a "H" function is not necessary if a) a logic condition exists which is mutually exclusive to both functions (e.g., a set "Route check" in the "H" and a clear "route check" in the "AS" function), and b) a particular literal is not an input. Where external relays are provided that require "back check," the logic shall rely on external inputs that verify the actual

- position of the external relay contacts.
18. If loss-of-shunt (LOS) protection is to be provided by timing (i.e., delayed application of an input and/or internal variable), then the timing shall be performed in the processor which is processing the inputs and not by a processor removed from the input to be timed by intermediate processing units or stages. Five second loss-of-shunt protection for route locking shall NOT be performed at the switch locking or route locking level. If timed LOS is implemented, it should be implemented at the track detector level. LOS on a block line for traffic LOS shall be implemented. LOS shall be implemented in such a way that it minimizes negative impacts on headway. Timed LOS on an approach circuit shall be implemented if necessary. The preferred approach is to implement LOS as an "AS" stick function in the approach logic.
 19. Software shall allow interrogation and status check of memory locations.
 20. Traffic locking (track unoccupancy and opposing route locking) shall be checked both at the initiation of a request to change established traffic direction, and as the final step in setting the entering end traffic.

C. Vital Hardware:

1. Isolation and Regulation
 - a. The equipment shall be provided complete with the necessary isolation and power regulation devices to assure its performance and reliability under service conditions.
 - b. Inputs for the equipment shall be electrically isolated from one another.
 - c. Vital outputs for the equipment shall be electrically and physically isolated from one another.
2. Use of any output contact for a load in excess of its design capability is not permitted.
3. The local interlocking functions shall be provided with a sufficient number and type of vital AC lamp drivers, vital outputs, and vital inputs to meet the following requirements:
 - a. Vital AC lamp drivers shall be capable of controlling a load of 28 watts per lamp with two lighted lamps.
 - b. The vital input and output printed circuit boards shall directly control and/or monitor track circuit, switch machine, signals and all other wayside equipment necessary for proper operation of the local interlocking with or without external interfacing relays.
4. The vital processor unit shall be provided with vital serial ports to allow vital serial communications with other vital processor units.
5. Each vital processor unit shall also be provided with non-vital serial ports.
 - a. The non-vital serial ports shall provide non-vital communication of data between the vital processor and either a separate non-vital supervisory control system or the unit's own non-vital supervisory control processor.
 - b. All data communications between the non-vital supervisory control system and the vital processor shall conform to RS232 or RS422 standards.
6. Each vital processor unit shall be equipped with a diagnostic port, consisting of a

serial communications data port conforming to RS232 standards. This diagnostic port shall be provided for the connection of portable computer test equipment to facilitate the running of diagnostic software for maintenance purposes and for the downloading of data for maintenance analysis at a location away from the equipment.

7. All data communications between vital processors, whether located at an adjacent location or at the same location, shall be through proven high speed vital means, immune to Electromagnetic Interference (EMI).
8. Removal or insertion of circuit boards under power shall not result in damage to any electrical circuit.
9. All wire connections to the cardfiles shall be via plug-connected cables.
10. Forced air ventilation shall not be used.
11. All portions of memory containing vital firmware routines shall be in a sealed or otherwise verifiable and protected package.
12. All interfaces to wayside apparatus, with the exception of signal lighting, and switch position indication shall be by vital relay interface unless the Contractor provides documentation and supporting evidence to the satisfaction of the Engineer that the system I/O will work in a more trouble-free and efficient manner if wired direct to the vital processor. The vital microprocessor system shall also have the ability to communicate through vital serial links with "slave" microprocessor racks. These slaves shall be used when the I/O capabilities of the "master" have been expended for controlling devices. The architecture of "slave" microprocessors shall be designed such that they will not adversely affect the total bit time throughput from adjacent locations.
13. Spare input and output board slots are required. Vital microprocessor motherboards shall allow the addition of inputs and outputs by the purchase of input/output boards and simple installation by PAAC. A minimum of 10% of all of the inputs and 10% of all of the outputs used at a location shall be provided as spare.
14. Project Manager approved labels shall be provided by each input and output indication which clearly denote the respective function of each, for the ease of maintenance and troubleshooting.
15. The microprocessor equipment shall be mounted complete with necessary accessories on standard EIA style 19-inch racks.
16. Power for the input/output circuits shall be supplied through a vital cut-off circuit. This circuit shall be driven by a vital clock signal generated by the processor checks and diagnostics. The vital clock signal shall pass through filters tuned to prevent a false signal from energizing the relay. The signal frequency shall be chosen such that it could not be generated by any other device in the equipment housing: for example, 60 Hz power supplies or battery chargers, audio or coded equipment, or harmonics of these devices. The vital cut-off circuit shall remove the vital clock signal and de-energize the vital cut-off relay.
17. The vital processors shall control several output devices which shall be energized with 12V DC, i.e., vital signal control relays, etc. Output boards shall be capable of withstanding without damage, the shorting of the output to ground or the opposite DC polarity. Such a short shall register an alarm to the central control office.

18. The Contractor shall certify in writing that the equipment provided under this Section, including software and future software revisions, both executive application, and user-defined, shall be available and will be serviced and supported for a period of ten (10) years after Contract completion.
 - a. If an executive EPROM change is necessary before final acceptance, all previously installed microprocessor EPROMs shall be updated by the Contractor.
 - b. If a compiler program change is necessary or upgraded, after final acceptance, the Contractor shall provide the Authority with the upgrade for a period of 10 years after final acceptance.
 - c. If a hardware change (card upgrade) is required before final acceptance, the Contractor shall upgrade all previously installed microprocessors.
 - d. No additional cost shall be provided to the Contractor for the upgrades or modifications listed above.
19. All power for the vital microprocessor interlocking shall be properly isolated from the effects of electromagnetic interference, lightning, noise, current surges, and grounds. Surge suppressor units to further enhance this isolation are required by this Contract and shall be provided by the Contractor.
20. A Project Manager approved vital means of indexing PCBs, either mechanically or in software, shall be implemented to ensure that only the proper PCBs are inserted in card slots.
21. All components of the system shall be capable of continuous operation at temperatures of minus 40 degrees Fahrenheit to plus 158 degrees Fahrenheit, and humidity levels of 0 - 95% non-condensing without any external environment controls.
22. All 'dirty' wiring (wiring not protected or isolated from the effects of electromagnetic interference, lightning, noise, current surges and grounds) shall be kept clear of the vital microprocessor as far as is practical and where that is not possible, the wiring methods shall utilize other means to protect against induced interference.
23. All monitoring equipment shall be able to be connected or disconnected from the microprocessor system while it is in operation.
24. All major assemblies, subassemblies, circuit cards and devices shall be permanently marked with the manufacturer's part identification number.
25. All ICs, PCBs, components, etc., which are subject to revision (such as PROMs) and/or are removable from assemblies, should have the revision level identified on the component.
26. The Contractor shall be responsible and verify that the equipment functions as manner intended in the environment in which it is to be installed and operated.

D. Performance:

1. It is essential that the system meet operating performance requirements (separate and distinct from unit or subsystem performance requirements). The Contractor is required to submit preliminary timing and system response analyses. Analyses should include transient and steady-state peak operational loading conditions. These

- analyses should be updated throughout the system design and implementation process. Analyses should minimally be required for the following:
2. Time to clear a route with and without switch transitions. Time should be measured from operator command initiation to display to the operator of the completed command (i.e., the route is indicated as lined and locked). This analysis shall be done for both the control center and the local control panel.
 3. Time for an outside agent (such as system user) to implement a restrictive condition. Analyses should be from the time the outside agent affects a system input or execute function, until the outside agent receives feedback that the system implemented the restrictive condition.
 4. Time to restart each type of processing unit. Analyses should be from the time restart is initiated until all critical functions affected by the processing unit have been restored to full functionality.
 5. Headway impact: In no case shall the headway be negatively impacted more than three seconds by any combination of processor delay times. This includes both vital and non-vital processors, all serial link delays, contact transfer times, and any other component of time delay. All outputs shall be acted upon within three seconds from the input scan regardless of which vital or non-vital microprocessor in the serial link scanned the input. It is the Contractor's responsibility to develop a system architecture that reduces the delay to meet this requirement. Should the Contractor's system architecture fail to meet these requirements, vital serial links will not be permitted between vital microprocessors at adjacent interlockings. Instead copper signal express cables will be used to pass vital information between the adjacent interlockings. All additional costs related to this implementation will be born by the Contractor.

E. Non-Vital Logic Controllers:

1. The non-vital logic controller provided shall be based on solid-state microprocessor technology and shall not require any off-line storage devices for operation or start-up.
2. All software programs shall be checked after power-up and continuously during operation for alterations to ensure no modifications have taken place after being installed. The central processing unit shall be continually tested to ensure all instructions are being executed properly and that processor integrity is being maintained.
3. The non-vital microprocessor shall incorporate self-checking features and diagnostic tests to ensure that the equipment, and program where applicable, are functioning properly. These checks shall be integral parts of both the hardware and software to provide for a secure system. Non-vital processors and Data Transmission Systems (DTS) shall minimize the possibility of false information being transmitted to external devices. Transmission of false information from a non-vital to a vital subsystem shall in no way affect the safety of the interlocking. Non-vital visual indications, such as LED lamps, shall demonstrate that the system is functioning properly; similarly, failure and diagnostic indications shall be provided. Indications shall isolate a failure to a particular function, or to the interface between two

- functions.
4. PROMs, EPROM's, and EEPROM's used shall be checked to ensure they have been unaltered during microprocessor execution. Benchmarks shall be established for blocks of memory to facilitate these checks.
 5. The non-vital microprocessor system shall interface with the vital interlocking system described within this specification section.
 6. Inputs for the equipment shall be buffered and shall be immune to contact bouncing and shall be electrically and physically isolated from one another. A visual indication, such as an LED lamp, shall be provided on the input board for each input to indicate when the input is activated.
 7. Outputs for the equipment shall be electrically and physically isolated from one another. A visual indication, such as an LED lamp, shall be provided on the output board for each output to indicate when the output is activated.
 8. The logical operations and equipment at interlockings shall be controlled by microprocessors. The operating programs and database definition shall be stored in nonvolatile memory so that automatic power fail/restart can be provided.
 9. The non-vital logic controllers shall perform the same functions as a conventional relay type entrance-exit system. In addition, the non-vital logic controller shall perform other functions as specified herein, including field automatic modes of operation.
 10. The Non-vital logic controllers shall include, but not be limited to the following controls:
 - a. Route Setting
 - b. Switch and Signal Operation
 - c. Route Cancellation
 - d. Switch Blocking
 - e. Track Blocking
 - f. Fleeting
 - g. Snowmelter Control
 - h. Maintainer's Call
 - i. Alarm Cancel
 - j. All other controls as may be required and that are specified in other Specification Sections or shown within the Contract Drawings.
 11. The Non-vital logic controllers shall include indication data to enable display update at the Office Supervisory Control Console CRT. The indications shall include, but not be limited to the following indications:
 - a. Signal Status
 - b. Switch Position
 - c. Switch Locking
 - d. Route Setting
 - e. Traffic Direction
 - f. Snowmelter Status
 - g. Track Occupancy - Block Status
 - h. Maintainer's Call
 - i. Control from Auto or Manual

- j. Fleeting Status
- k. Intrusion
- l. Fire Alarm or Fire Trouble
- m. Power Off
- n. All other alarms and indications as may be required and that are specified in other Specification Sections or shown within the Contract Drawings.

F. Non-Vital Logic Controller Software:

- 1. Serial Data Transmission
 - a. Serial data transmission of non-vital data over non-vital serial links shall use either CRC or check sum methods to provide a high level of assurance that invalid data is not accepted.
 - b. Non-vital systems shall default all associated data to the most restrictive state unless a valid transmission of data is received.
- 2. Diagnostic checks shall act on current (fresh) data only. Memory locations used to determine the proper states of inputs and outputs shall be cleared and current data destroyed prior to being reused during each cycle to ensure the integrity of the data. The diagnostic checks shall be independent of the user application logic for the system. The diagnostic checks shall be incorporated in the executive systems software and shall operate independent of the user application software for the system.
- 3. Background diagnostic tasks shall run during application software wait states and shall serve to monitor and verify the integrity of the software execution. Synchronized tasks shall execute properly and a synchronized task shall execute in the proper order. Checks shall be included to shut down the system in the event of an executive microprocessor overload.
- 4. Compiler software shall be supplied to maintain and upgrade the non-vital application firmware. The compiler software shall be licensed to the Authority for unrestricted use. Software technical support and revisions shall be provided for a minimum ten (10) years by the Contractor without further cost to the Authority. Executive firmware, compiler software and hardware shall be supported as described elsewhere within this specification section. Configuration control for application firmware shall also be as specified elsewhere within this specification section.
- 5. The system software shall recognize a secure distinction between the executive and application firmware such that it shall be impossible through the implementation of the application firmware to overwrite or otherwise modify the executive firmware.
- 6. There shall be no data contained within executive firmware that will limit or prevent the microprocessor system from being reconfigured for alternative site configurations by modification of application firmware.
- 7. Executive firmware shall be maintained in non-volatile memory that cannot be altered by any operation of any component of the microprocessor system. The executive firmware data storage shall include a check sum or CRC to provide a method of determining data validity. Diagnostic checks shall be incorporated which verify the integrity of the executive firmware during operation.

8. Application firmware shall be maintained in non-volatile memory that cannot be altered by any operation of any component of the microprocessor system. The application firmware data storage shall include a check sum or CRC to provide a method of determining data validity and verification of the firmware in use. Diagnostic checks shall be incorporated which verify the integrity of the application firmware during operation.
 9. A Software Verification and Validation Plan and site-specific application logic verifier as specified elsewhere within this specification section shall be provided.
- G. Non-Vital Logic Controller Hardware:
1. Diagnostic indications shall isolate a failure to a particular function or the interface between the failing function.
 2. Labels and annotation shall be provided for each input and output indication which shall clearly denote the respective function for ease of troubleshooting and maintenance.
 3. All components of the supervisory control system shall be in accordance with the environmental parameters described in the Signal System Requirements Section of these Specifications.
 4. The microprocessor equipment, including all field spare PCB cards, shall be mounted complete with all necessary accessories on standard 19 inch racks.
 5. All power for the non-vital microprocessor shall be properly isolated from the effects of electromagnetic interference, lightning, noise, humidity, current fluctuations, and grounds. All 'dirty' wiring shall be kept clear of the microprocessor as far as is practical and where that is not possible, the wiring methods shall utilize other means to counter induced interference.
 6. All monitoring equipment shall be able to be connected or disconnected with the microprocessor system in operation.
 7. All major assemblies, subassemblies, circuit cards and devices shall be permanently marked with the manufacturer's part identification number.
 8. The local control console will be tied directly to the input and output boards of the non-vital electronic equipment.
 9. Ten percent spare inputs and outputs shall be provided per cardfile.
 10. Space shall be provided in the non-vital microprocessor cardfile for 10% spare input and 10% spare output boards.

2.03 TEST EQUIPMENT

- A. Test devices shall be furnished for all solid-state equipment furnished under this Contract.
- B. A program test monitor shall also be provided to verify the integrity of the logic memory modules. The program test monitor shall plug into a serial port and provide the Authority with the ability to interrogate internal equipment states. This shall provide diagnostic information on the program as it runs, and shall be capable of functioning both on and off-line.

- C. The Contractor shall provide two (2) laptop type personal computers running the latest operating system (OS) version of Microsoft Windows© and contain a Central Processing Unit (CPU) with a minimum processor speed of 3Ghz and 1gb of Random Access Memory (RAM). The laptops shall be equipped with a minimum 80 gigabyte hard drive, CD-RW drive, 3 ½" floppy drive, and two (2) spare batteries per laptop.
- D. The Contractor shall provide all peripheral cables and adaptors for the test laptops needed to monitor any of the solid-state equipment as outlined in these specifications. The laptops shall contain all test programs as described within this section.
- E. All test devices shall be self-contained and portable.
- F. A PROM test reader shall be provided to verify the integrity of programmed chips unless flashable EPROM's are used.
- G. Manuals with detailed instructions on the use of the test equipment shall be provided for each unit provided.
- H. The Contractor shall provide the test equipment described within this Section, separate from the tools and test equipment that the Authority purchases from the Contractor's recommended spare parts list and for no additional payment from the predetermined amount described in Section 01840, "Spare Parts and Test Equipment."

ARTICLE 3 EXECUTION

3.01 DOCUMENTATION

- A. Maintenance Manuals and Operating Manuals shall be provided per Section 01910, "Operations, Maintenance and Repair Data."

3.02 VITAL AND NON-VITAL PROCESSOR EQUIPMENT

- A. Each processor unit shall consist of printed circuit boards of the required types, mounted within one or two cardfiles.
- B. All components of each processor unit shall be mounted in a single instrument rack. All wire connections to the cardfile shall be via plug-connected cables. All plug connectors, data transmission equipment, power supplies, power conditioning devices, terminal boards, wire connectors, and other equipment required to achieve a complete, standalone subsystem shall be mounted within the instrument rack along with the associated processor units.
- C. The Microprocessor-Based Vital Interlocking System and Non-Vital Logic Controller shall be installed as part of the factory fabrication of each complete CIH, Satellite house, or train control room. The microprocessor-based equipment to be furnished for this Project shall be provided on pre-wired rack assemblies and shall be installed in the interlocking and station relay rooms as per the Contract Drawings.

- D. The installation of the microprocessor equipment shall be coordinated with the installation of all other equipment described in Division 13.

3.03 TESTING

- A. The system apparatus shall be included in the complete factory test procedures as required by the Signal System Testing and Reliability Assessment Section of these Specifications. Final in-service testing shall also comply with this specification.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13579
DESIGN REQUIREMENTS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for design requirements, in accordance with the Contract Documents.
- B. The work of this section includes, but is not limited to, the following activities:
 1. Conceptual Design Review
 2. Preliminary Design Review
 3. Final Design Review
 4. Post Final Design Review change control
 5. Design and Construction Drawings and Data
 6. Parts List
 7. As-built Drawings and Documentation
 8. Software Documentation and Support Items
- C. The Contract Documents provide the performance parameters and design criteria to complete the design requirements. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 13570, "Signal System Requirements,"
- B. Section 13574, "Wayside Signal Equipment,"
- C. Section 13576, "Circuit Requirements,"
- D. Section 13577, "Solid-State Equipment,"
- E. Section 13580, "Train-to-Wayside Communications,"
- F. Section 13581, "Local Control Panels,"
- G. Section 13582, "Safety and Systems Assurance,"
- H. Section 13585, "Installation Requirements,"
- I. Section 13587, "Wire and Cable,"
- J. Section 13588, "Relays and Plugboards,"

- K. Section 13589, "Electrical and Electronic Components,"
- L. Section 13590, "Housing and Housing Equipment,"
- M. Section 13591, "Tags, Locks and Keys,"
- N. Section 13593, "Signal Power Distribution,"
- O. Section 13595, "Signal System Test and Inspection."

1.03 REFERENCE STANDARDS

- A. AREMA Communication and Signal Manual of Recommended Practices.
- B. FRA.
- C. NEC.
- D. NESC.
- E. ICEA.
- F. ASTM.
- G. ANSI.
- H. UL.

1.04 SUBMITTALS

- A. Conceptual Design Review (CDR) Documentation.
- B. Preliminary Design Review (PDR) Documentation.
- C. Final Design Review (FDR) Documentation.
- D. Design and Construction Drawings and Data.
- E. Parts List.
- F. As-built Drawings, Documentation and Software Programs.
- G. Software Documentation and Support items.
- H. The Contractor's design drawings shall be sealed by a Professional Engineer registered in the State of Pennsylvania.

ARTICLE 2 PRODUCTS

2.01 GENERAL PRODUCT REQUIREMENTS

- A.** The Contractor shall be responsible for the safety of the Signal System and shall optimize reliability and maintainability.
- B.** All equipment and material shall be standard products of manufacturers regularly engaged in the production of signaling and train control equipment and material, and conform to the standards specified here-in where applicable.
- C.** All equipment, materials and products provided by the Contractor shall require approval of the Engineer.
- D.** Assemblies and components that perform identical functions within the Signal System shall be mechanically and electrically interchangeable. Standardized, commercially available components, if available from multiple sources, shall be used whenever possible, particularly for items which require replacement at predictable intervals.
- E.** Geographic Alignment
 - 1. The relative lay of this system shall be considered North and South. North is inbound, away from the Central Business District and towards the Allegheny Terminal. South is outbound, towards the Central Business District and away from the Allegheny Terminal.
- F.** Modular Design
 - 1. The Contractor shall use modular design throughout and shall organize mechanical components to minimize mixing of equipment associated with two subsystems in one plug-in assembly.
 - 2. Equipment serving similar functions shall be in the same relative location on all racks where practical.
 - 3. Printed circuit cards designed to perform the same function shall be interchangeable regardless of whether these cards are used in the same or different rack-mounted plug-in assemblies.
 - 4. All printed circuit cards used for signal equipment shall be mechanically or electrically keyed to prevent improper insertion or operation.
- G.** Test Points
 - 1. Test points for checking essential voltages and waveforms and for injecting test signals shall be provided where required for troubleshooting and routine maintenance except where the vital function of a circuit is compromised.
 - 2. All test points shall be accessible without removing any components.
 - 3. Digital electronic equipment may use status or fault indicators instead of test points.
- H.** Adjustable
 - 1. Adjustable components shall be avoided wherever possible by use of appropriate circuitry, stable components, and high-tolerance circuits.

2. Adjustable components not intended for adjustment by operating personnel shall have locking devices or be self-locking to prevent inadvertent operation or drift. Special precautions, including limitation of adjustment range, shall be established for vital calibrations.
 3. Interacting adjustments shall be avoided.
 4. Where possible, replacement of components or printed circuit cards with spares shall not require compensating adjustments to other components or modules.
- I. When built-in indicators or a meter is associated with adjustments, the adjustment point shall be sufficiently closed to the associated indicator so both may be manipulated and observed by one person.
- J. Environmental Design Parameters:
1. All field installed systems and equipment, including vital and non-vital microprocessor equipment, but excepting modems, data transmission systems, and event recorder systems shall perform properly without damage under the following conditions:
 - a. Ambient temperature range of minus 40 degrees F to plus 158 degrees F.
 - b. Relative humidity range of 0 to 95 percent.
 - c. Signal equipment installed outside of the instrument house or relay room shall be designed to operate satisfactorily in all weather conditions such as rain, snow, dirt, temperature variations, and humidity variations. In addition, the recommendations of the AREMA Communication and Signal Manual of Recommended Practices, Part 1.5.5 shall be followed to minimize condensation and frost buildup.
 - d. The electrical environment to which the signal equipment will be exposed shall be determined by the Contractor. Design, manufacture, and field installation of the signal system shall prevent the site environment from affecting the signal system operation.
 2. Modems, data transmission systems, and event recorders installed within instrument housings shall perform properly without damage under the conditions described in Part 1, paragraph 1.06.B.1 above, with the exception that ambient operating temperature shall be -30F to +158°F.
- K. EMI-Related Design Requirements
1. The system shall be designed to operate in the electromagnetic environment of the LRT system and not cause interference to other systems.
 2. Equipment shall be designed, selected, and installed with consideration given to the electromagnetic environment, which includes but is not limited to traction power supply, AC power distribution systems, vehicle propulsion systems, communications systems, adjacent railroads, and electric utility lines.
- L. Compatibility with Existing System
1. Signal equipment which interfaces with the existing equipment shall be interconnected and compatible with the existing to form a complete, functional, and seamless signal system.

M. Maintainability Design Requirements

1. All test points, indications, and components requiring adjustment or replacement shall be visible and accessible while mounted in their normal position, without disassembly of other components.
2. Test points for checking essential voltages and wave forms shall be clearly and permanently labeled and provided wherever required for trouble shooting and routine maintenance, and be capable of accepting probes and connectors used with standard equipment such as voltmeters and oscilloscopes. Accessible points shall be provided and labeled where signals need to be injected for testing.
3. Built in indicators or meter shall be provided where observations or adjustments are necessary. All electronic modules shall be equipped with LED indicators. They shall at a minimum demonstrate that each function of the module is performing correctly. All indicators shall be labeled.

N. Safety Requirements

1. Whenever an unsafe condition could develop from an equipment failure, failsafe design techniques shall be used to prevent the occurrence of unsafe conditions. An unsafe condition is a condition in which a hazard to property, equipment, or life can exist and that hazard can lead to major damage, serious injury, or death.
2. Failsafe principles shall mean that whenever equipment fails, or adverse environmental conditions affect proper operation of a system involved with the safety of life or property, the system shall revert to a state known to be safe.
3. Failsafe principles shall include but not limited to the following:
 - a. Failsafe circuits shall employ the closed loop principle and protect against any combination of open circuits, shorts or grounds.
 - b. Vital relay circuits shall meet AREMA Communications and Signals Manual of Recommended Practices requirements for the use of vital relays and design.
 - c. Components or wires becoming grounded or broken, or with damaged contacts, shall not cause an unsafe condition when added to one or more failures. Grounding or test points shall not cause an unsafe condition.
 - d. Any amplifier, generator, or active device breaking into spurious oscillations shall not cause an unsafe condition.
 - e. Filters used in failsafe circuits shall be designed to prevent undesired signals from passing through the filters at levels which could cause an unsafe condition in event of component failures.
 - f. Components or systems which are not self-detecting shall not cause unsafe conditions, even if added to other failures.
 - g. A single independent failure or any number of simultaneous component or system failures attributable to the same cause or related causes shall not cause unsafe conditions.
 - h. Removal of printed circuit boards or assemblies shall not cause unsafe conditions.
 - i. Any increase or decrease in both AC and DC power supply voltages shall not cause unsafe conditions.

- j. Each circuit, the functioning of which affects safety or train operations, shall be kept free of any ground or combination of grounds which will permit a flow of current equal or in excess of 75 percent of the release value of any relay or other electromagnetic device in the circuit, except circuits which break signal control circuits using a grounded common, and alternating current power distribution circuits which are grounded in the interest of safety.
 - k. All vital relay circuits that leave or enter signal houses/rooms and instrument cases shall be double-break circuits.
4. Equipment failures and conditions which shall be considered in producing a fail-safe design include, but are not limited to the following:
- a. Vital relays: As specified in these Contract Documents.
 - b. Non-Vital Relays: Open coil, high contact resistance, shorted coil, armature sticking, contact sticking.
 - c. Transformers: Open primary, open secondary, shorted turns, primary-to-secondary shorts, and combinations of the foregoing.
 - d. Capacitors: Shorts, opens, and leakage.
 - e. Resistors: Shorts, opens, increase and decrease in resistance.
 - f. Transistors; Diodes: Shorts, opens, leakage.
 - g. Coils: Open and shorted turns.
 - h. Loss and degradation of power sources.
 - i. Abnormal signal levels, frequencies, and delays.
 - j. Effects of electrical interference.
 - k. Absent and abnormal input signals.
 - l. Opens and shorts in internal circuitry at inputs and outputs.
 - m. Mechanical vibration and shock including but not limited to train movement, switch operation, operation of heavy machinery, the passage of motor vehicles, and seismic activity.
 - n. Drift and instability of amplifiers, receivers, transmitters, oscillators switching circuits, and power supplies.
 - o. Deterioration of contacts, connectors, terminals, solder connections, printed circuits, and mechanical devices.

O. Layout

- 1. Rack arrangement: As specified in Section 13590, "Housings and Housing Equipment."
- 2. Equipment arrangement
 - a. Relays and equipment panels shall not be mounted higher than 6.5 feet or lower than 18 inches from the finished floor.
 - b. Terminal and connector panels and power distribution panels shall be mounted above all other apparatus mounted on rack. Power distribution panels shall house power connectors and filters for equipment rack power.
 - c. All equipment and components shall be accessible for testing or replacement without removal of other components.
 - d. Two or more points of adjustment required during the same operation shall be

located in such a way to be operated by one person.

P. Wiring

1. All cables shall be terminated on standard AREMA terminals with concave test link nuts. These nuts, when backed off, will open circuits without having to remove wires from the terminal posts. A maximum of two wires shall be permitted on each AREMA terminal.
2. Main power feeders shall have segregated facilities for entering and exiting each relay/instrument housing/room. Power feeders shall be terminated on the power rack, sideboards or shelves and protective covers provided for personnel safety.
3. Wires distributing AC and DC power within each instrument housing/room and case shall originate from the power rack and terminate on power distribution terminals of individual racks.
4. Except for main power feeders, all wiring entering or exiting each equipment housing/room shall be connected with crimp connectors to AREMA terminals located on the entrance rack or main terminal boards.
5. Entrance rack or terminal board terminations shall be constructed and arranged to permit relay/instrument housing/room and case wiring to be isolated from field wiring, on an individual wire basis, without removing wires from their terminals. This shall be accomplished by the use of standard AREMA terminals and concave test link nuts as specified in AREMA Communications and Signals Manual of Recommended Practices, Part 14.1.11 or as approved by the Engineer.
6. Interconnecting wiring from power racks, equipment racks, entrance racks or terminal boards shall be installed in overhead cable trays or troughs to the individual equipment racks. Where plug connectors are used, wiring shall be arranged to prevent voltage on exposed pins when disconnected.
7. Vertical wire runs from the overhead cable tray to individual equipment racks shall be neatly formed and secured at 6 inch intervals. Branch wires form these vertical runs to individual relays or equipment on racks shall be run in plastic trays.
8. Where a full hand grasp is required to connect or disconnect a connector or fastener, a minimum of 2 inches of clear space around the connector or fastener shall be provided. A minimum of 0.75 inch clear space shall be provided around connectors and fasteners which can be connected or disconnected with thumb or fingertips.
9. All wiring shall be supported at intervals that maintain an orderly installation and provide strain relief, particularly near terminal points.
10. Mechanical strength of each connection shall be at least 85 percent of the mechanical strength of the wire. Electrical conductivity of each connection shall be at least 95 percent of the electrical conductivity of the wire.
11. A minimum of 20 percent spare terminals and spare wires in multiconductor cables (6 minimum) shall be provided on each terminal block. Terminals used for the termination of spare wires shall be considered spare terminals. Exceptions to this requirement shall be submitted to the Engineer for approval.
12. Where card cages, switch modules, or switch matrices are installed, all

connections on the back plane or switch base shall be wired to the main frame regardless of whether cards are to be installed or switch or light functions are to be used in the initial system functions. Panel connections shall be plug or connector ended to facilitate removal for maintenance.

13. All wires connecting to relay plugboards and sockets shall be crimped.
- Q. All exposed AREMA terminals containing a voltage of 110V or higher shall be protected with insulated molded caps (Union Switch & Signal #J078147 or approved equal).
- R. Circuit Design Requirements:
 1. Train safety shall be the prime consideration in the design of the NSC Signal System and in the selection of its components including vital processors, relays and other devices with moving parts, insulated wire, wire terminals, binding posts, housings, conduits, resistors, capacitors, transformers, inductors and other similar items. The entire Signal System shall meet or exceed the requirements of this Section.
 2. Circuit design shall conform to the AREMA Communication and Signal Manual of Recommended Practices and Authority design practices. Signal system nomenclature shall be interpreted as shown on the Contract Drawings.
 3. In this Section the terms "restrictive" and "permissive" are used in connection with the binary outputs of two-position components or subsystems and denote such alternatives as: a lower speed and a higher speed; deceleration and acceleration; brakes applied and brakes released; actuation of alarm and no actuation of alarm; etc., respectively.
 4. The following requirements shall govern the design of the portions of the system or a subsystem which effect train safety:
 - a. Only components which have high reliability and predictable failure modes and rates and which have been proven in conditions similar to the projected service shall be utilized.
 - b. Components shall be combined in a manner that a restrictive rather than a permissive condition will result from component failure.
 - c. All circuits which are not confined to one housing, and which affect safety shall be double-wire, double-break, except signal lighting circuits.
 - d. The design shall be based on closed circuit principles. Broken wires, broken rails, dirty contacts, a relay failing to respond when energized or a loss of power supply energy shall not result in unsafe conditions.
 - e. Component or system failures shall cause a more restrictive signal indication than permitted with no failure.
 - f. System safety design shall be such that any number of simultaneous component or system failures attributable to the same cause or related causes shall not cause unsafe conditions. Failures that are not independent (those failures which in turn always cause others), shall be considered in combination as a single failure and shall not cause an unsafe condition. Any non-detectable failure in combination with any other failure shall not permit an unsafe condition to occur.
 - g. Electronic circuit design shall ensure that the following types of component

- failures have a restrictive rather than a permissive effect:
- (1) Two terminal devices: open, short, partial open or partial opens and/or partial shorts.
 - (2) Multi-terminal devices: combination of opens, shorts, partial opens and/or partial shorts.
- h. Wherever possible, built-in checks shall be included that impose a restriction and/or actuate an alarm whenever a device fails to assume its most restrictive position and conditions require that it should.
 - i. Redundant design by itself shall not be considered an acceptable method of assuring design safety.
 - j. Questions on design intent shall be directed to the Authority and approved before commencement of design.
 - k. The vital application firmware shall define the operation of the vital interlocking system. Control logic to be incorporated in the vital application firmware is as specified in the Solid State Equipment Section of these Specifications and as shown on the Contract Drawings.
- 5. Service Proven Equipment and Design
 - a. The Contractor shall furnish signal equipment proven in similar North American transit service and shall make use of its experience to prepare a suitable and proven detail design for this Project.
- S. The Contractor shall be fully responsible for the safety of the new NSC Signal System, independent of any other requirements of this Specification. The "Block Layouts," and "Control Lines" provided in the Contract are to be followed and incorporated in the final design of the NSC Signal System as shown.

ARTICLE 3 EXECUTION

3.01 DESIGN REVIEWS

- A. There shall be three formal design review meetings prior to the Engineer's acceptance of final design of the Signal System. The required design reviews are:
 1. Conceptual Design Review.
 2. Preliminary Design Review.
 3. Final Design Review.
- B. Each design review has purpose, with specific documents and issues that are to be reviewed, resolved, and approved before proceeding to the next step.
- C. Before each design review meeting, the following shall be distributed by the Contractor to those attending at least 21 days before the meeting.
 1. Date, time, and place of meeting.
 2. List of invited attendees.
 3. Agenda listing purpose of the meeting, objectives to be achieved, and items to be discussed.
 4. Submittals pertaining to the design review.

5. List of any open items to be discussed from previous meeting.
- D. The Contractor's System Assurance organization shall participate in all design reviews.
- E. Design review meetings shall be included in the Project Schedule.
- F. The Engineer will publish minutes of the design review meetings.

3.02 CONCEPTUAL DESIGN REVIEW (CDR)

- A. The purpose of the CDR is to ensure the Contractor has a full understanding of the Authority's operations and Project requirements, and to give the Contractor the opportunity to explain how its proposed design meets those requirements
- B. The following submittals shall be distributed before the CDR:
 1. Design Definition Document.
 2. Preliminary Operations Scenarios.
 3. Quality Assurance Program and other submittals required by Section 01400, "Quality and Product Reference".
 4. Service History of Vital Equipment Locations. Refer to Section 13577, "Solid-State Equipment.
 5. Systems Assurance Program Plan. Refer to Section 13582, "Safety and Systems Assurance."
 6. Most recent updates to the Project Schedule.
 7. Inspection and Test Plan. Refer to Section 13595, "Signal System Test and Inspection."
 8. Other submittals as indicated in Section 01300, "Administrative Requirements".
- C. At the CDR, following issues shall be discussed:
 1. The Contractor's familiarity with the intended operations and maintenance environment of Authority.
 2. The Contractor's understanding of the system requirements.
 3. The Contractor's proposed Quality Assurance Program.
 4. The Contractor's process that shall be used to develop and implement the design.
 5. Information needs and decisions required.
 6. Submittals distributed before the CDR.

3.03 PRELIMINARY DESIGN REVIEW (PDR)

- A. The purpose of the PDR is to:
 1. Assess the progress, consistency, and technical adequacy of the design.
 2. Check the compatibility of the design with functional and performance requirements.
 3. Verify the compatibility of the interfaces between the software, hardware, and final product.

- B. The following submittals shall be distributed before the PDR:
1. Final Operations Scenarios.
 2. Design drawings for the first location.
 - a. Arrangement plans: Show the arrangement of equipment, facilities, or components in a room, rack, junction box, housing, or module. Include dimensions to identify locations and clearance between components.
 - b. Typical Circuit drawings: Show the control, operating, and indicating circuits logic printout and relay circuit plans identifying all circuit breaks, connectors, branches, and terminations. Show actual wire routing and termination scheme. Circuit drawings are further described in Section 13576, "Circuit Requirements."
 - c. Electrical wiring and connection diagrams: Show the details of electrical connections for various parts of the signal system equipment.
 - d. Power distributions schematics: Show the various power distribution systems or subsystems including the power calculations.
 - e. Equipment layout drawings: Show the layout of all equipment in room, including equipment locations, room dimensions, and the location of lights, wireways, and conduits.
 - f. Local Control Panel (LCP) Faceplate Layouts
 3. System design drawings.
 - a. Block diagrams: Show the system, subsystem, and modules.
 - b. Control line drawing: Show the control lines for each track section or block in both the normal and reverse direction of traffic, approaches, all block boundaries, insulated joints, signals, points of switch, grade and curve data, true distance versus stationary conversions, civil and safety speed restrictions, and approach locking zones.
 - c. Product and equipment drawings: Include power supplies, switch machines, signal modules, etc. Show dimensions and internal mechanical and electrical details.
 - d. System and subsystem drawings: Show the wiring and connection diagrams for the individual system and subsystems being provided.
 4. TWC equipment Product Data, Shop Drawings and specifications.
 5. Installation drawings.
 - a. Equipment layouts.
 - b. Relay room.
 - c. Junction boxes.
 - d. Mounting details.
 - e. Location plans.
 - f. Cable plans.
 - g. Conduit and cable trough layouts.
 6. Inspection and Test Plan. Refer to Section 13595, "Signal System Test and Inspection."
 7. Preliminary Parts List.
 8. Preliminary Recommended Spare Parts List and List of Special Tool and Test Equipment. Refer to Section 18040, "Spare Parts and Test Equipment."

9. Training Program Plan. Refer to Section 01910, "Operations, Maintenance and Repair Data."
 10. Protocols and Code and Function Assignments for OCC controls and indications. Refer to Section 16950, "Operations Control Center System (OCCS) Upgrade."
 11. Other submittals as may be indicated elsewhere within these Specifications.
- C. The Contractor is encouraged to submit PDR information incrementally to reduce the duration of the formal meeting. Ideally, the formal PDR meeting should be limited to confirmation or previously reviewed, commented on, and approved-in-principle submittals and resolution of open items.
- D. At the PDR, the following issues shall be discussed:
1. Overall system design and operation.
 2. Hardware components to be supplied under the Contract.
 3. System interfaces, both internal and external.
 4. How design meets requirements for reliability, availability, and maintainability.
 5. Training program, including training materials, facilities, products, classes, and schedule.
 6. Special tools and test equipment.
 7. Impact of design decisions on the Project Schedule.
 8. Information needs and decisions required.

3.04 FINAL DESIGN REVIEW (FDR)

- A. The purpose of the FDR is to verify that the detailed design meets performance and technical requirements before implementation.
- B. The following submittals shall be distributed before the FDR:
1. System design drawings.
 - a. Cable plans: Show point-to-point cable runs and indicate cable makeup, cable identification number, conductor size, conduit identification, cable tray identification, duck identification, and splice locations.
 - b. Double line track plans: Show the track configuration, including profile/alignment, civil speed limits, type of civil structure information, and the location of wayside equipment.
 - c. Route and aspect charts: Show all elements pertinent to the routing of trains through interlockings.
 2. System integration plan.
 3. System changeover plan.
 4. Recommended Spare Parts List and List of Special Tool and Test Equipment. Refer to Section 01830: "Spare Parts and Test Equipment."
 5. Parts List.
 6. Final Inspection and Test Plan.
 7. Other submittals as may be indicated elsewhere within these Specifications.
- C. Contractor is encouraged to submit FDR information incrementally to reduce the

duration of the formal meeting.

- D. At the FDR, the following issues shall be discussed and demonstrated:
 1. Complete system satisfies the performance and design requirements.
 2. Interfacing to internal and external systems meets requirements.
 3. System maintenance, the effects of system maintenance on hardware and software components, and the role of Authority maintenance personnel.
 4. Plan for conducting system integration test.
 5. Plan for transitioning from the existing system to the new system.
 6. Plan for providing system support.
 7. Proposed change management procedure. Refer to Section 01430, "Quality and Configuration Management."
 8. Impact of design decisions on the Project Schedule.
 9. Information need and decisions required.

3.05 POST-FDR CHANGE CONTROL

- A. After completing the FDR, system design is frozen. From this point on, engineering change control procedures are in effect as described in Section 01739, "Quality and Configuration Management."

3.06 DESIGN AND CONSTRUCTION DRAWINGS AND DATA

- A. Design and construction drawings and data shall be prepared and submitted as specified in the contract documents.
- B. Drawings prepared for submittal shall be organized into sets, generally one set per equipment location. Individual sets shall be supplied for each signal location; typicals will not be accepted. Contractor shall not conduct System Level Factory Inspections and Tests of a location until its drawings are approved by the Engineer.
- C. Each set shall include the following types of drawings, if applicable, arranged in the order listed below:
 1. Title, Index, Symbol and Abbreviations Sheets.
 2. Location plan(s) drawn to scale of 1 inch equals 10 feet, showing a double-line track plan and the location, chaining outline, and installation details of all wayside equipment, including signals, impedance bonds, track circuits, switches, relay rooms/instrument houses and cases, switch heater cases, junction boxes, and track loops.
 3. Installation plans, drawn to scale, including mounting requirements, clearances, rail connections, foundations, and all data necessary for a complete physical installation. The plans shall identify the location of the cable and equipment installation.
 4. Cable plans, drawn to scale, showing all cable runs between locations and junction boxes where cables are terminated and dropped to serve equipment locations. Nomenclature, type, number, and gauge of conductors shall be shown

- for each cable run.
- 5. Complete material and parts tabulation for all equipment assemblies used on the Project. Each separately identified item or component that is dealt with at field level shall be assigned an item number which shall appear adjacent to the representation of the item on all drawings. The material tabulation shall identify each item by description, part number, drawing number, general characteristics, and manufacturer's or supplier's model number. The material tabulation shall be updated as new or different items are incorporated in the design and retransmitted for approval.
 - 6. Track circuit drawings, drawn to scale, showing all track circuits for the location. The track circuits shall be placed on the drawing so that their physical placement on the drawing correlates with the actual location of the track circuit.
 - 7. Line circuit drawings, drawn to scale, showing all line circuits terminating at the location, with circuits continuing southward to the right.
 - 8. Signal control logic, equivalent and circuit drawings.
 - 9. Switch control logic, equivalent, and circuit drawings.
 - 10. Drawings of repeaters and miscellaneous circuits and logic.
 - 11. Power distribution drawings, including bus loops where used, for each relay rack.
 - 12. Rack layout drawings showing the physical position and material reference number of each piece of equipment on each rack.
 - 13. Terminal board layout drawings for each terminal board at the location showing each terminal, terminal number, and the nomenclature of each wire.
 - 14. Layout drawings of each equipment enclosures showing door positions, racks, shelves, terminal boards, and cable entrances.
 - 15. On wiring diagrams, the circuits and information from two or more consecutive drawing types may be consolidated into one drawing provided the order of the drawing information remains as shown. Material lists, catalog information, spare parts list, shop assembly drawings, and drawings which are not specifically associated with any one location are not to be included in each drawing set, but shall be included in other design submittals.
- D. Installation drawings shall be submitted for approval at least 120 days before installation is scheduled to begin. Installation without approved drawings shall be at Contractor risk.

3.07 PARTS LIST

- A. Contractor shall submit a preliminary parts list at PDR, and a final parts list at FDR for all equipment furnished under the Contract.
- B. The list shall include replaceable components, circuit boards, relays, switches, signals, switch locks, assemblies, consumable items, meters and instruments, electrical fittings, nameplates, tags, and all comparable items.
- C. The listing shall include component name, drawing reference, description, rating, accuracy class, tolerance, part number, supplier or source, and any other essential data.

- D. The parts list shall be provided in a matrix form that shows the quantity of each item used at each location such as an interlocking, or relay/instrument house or case.
- E. This matrix shall be the basis of the Recommended Spare Parts list as described in Section 01840, "Spare Parts and Test Equipment."

3.08 AS-BUILT DRAWINGS AND DOCUMENTATION

- A. When all equipment has been installed and all changes have been placed in service, Contractor shall prepare and provide Project Record Documents and as-built drawings, documentation, and program printouts of all software for each processor unit, as specified in the Contract Documents.
- B. In addition, Contractor shall furnish all drawings on CD-ROM in DWG format utilizing AutoCad Version 2008. A list of each file name by drawing number, date, and file size shall also be provided on the CD-ROM.
- C. Modified non-vital microprocessor program listings and electronic files shall reflect the as-built condition. The format and media shall be submitted for review and approval of the Engineer.

3.09 SOFTWARE DOCUMENTATION AND SUPPORT ITEMS

- A. All system application-dependent software/firmware shall be completely maintainable by Authority's maintenance personnel. This includes all application-dependent logic programming of both vital and non-vital processors.
- B. The Contractor shall furnish and supply development tools, documentation, compilers, assemblers, loading facilities, PROM programming equipment, and all other support facilities and tools necessary for the design and implementation of application-dependent software/firmware.
- C. It is the Authority's intent that future changes to interlocking logic, embedded timer values, control lines, and other signal system parameters can be designed and implemented by the Authority's personnel.
- D. The Contractor shall furnish, install, and test a complete set of computer hardware, including monitor and other peripherals necessary for the design and implementation of changes to any and all application-dependent software/firmware supplied as part of this Contract.
- E. The Contractor shall provide the software documentation and support items described within this Article 3.09 separate from the tools and test equipment that Authority purchases from the Contractor's Recommended Spare Parts List and for no additional payment for the predetermined amount described in Section 01840, "Spare Parts and Test Equipment."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 13579.001 - Conceptual Design Review shall be measured as a lump sum unit, complete in place.
- B. Item 13579.002 - Preliminary Design Review shall be measured as a lump sum unit, complete in place.
- C. Item 13579.003 - Final Design Review shall be measured as a lump sum unit, complete in place.
- D. Item 13579.004 - Software Documentation and Support shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. Item 13579.001 - Conceptual Design Review will be paid at the lump sum price and shall include the cost of all related work specified in this Section.
- B. Item 13579.002 - Preliminary Design Review will be paid at the lump sum price and shall include the cost of all related work specified in this Section.
- C. Item 13579.003 - Final Design Review will be paid at the lump sum price and shall include the cost of all related work specified in this Section.
- D. Item 13579.004 - Software Documentation and Support will be paid at the lump sum price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 13580

TRAIN TO WAYSIDE COMMUNICATIONS (TWC)

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for Train to Wayside Communications (TWC), in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Hardware and software modifications to existing locations in order to implement the design.
 - 2. Furnishing of test equipment to setup and troubleshoot the TWC wayside and carborne components.
 - 3. Design, furnishing, installation and test of TWC equipment at new locations in order to implement the design.
- C. The Contract Documents provide the performance parameters and design criteria to complete the Train to Wayside Communications (TWC). The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 01739, "Quality and Configuration Management"
- C. Section 01840, "Spare Parts and Test Equipment"
- D. Section 01910, "Operations, Maintenance and Repair Data"
- E. Section 13570, "Signal System Requirements"
- F. Section 13576, "Circuit Requirements"
- G. Section 13577, "Solid-State Equipment"
- H. Section 13585, "Installation Requirements"
- I. Section 13587, "Wire and Cable"
- J. Section 13595, "Signal System Test and Inspection"

1.03 REFERENCE STANDARDS

- A. AREMA Communication and Signal Manual of Recommended Practices.
- B. MIL-STD 810, "Environmental Test Methods and Engineering Guidelines."

1.04 SUBMITTALS

- A. Product Data, Shop Drawings and specifications for all TWC system equipment.
- B. Installation Shop Drawings.
- C. Genisys and TWC programming changes.
- D. Route ID and routing list.

1.05 DESIGN REQUIREMENTS FOR THE TWC SYSTEM

- A. The Contractor's work includes hardware and software modifications to existing locations in order to implement the design.
- B. The equipment to be supplied by the Contractor shall include test equipment to setup and troubleshoot the TWC wayside and carborne components.
- C. The Contractor shall furnish, install and test TWC equipment that provides for accurate and secure transmission of information between the vehicle equipment and the wayside interrogators at appropriate points along and route of travel. At these points, a fixed coil shall pick up the transmission of information from the vehicle transponder as it passes over the coil.
- D. The TWC equipment shall be capable of initiating auto routing, requesting and canceling a signal or route, and transmitting train ID.
- E. The TWC equipment shall be fully compatible with TWC equipment currently in service on the LRT system, both carborne and wayside. The Contractor shall provide Hanning & Kahl Model HCS-R radio Control system TWC equipment or approved equal as this is what is currently installed on the existing Authority LRVs.
- F. The carborne TWC equipment shall transmit the following information and controls to the wayside equipment:

Permanent Vehicle ID	12 bits of 3 Binary coded decimals
1. Spare (old PCC/LRV bits)	4 bits
2. Route ID	12 bits of 3 Binary coded decimals
3. Silent alarm	1 bit
4. Trip indication	1 bit
5. Start control	1 bit
6. Cancel control	1 bit

1.06 ROUTE CODE INFORMATION

A. Table 13580-1 below lists the route code entered by the LRV operator for the existing TWC system and the corresponding route associated with the code. In the current system, all inbound trains to Gateway Station are automatically routed back via the loop at Gateway Interlocking. This Project will remove the existing loop at Gateway and extend the line to Allegheny Interlocking which is configured as a terminal. As such, in the final configuration of the system, the existing route codes that currently loop back at Gateway will be utilized for the turn back operation at Allegheny Station and Terminal. This change is indicated within Table 13580-1.

Table 13580-1, Route Codes for Allegheny Station Turn-back

TWC CODE	I=Inbound O=Outbound	Route Description
042	O	SHV to Library via WJ Pocket Track
052	I	Library to Yard via WJ Pocket Track
952	I	Library to Yard Pocket Track via WJ Pocket Track
101	I/O	SHV to Allegheny Station to Yard via Beechview and Mt. Washington Tunnel
102	I/O	SHV to Allegheny Station to Yard via Overbrook and Mt. Washington Tunnel
103	I/O	SHV to Allegheny Station to Yard via Beechview and Arlington
104	I/O	SHV to Allegheny Station to Yard via Overbrook and Arlington
191	I/O	SHV to Allegheny Station to Yard Pocket Track via Beechview and Mt. Washington Tunnel
192	I/O	SHV to Allegheny Station to Yard Pocket Track via Overbrook and Mt. Washington Tunnel
193	I/O	SHV to Allegheny Station to Yard Pocket Track via Beechview and Arlington
194	I/O	SHV to Allegheny Station to Yard Pocket Track via Overbrook and Arlington
131	I/O	Library to Allegheny Station to Library via Beechview and Mt. Washington Tunnel
132	I/O	Library to Allegheny Station to Library via Overbrook and Mt. Washington Tunnel
none	I/O	Mt Lebo to Allegheny Station to Mt Lebo via Beechview and Mt. Washington Tunnel
141	I/O	Mt Lebo to Allegheny Station to Mt Lebo via Beechview and Mt. Washington Tunnel
012	I/O	Yard to WJ Pocket Track to Yard
912	I/O	Yard to WJ Pocket Track to Yard Pocket Track
092	I/O	Library to WJ Pocket Track to

TWC CODE	I=Inbound O=Outbound	Route Description
		Library
111	I/O	SHV to Allegheny Station to SHV via Beechview and Mt. Washington Tunnel
112	I/O	SHV to Allegheny Station to SHV via Overbrook and Mt. Washington Tunnel
113	I/O	SHV to Allegheny Station to SHV via Beechview and Arlington
114	I/O	SHV to Allegheny Station to SHV via Overbrook and Arlington
133	I/O	Library to Allegheny Station to Library via Beechview and Arlington
134	I/O	Library to Allegheny Station to Library via Overbrook and Arlington
143	I/O	Mt. Lebo to Allegheny Station to Mt. Lebo via Arlington
151	I/O	CS Junction to Allegheny Station to CS Junction via Beechview and Mt. Washington Tunnel
152	I/O	CS Junction to Allegheny Station to CS Junction via Beechview and Arlington
161	I/O	SH Junction (OB Stub) to Allegheny Station to SH Junction (Stub) via Mt. Washington Tunnel
162	I/O	SH Junction (OB Stub) to Allegheny Station to SH Junction (Stub) via Arlington
201	I/O	Yard to Allegheny Station to Yard via Beechview and Mt Washington Tunnel
202	I/O	Yard to Allegheny Station to Yard via Overbrook and Mt. Washington Tunnel
203	I/O	Yard to Allegheny Station to Yard via Beechview and Arlington
204	I/O	Yard to Allegheny Station to Yard via Overbrook and Arlington
291	I/O	Yard to Allegheny Station to Yard Pocket Track via Beechview and Mt Washington Tunnel
292	I/O	Yard to Allegheny Station to Yard Pocket Track via Overbrook and Mt. Washington Tunnel
293	I/O	Yard to Allegheny Station to Yard Pocket Track via Beechview and Arlington
294	I/O	Yard to Allegheny Station to Yard Pocket Track via Overbrook and Arlington

- B. Gateway Station will be temporarily closed to passenger operations during the construction of this Project. During this shutdown, turn-back operations shall take place at Wood Street Station. As such, the existing TWC route codes entered by the LRV operator for the existing TWC system shall be utilized to provide temporary turn-back operations at Wood Street Interlocking. This change is indicated within Table 13580-2. Route 42S, 42L and 52 Trains (Beechview and Allentown Line) shall be temporarily routed to the Outbound Platform (Left Track) at Wood Street Station.

Route 47L and 47S Trains (Overbrook Line) shall be temporarily routed to the Inbound Platform (Right Track) at Wood Street Station. The Contractor shall provide all TWC equipment required to implement the temporary turn back operation at Wood Street Station. The Contractor shall also remove this equipment and return it to the Authority at South Hills Village when the construction of this Project is complete so as to enable train operations and turn-back at the new Allegheny Station and Terminal. Table 13580-2 below lists the route code entered by the LRV operator for the temporary turn-back operation.

Table 13580-2, Route Codes for Wood Street Temporary Turn back

TWC CODE	I=Inbound O=Outbound	Route Description
042	O	SHV to Library via WJ Pocket Track
052	I	Library to Yard via WJ Pocket Track
952	I	Library to Yard Pocket Track via WJ Pocket Track
101	I/O	SHV to Wood Street Station Outbound Platform to Yard via Beechview and Mt. Washington Tunnel
102	I/O	SHV to Wood Street Station Inbound Platform to Yard via Overbrook and Mt. Washington Tunnel
103	I/O	SHV to Wood Street Station Outbound Platform to Yard via Beechview and Arlington
104	I/O	SHV to Wood Street Station Outbound Platform to Yard via Overbrook and Arlington
191	I/O	SHV to Wood Street Station Outbound Platform to Yard Pocket Track via Beechview and Mt. Washington Tunnel
192	I/O	SHV to Wood Street Station Inbound Platform to Yard Pocket Track via Overbrook and Mt. Washington Tunnel
193	I/O	SHV to Wood Street Station Outbound Platform to Yard Pocket Track via Beechview and Arlington
194	I/O	SHV to Wood Street Station Outbound Platform to Yard Pocket Track via Overbrook and Arlington
131	I/O	Library to Wood Street Station Outbound Platform to Library via Beechview and Mt. Washington Tunnel
132	I/O	Library to Wood Street Station Inbound Platform to Library via Overbrook and Mt. Washington Tunnel
none	I/O	Mt Lebo to Wood Street Station Outbound Platform to Mt Lebo via Beechview and Mt. Washington Tunnel
141	I/O	Mt Lebo to Wood Street Station Outbound Platform to Mt Lebo via Beechview and Mt. Washington Tunnel
012	I/O	Yard to WJ Pocket Track to Yard
912	I/O	Yard to WJ Pocket Track to Yard Pocket Track
092	I/O	Library to WJ Pocket Track to

TWC CODE	I=Inbound O=Outbound	Route Description
		Library
111	I/O	SHV to Wood Street Station Outbound Platform to SHV via Beechview and Mt. Washington Tunnel
112	I/O	SHV to Wood Street Station Inbound Platform to SHV via Overbrook and Mt. Washington Tunnel
113	I/O	SHV to Wood Street Station Outbound Platform to SHV via Beechview and Arlington
114	I/O	SHV to Wood Street Station Outbound Platform to SHV via Overbrook and Arlington
133	I/O	Library to Wood Street Station Outbound Platform to Library via Beechview and Arlington
134	I/O	Library to Wood Street Station Outbound Platform to Library via Overbrook and Arlington
143	I/O	Mt. Lebo to Wood Street Station Outbound Platform to Mt. Lebo via Arlington
151	I/O	CS Junction to Wood Street Station Outbound Platform to CS Junction via Beechview and Mt. Washington Tunnel
152	I/O	CS Junction to Wood Street Station Outbound Platform to CS Junction via Beechview and Arlington
161	I/O	SH Junction (OB Stub) to Wood Street Station Inbound Platform to SH Junction (Stub) via Mt. Washington Tunnel
162	I/O	SH Junction (OB Stub) to Wood Street Station Outbound Platform to SH Junction (Stub) via Arlington
201	I/O	Yard to Wood Street Station Outbound Platform to Yard via Beechview and Mt Washington Tunnel
202	I/O	Yard to Wood Street Station Inbound Platform to Yard via Overbrook and Mt. Washington Tunnel
203	I/O	Yard to Wood Street Station Outbound Platform to Yard via Beechview and Arlington
204	I/O	Yard to Wood Street Station Outbound Platform to Yard via Overbrook and Arlington
291	I/O	Yard to Wood Street Station Outbound Platform to Yard Pocket Track via Beechview and Mt Washington Tunnel
292	I/O	Yard to Wood Street Station Inbound Platform to Yard Pocket Track via Overbrook and Mt. Washington Tunnel
293	I/O	Yard to Wood Street Station Outbound Platform to Yard Pocket Track via Beechview and Arlington
294	I/O	Yard to Wood Street Station Outbound Platform to Yard Pocket Track via Overbrook and Arlington

C. The Contractor shall provide all software revisions and any necessary hardware or wiring revisions to the existing TWC system interrogator units at Wood Street

Interlocking and at Gateway Interlocking that are required to implement the route codes indicated within Table 13580-1 and 13580-2 above. In addition, The Contractor shall provide all TWC software, hardware and wiring at Allegheny Interlocking required to implement the route codes indicated within Table 13580-1 above. Such programming changes shall be submitted to the Engineer for review and approval.

- D. The Contractor shall provide the development system, computers, and any other items required for modifying the TWC system interrogator programs.

1.07 DESIGN REQUIREMENTS FOR WAYSIDE COMPONENTS

- A. Interrogator: The wayside components of the TWC System shall include an interrogator that is comprised of all of the wayside control equipment necessary to query transmitted decoded data messages for the vehicle transponder.
1. The interrogator shall interrogate carborne transponders and receive and process the transponder's reply.
 2. The interrogator shall transmit a signal, via the coil, to interrogate any vehicle transponders within the range of the coil.
 - a. The transmitter shall emit a signal for interrogation of the carborne transponder and to enable the interrogator receiver.
 3. The interrogator shall receive data messages from the vehicle transponder in range of the coil.
 4. The outputs shall be activated when a received message originating from a carborne transponder matches a pre-programmed bit pattern residing in the unit.
 - a. The system shall permit all route ID codes to generate the required automatic routes.
 - b. The system shall permit easy modifications of this programming.
 5. The interrogator shall be capable of receiving alternate messages from the transponder while stopped over a coil.
 6. Only one coil shall be active at any one time during the scanning process. If a transponder is present over one or more coils, the interrogator will process each transponder message in turn.
 7. The interrogator shall be outfitted with the following selection facilities:
 - a. Operating mode.
 - b. Transmitter gain.
 - c. Slow-down time (not in loop scanning) of internal or external clock (master/slave).
 - d. Parity check.
 - e. Single or double interrogation.
 - f. Slow-down function.
 - g. Application cards that provide a number of other adjustment facilities.

- B. Coil: The wayside components of the TWC System shall include a coil to receive transmissions from the vehicle transponder and forward the message to the wayside interrogator and shall be installed per the manufacturer's recommendations.

- C. Loop Scanner: A loop scanner feature shall be provided in order to permit one interrogator to serve up four coils. The loop scanner shall be used in conjunction with an interrogator configured to operate with more than one coil. The loop scanner shall serve as a junction box for terminating the coil feeder cables and contain circuitry to oversee the scanning (multiplexing) of more than one coil. Unused loop outputs must be terminated with a resistor or as recommended by the manufacturer.
- D. Wayside Coil Locations
 - 1. Not all wayside coils may be used for auto routing. Some coils may exist only to communicate the vehicle location to the OCC.
 - 2. All wayside coils shall communicate with the OCC, regardless of auto-routing status.
 - 3. All wayside coils shall be located as per the Contract Drawings.

1.08 DESIGN REQUIREMENTS FOR TEST EQUIPMENT

- A. Test Transponder.
 - 1. The Contractor shall provide a test transponder that has the ability to test an interrogator and the loop system for proper operation. The test transponder along with a portable test interrogator equipped with a data display card will be used to ensure that the system and printed circuit boards are functioning properly as designed.
- B. Portable Test Interrogator
 - 1. The Contractor shall provide a portable test interrogator that has the ability to test and aid in the setting up of the loop system. The test interrogator shall have the ability to display the TWC message that is being sent by either the LRV transponder or the test transponder via a data loop display card.
- C. Data Loop Display Card
 - 1. The Contractor shall provide a data loop display card for use in the portable test interrogator. The card shall have the ability to accurately display a TWC message via LED's or a numeric digital display.
- D. Test Radio
 - 1. The Contractor shall provide a test radio that has the ability to test the amplification strength of the interrogation signal being outputted by the portable test interrogator or the wayside interrogator when used in conjunction with the test transponder.

ARTICLE 2 PRODUCTS

2.01 WAYSIDE COMPONENTS

- A. Interrogator
 - 1. The interrogator shall be modular in nature and manufactured in a freestanding 19

- inch railroad signal rack.
2. All electronic circuitry for the interrogator shall be on removable printed circuit boards.
 3. The interrogator power supply shall operate from standard 120 VAC commercial power and provide the power to operate the interrogator unit.
 4. The various required interrogator functions shall be provided in a modular fashion so that separate functions are isolated to a particular printed circuit board or card.
 - a. Relay Output Card: This card shall be installed in on the available applications slots of the interrogator card rack and serve as the interface of the Programmable Decoder Card. An 8-bit output port on the Programmable Decoder Card shall be used to switch each one of eight relay coils on the relay output card. These 8 relays, each containing from-1C contact, shall be used to interface the TWC functions.
 - b. An LED or some other indicator on the board shall illuminate when active transponder is over the coil and the received signal is being processed.
 - c. Programmable Decoder (PD) Card
 - 1) The primary responsibility of the PD card shall be the reception and decoding of digital messages from passing transponder-equipped vehicles via the interrogator application backplane.
 - 2) The state of each opto-output circuit shall be based on a specific pre-programmed data bit pattern.
 - 3) Software decoding instructions (masks) shall be created by means of a PC application program via personal or laptop computer.
 - 4) The decoder programmed masks shall be downloaded into the non-volatile memory of the PD card along with the required output response. It shall be possible to program and decode up to 99 different messages.

B. Coil

1. Loops coils installed by the Contractor shall be of the type and size recommended by the manufacturer and shall be submitted to the Engineer for approval.
2. Loop coils will be installed in such manner so as to mitigate the effects of inductive coupling between the current in the rails and the coil, in a manner as recommended by the manufacturer.
3. If required, the filter box to tune loop coils shall be made moisture-proof, and thus suitable for direct burial, by the use of a self-hardening, two-component resin sealant-encapsulation potting kit as recommended by the manufacturer. The filter box shall be encapsulated immediately after loop tuning has been accomplished or as soon as weather and temperature conditions permit.
4. Cable from the filter box to the wayside interrogator equipment shall be of the type and size recommended by the manufacturer and shall be submitted to the Engineer for approval.

2.02 TEST EQUIPMENT

- A. The Contractor shall provide the following test equipment:

1. Test Transponder
 - a. The test transponder shall be equipped with its own power supply.
2. Portable Test Interrogator.
 - a. The portable test interrogator (PTI) that shall be configured for single loop interrogation.
3. Data Loop Display Card.
4. Test Radio.

ARTICLE 3 EXECUTION

3.01 FIRST ARTICLE INSPECTION TEST (FAIT)

- A. The FAIT shall verify the proper operation of the equipment tested and the completeness of the test procedure used.

3.02 WAYSIDE EQUIPMENT INSTALLATION TESTING

- A. The Contractor shall provide all necessary existing Genisys and TWC system reprogramming, field wiring, all necessary hardware modifications, and verify proper operation at all locations that have existing Genisys and TWC equipment.
- B. The Contractor shall coordinate the installation and testing of TWC with OCC.
- C. The Contractor shall furnish test devices for the solid-state equipment furnished under this Contract.
- D. An I/O board tester shall be provided which can exercise and verify the integrity of individual inputs and outputs.
- E. The test devices shall be self-contained and portable.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions if the Work.

END OF SECTION

SECTION 13581

LOCAL CONTROL PANELS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for local control panels, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Designing, providing and implementing modifications to the existing Wood Street Interlocking local control panel
 - 2. Designing, providing and implementing modifications to the existing Gateway Interlocking local control panel.
 - 3. Designing and providing a new local control panel at the Allegheny Interlocking new Relay Room
- C. The Contract Documents provide the performance parameters and design criteria to complete the local control panels. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 01739, "Quality and Configuration Management"
- C. Section 01840, "Spare Parts and Test Equipment"
- D. Section 01910, "Operations, Maintenance and Repair Data"
- E. Section 13570, "Signal System Requirements,"
- F. Section 13590, "Housing and Housing Equipment."

1.03 SUBMITTALS

- A. Product data and specifications for all components.
- B. Shop Drawings and specifications for all LCPs.
- C. Terminal board layouts and power loop circuit drawings for new LCPs.
- D. Faceplate drawings of the new LCPs.

ARTICLE 2 PRODUCTS

2.01 LOCAL CONTROL PANELS

- A. A new LCP shall be provided by the Contractor in the new Relay Room at Allegheny Interlocking.
- B. The Contractor shall modify the existing LCPs in the existing Relay Rooms at Wood Street and Gateway Interlockings as shown on the Contract Documents.
- C. A functional description of the existing local control panel at Gateway Interlocking is provided below for the Contractors use. The Contractor shall use the information provided below as guidance when providing the new LCPs and modifying the existing LCP required by this Contract.
- D. The LCPs shall be constructed of 1" mosaic tiles of an approved color with etched block lettering and symbols. Track diagram, signal and switch symbols, lettering and numbering shall be etched on the panel as shown on the Contract Drawings. Orientation of the panel schematic shall be such that the directions on the panel, when mounted in the Relay Room coincide with the direction of the track. Levers, switches and indication lights shall be mounted on the panel as shown on Contract Drawings.
- E. LCPs shall contain the controls and indications necessary for:
 1. Track Occupancy indication for all circuits within the control limits of each interlocking, as shown on the Contract Drawings.
 2. Traffic Direction indication.
 3. Switch Position control and indication.
 4. Signal Request/Cancel control and indication.
 5. Exit Inhibit control and indication.
 6. AC & DC Power Off and Ground indications.
 7. DC Ground Detection.
 8. Intrusion Detection.
 9. Fire Detection.
 10. Blown Fuse Indications.
 11. Maintainer's Indication.
 12. AUTO/LOCAL/OCC (Operations Control Center) Mode control and indications.
 13. Display activation.
 14. Lamp Test activation.
- F. Indication LEDs: All indications on the LCP shall be provided by colored LEDs. The operation and color of the indications will be as follows with wired circuits intact, LEDs functioning and the display switch "on":
 1. Maintainer Call Indicator:
 - a. White – Indicates a requirement for the maintainer(s) to contact OCC.
 - b. Off – No action required.

2. Blown Fuse Indicator:
 - a. Red – Indicates that fuse or fuses are blown supplying energy to signals or track circuits.
 - b. Off – Indicates all fuses intact.
3. AC Source, Normal Indicator:
 - a. Red – Indicates that the relay room/house is powered by the normal AC source with respect to the transfer switch position.
 - b. Off – Indicates that the transfer switch is not in reserve source position or the B12 (DC) energy is off.
4. AC Source, Reserve Indicator:
 - a. Red – Indicates that the relay room/house is powered by the reserve AC source with respect to the transfer switch position.
 - b. Off – Indicates that the transfer switch is not in reserve source position or the B12 (DC) energy is off.
5. DC Source, Normal Indicator:
 - a. Green – Indicates that 12 Volt DC output is present from the normal supply.
 - b. Off – Indicates that the system is not operating on the 12 Volt DC normal supply.
6. DC Source, Reserve Indicator:
 - a. Red – Indicates that 12 Volt DC output is present and the system is operating from the reserve supply.
 - b. Off – Indicates that the system is not operating on the 12 Volt DC reserve supply.
7. AC Ground Detection Indicator:
 - a. Red – Indicates that a ground fault has been detected in the 120 Volt AC that supplies power to the signals and track circuits.
 - b. Off – No AC ground fault.
8. DC Ground Detection Indicator:
 - a. Red – Indicates that a ground fault has been detected in the 12 Volt DC power buss.
 - b. Off – No DC ground fault
9. Fire Indicator:
 - a. Red – Indicates that fire symptoms have been detected.
 - b. Off – No fire symptoms detected.
10. Intrusion Indicator:
 - a. Red – Indicates an intrusion has been detected.
 - b. Off – No intrusion detected.
11. Snow Melter Indicator:
 - a. Amber – Indicates that the snow melter case is supplying power to the snow melter elements.
 - b. Off – No power is being supplied to snow melter elements.
12. Auto Control Mode Indicator:
 - a. White – Indicates that the current control of the interlocking is the automatic mode.
13. Local Control Mode Indicator:

- a. White – Indicates that the current control of the interlocking is the local mode.
- 14. OCC Control Mode Indicator:
 - a. White – Indicate that the current control of the interlocking is the OCC (remote) mode.
- 15. Area Blocking Indicator:
 - a. Blue – Indicates area blocking is established on represented block.
 - b. Off – Indicates area blocking not in effect on represented block.
- 16. Call On Indicator:
 - a. White – Indicates that the corresponding signal entrance is being cleared by a call on operation. This indicator functions in conjunction with the respective signal's green indicator.
 - b. Off – Indicates the respective signal not cleared by a call on operation.
- 17. Fleeting Indicator:
 - a. Red – Indicates that the respective signal entrance has been fleeted.
 - b. Off – Indicates no fleeting on the respective signal.
- 18. Approach Track Indicator:
 - a. Red – Indicates that the respective track segment is being deenergized by a train, a track vehicle or by a failure of the track circuit itself.
 - b. Off – Indicates that the respective track segment is operational and no occupancy exists.
- 19. Signal Indicator:
 - a. Red – Indicates an entrance has been selected for a route and/or the respective signal is at stop.
 - b. Green – Indicates a permissive route has been established from the entrance that is being governed by the signal.
 - c. Off – Indicates that the signal location has not been selected or cleared as a route entrance.
- 20. Exit Available/Track Indicator:
 - a. White – Indicates that the adjacent signal location is available as an exit point for a route.
 - b. Red – Indicates that the respective track segment is being deenergized by a train, a track vehicle or by a failure of the track circuit itself.
 - c. Off – Indicates that the track segment is operational but is not included in an aligned and locked route or the adjacent signal location is not available as an exiting point.
- 21. Route/Track Indicator:
 - a. White – Indicates that the track segment is included in an aligned and locked route.
 - b. Red – Indicates that the respective track segment is being deenergized by a train, a track vehicle or a failure of the track circuit itself.
 - c. Off – Indicates that the track segment is operational but is not included in an aligned and locked route.
- 22. Switch/Track Indicator
 - a. White – Indicates that the switch is in correspondence and is locked or has

- been called to the position represented by location of indicator on the track diagram.
- b. Red – Indicates that the respective track segment is being deenergized by a train, a track vehicle or a failure of the track circuit itself. This indicator (in the reverse switch segment) indicates that the switch is out of correspondence.
 - c. Off – Indicates that that the track segment is operational but no route has been aligned and locked and the switch position has not been requested and is in correspondence.
23. Switch Locked Indicator:
- a. Red – Indicates that the power switches are electrically locked in position.
 - b. Off – Indicates that the power switches are available to be called into the opposite position
- G. Control and switch levers provided by the Contractor shall conform to the following:
- 1. They must be compatible with equipment currently in use on the Authority's system and should be interchangeable with current stock.
 - 2. Meet all power and contact rating requirements as per the Contractor's design and power calculations.
 - 3. Center off momentary, single unit lever, toggle and pushbutton switches shall be provided for the following functions:
 - a. Local Control Mode Switch:
 - 1) Pressed – Sends a request to OCC for local control. Upon OCC granting the request, the LCP is put in control of the interlocking operations and the Local Control Indicator illuminates. If the switch is pressed while the Emergency Key Switch is in the “on” position, the LCP is immediately put in control of the interlocking operations bypassing the need for OCC approval and the Local Control Indicator illuminates.
 - 2) Pulled – Cancels the local mode of operation, returning the system to the automatic mode.
 - b. Switch Position Button:
 - 1) Pressed – Enable the switch position indicating circuit to display the switch positions on the LCP via the Switch/Track Indicators. Panel must be in Local Mode for this function to operate.
 - c. Snow Melter Control Switch:
 - 1) Pressed – Turns the snow melter case “on” to supply power to the snow melter elements.
 - 2) Pulled – Turns the snow melter case “off” removing power to the snow melter elements.
 - d. Signal Call On Switch:
 - 1) Pressed – Allows a previously established route through an interlocking to display a Stop And Proceed (FL-R/R) aspect where the route could not be cleared due to a call on condition, generally track circuits in the requested route are occupied or there is an interlocking track circuit failure. Approach track must be occupied for this feature to function.

- 2) Pulled – Cancels call on but maintains the previously selected route.
 - e. Signal Control Switch:
 - 1) Pressed –
 - a) Selects interlocking route entrance if the control point has not already been determined to be an available exit for a previously selected entrance.
 - b) Selects interlocking route exit if control point has been designated as an available exit for a previously selected entrance.
 - 2) Rotated Toward Interlocking – Establishes fleeting for a route whose entrance was selected by the same signal control switch. Effective only when signal indicator is illuminated.
 - 3) Rotated Away From Interlocking – Cancels fleeting that has been established for a route whose entrance was selected by the same signal control switch.
 - 4) Pulled – Cancels entrance selection, route, fleeting and call on of a route (if established) whose entrance was selected by the same signal control switch.
 - f. Lamp Test Switch:
 - 1) Turned Right – Turns on white and green indicators on LCP.
 - 2) Turned Left – Turns on red, amber and blue indicators on LCP.
- H. A Single Pole Double Throw (SPDT) toggle (On/Off/On) switch shall be provided for the following functions:
- 1. Auxiliary Switch Control (Test Key):
 - a. Up – Calls the respective power operated turnout or crossover to the normal position unless prevented by the locking circuits.
 - b. Center – Puts turnout or crossover within control of the normal routing interlocking system.
 - c. Down – Calls the respective power operated turnout or crossover to the reverse position unless prevented by the locking circuits.
- I. A Single Pole Single Throw (SPST) toggle (On/Off) switch shall be provided for the following function:
- 1. Panel Lighting Control Switch:
 - a. Up – Controls the energy that is supplied to light the LCP indications. This feature may be applied as a non-vital input to the microprocessor system if driven by the same.
 - b. Down – Turns off the energy to the LCP indications.
- J. An Emergency (two-position On/Off) Key Switch shall be provided.
- 1. All LCP keys shall be the same as those currently in use on the Authority's system and operate no other locks in the system.
 - 2. With key inserted into lock tumbler, the Emergency Key Switch will function as follow:
 - a. Turned Clockwise – This position shall activate the Emergency bypass feature as described in Article 2.01F "Local Control Mode Switch." This

- position shall be considered it's "on" position. It shall be impossible to remove the key from this position.
- b. Turned Counter Clockwise (original position) – This position shall deactivate the local controls of the LCP and return control of the interlocking to the automatic mode. It shall be possible to remove the key from the lock tumbler while in this position.
- K. The Contractor shall submit faceplate drawings for review and approval of the Engineer.

2.02 EXISTING RELAY ROOM LOCAL CONTROL PANELS

- A. The Contractor shall modify the existing mosaic style LCP at Wood Street Interlocking and Gateway Interlocking to provide for the new interlocking arrangement. The Contractor shall add/remove controls and indications from the LCP in order to properly interface with the new North Shore Connector signal system. All material provided will be compatible with existing equipment in form and function as described in Article 2.01.
- B. The Contractor shall revise the non-vital Site Specific Application Logic (SSAL) for Gateway and Wood Street Interlockings necessary to implement the LCP changes. The Contractor shall also provide the hardware, application firmware and wiring interface between the new LCP and the existing vital and non-vital microprocessors at these locations.

2.03 LOCAL CONTROL PANEL AT ALLEGHENY INTERLOCKING RELAY ROOM

- A. The Contractor shall provide a new mosaic style LCP at Allegheny Interlocking. The Contractor shall furnish and install all new indications, control switches, wiring, and hardware necessary to implement the installation. All material provided shall be compatible with existing equipment in form and function as described in Article 2.01.
- B. The Contractor shall furnish new non-vital Site Specific Application Logic (SSAL) for Allegheny Interlocking necessary to implement the new local control panel. The Contractor shall also provide the hardware, application firmware and wiring interface between the new LCP and the new vital and non-vital microprocessor.

ARTICLE 3 EXECUTION

3.01 LCP MOUNTING

- A. Panels shall be mounted as specified in Section 13590, "Housing and Housing Equipment."
- B. The orientation of the LCPs shall coincide with the track layout.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13582

SAFETY AND SYSTEMS ASSURANCE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for safety and systems assurance, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Systems Assurance Program Plan (SAPP)
 - 2. System Safety Program Plan (SSPP)
 - 3. Reliability Program
 - 4. Maintainability Program
 - 5. System Safety Analyses
 - 6. Safety Test and Verification Plan
 - 7. Safety Certification Program
- C. The Contract Documents provide the performance parameters and design criteria to complete the safety and systems assurance. The Contractor shall be responsible to provide a complete design for this portion of the Work. The Contractor's submittal shall be incorporated within the Authority's SSPP as required by 49 CFR Part 659. In accordance with this requirement, the Contractor's work shall also conform to the requirements of this document.
- D. All testing described within Section 13595, "Signal System Test and Inspection" shall also be integrated within the Authority's Safety Certification Plan. As such, the Contractor's testing and test documentation shall be in general conformance with the requirements of 49 CFR Part 659.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 01739, "Quality and Configuration Management"
- C. Section 01910, "Operations, Maintenance and Repair Data"

1.03 REFERENCE STANDARDS

- A. APTA Start Committee Guidelines for Preparation of System Safety Program Plan.
- B. AFSC DH 1-6 Design Handbook – System Safety.
- C. MIL-STD 721, 781 D, 785 B, and 882C.

D. MIL-HDBK 217 and 781.

1.04 SUBMITTALS

- A. SAPP as defined in Article 2.01 and including a SSPP, Reliability Program, and Maintainability Program.
- B. Reliability Calculations and Data.
- C. Reliability Test Plan, Procedures and Report.
- D. System safety and hazard analyses as defined in Article 2.06, including a list of safety critical items.
- E. Safety Test and Verification Plan and Report as defined in Article 2.07.
- F. Safety Certification Checklists for each signal equipment location and onboard ATP system, as defined in Article 2.08.

1.05 DEFINITIONS

- A. System Safety Analyses Definitions:
 - 1. Hazard Category I - Catastrophic: Operating conditions such that personnel error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies may cause death or system loss.
 - 2. Hazard Category II - Critical: Operating conditions such that personnel error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies may cause severe injury to personnel, severe occupational illness, or major system damage.
 - 3. Hazard Category III - Marginal: Operating conditions such that personnel error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies may cause minor injury, minor occupational illness, or minor system damage.
 - 4. Hazard Category IV - Negligible: Operating conditions such that personnel error, environment, design deficiencies, subsystem or component failure, or procedural deficiencies will not result in injury to personnel, occupational illness, or damage to the system.

ARTICLE 2 PRODUCTS

2.01 SYSTEMS ASSURANCE PROGRAM PLAN (SAPP)

- A. The Contractor shall produce and implement a SAPP, which integrates the system assurance elements in all phases of this Contract. A disciplined approach shall be incorporated to evaluate Signal System designs with regard to system safety, reliability and maintainability, with the objective of prescribing corrective action in a timely and cost effective manner.

- B. The SAPP shall be in accordance with the latest revision of the following documents:
 - a. MIL-STD-882C System Safety Program Requirements.
 - b. MIL-STD-721 Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety.
 - c. AFSC DH 1-6 Design Handbook – System Safety.
 - d. APTA Start Guidelines for Preparation of System Committee Safety Program Plans.
- C. The SAPP shall be organized to include specific sections for the disciplines of system safety, reliability, and maintainability.
- D. Procedures shall be described to perform all specific tasks necessary to meet system safety, reliability, and maintainability requirements.
- E. The responsibilities and functions of personnel directly associated with systems assurance policies and implementation of the program shall be clearly defined. The systems assurance organization shall be described. The Contractor shall define the responsibilities of the personnel within the Contractor's organization, who have authority to control the systems assurance portion of the Work and report independently to the Contractor's management.
- F. The Contractor shall identify systems assurance interface requirements between the Signal System and other light rail systems. These requirements include man/machine interfaces, maintenance, training, rules, and procedures.
- G. The Contractor shall revise the SAPP as necessary throughout the project. As the project proceeds, the Contractor shall report progress achieved in areas of safety and systems assurance based on the milestones in the SAPP.
- H. Subcontractors and suppliers shall also comply with the Contractor's SAPP. Requirements for human factors (human engineering) and quality assurance, although not addressed directly herein, are integral parts of systems assurance and are to be considered in development of the SAPP.

2.02 OBJECTIVES AND CRITERIA

- A. The primary objective of the systems assurance program shall be to optimize system safety, reliability, and maintainability characteristics of the signal system by:
 - 1. Eliminating critical and catastrophic hazards.
 - 2. Providing a high degree of reliability.
 - 3. Minimizing downtime during maintenance and malfunctions
- B. A secondary objective of the systems assurance program shall be to minimize the magnitude and seriousness of those events or malfunctions which could result in injury to patrons or personnel and damage to equipment or property, but which cannot be completely eliminated.

- C. Criteria shall be formulated and documented to satisfy the requirements for systems assurance through the guarantee period of the Contract.
- D. During design and installation of the Signal System, the Contractor shall employ the objectives, requirements, criteria, and methodology stated in the SAPP to accomplish the goals of system safety.
- E. Identification and Control of Potential Hazards:
 - 1. Scientific and engineering principles shall be applied to identify and analyze potential hazards and to eliminate, control, or minimize hazards.

2.03 SYSTEM SAFETY PROGRAM PLAN

- A. A detailed system safety program plan shall be included as part of the SAPP, and shall contain, at minimum:
 - 1. Task listing and time phasing of each task.
 - 2. Organization and responsibility of key personnel.
- B. The plan shall include procedures to accomplish the system safety tasks, including provisions to:
 - 1. Correct system safety deficiencies noted during the design phase as soon as possible, but not later than Final Design Review.
 - 2. Evaluate system design and design changes.
 - 3. Conduct system safety analyses of each subsystem and its interface areas.
 - 4. Take immediate corrective actions to prevent personal injury or system damage when a Category I or II hazard is identified. Hazards are defined in Paragraph 2.06 A.
 - 5. All hazards shall be controlled to an acceptable level as defined by MIL-STD 882.
 - 6. Implement safety changes which are the Contractor initiated and approved by the Engineer, and those initiated by the Engineer which fall within the Contractor's area of responsibility.
 - 7. Coordinate the activities of the Contractor's system safety program with Authority's System Safety Program Plan.
- C. System safety criteria shall be implemented by the Contractor throughout all aspects of design development, test, delivery, installation, and maintenance, and shall address the following:
 - 1. Design safety:
 - a. Employment of system safety techniques to minimize or control hazards identified by failure analyses.
 - b. Coordination with reliability, maintainability, and design engineers to avoid potential hazards resulting from complexity of design.
 - c. Standardization of design by utilization of proven standards of the transit industry and applicable regulatory codes.
 - 2. Potential failures:
 - a. Assurance that a single-point failure in a dynamic system will not result in a

- critical or catastrophic hazard.
- b. Elimination or minimization of the hazards by design, except in specific cases where high reliability, failsafe items may be used, based upon a properly documented past history of low failure rate, if approved by the Engineer after submission of the history of these items.
 - c. Control of potential failures of less than a critical classification through use of safety devices and approved operating or maintenance procedures.
3. Human factors:
- a. Prevent/minimize human error(s) when responding to field and operational conditions by eliminating conflicting or ambiguous alarms and status indications;
 - b. Conflicting or ambiguous instructions;
 - c. Lengthy or complicated instructions;
 - d. Inherent design errors/problems;
 - e. Unclear or incomplete supporting hardware and software documentation.
- D. A data collection and feedback system shall be used to establish requirements for redesign, design changes, and corrective actions. A follow-up procedure shall be utilized to verify results of completed action as follows:
- 1. During early phases of system development, the data shall include hazards identified during analyses. The Contractor shall inform the Engineer of problems in design and hardware development, and take early remedial action.
 - 2. In latter stages of system development, and during installation, the Contractor shall indicate appropriate corrective action, and verify the requirements and results of corrective action taken.
- E. Training: The Contractor shall include information on system safety methods and procedures, protective devices, and emergency equipment in the training program. Reference Section 01910, "Operations, Maintenance and Repair Data."

2.04 RELIABILITY PROGRAM

- A. A reliability program established in general accordance with the applicable portions of MIL-STD 785B shall be included as part of the SAPP, and shall contain, at minimum:
 - 1. Organization and responsibilities of key personnel.
 - 2. Interfaces between reliability, maintainability, system safety, and other closely related programs, and support to efforts such as:
 - a. Logistic support and maintenance planning.
 - b. Design.
 - c. Quality assurance and quality control.
 - d. Standardization.
 - e. Systems engineering.
 - f. Personnel subsystem program (human engineering, life support, training, and personnel resources).
 - 3. Provision for source selection, first article inspection, and surveillance of subcontractors' and suppliers' reliability activities.

4. Procedures and controls, including piece part selection and screening, manufacturing process controls, procurement controls, and test procedures, to be utilized during production to achieve reliability requirements.
5. Provisions to evaluate operational and design changes for possible effects upon system reliability.
6. Description of methods which the Contractor will use to predict compliance with reliability goals.
7. Description of reliability testing that the Contractor will conduct to demonstrate achievement of reliability goals.

B. Quantitative Requirements

1. The Contractor's individual equipment items shall meet the following requirements, expressed in Mean Time Between Failure (MTBF) hours.

a. Relays	500,000 hours
b. Switch machines	200,000 hours
c. Wayside signals	300,000 hours
d. Local control panels	30,000 hours
e. TWC equipment	50,000 hours
f. Power frequency track circuits	75,000 hours
g. Ground detectors	500,000 hours
h. Vital processors (single CPU PCB)	200,000 hours
i. Power supplies	300,000 hours
2. The Contractor's Signal System shall meet the following requirements, expressed in Mean Time Between Service Failures (MTBSF) hours for each wayside signal equipment location. A service failure shall be defined as a failure within the location causing any disruption in transit service in excess of 10 minutes. If the MTBSF for a location is found to be lower than 9000 hours, the Contractor shall modify the work to meet or exceed that number at no additional cost to Authority.
 - a. The calculation of MTBSF shall require identification of component failures within the system that cause a service failure. A Failure Mode Effects Analysis shall be performed on each location identifying components that could cause service failures. The calculated Mean Time Between Failures for these components shall then determine the MTBSF of the location.

C. Reliability Calculations and Data

1. The Contractor shall submit calculations, or other data requested by the Engineer to show that its proposed equipment will meet reliability requirements. The Contractor shall not manufacture any equipment until calculations or data are approved by the Engineer.
2. Reliability calculations shall be done in accordance with MIL-HDBK-217, or in the case of demonstrated reliability calculations, in accordance with MIL-STD-781D and MIL-HDBK-781.
3. The Contractor may propose alternate means of calculating reliability, such as providing service records for proven equipment, upon approval of the Engineer.

D. Reliability Demonstration Test

1. The Contractor shall submit a Reliability Test Plan and Reliability Test Procedures for approval of the Engineer.
 2. The Contractor shall conduct a reliability demonstration in accordance with the approved Plan and Procedures and submit a Test Report to show that specified reliability requirements are met. The reliability demonstration shall be conducted during the first 6 months of Revenue Service of the North Shore Connector Signal System and shall not begin until the Contractor has successfully completed all other system tests on the North Shore Connector.
 3. Upon approval of the Engineer, an initial period at the beginning of Revenue Service may be allowed for “debugging” the Signal System prior to the start of the reliability demonstration.
- E. If necessary to meet the specified reliability requirements, the Contractor shall revise its Signal System at no additional cost to Authority.

2.05 MAINTANABILITY PROGRAM

- A. A maintainability program shall be included as part of the SAPP, and shall contain, at minimum:
 1. The provisions of Paragraphs 2.04.A.1 through 2.04.A.4 inclusive.
 2. Provisions for early fault detection and rapid fault isolation to the proper service level for minimization of costs and Mean Time to Restore (MTTR).
 3. Provisions for simplification of fault detection, isolation, and repair so as to minimize the skill levels and training requirements for maintenance personnel by use of maintenance aids or test equipment.
 4. Provisions for accessibility for maintenance tasks.
 5. Provisions for reduction of the following: complexity of the maintenance, design-dictated maintenance activities and related costs, maintenance down-time and effects on system operation, maintenance costs, potential for maintenance error, and man/machine interface problems.
 6. Provisions to evaluate operational and design changes for possible effects upon maintainability requirements.

2.06 SYSTEM SAFETY ANALYSES

- A. The Contractor shall perform safety analyses to identify potentially hazardous conditions. System safety analyses shall be applied to:
 1. Evaluate alternatives.
 2. Evaluate and verify safety requirements of each system.
 3. Evaluate operation/emergency procedures and training requirements.
 4. Provide visibility of relative safety and risk within system components.
 5. Perform analyses of subsystems and potential hazard areas of the systems including the following:
 - a. Vital failsafe circuits and subsystems.
 - b. System communications links.
 - c. Interface between each system and operating and maintenance personnel.

- d. Interface between each system and other systems that directly interface with it.
 - e. Miscellaneous subsystems including safety test facilities and procedures.
 - f. Operations and maintenance manuals.
- B. In performing the required analyses, the depth of detail shall be dictated by hardware components called for in the final design, identified critical items, and unresolved potential failures of critical or greater hazard severity. The Contractor shall submit the following analyses for review and approval of the Engineer:
 1. Preliminary Hazard Analysis (PHA).
 2. System Hazard Analysis (SHA).
 3. Operating & Support Hazard Analysis (O&SHA).
 4. Fault Hazard Analysis (FHA).
 5. Quantitative analyses such as fault tree or logic network.
- C. Analyses shall be documented in an Engineer approved format.
- D. A compilation of safety-critical items identified during the system safety analyses shall be maintained. The format shall be approved by Engineer. The Contractor shall document for approval any rationale in lieu of corrective action. A special review of unresolved critical items with the Engineer shall be conducted.
- E. Existing analyses and data properly documented and verifiable and which present material in a neat, concise and logical manner may be submitted for equipment and applications which are identical or manifestly similar.
- F. All identified Category I (catastrophic) hazards and Category II (critical) hazards shall be eliminated by redesign or other corrective action, or controlled to an acceptable level, as defined by MIL-STD 882C. Documentation of methods used shall be submitted.

2.07 SAFETY TEST AND VERIFICATION PLAN

- A. The Contractor shall implement a test and verification plan to verify that design safety requirements have been met. A combination of analytical and test methods shall be considered. Safety tests shall be integrated into the appropriate test plans developed in accordance with other sections. The test and verification plan shall be submitted for review and approval of the Engineer before the final design review (FDR). After tests are completed, the Contractor shall submit an overall testing report of system safety test results. Test data, test log summaries, and corrective action recommendations shall be included. This report shall be submitted prior to Revenue Service.
- B. Where complete safety testing in an operational environment is not feasible or could cause system damage, the Contractor shall demonstrate and verify safety characteristics in design and procedures by laboratory tests, functional mock-ups, or failure simulation. Induced or simulated failures shall be used to demonstrate an

- acceptable degree of safety for the failure modes identified as critical by the Contractor's safety analyses.
- C. The Contractor shall verify, by analytical means, failure modes identified during analyses, which were resolved by rationale or operating/emergency procedures.
 - D. Specific safety verification shall be included for:
 1. Vital failsafe circuits.
 2. Train detection/loss of detection.
 - E. The Contractor's detailed test plans shall ensure that:
 1. Safety is adequately demonstrated.
 2. Testing will be carried out in a safe manner.
 3. Any additional hazard introduced by testing procedures, instrumentation, and test hardware is properly identified and minimized.
 - F. Provisions for compiling all safety verification data on simulation and testing into the system testing reports shall be included. Results of failures shall be documented, and documentation shall be maintained throughout the Project as evidence of proper safety in system design, installation, and operation.

2.08 SAFETY CERTIFICATION PROGRAM

- A. Prior to Revenue Service, the Contractor shall provide a completed safety requirements checklist for each signal equipment location system to certify it has performed all safety requirement tests for each item on the checklist. Certification shall indicate that each location system has been designed, furnished, installed and tested in accordance with the Contract Documents, and that each is safe for revenue service.
- B. The list shall include at least the following as required for the signal equipment location:
 1. Vital circuit breakdown and function.
 2. Non-vital circuit breakdown and function.
 3. Relays.
 4. Switch machines.
 5. Wayside signals.
 6. Local control panels.
 7. Train to wayside communications and automatic route selection.
 8. Power frequency track circuits.
 9. Ground detectors, equipment grounding and ground resistance.
 10. Impedance bonds.
 11. Negative return bonding.
 12. Cables.
 13. Installation verification.
 14. System integration.

15. Signal system demonstration.
 16. Vital processor interlockings.
 1. Communication to adjacent locations.
- C. Each of the items on the list shall be signed and dated by the Contractor to certify that tests have been successfully completed.

ARTICLE 3 EXECUTION

3.01 COORDINATION

- A. Design Impact
 1. The Contractor shall closely coordinate the systems assurance program and results of system safety analyses with design disciplines, particularly as the results affect design and hardware development.
 2. The Contractor's design shall incorporate:
 - a. Test points and built-in test capabilities.
 - b. Installation of in-service status display indicators to facilitate fault isolation and test.
 - c. High reliability parts with easy accessibility and quick disconnect connectors.
 - d. Mechanical keying to reduce errors during installation.
- B. Design Problems
 1. The Contractor shall document instances where evaluation or analyses indicates an unresolved problem area, and formulate appropriate recommendations.
 2. The Contractor shall maintain records, which show that follow-up action has been taken to resolve the problem.
- C. Design Reviews
 1. The Contractor's system assurance organization shall participate in all design reviews.

3.02 RECORDS MANAGEMENT

- A. Documentation of systems assurance shall be maintained throughout the Project, and be available for examination by the Engineer.

3.03 DESIGN

- A. During consideration of precedence in control of system hazards, the Contractor shall take cognizance of human limitations as a design constraint. Actions shall be taken to satisfy requirements in the following order of precedence:
 1. Design or redesign for minimum hazards, reducing or minimizing the probability that the system will enter a hazardous mode. Give consideration to the following:
 - a. Incorporation of failsafe features which would cause the system to transfer from a high loss or risk mode to a lower loss or risk mode upon the occurrence of a critical failure.

- b. Reduction of the probability of occurrence of a failure by increased component reliability.
2. Use safety devices to reduce the magnitude of loss or risk once a hazardous mode has been entered. Ensure, however, the safety device does not introduce an additional hazard or system malfunction.
3. Use warning devices and systems, which are an audio/visual portion of a failsafe system in which the human is the responder.
4. Recommend special equipment operating procedures to reduce the probability of a hazardous event and provide training.
5. Recommend the level of training required based on the complexity of the task and minimum trainee qualifications.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 13582.001 - Safety and Systems Assurance, Design Phase shall be measured as a lump sum unit, complete in place.
- B. Item 13582.002 - Safety and Systems Assurance, Test Phase, shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. Item 13582.001 - Safety and Systems Assurance, Design Phase will be paid at the lump sum price and shall include cost of all related work specified in this Section.
- B. Item 13582.002 - Safety and Systems Assurance, Test Phase will be paid at the lump sum price and shall include the cost of all related work specified in this Section.

END OF SECTION

SECTION 13585
INSTALLATION REQUIREMENTS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for installation requirements, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Coordination of work with Authority Operations
 - 2. Conduit and cable trough
 - 3. Grounding
 - 4. Relays and plugboards
 - 5. Wayside signals
 - 6. Switch operating layouts
 - 7. Switch Heaters
 - 8. Switch heater contactor enclosure
 - 9. DC disconnect fuse box, 650 VDC
 - 10. Wayside signal equipment
 - 11. Bonds and rail connections
 - 12. Power Frequency track circuits
 - 13. Signal cable installation
 - 14. Aerial cable installation
 - 15. Wiring
 - 16. Painting
 - 17. Relay Rooms and Junction Boxes
- C. The Contract Documents provide the performance parameters and design criteria to complete the installation requirements. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 01920, "Cutting and Patching"
- C. Section 03211, "Reinforcement Bars and Dowels"
- D. Section 03305, "Cast-in-Place Concrete and Cement concrete Structures"
- E. Section 13570, "Signal Requirements"

- F. Section 13574, "Wayside Signal Equipment"
- G. Section 13577, "Solid State Equipment"
- H. Section 13580, "Train to Wayside Communications"
- I. Section 13587, "Wire and Cable"
- J. Section 13588, "Relays and Plugboards"
- K. Section 13589, "Electrical and Electronic Components"
- L. Section 13590, "Housings and Housing Equipment"
- M. Section 13591, "Tags, Locks and Keys"
- N. Section 13593, "Signal Power Distribution"
- O. Section 13595, "Signal System Test and Inspection"
- P. Section 13580, "Train to Wayside Communications (TWC)"
- Q. Section 13587, "Wire and Cable"
- R. Section 16111, "Conduit"
- S. Section 16130, "Raceways and Boxes"

1.03 REFERENCE STANDARDS

- A. AREMA Communications and Signals Manual of Recommended Practices, and the Engineering and Mechanical Division Electrical Manual of Recommended Practices.
- B. ASTM Standard A457-89.
- C. MIL 1-7798A.
- D. NEMA Standards TC2 and TC3.
- E. UL Standard 514.

1.04 SUBMITTALS

- A. Product Data and Specifications for Installation Materials.
- B. Shop Drawings showing location and installation details for conduits, cable through, bonding, and cables.
- C. Ground Resistance Measurement Method.

- D. Installation Shop Drawings and details for all equipment and materials.
- E. Sag and Tension calculations for Aerial Cable.
- F. Wire terminal samples.
- G. Paint Specifications.
- H. As-built Shop Drawings showing actual routing of conduits, bonding, and cables.
- I. Relay Room rack and cable installation Shop Drawings, including conduit/cable routing details.

1.05 DELIVERY, STORAGE AND HANDLING

- A. The Contractor shall deliver, handle, and store materials in accordance with manufacturer's instructions. The Contractor shall submit for approval the methods by which he shall bundle and deliver the concrete cable trough.
- B. Conduit stored on unpaved surfaces outdoors shall be supported at least one foot above grade, or shall be provided with end closures to that height
- C. Conduits shall be sealed with end closures during the course of construction, to protect threads and to prevent the entry of foreign material.

ARTICLE 2 PRODUCTS

2.01 STEEL CONDUIT:

- A. Rigid steel conduit shall be in accordance with Specification Section 16111, Conduit.

2.03. LIQUID-TIGHT FLEXIBLE METALLIC-CONDUIT AND FITTINGS

- A. Liquid-tight flexible metallic conduit and fittings shall be in accordance with Specification Section 16111, Conduit.

2.04. CONCRETE CABLE TROUGH

- A. Qualifications
 - 1. Concrete cable trough furnished under these specifications shall be of a product design that has been tested and has passed the qualification tests as specified within this Specification Section.
 - 2. Material
 - a. The concrete cable trough shall be composed of a high density polymer concrete material that has dielectric qualities and shall be totally nonporous and shall resist the degrading action of freeze/thaw cycles. The material shall also be unaffected by grease, oil, and salt.
 - b. The cover material shall be of a dielectric characteristic, non-metallic, and shall

- be reinforced with a glass fiber for impact resistance.
 - c. The weight of each cover shall not exceed the allowable handling weight of two persons.
3. Construction
- a. The concrete cable channel system shall include the U-shaped channel, covers, and all necessary special fittings.
 - b. The concrete cable channel shall be of the self-supporting type equipped with easy access covers. The weight of each cover shall not exceed the allowable handling weight as per OSHA requirement.
 - c. The concrete cable channel including covers shall support H-20 loading as per the following standards:
 - 1) CSA-57, "Design of Highway Bridges," "AASHTO Standard Specifications for Highway Bridges."
 - d. A minimum of two drain holes shall be provided in each 10 ft. section.
 - e. Locking mechanisms for the covers shall be provided. Material for the locking mechanisms shall be galvanized or stainless steel.
 - f. Cable trough shall be of sufficient size to leave at least one-third of the wire space free after all Signal System cables are installed.
 - g. Where cable trough is installed on curved wall sections, the ends shall be field cut to permit tight installation against the tunnel wall. Field cuts shall provide for a tight and uniform surface between cable trough sections.
- B. The cable trough shall be as the type known as Plastibeton manufactured by Synertech, Inc., Model Number 2012, (2 feet, 1 and ¼ inch wide by 1 foot 3 and 3/4 inches high), or approved equal. The Contractor shall not provide cable trough that is installed higher than the top of rail or wider than 2 feet, 1 and ¼ inch.

2.05. MESSENGER WIRE FOR AERIAL CABLE

- A. The Contractor shall provide messenger wire for installation of aerial cable. It shall be zinc-coated wire conforming to ASTM Standard A475-89, Utilities grade strand, Class A coating.
- B. Messenger wire shall be sized to support 125% of the calculated cable load.

2.06. TAPE

- A. Rubber Tape
 - 1. Field-applied rubber tape, furnished and applied by the Contractor, shall be of the type manufactured by the Okonite Company or approved equal.
- B. Friction Tape
 - 1. Field-applied friction tape, furnished and applied by the Contractor, shall be 0.75 inches wide, shall meet Military Specification MIL 1-7798-A, be overlapped at least ¼ of its width, and be given a coating of insulating paint such as "P and B"

supplied by Rubberoid Company, or "Victolac" supplied by Western RR Supply Company, or an approved equal.

ARTICLE 3 EXECUTION

3.01 GENERAL

- A. The Contractor shall cover all holes, trenches and excavations and excavations when they are not attended. Hole covers shall be clearly marked in accordance with OSHA requirements. Dimensional lumber, planking and plywood shall be used for the covering of holes trenches and excavation. Hole covers shall be affixed with nails or screws such that they cannot be accidentally removed. The use of tape for a barrier shall not be acceptable for protection.
- B. All signal and power bonds necessary to meet all functional requirements of the Contract shall be provided and installed.
- C. Unless otherwise specified, all hangers, brackets, clamps, bolts, nuts, or washers shall be hot-dip galvanized. The zinc coating shall be of commercially pure zinc and shall be continuous and through with at least 2 ounces of zinc per 1 square foot of galvanized surface. Plating shall not scale, blister, or be removed by any process of handling during installation. All material shall be cut, formed, or drilled prior to plating.
- D. Final conduit locations shall be determined by the Contractor for approval by the Engineer for all wayside track installations including but not limited too, impedance bonds, track circuit cables, track switch machines, power cables, train stop, and wayside signal lighting cables.
- E. All painting shall be performed prior to installation. Any painted areas damaged during shipment or installation shall be repainted with matching colors.
- F. Where emergency guardrail interferes with the installation of wayside signal equipment, guardrail shall be cut or notched and ground smooth in a manner approved by the Engineer. Insulated joints shall be provided on the guardrail as required, to prevent guardrail from providing an electrical path around an insulated joint on running rails for proper track circuit operation.
- G. Service loops shall be provided in all wire terminations.

3.02 COORDINATION OF THE WORK WITH AUTHORITY OPERATIONS

- A. Part of the Work of this Contract is to be performed on the Authority's operating LRV system. All work shall be scheduled with approval of the Engineer to minimize disruption to train traffic.
- B. The Contractor shall be permitted access to operating portions of the system on a

prearranged basis. Access request shall be submitted in writing, with at least two weeks notice, to the Engineer.

- C. Any installation or testing which affects existing train operations shall be done during the hours specified by the Engineer and must be completed in sufficient time to allow for normal train service. It shall be the Contractor's responsibility to supply sufficient competent employees and reserves to ensure restoration of scheduled service within the allotted time. The Contractor shall furnish all equipment such as, but not limited to flags, safety vest, flares, phones, and radios.
- D. The Contractor shall submit an installation, testing and cutover sequence plan for all areas of new construction, which affect existing train operations. The plan shall be submitted at least 60 days prior to commencing any field installation work, and shall include, at a minimum, the following.
 - 1. Narrative descriptions and schematics to maintain existing train operations.
 - 2. Narrative descriptions and schematics for temporary or interim circuits and materials.
 - 3. Narrative descriptions and schematics for final circuits and materials.
 - 4. Description of the crew size and equipment to be used.
 - 5. Description for the implementation and sequencing of all required tests.

3.03 CONDUIT AND CABLE TROUGH

- A. The Contractor shall provide and install all conduit required to route signal and communications cables. The Contractor shall repair any damage or disruption to existing or new tunnel walls, tunnel floor, sub ballast, geotextile material, or ballast caused by its installation of conduit, using the same type of materials as existing, or equal approved by Engineer. Holes shall be patched in accordance with the requirements of Specification Section 01920, Cutting and Patching.
- B. The Contractor shall furnish and install cable trough at new Gateway Station and at the eastern and western limits of Northside Station and throughout the boat section as shown in the Contract Drawings. This is a proposed routing, not all transitions and terminations points are shown. The Contractor shall submit the detailed routing to the Engineer for approval, including viable alternatives based on field conditions.
- C. On the elevated structure, the Contractor shall furnish and install raceway covers that are of the same material and construction as the Concrete Cable Trough specified within this Section. The raceway covers shall be 1-½ inches thick and shall be 19-¼ inch wide, furnished in lengths that are 3 feet, 3-3/8 inch long.
- D. The Contractor shall design, furnish, and install any connections required between the cable trough and pull boxes, junction boxes, conduits, or other constructions required for routing the signal and communications cables. The Contractor shall provide a watertight connection to pull boxes and junction boxes.

- E. The Contractor shall affix the cable trough to the deck floor utilizing manufacturer's recommended installation practices.
- F. The Contractor shall submit an installation plan for cable trough showing the complete layout of materials. This shall include details for size and direction changes; connections to conduit, pull-boxes; or other special constructions.

3.04 GROUNDING

- A. General
 - 1. The grounding system shall preclude any closed loop grounding arrangement.
 - 2. Ground connection to the track rails or use of the neutral conductors of the local power utility company or AC signal supply system shall not be permitted.
 - 3. The Contractor shall submit the method of measuring ground resistance to the Engineer for review and approval.
- B. Grounding Conductor Connection
 - 1. A maximum resistance of 15 ohms for all made grounds shall be provided.
 - 2. When the ohmic resistance between the equipment and earth exceeds 15 ohms, additional connections will be made between the equipment and the grounding conductor to lower the resistance to 15 ohms. No salts or other chemicals shall be used to achieve the resistance of 15 ohms.
 - 3. A minimum No. 6 AWG stranded copper wire shall be furnished and exothermically welded to the grounding conductor. The other end of the ground wire shall be connected to the ground bus or ground stud at the junction box with the shortest and most direct route with no sharp bends.
 - 4. For signal devices located on the aerial structure, a ground wire shall be installed between the device and the ground plate. Ground plates are located at all signal locations and are located within both walkway cable troughs at each end of the bent. Mechanical connections shall be utilized.
 - 5. For signal devices in the tunnel, a ground wire shall be installed between the device and the aerial ground wire. Mechanical connections shall be utilized.
 - 5. Relay Rooms: Grounding bus bars for relay rooms shall be made of a hard drawn pure copper bar having a minimum conductivity of 98 percent per ASTM B187-73. Each bar shall measure 1/8-inch by 3 inches by 12 inches minimum, and shall be insulated from its connection to the floor or wall. Each grounding bus shall have a smooth flat surface drilled to accept the following connectors furnished by the Contractor:
 - a. Connector suitable for terminating the ground wire to the racks within the relay room.
 - b. Connector suitable for terminating the ground wire from the made ground external to the relay room.
 - c. Connector suitable for terminating the ground wire to the relay room.
 - 6. Ground wire connection shall be minimum No. 6 AWG stranded copper wire.
 - 7. Resistance between ground and the relay room ground bus shall not exceed 15 ohms.

8. Grounding of microprocessor based equipment shall be in accordance with manufacturers' specifications.
 9. Within relay rooms, two ground systems shall be used. All electronic and microprocessor equipment ground wires shall be terminated on a floating electronic equipment ground bus. The ground wires of all other equipment within the relay rooms shall be terminated on the main ground bus within the room. A removable jumper will be supplied to connect these two busses together should the Authority desire to do so.
- C. Wayside Signals: All signals shall be grounded. Resistance between ground and the signal structure shall not exceed 15 ohms.
- D. Junction Boxes: Junction Boxes shall be grounded. A separate ground wire exothermically welded to the grounding conductor shall be connected to the minimum 0.375 inch stud bolt furnished with the box. Resistance between the junction box and ground shall not exceed 15 ohms.

3.05 RELAYS AND PLUGBOARDS

- A. The Contractor shall ensure that relay-operating characteristics have not been altered during shipping or storage procedures.
- B. Relays shall not be mounted within the rack at a height of more than six feet-six inches (6'-6") from the floor or closer than ten inches (10") to the floor. Install and wire relays within the relay rooms. Relays of like association shall be grouped together within the racks. Relays shall be mounted within the racks with the front of each pair of racks facing each other.
- C. A minimum of 20% spare space for additional relays will be provided within each instrument rack.
- D. Ensure that all AC and DC power buses are open while installing relays.
- E. Install all non-vital relays on Din 35 mounting rails within the rack.

3.06 WAYSIDE SIGNALS

- A. All signal layouts shall be installed at locations shown on the Contract Drawings, in accordance with the approved installation plans and as specified herein. All signals shall be pre-aligned to the satisfaction of the Engineer prior to cut-over. No part, either fixed or movable, of any signal layout shall project into the clearance envelope of the transit vehicles, as shown on the Contract Drawings. This shall include, but not be limited to, the opened covers or doors of the signal housing and signal junction boxes.
- B. Signals shall be installed on the right side of the right-of-way (for the direction in which their aspects govern) wherever clearance and sighting conditions permit.

- Alternate installations shall require approval of the Engineer.
- C. Where local conditions beyond the control of the Contractor make it impossible or unsafe to use the standard specified methods for installing a wayside signal, or where the standard specified installation would result in sighting problem, the Contractor shall, at no additional cost to Authority, design an alternate installation which is acceptable to the Engineer.
 - D. Signals shall be mounted on concrete as shown on the Contract Drawings. The signal mounting bracket shall be attached to the concrete by means of anchor bolts, or inserts as shown on the Contract Drawings.
 - E. Concrete structure mounted signal bases shall be shimmed as necessary to allow a plumb and level installation.
 - F. Signals shall be properly installed, aligned, and focused, both horizontally and vertically, to obtain the sighting distances required by this Specification. Signals shall be factory certified as being in proper focus prior to shipment.
 - G. All high signals shall be installed with the center of red lens 108 inches above top-of-rail.
 - H. Signals shall be aligned and focused, both horizontally and vertically, in such a manner that the aspects displayed, when viewed from the transit vehicle operator's cab, shall be distinct, unmistakable and continuously visible at a distance of 500 feet, day or night, under the most adverse environmental conditions.
 - I. Where track or tunnel curvature or grade change makes sighting impossible at 500 feet, signal shall be mounted, aligned and focused to provide continuous sighting over the greatest distance possible, but under no circumstances shall this continuous sighting distance be less than 300 feet unless otherwise approved by the Engineer.

3.07 SWITCH OPERATING LAYOUTS

- A. Power operated track switch machines shall be installed at locations shown in the Contract Drawings. They will be installed by direct fixation in accordance with the Contract Drawings, taking into consideration the manufacturer's recommended installation procedure.
- B. Cables terminating in the track switch junction box shall be dressed and potheaded. Fan the individual conductors in a neat manner, properly tagged and terminated.
- C. The Contractor shall install connectors and electrical fittings for cable installation for each switch-and-lock movement layout as shown on the approved plans.
- D. The Contractor shall install the switch machines so that the identification numbers thereon correspond properly with the identification and locations shown on the Contract

Drawings.

- E. The Contractor shall make a preliminary operating adjustment of switch-and-lock movement layout at the time of installation and a final adjustment when placing in service.
- F. Temporary switch point protection shall be installed as each set of track switch points are installed. The Contractor shall provide all necessary equipment, material, labor and circuit wiring plans for each temporary stage of installation. The point protection circuitry must be submitted for review by the Engineer prior to the installation of each track switch. Each set of switch points shall be blocked, clamped and locked in the normal position and the point protection circuitry wired and tested prior to return to revenue service after each construction sequence involving the track switches.
- G. Lubrication
 - 1. After installation, switch-and-lock movement shall be properly lubricated and maintained by the Contractor until accepted by the Authority, who will have the right to monitor the Contractor's compliance with this maintenance requirement from time-to-time as may be necessary.
 - 2. Care shall be exercised to ensure that the switch-and-lock movement layouts are thoroughly lubricated at all lubricating points and that all machined and threaded surfaces susceptible to rusting, both external and internal, are thoroughly coated with the type Rust Veto Heavy grease, as manufactured by E. F. Houghton Co., Valley Forge, PA, or an approved equal.
 - 3. The switch slide plates shall be lubricated on all bearing surfaces with an approved graphite lubricant. The plates shall be thoroughly steam cleaned to remove all oil or grease prior to application of the graphite.
- H. The Contractor shall be responsible for drilling and/or reaming of all holes of extension gauge plates and mounting brackets where required to meet the requirements of this Specification.

3.08 SWITCH HEATERS

- A. The Contractor shall install track switch heaters on the outside of the stock rail as shown in the Contract Drawings
- B. The Contractor shall install crib heaters as shown on the Contract Drawings.
- C. The Contractor shall be responsible for the removal and replacement of rail wedges where necessary.

3.08 SWITCH HEATER CONTACTOR ENCLOSURE

- A. The Contractor shall install contactor enclosures as shown on the Contract Drawings.
- B. All necessary mounting and fastening materials shall be installed, including

connecting conduit, conduit fittings, clamps, nipples, and supporting brackets necessary for mounting at any location.

- C. The Contractor shall make all electrical connections between the case and each heater element flexible lead with No. 6 AWG wire, minimum.
- D. Inside the switch heater case, a shield shall be provided to cover over the high voltage equipment. All high voltage equipment shall be clearly separated from the low voltage equipment, including cables.
- E. All conduits shall enter the switch heater case from the bottom to prevent water entrance.
- F. A 240/120 VAC fused disconnect switch for control voltage, shall be mounted on the outside of the contactor enclosure.

3.09 DC DISCONNECT FUSE BOX, 650 VDC

- A. The Contractor shall mount hot stick operated fused disconnect switches on catenary poles 16 feet above the base.
- B. The fused disconnect switches shall be installed complete, including internal equipment, fuses, insulated supporting brackets, cable, clamp and other necessary materials.

3.10 WAYSIDE SIGNAL EQUIPMENT

- A. Wayside signal equipment such as switch machines, impedance bonds, cables, junction boxes, and TWC loops, train stops and wayside signals shall be installed between the rails or along the trackside.
- B. Junction boxes required for cable terminations or electronic circuits shall be mounted in the track deck, on the tunnel walls as shown on the Contract Drawings, or in the case of the power operated switch layouts, in the vicinity of the switch machine affixed to the deck. Mast mounted signals shall be provided with a junction box base.
- C. Impedance bond layouts of the required configuration shall be installed at the following locations, and at locations shown on the Contract Drawings:
 1. Negative propulsion return locations near traction power substations.
 2. Locations where negative propulsion return crossbonding is required between tracks.
 3. Boundaries of the power frequency track circuits.
- D. The Contractor shall mount the impedance bonds between the rails utilizing any required ancillary devices in accordance with these Contract Documents, as approved by the Engineer. At negative return impedance bond locations impedance bonds shall be mounted outside of the running rails as shown on the Contract Drawings.

- E. TWC loop coils and filters shall be installed to manufacturer's specifications and shall comply with Section 13580 "Train to Wayside Communications (TWC)."

3.11 BONDS AND RAIL CONNECTIONS

A. General

1. All bonding wires or cables not installed in conduit shall be secured to the ties. All wires and cables installed between the rails shall be routed and secured in a manner that provides maximum protection from dragging equipment and track maintenance equipment.
2. All negative return cables shall be exothermically welded to the rails.
3. All terminals and electrical connection lugs on impedance bonds and negative-return cables shall be thoroughly cleaned immediately before being connected.

B. Traction Power Negative Return Bonds

1. Install two railhead power bonds, as shown in the Contract Drawings and specified within Section 13587, "Wire and Cable," across all non-insulated rail joints on rails carrying traction power negative return currents. Rail joint bonds shall be exothermic welded to the non-gauge side of the railhead, within the limits of the rail joint bar. At the switch heel blocks, install one 500 kcmil power bond (web type).
2. Install two power bond strand cables, as specified in Section 13587, "Wire and Cable," around frogs and switch points as required. Bond strand cable shall be exothermic welded to the neutral axis of the rail.
3. Install two 500 kcmil cables, as specified in Section 13587, "Wire and Cable," where required for negative return rail transpositions. Cables shall be exothermic welded to the neutral axis of the rail.
4. Install two 500 kcmil cables, as specified in Section 13587, "Wire and Cable," to connect each running rail to the proper lug on impedance bonds. Cables shall be exothermic welded to the neutral axis of the rail.
5. Install two 1000 kcmil or four 500 kcmil cables as specified in Section 13587, "Wire and Cable," to connect impedance bond to impedance bond, where required.
6. Install four 1000 kcmil cables as specified in Section 13587, "Wire and Cable," from the center tap of the impedance bond on one track to the center tap of the impedance bond on adjacent tracks at crossbond locations, where required.
7. At substation locations, provide four 1000 kcmil cables for each rail to connect each running rail to the impedance bond. For each 1000 kcmil cable, furnish and install a connection to reduce 1000 kcmil cable to two 500 kcmil cables, then exothermic weld 500 kcmil cables to the neutral axis of the rail. Connect traction power negative return cables (4-1000 kcmil cables), to the signal equipment on the mainline. Connection shall be made to a copper bus, which is connected to the center tap of the impedance bond. Minimum cross-sectional area of the copper bus shall be equivalent to the sum of the cross-sectional areas of the cables to be connected.

C. Signal Rail Bonds

1. Provide two railroad signal bonds across all non-insulated rail joints, as specified in Section 13587, "Wire and Cable," as shown on the Contract Drawings. Signal bonds shall be exothermic welded to the railhead on the non-gauge side of all rails carrying only signal currents.
2. Provide two signal bonds around frogs and switch points as shown on the Contract Drawings. Signal bonds shall be bond strand wire as specified in Section 13587, "Wire and Cable," exothermic welded to the neutral axis of the rail.
3. Track circuit connections to the rail for track circuits shall be made with a piece of bond strand wire as specified in Section 13587, "Wire and Cable," which is manufactured for that specific application, exothermic welded to the neutral axis of the rail, as shown in the Contract Drawings.
4. Signal rail transpositions, where required for power frequency track circuits, shall be made with two lengths of bond strand wire, as specified, exothermic welded to the neutral axis of the rail.

D. Bond Center Tap Connections

1. The Contractor shall install all electrical connections to impedance bond center taps. All connections to impedance bonds shall be made with brass bolts and nuts. Where more than two cables must be attached to a single impedance bond center tap, the Contractor shall provide a copper adapter plate having one hole for bolting to the bond center tap and one hole for bolting each cable or pair of cables to be connected. This plate shall be rated for twice the current-carrying capacity of the bond track winding. All of the center-tap connection cables at a given location shall be the same length.
2. For cross bonding purposes, the Contractor shall install two cables of the required size in the ballast, or on the tunnel floor. These cables shall be equipped with compression-eye terminal lugs on both ends.

E. Qualifications:

1. Only properly qualified welders shall be employed by the Contractor for the application of the bonds. Each welder shall first make complete connections to the rail for one impedance bond in the field. These connections shall be inspected, tested and certified by a representative of the manufacturer of the exothermic materials. The inspection shall include 3 blows to each connection with a 3 pound hammer; the connections must not break. The welder may then proceed with further connections. The Authority's representative shall be present at this inspection.

F. Welding

1. The bonds, except railhead bonds as indicated on the Contract Drawings, shall be applied to the rails at the neutral axis of the outside of the rail.
2. The surface of the rails that contact the weld metal shall be ground clean by use of a grinding wheel approved by the manufacturer of the exothermic weld equipment.
3. After grinding, the rails shall be cleaned with non-toxic solvent to remove all

- traces of grease.
4. The bonds shall then be welded by an exothermic process in accordance with the manufacturer recommendations.
 5. All rail connections and bonds shall be at least 1 foot away from all rail welds.
- G. Moisture: Welding shall not be done during any form of precipitation, unless the rail and welding materials are kept completely dry and clean. Any welds which fail shall be removed, the rail ground smooth, and the bonds replaced and rewelded.
- H. Testing
1. The Contractor shall be required to randomly test twenty percent of the bonded joints in the presence of the Engineer by measuring their resistance with a Kelvin double bridge and portable battery, or with other approved instrumentation.
 2. Any completed joint whose resistance measures higher than the resistance of 3 feet of rail will not be accepted, except in the case of long special-work bonds, the calculated resistance of the bonding may be added.
 3. Any bonded joints having a resistance higher than that defined above shall have the bonding rewelded, or removed and replaced with new bonds.

3.12 POWER FREQUENCY TRACK CIRCUITS

- A. Power frequency track circuits shall be arranged to provide continuous train detection.
- B. All power frequency track circuit equipment shall be centrally located within the relay rooms, with the exception of the wayside junction boxes, bootlegs and track lead cabling.

3.13 SIGNAL CABLE INSTALLATION

- A. General
1. The Contractor shall furnish, install, connect and test all wire and cable required for the signal, and train control.
 2. The Contractor shall furnish and install communication cables in accordance with the Contract Documents.
 3. Cable shall be installed within conduit or trough, or suspended from messenger wire as specified herein.
 4. Cables installed within the walkway cable trough on the elevated structure shall be racked and clamped so as to prevent cable movement within the cable trough due to the grades encountered. The cables shall be affixed to cable support channeling as manufactured by Unistrut, Inc. or approved equal. The cable support channeling shall be installed within the walkway cable trough at twenty foot intervals. The cable support channeling shall be installed to the bottom of the concrete cable trough with drop in concrete anchors.
- B. Splicing
1. Taps and in-line splices shall not be permitted in any cable. Cables and wires shall

be brought into the junction boxes or other housings/rooms and terminated.

C. Slack

1. Sufficient slack in wires and cables at signals and signal heads, junction boxes, housings/rooms, entrance racks, relay racks and other equipment shall be provided. A slack loop per the Contract Drawings shall be provided underground or in the cable trough, as space permits, where the cable enters an enclosure.

D. Sealing Ducts

1. The Contractor shall furnish and place cable sealing compound to seal all cable openings in walls and floors and cable entrances to equipment housings/rooms, junction boxes, all duct or pipe openings, including spare openings, after cables have been installed.

E. Sealing Cable

1. Whenever it becomes necessary to cut any cable, the cut ends shall immediately be capped and sealed per manufacturer's instructions.

F. Protection of Cables

1. Care shall be taken in handling cables so as not to subject the jacket to undue abuse. Vehicular traffic shall not be allowed to pass over cable nor shall it be pulled over rocks, fences or other sharp objects. Cable reels shall be set up so the cable is pulled from the top of the reel. Abrasion at cable supports or other adjacent structures shall be avoided. At points where proper clearances cannot be maintained, place plastic guards over exposed area of cable. A standard line wire grip or come-along shall be used when pulling up and tensioning cable. The support wire insulation must be removed for this operation.

G. Continuity

1. Cables shall be installed in one continuous length between equipment enclosures or terminal boxes. It shall be the Contractor's responsibility to measure each run before pulling and cutting cable lengths from the reels.

H. Cable Pulling

1. Cables shall be pulled into conduits and suspended from messenger wire. The Engineer shall approve any deviations in cable routing.
2. Pulling sheaves shall allow for no less than 16 times cable outer diameter for cable pulling radius.
3. The Contractor shall select cable pull and feed locations best suited to minimize overall cable pulling tension.
4. Cable pulling tensions shall be eased by the application of cable pulling lubricant as the cable is pulled into the duct.
5. Cable pulling lubricant shall not harm the cable jacket, and shall be a type approved by the cable manufacturer.
6. Installation of the cable shall follow the cable manufacturer's recommendation for the specific type being installed and shall not exceed any limits identified in the

installation instructions.

- I. Water in Ducts:
 - 1. Water may accumulate in duct lines and cable troughs. Any pumping necessary to keep trenches and ducts dry during the Contractor's operations shall be performed by the Contractor. The Contractor shall swab out ducts or conduits before pulling in cables.
- J. Protection While Pulling
 - 1. The method of pulling cables into ducts shall be approved by the Engineer. Cable-pulling tensions, speeds, lubricants, and other pertinent factors in connection with pulling and handling shall be in accordance with the cable manufacturer's recommendations.
 - 2. A cable protector shall be fitted in the end of the duct during any pulling operation, to prevent injury to the cable.
 - 3. While cables are being pulled into duct and conduit, they shall be protected by underground cable feeder straighteners and rollers.
 - 4. Where more than a single cable is being pulled in, all cables together shall be pulled directly into the duct from the shipping coils or reels in which they were received.
 - 5. Cable grips shall be designed for such purpose and shall not cut or otherwise damage the cable.
 - 6. No cable shall be pulled with ends open. A rubber tape seal shall be maintained at all times.
- K. Supporting Cable
 - 1. Cable shall be racked, trained and supported in manholes and enclosures and shall be in accordance with the manufacturer's recommendations for the minimum bending radius.
 - 2. The minimum bending radius of fiber optic cable shall be in conformance to the manufacturer's recommendations.
 - 3. Cable racking shall be provided by the Contractor for both train control and communications cable.
- L. Slack at Ends
 - 1. Sufficient slack in cables in relay rooms, equipment enclosures, junction boxes and manholes shall be provided so that all connections, splices, and tests and adjustments can be easily made.
 - 2. Whenever cables are cut, the ends shall be immediately capped and sealed to positively exclude moisture. The seals shall be carefully maintained until final connections are made.
- M. Damaged Cable
 - 1. Great care shall be exercised in handling the cable and, in pulling the cable in ducts and conduits, and in laying the cable in trenches to prevent damage to the insulation.

2. Cable splicing to repair damaged cable will not be permitted and any length of cable damaged shall be replaced at the Contractor's expense with cable of the same size, make, type and quality.

N. Test Mandrel

1. The Contractor's cable pulling shall be in accordance with accepted modern practices so as to prevent damage to the cable.
2. Before pulling cables into any conduit, the Contractor shall swab out that conduit and pull a round test mandrel through the entire length of the duct which is to be occupied in order to assure that it is cleared of all obstructions.
3. The test mandrel shall be of a size especially designed for the duct being tested.
4. The mandrel shall be of a rigid type not less than 12 inches in length and shall have tool-steel cutting ends to remove obstructions.

3.14 AERIAL CABLE INSTALLATION

- A. The Contractor shall submit sag and tension calculations, hardware descriptions and installation drawings for approval by the Engineer.
- B. The Contractor shall furnish and install all installation hardware for aerial cable on catenary poles and wall mounts.
- C. Installation Requirements:
 1. When installing cables on the messenger wire, they shall first be tied to the messenger with temporary marline or rope ties placed sufficiently close together to hold the cable without undue sagging or slack, then permanently tied with cable straps placed on 15 inch centers.
 2. At each line drop, the cable shall be securely tied to the messenger with nylon cord ties approved by the Engineer.
 3. Each cable strap shall be a complete unit consisting of pre-formed, ribbed 19 gauge bronze hook 0.625 inches wide; and serrated extruded black polyethylene wire insulation with holes for the wire.
 4. Where multiple cables are installed on one messenger, care shall be taken to prevent twisting of the cables.
 5. Should it be necessary to add cable or cables to those previously installed on the messenger wire, they shall first be tied to the messenger with temporary ties spaced sufficiently close to prevent undue sagging between ties. The temporary ties shall support the existing cables and the new cables so that the old ties or straps may be removed. The entire group of cables shall then be retied to the messenger with new straps and ties. Re-use of straps or ties is not permitted.
 6. Temporary wire or cable installed on messenger wire shall be fastened to the messenger by temporary marline or rope ties, and be placed to hold the cable without undue sagging.
 7. Self-supporting aerial cable, which incorporates supporting messenger, may be provided when approved by the Engineer.

3.15 WIRING

- A. Terminals: These requirements for electrical connections shall apply to field wiring. All wires which are terminated on AREMA binding posts shall be fitted with an approved insulated crimped type terminal as described in AREMA Communications and Signals Manual of Recommended Practices, Part 14.1.1 or equivalent. These terminals shall be placed on the wire by means of standard forming tools of the proper size, equipped with locks to assure that the proper pressure is applied before the tool is released. Care shall be taken to assure that the correct size of wire terminal is used and that the wire is thoroughly cleaned and centered properly in the wire terminal when using the forming tool.
- B. Stripping of Wires: Wire terminals shall not be bent, nicked or otherwise damaged. An approved wire-stripping tool shall be carefully used to remove the insulation from No. 9 AWG and smaller wires. Scraping of these conductors with any sharp instruments shall not be permitted. For wires larger than No. 9 AWG, a knife may be used to remove the insulation, upon approval by the Engineer, extreme care being taken to prevent nicking the conductors. The Contractor shall furnish the Engineer with Samples of the terminals proposed for use for connecting all wires to AREMA binding posts. The terminals shall be subject to approval by the Engineer.
- C. Wire Connections: Connections to bases for plug-in relays and similar connections to lever and lamp contacts shall be crimped using an approved connector. Not more than two wires shall be terminated to a connector on relay bases.
- D. Quality of Work: Should any evidence of improper or poor workmanship arise, Contractor shall, upon written request of the Engineer, remove the responsible parties from the Work, and re-do the faulty work without extra compensation.
- E. A 6 inch, minimum, slack loop shall be provided for all wiring to vital relays and to all cable terminations on the entrance rack or within the tops of the track circuit racks within the relay rooms.
- F. No splices shall be made in any wire.

3.16 PAINTING

- A. Requirement: All painting and other coating shall be furnished and applied as specified in this Article unless otherwise specified.
- B. Standards: The painting and coating of materials and equipment furnished under these Specifications shall comply with the requirements of AREMA Communications and Signals Manual of Recommended Practices, Part 2.4.30, with the exception of galvanized and plated surfaces, aluminum, machined surfaces, wires and cable, bolts and nuts for field assembly and other similar surfaces and materials.
- C. Brand: Paints for primer and finishing coats shall be subject to approval of the

Engineer.

- D. Application: No paint shall be applied on wet, damp, frosted or dirty surfaces, or when the temperature is below 54 degrees F or above the paint manufacturer's recommended maximum temperature, or when in the opinion of the Engineer, conditions are otherwise unsuitable for painting.
- E. Primer: Galvanized surfaces to be painted under this Contract shall be field treated, prior to the application of any paint, with an approved primer or treatment.
- F. Inaccessible Surfaces: Surfaces required to be painted that will be inaccessible after installation or erection shall be given two additional field coats of the specified paint before installation or erection.
- G. Signal Heads: Hoods and faces of signal units shall be painted a flat black.
- H. After installation and prior to Contract completion and acceptance, the exterior of each signal layout switch machine layout, train stop, and junction box, shall have a final coat of paint of the same quality and texture as the manufacturer's finish coat.
- I. Damage: If any painted surface is damaged prior to the completion of the Work under this Contract, such damaged surface shall be cleaned, touched-up or completely repainted by Contractor without additional compensation.
- J. The Contractor shall furnish the Authority 2 gallons of touch up paint for each finish color at the end of the work.

3.17 RELAY ROOMS AND JUNCTION BOXES

- A. Junction Boxes:
 - 1. Junction boxes shall be installed at locations shown on the Contract Drawings. Junction boxes shall be furnished and installed as specified herein and in accordance with the Contract Drawings and the approved installation procedure.
 - a. Junction boxes installed on the elevated structure or in the subway shall be mounted as indicated on the Contract Drawings.
 - 2. Junction boxes shall be electrically insulated and grounded as specified herein and in accordance with the approved installation procedure.
 - 3. The junction box shall be shimmed as necessary to affect a level and plumb installation.
 - 4. A No. 6 stranded insulated copper wire shall be used to connect the junction box ground bus, if any, and external connection point.
 - 5. All cable entrance conduits shall be sealed with a compound such as the type known as "Duxseal" as manufactured by Manville Co or an approved equal.
 - 6. Cables shall be terminated on designated terminal boards, with field installed wire terminals, in order to provide a cut to fit, dressed, trained and finished final appearance.

7. Junction box terminal boards, terminal blocks, wiring, and cable terminations, shall be in accordance with the requirements, and any references stated within this Specification Section.
- B. Equipment and systems shall be installed in the relay rooms in accordance with the following:
 1. Instrument racks shall be installed as shown on the Contractor's approved design plans. The racks, relays, other equipment and all necessary mounting and fastening materials required to mount the racks shall be installed as approved by the Engineer. Similar types of equipment or functions of a similar nature will be grouped together.
 2. The racks shall be electrically insulated from each other and from the shock mounted supporting framework.
 3. All interconnecting cables, wiring and connections to power sources and entrance racks shall be installed as shown on the Contractor's approved design plans, including interconnections to self-contained rack mounted equipment units.
 4. Interconnecting cables from the entrance racks shall be trained in cable trays and shall be connected on the terminal and power panels of each individual instrument rack. Slack shall be provided for each interconnecting cable or wire.
 5. All wires to relays shall be of sufficient length to permit re-termination to any contact on the same relay.
 6. Wire bundles within the rack shall be harnessed in a neat manner and tied with nylon tie-wraps without sharp edges.
 7. All cable entrance conduits shall be sealed with a compound such as the type known as "Duxseal" as manufactured by Manville Co., or an approved equal.
 8. Cables shall be terminated on designated terminal boards, with field installed wire terminals landed on AAR style test terminals, in order to provide a cut to fit, dressed, trained and finished final appearance.
 9. Relays shall be installed on the relay plug boards corresponding to the relay nomenclature and rack assignment and securely fastened in place with the hardware provided. Relays shall be grouped in functional, logical order. Relays shall be the same ones used in the factory test and placed in the same position as used in the factory test.
10. Spacing for Racks:
 - a. Where possible, a minimum of four and ½ feet between centers of rows of racks will be provided. If racks are back-to-back, 4 feet minimum between centers will be allowed if necessary to permit installation of all required racks in available space.
 - b. Adjacent rows will be arranged with equipment mounted front-to-front or back-to-back.
 - c. A three-foot minimum aisle between wall and ends of rack rows will be provided unless otherwise approved by the Engineer.
 - d. The center of rack rows facing a wall shall be a minimum of four feet from the wall if possible.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13587

WIRE AND CABLE

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for wire and cable, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Interior Wire and Cable
 - 2. Exterior Cable

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 13570, "Signal System Requirements"
- C. Section 13574, "Wayside Signal Equipment"
- D. Section 13576, "Circuit Requirements"
- E. Section 13577, "Solid State Equipment"
- F. Section 13579, "Design Requirements"
- G. Section 13580, "Train to Wayside Communications (TWC)"
- H. Section 13581, "Local Control Panels"
- I. Section 13585, "Installation Requirements"
- J. Section 13587, "Wire and Cable"
- K. Section 13588, "Relays and Plugboards"
- L. Section 13589, "Electrical and Electronic Components"
- M. Section 13590, "Housings and Housing Equipment"
- N. Section 13593, "Signal Power Distribution"
- O. Section 13595, "Signal System Test and Inspection"

1.03 REFERENCE STANDARDS

- A. AREMA Communications and Signals Manual of Recommended Practices.
- B. ASTM Standards B-3, B-8, B-33, B-105, B-173, B-189, 1248, D-3159, D-2802, and E-1354.
- C. IEEE Standard 383.
- D. ICEA Standard S-95-658.
- E. NEC.
- F. NEMA Standards HP-100, WC8, and WC26.
- G. UL Standard 758.
- H. NFPA Standard 130 (for all subway cables).

1.04 SUBMITTALS

- A. Results of control testing.
- B. Product Data, Shop Drawings and specifications showing details of fabrication and technical data for each type of cable to be furnished.
- C. Installation Shop Drawings showing specialized requirements for installation and termination.
- D. Cable plan showing the locations and functions of all cables to be installed.
- E. Samples of each type of cable to be supplied cut to 3 inch in length.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall have 15 years of documented experience in supplying cable to the railway or transit industry for use in installations similar to those required by this Contract. A certification letter shall be submitted by the Contractor.
- B. Control Testing: The following control tests shall be performed during manufacture.
 - 1. Voltage and insulation resistance tests on cables in accordance with ICEA S-95-658, modified as follows:
 - a. Test potentials for both AC and DC as specified herein.
 - b. All immersion tests after 24 hours minimum immersion.
 - c. Individual conductors of multiple conductor cables tested before assembly as specified for single conductor cables.
 - 2. Shield isolation test on all combinations of pairs and over-all shield. After one minute at 500 volts, minimum resistance shall be 0.1 megohms per 1 foot.
 - 3. Conductor resistance test on all cables in accordance with ICEA S-95-658.

4. Physical characteristic tests on at least one sample from each type and size of cable in accordance with ICEA S-95-658.
- C. AC voltage withstand test on each shipping reel of finished cable at the test insulation voltage for 1 minute prior to shipment.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Contractor shall pack and mark wire and cable in accordance with the AREMA Communications and Signals Manual of Recommended Practices, Part 10.3.17, except as otherwise specified.
- B. Contractor shall ship, store, and handle material as specified in the AREMA Communications and Signals Manual of Recommended Practices, Part 10.4.1.
- C. Cable ends shall be sealed to prevent entrance of moisture during storage and handling prior to final cable termination.

1.07 PACKAGING

- A. Stranded wire and cables shall be wound on reels or spools. Each reel or spool shall have an appropriate diameter for the respective wire size. See NEMA WC26 for required reel diameter. The reels or spools shall be finished to prevent corrosion under typical storage and handling conditions. The method of attachment of the flanges to the barrels on metal reels or spools shall be structurally equivalent to a full crimp.
- B. Wire shall be closely and tightly wound in layers. All cable ends must be securely fastened so they do not become loose in transit.
- C. As appropriate, solid conductor wire shall be packaged on 16 inch spools or in barrel packs to reduce wire curl.
- D. Contractor shall specify the requirements for acceptable minimum continuous wire lengths and the number of continuous wire lengths permitted per reel or spool.
- E. Each reel or spool shall be marked with weather resistant tags, identifying the amount of wire per continuous length and the number of lengths. In addition, the following information shall be included on the tags:
 1. Manufacturer's Part Number.
 2. Wire size and stranding.
 3. Date of manufacture.
 4. Name of manufacturer.
 5. Cable description, if applicable.

ARTICLE 2 PRODUCTS

2.01 SIGNAL WIRE AND CABLE

- A. General**
 - 1. Cable with insulating and jacketing materials capable of a 40-year average service life shall be provided.
 - 2. Cable shall be suitable for installation at minus plus 5 degrees F.
 - 3. Capacitance of cables shall be within the limits prescribed by the manufacturer of the equipment to which the cable is connected.
 - 4. All interior and exterior cable and/or wire that is deployed in the tunnel, and cut-and-cover areas shall be provided with low smoke zero halogen jackets, and meet all of the Fire, Smoke and Smoke Toxicity requirements of this Section.
- B. Minimum voltage rating for both AC and DC shall be as follows:**
 - 1. Track circuit cable: 2000 volts.
 - 2. All snowmelter control case, switch heater element and switch rod heater unit wiring and cables: 1000 volts.
 - 3. All other cables shall be rated for 600 volts minimum.
- C. Conductors shall be sized to ensure operation of the equipment based on the equipment loads and operating parameters for the systems in accordance with the NEC and as specified herein. Coated conductors of annealed copper wire shall be in accordance with ASTM B33. Class B and Class C stranded conductors shall conform to ASTM B8, Table 2, and Class G stranded conductors shall conform to ASTM B173 as follows:**
 - 1. Equipment module, signal, and instrumentation external wiring: No. 20 AWG minimum, Class B.
 - 2. Rack to rack: No. 20 AWG minimum, Class B (multi-conductor cable).
 - 3. Rack to rack: 14 AWG minimum, Class B (single conductor).
 - 4. Track circuits: No. 6 AWG minimum twisted, Class C.
 - 5. Track switch machine, power: No. 9 AWG minimum, Class C.
 - 6. Track switch machine, control and indication: No. 14 AWG minimum, Class B.
 - 7. Wayside signal lighting circuits: No. 9 AWG minimum, Class C.
 - 8. Power bonds: C type, 250 kcmil, Class G, bare.
 - 9. Crossbonds and impedance bond connections: Class G.
 - 10. Bond strand wire: No. 6 AWG minimum, Class H.
 - 11. Signal bonds: C type, cadmium bronze, ASTM B105, Alloy 80, bare stranded rope lay with one center rope of 19 wires surrounded by six ropes of 19 wires each, using wires of 0.0125 inches with nominal cable diameter of 0.1875 inches.
 - 12. All other circuits: No. 14 AWG minimum, Class B.
- D. Interior Cables**
 - 1. To be used only for wiring inside signal relay rooms.
 - 2. Certified for continuous operation at 239 degrees F in wet or dry locations.
 - 3. Conductors
 - a. Stranded Conductors
 - 1) Conductors shall be tin plated, soft or annealed copper wire for electrical purposes, per the latest revision of ASTM B-33 and B-3.
 - 2) Strands and rope members shall be concentrically stranded using uni-lay

(UNI), concentric (CON), and bunch (BUN) construction as specified in Table 13587-1 below:

Table 13587-1, Construction of Bare Stranded Conductor, Relay Rooms

Conductor <u>Size</u> (AWG)	Stranding (NO/Size)	Strand Type	Conductor Nominal <u>Diameter</u> (mils)	Nominal DC Resistance @ 68°F (ohms/1000')
24	19/36	UNI	23.6	25.7
22	19/34	UNI	29.6	15.8
22	7/30	CON	30.9	16.9
20	19/32	UNI	37.8	9.63
18	19/30	UNI	46.7	6.15
16	19/29	UNI	53	4.77
14	19/27	UNI	66.2	3.04
14	37/30	CON *	71	3.05
12	37/28	CON *	87.2	2.02
10	37/26	CON *	110	1.26
9	37/019	CON *	129	0.83
9	19x7/.010	UNI/ROPE	148	0.88
8	19x7/29	UNI/ROPE	162	0.682
6	19x7/27	UNI/ROPE	203	0.433
4	19x7/25	UNI/ROPE	257	0.268
2	19x35/30	CON/ROPE	331	0.173
1	19x43/30	CON/ROPE	360	0.146
1/0	19x55/30	CON/ROPE	418	0.111
2/0	19x70/30	CON/ROPE	464	0.0872
3/0	37x45/30	CON/ROPE	531	0.0696
4/0	37x57/30	CON/ROPE	598	0.055
500 kcmil	7x19x38/30	BUN/ROPE	988	0.022

*Double Pass Concentric

b. Solid Conductors

- 1) Solid conductors shall only be used for wire wrap applications.
- 2) Conductors shall be tin plated, soft or annealed copper wire for electrical purposes, per the latest revision of ASTM B-33 and B-3.
- 3) Diameters shall be as specified below in Table 13587-2:

Table 13587-2, Solid Conductor Diameter, Relay Rooms

Conductor <u>Size</u> (AWG)	Conductor Nominal <u>Diameter</u> (mils)	Nominal DC Resistance @ 68°F (ohms/1000 ft)
30	10.3	114
28	13	70.5
26	16.4	44.7
24	20.7	27.8
22	26.1	17.1
20	32.9	10.5

c. Insulation

- 1) The insulation material for stranded and solid conductor wires shall be modified ethylene tetrafluoroethylene (ETFE) per ASTM D3159-a, unless otherwise specified.
 - a) All insulation for AWG 12 through AWG 24 shall be Tefzel 200 or equivalent. Tefzel HT-2127 or equivalent may be substituted for Tefzel 200 for enhanced flexibility.
 - b) All insulation for AWG 10 through 500 kcmil shall be Tefzel 280 or equivalent.
 - c) All insulation for the solid conductor wire wrap wire shall be Tefzel 750 or equivalent per UL Subject 758, Style 10125 and will include wire sizes AWG 26-30.

d. Wire Constructions

- 1) The finished wire diameters, weights, and ampacity ratings are shown for 0-150 volt, 0-300 volt, or 0-600 volt, 0-1000 volt, and 0-2000 volt rated stranded wires in Table 13587-3 below. All conductors shall meet the requirements in item 3.a above.
- 2) The finished wire diameters and weights for 0-300 volt solid conductor wire are also shown below. All conductors shall meet the requirements in item 3.b above.

Table 13587-3, Wire Construction with Insulation, Relay RoomsStranded Wires Rated 0-150V

<u>Conductor Size (AWG)</u>	<u>Nominal Insulation Thickness</u>	<u>Nominal Wire OD</u>	<u>Nominal Weight</u>	<u>Ampacity</u>
	(mils)	(mils)	(lbs/M ft)	
24	10	43.6	2.3	1.5
22	10	49.6	3.2	4.0
22 (7/30)	10	49.8	3.2	4.0
20	10	57.8	4.8	6.5
18	10	66.7	7.1	19.0
16	10	73.0	8.8	24.0

Stranded Wires Rated 0-300V

<u>Conductor Size (AWG)</u>	<u>Nominal Insulation Thickness</u>	<u>Nominal Wire OD</u>	<u>Nominal Weight</u>	<u>Ampacity</u>
	(mils)	(mils)	(lbs/M ft)	
24	12	47.6	2.5	1.5
22	12	53.6	3.5	4.0
22 (7/30)	12	53.8	3.5	4.0
20	12	61.8	5.1	6.5
18	12	70.7	7.4	19.0
16	12	77.0	9.1	24.0
14 (UNI)	12	90.2	13.9	34.0
14 (CON)	12	95.0	14.6	34.0

Stranded Wires Rated 0-600V

<u>Conductor Size (AWG)</u>	<u>Nominal Insulation Thickness</u>	<u>Nominal Wire OD</u>	<u>Nominal Weight</u>	<u>Ampacity</u>
	(mils)	(mils)	(lbs/M ft)	
24	15	53.6	2.8	1.5
22	15	59.6	3.9	4.0
22 (7/30)	15	59.8	3.9	4.0
20	15	67.8	5.6	6.5
18	15	76.7	7.9	19.0
16	15	83	9.7	24.0
14 (UNI)	15	96.2	14.6	34.0
14 (CON)	15	101.0	15.3	34.0
12	15	117.2	21.7	43.0
10	17	144.0	33.7	55.0
9 (37/.019)	17	163.0	47.1	-

<u>Conductor Size (AWG)</u>	<u>Nominal Insulation Thickness</u>	<u>Nominal Wire OD</u>	<u>Nominal Weight</u>	<u>Ampacity</u>
9 (19x7/.01)	17	182.0	47.5	-
8	17	196.0	59.3	76.0
6	20	243.0	93.4	96.0
4	24	305.0	146.0	143.0
2	26	383.0	226.0	160.0
1	28	416.0	271.0	186.0
1/0	30	478.0	358.0	215.0
2/0	39	542.0	457.0	251.0
3/0	50	631.0	598.0	288.0
4/0	50	698.0	737.0	332.0
500 kcmil	50	1088.0	1770.0	580.0

Stranded Wires Rated 0-1000V

<u>Conductor Size (AWG)</u>	<u>Nominal Insulation Thickness</u>	<u>Nominal Wire OD</u>	<u>Nominal Weight</u>	<u>Ampacity</u>
	(mils)	(mils)	(lbs/M ft)	
18	18	82.7	8.5	19
16	18	89.0	10.3	24
14 (UNI)	18	102.2	15.3	34
14 (CON)	18	107.0	16.0	34
12	18	123.2	22.5	43
10	20	150.0	34.7	55
9 (37/.019)	20	169.0	48.3	-
9 (19x7/.01)	20	188.0	48.6	-
8	22	206.0	61.5	76
6	22	247.0	93.7	96
4	24	305.0	146.0	143
2	26	383.0	226.0	160
1	28	416.0	271.0	186
1/0	30	478.0	358.0	215
2/0	39	542.0	457.0	251
3/0	50	631.0	598.0	288
4/0	50	698.0	737.0	332
500 kcmil	50	1088.0	1770.0	580

Stranded Wires Rated 0-2000V

<u>Conductor Size (AWG)</u>	<u>Nominal Insulation Thickness</u>	<u>Nominal Wire OD</u>	<u>Nominal Weight</u>	<u>Ampacity</u>
	(mils)	(mils)	(lbs/M ft)	
16	20	93.0	10.8	24
14 (UNI)	20	106.2	15.8	34

<u>Conductor Size (AWG)</u>	<u>Nominal Insulation</u>		<u>Nominal Wire OD</u>	<u>Nominal Weight</u> (lbs/M ft)	<u>Ampacity</u>
	<u>Thickness</u> (mils)		(mils)		
14 (CON)	20		110.0	16.6	34
12	20		127.2	23.2	43
10	24		158.0	36.2	55
9 (37/.019)	24		177.0	50.0	-
9 (19x7/.01)	24		196.0	50.5	-
8	24		210.0	62.5	76
6	26		255.0	96.1	96
4	26		309.0	147.7	143
2	28		387.0	227.7	160
1	28		421.0	271.0	186
1/0	30		478.0	358.0	215
2/0	39		542.0	457.0	251
3/0	50		631.0	598.0	288
4/0	50		698.0	737.0	332
500 kcmil	50		1088.0	1770.0	580

Solid Conductor Wire Wrap Rated 0-300V

<u>Conductor Size (AWG)</u>	<u>Nominal Insulation</u>		<u>Nominal Wire OD</u>	<u>Nominal Weight</u> (lbs/M ft)	<u>Ampacity</u>
	<u>Thickness</u> (mils)		(mils)		
30	6		22.3	0.54	-
28	6		25.0	0.76	-
26	6		28.4	1.1	-
24	6		32.7	1.6	-
22	6		37.8	2.4	-
20	6		44.9	3.7	-

*Ampacity rating not available for these low amperage circuits.

- e. Insulation thickness: Stranded and Solid Wires
 - 1) The nominal or average thickness of the insulation shall be as specified above in Table 13587-3. The minimum thickness at any point shall not be less than 90 percent per NEMA HP-100-1991, Section 3.2.
- f. Identification
 - 1) Repeated at intervals no greater than 24 inches:
 - a) Manufacturer's name.
 - b) Year manufactured.
 - c) Insulation material (ETFE).
 - d) Conductor size.
 - e) Voltage rating.
 - 2) The identifying marking shall be easily readable and shall withstand 125

- cycles (250 strokes) using a scrape abrasion tester with a $\frac{1}{2}$ lb. weight, a wire mandrel with a diameter of 25 plus or minus 2 mils, a stroke length of 0.375 inch and a frequency of 60 cycles/minute.
- 3) Each solid wire surface shall be printed with the UL Style Number, the manufacturer and the conductor gauge. This information shall be repeated at intervals no greater than 24 inches. The identifying marking shall be easily readable and meet the requirements specified above in 2).
- g. Wire performance requirements
- 1) Insulation shall be applied directly to the surface of the specified conductors and adhere tightly to the surface, but must be free stripping, leaving the conductor clean and bare.
 - 2) The following "Routine Tests" shall be performed for each production run.
 - a) Impulse dielectric or direct current spark test 100 percent of the wire per the following requirements in Table 13587-4:

Table 13587-4

	Impulse Dielectric	Test Voltage KVAC (Peak)	KVDC	DC Spark Test Voltage
Wire rated 0-150V		1.5		3.0
Wire rated 0-300V		5.0		7.0
Wire rated 0-600V		6.5		12.0
Wire rated 0-1000V		8.0		16.0
Wire rated 0-2000V		10.0		20.0

- b) Insulation strip force test and requirements:
- i) Apparatus: Use a tension testing apparatus equipped to operate in a tensile mode in conjunction with a fixture attached to one jaw of the tensile testing machine. The fixture is a metal plate approximately 0.2 inch thick with a hole 5 percent to 10 percent larger than the conductor diameter.
 - ii) Test specimen: The test specimens shall be approximately 5 inches long. Test a minimum of three specimens.
 - iii) Test procedure: Allow the specimen to completely stabilize at room temperature. Prepare the specimen for testing by carefully removing the insulation from both ends with the exception of a 1.0 in section of undisturbed insulation located in the middle of the test specimen. Remove the insulation so that the exposed insulation ends are square with respect to the conductor. Insert one end of the exposed conductor through the fixture hole and clamp this end to the traveling section of the tensile tester. Do this without applying any force to the insulation test specimen

and leave approximately 0.5 in of slack between the fixture hole contact point and the insulation piece. Using the tensile tester, pull the conductor approximately 1.0 in through the insulation at a rate of 2.0 in/min. and record the maximum force indicated.

Do not displace the insulation over the end of the conductor.

- iv) Requirement: For stranded conductors, the force required to remove the insulation shall be a minimum of two pounds and a maximum of nine pounds. For solid conductors, the force required to remove the insulation shall be a minimum of 0.5 pounds and a maximum of 5 pounds.

c) Insulation Shrinkage

- i) The Shrinkage Test measures the ability of insulation to be exposed to an elevated temperature without changing its length at the termination of the wire. It is important to maintain complete coverage of the conductor at the termination to insure the electrical barrier is intact.

- ii) Procedure: 1.0 inch of insulation shall be stripped from each end of a 14 inch specimen of finished wire using a razor blade, or equivalent instrument, held perpendicular to the axis of the wire for the insulation removal operation. The length of exposed conductor at each end of the specimen shall be determined to the nearest 0.01 inch. The specimen shall be exposed to 356 degrees F for 6 hours in an air oven. At the end of 6 hours, the specimen shall be removed from the oven and allow to return to room temperature. The shrinkage of the insulation shall then be measured as the greatest additional distance which any layer of the insulation has receded from either end of the conductor. The measurement obtained at either end showing the greatest shrinkage shall be considered the shrinkage of the specimen. Three specimens shall be tested.

- iii) Requirement: The maximum allowable shrinkage for wire sizes AWG 30 - 16 is 0.125 inches, for wire sizes AWG 14 - 6 is 0.250 inches and for wire sizes AWG 4 - 500 kcmil is 0.375 inches.

- d) The insulation must meet the tensile strength, elongation at rupture, heat shock, and cold bend requirements of NEMA HP100.2-1991, Table 2-1.

- i) The insulation must meet the aging requirements, heat distortion, insulation resistance, and dielectric constant (SIC) requirements of NEMA HP100.2-1991, Table 2-1 and the additional tests specified herein. These tests are considered "Material Tests" and must be performed every five years.

- e) Fire, smoke and smoke toxicity test

- i) Flammability and Smoke Evolution Test: The Flammability and Smoke Evolution Tests employ modern test methods, which

measure the fire properties most important to controlling fire and smoke hazards. Used in conjunction with the Smoke Toxicity Test, they constitute a fair evaluation of tradeoffs –very good properties in one area can often offset marginal properties in other areas.

- ii) The Flammability test is ASTM E-1354, Standard Test Method for Heat and Visible Smoke Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter.
 - a. Procedure: Specimens shall be 4 inch in length and placed side by side in a single layer to cover the entire surface of the specimen holder.
 - b. The apparatus shall be operated at a heat flux of 35kW/sq.m in the horizontal orientation.
 - c. The following information shall be reported: Specimen thickness, or diameter of cable in mm (d). Time to sustain flaming in seconds tig. Average heat release rate for the period beginning when 10 percent of the ultimate specimen mass loss has occurred and ending at a time when 90 percent of the ultimate sample mass loss has occurred, in kW/sq. m (q"). Average mass loss per unit area for the same period as above, in g/s sq. m. (m"). Average specific smoke extinction area in sq. m/g (o).
 - d. Requirements
 - i. Smoke evolution rate: The product of the average mass loss rate, m", and the specific smoke extinction area, o, shall be equal to or less than $(16/d)$ sq. m/s, where "d" is the cable diameter.
 - ii. Heat release rate: The average release rate, q", shall be equal to or less than $(1400/d)$ kW/sq. m, where d is the cable diameter.
 - iii. Tenable smoke density: The product of the smoke toxic potency, LC(50), the smoke specific extinction area, o, and the percent of sample vaporized, f, shall be equal to or greater than 0.2.
 - iii) Smoke Toxicity: The Smoke Toxicity Test specified here is one of the modern test methods that measure the properties most important to controlling fire and smoke hazards. Used in conjunction with the flammability and smoke evolution, they constitute a pair evaluation of tradeoffs - very good properties in one area can often offset marginal properties in other areas. Procedure: The smoke toxicity test is the University of Pittsburgh Smoke Toxicity Test Protocol as described in the New York State Flammability Regulations.
 - a. The test shall be carried out according to the published procedure. The following information shall be reported:

- i. LC(50), the toxic potency in grams.
 - ii. The percent residue, p.
 - iii. The fraction of sample vaporized, $f=(100-p)/100$.
- b. Requirement
- i. Toxic gas production: The toxic gas parameter, T, shall be less than or equal to $2100/d$ $T = (m'')x(450-t(tig))/(f(LC(50)))$.
Where m'' is the average mass loss rate, f is the fraction of smoke vaporized and LC(50) is the toxic potency.
 - ii. These tests and requirements replace the IEEE 383 flame propagation tests included in the NEMA HP100-1991 and NEMA HP100.2-1991 standard.
 - iv. Qualification of these requirements shall be with 12 and 20 AWG conductors rated at 2000 and 600V respectively.

f) Corrosivity

- i) The copper mirror corrosion test detects corrosive materials that may be driven off the insulation material at elevated temperatures and have the potential for conductor corrosion.
- ii) Procedure:
 - a. Cut a piece of insulation into small pieces and place 0.4 grams of the insulation into each of two test tubes. Use a third test tube as a control.
 - b. Suspend a copper glass mirror about 0.25 inches wide by 1.0 inch in each of the test tubes. Suspend a thermometer, 6-7 inches above the bottom of one of the test tube. Fine copper wires attached to a cork may be used to suspend these items. Seal the test tubes with the cork wrapped in aluminum foil.
 - c. The mirror shall be vacuum deposited copper with a thickness equal to 10 plus or minus 5 percent transmission of normal incident light at 5000A. Use the mirror only if no oxide film is present and the copper is not visibly damaged.
 - d. Immerse the bottom two inches of the three test tubes in an oil bath at 347 degrees F for 16 hours. Keep the portion of the test tubes containing the mirror at a temperature below 140 degrees F.
 - e. After cooling, examine the mirrors by placing them against a white background in good light. Any removal of copper from the mirrors will be a sign of corrosion. Disregard and removal of copper from the bottom 0.06 inches of the mirror, as drippings can cause this condition. Do not

- consider discoloration of the copper film or reduction of its thickness as corrosion. Consider the removal of copper so as to be transparent as the corrosion and estimate the area of copper removal.
- f. Examine the control mirror for corrosive damage and compare with the exposed mirrors.
- iii) Requirement: When compared to the control mirrors, the removal of 5 percent or more of the area of either of the test mirrors shall be considered as failure.
- h. Color Coding of Wires
- 1) Stranded Wires
- a) Cables with unpaired wires shall be solid colored in the color sequence shown in Table 13587-5 below. The second color is achieved by using a stripe that is clearly identifiable and permanent.

Table 13587-5, Color Code of Individual Wires of Multi-conductor Cables

1.	Black	22.	Black/Orange
2.	Brown	23.	Black/Yellow
3.	Red	24.	Black/Green
4.	Orange	25.	Black/Blue
5.	Yellow	26.	Black/Violet
6.	Green	27.	Black/Gray
7.	Blue	28.	Black/White
8.	Violet	29.	Brown/Black
9.	Gray	30.	Brown/Red
10.	White	31.	Brown/Orange
11.	White/Black	32.	Brown/Yellow
12.	White/Brown	33.	Brown/Green
13.	White/Red	34.	Brown/Blue
14.	White/Orange	35.	Brown/Violet
15.	White/Yellow	36.	Brown/Gray
16.	White/Green	37.	Brown/White
17.	White/Blue	38.	Red/Black
18.	White/Violet	39.	Red/Brown
19.	White/Gray	40.	Red/Orange
20.	Black/Brown	41.	Red/Yellow
21.	Black/Red	42.	Red/Green
43.	Red/Blue	47.	Orange/Black
44.	Red/Violet	48.	Orange/Brown
45.	Red/Gray	49.	Orange/Red
46.	Red/White	50.	Orange/Yellow

- 2) In paired cables, one wire of each pair shall be white and the other wire shall be coded in accordance with the sequence of the first 21 wires given

in table above, omitting the solid white. This color sequence shall be repeated as required for identification of all pairs.

- 3) Solid Conductor Wire – Wire Wrap: Solid color as specified by the Purchaser shall be used for these wires.

i. Jacket

- 1) Jacket of extruded block low density, high molecular weight polyethylene material shall be provided for:
 - a) Single conductor cables.
 - b) Outer jacket of multiple conductor cables.
 - c) Average jacket thickness on single conductor cables shall be 15 mils minimum.
 - d) Average jacket thickness for outer or overall jacket on multiple conductor cables shall be 45 mils minimum.
 - e) The minimum jacket thickness at any point shall not be less than 90 percent of that specified.

E. Assembly of Multiple Conductor Cables

1. The number of spare conductors for all local multiple conductor cables shall be at least 10 percent, but not less than 1 spare conductor.
2. Signal express cables shall be sized as indicated on the Contract Drawings.
3. Interior multiple conductor cables assembled in accordance with the AREMA Communications and Signals Manual of Recommended Practices, Part 10.3.15, Paragraph 9, except jacket as specified herein and fillers of flame resistant, non-wicking material.

F. Exterior Cables

1. Except where interior type cable is specifically permitted, use exterior cable for all circuits operating at or above 120 VAC/VDC and for all power, signal, control, and instrumentation circuits installed along the wayside.
2. Exterior cable shall be suitable for direct burial unless otherwise approved by Engineer.
3. Certified for continuous operation at 194 degrees F.
4. Insulation
 - a. Single conductor cables and individual conductors of multiple conductor cables insulated with a tight-fitting, clean stripping, ozone resistant ethylene propylene rubber or synthetic rubber vulcanized elastomer.
 - b. Average thickness of insulation not less than that specified below. Minimum thickness at any point not less than 90 percent of that specified.
 - 1) Insulation thickness and test voltages of single conductor cable prior to jacket application for circuits rated up to 2000 volts is shown in Table 13587-6 below:

Table 13587-6, Construction of Single Conductor Exterior Cables

Conductor Size	Insulation Thickness In Mils	Test Voltage in kV	
		AC	DC
14 to 9 AWG	78	10	30
8 to 2 AWG	94	11	33
1 to 4/0 AWG	94	11	33
250 to 500 kcmil	105	12.5	37.5
750 to 1000 kcmil	105	12.5	37.5

- 2) Insulation thickness and test voltages for individual conductors of multiple conductor cables on circuits rated up to 2000 volts is shown in Table 13587-7 below:

Table 13587-7, Construction of Multiple Conductor Exterior Cables

Conductor Size	Insulation Thickness In Mils	Test Voltage in kV	
		AC	DC
20 to 18 AWG	45	5.5	16.5
16 AWG	65	8.0	24.0
14 to 9 AWG	78	10	30
8 to 2 AWG	94	11	33
1 to 4/0 AWG	105	12.5	37.5

- c. Physical and electrical characteristics conforming to Table I when tested in accordance with ICEA S-95-658, as modified herein.
5. Outer Jackets
- a. Low smoke, halogen free polymeric cable outer jackets shall be provided for all external signal cable jackets in accordance with the requirements of the AREMA Communications and Signals Manual of Recommended Practices, Part 10.3.13.

G. Exterior multiple conductor cables

- Assembled in accordance with the AREMA Communications and Signals Manual of Recommended Practices Part 10.3.17, paragraph 9, except jacket as specified herein and fillers of flame-resistant, non-wicking material.
- Cables shall also have over the assembled conductors and fillers a shock absorbing layer of moisture resistant extruded elastomeric material. The thickness shall be as follows:

Core Diameter	Ave. Cushion Layer Thickness
Less than 1.5 inches	47 mils
1.501 inches and larger	62 mils

3. A pull cord shall be included beneath the cushion layer to provide for removal of the layer for terminating.
4. Exterior type cables including single pair twisted cable provided with a 10 mil minimum bronze tape beneath outer jacket for rodent and other environmental protection.
5. Additional shielding with metal tape or metal braid appropriate for installation and service conditions, and in accordance with ICEA S-95-658, as required.
6. Two conductor twisted pair cable and multiple twisted pair cables shall be assembled as specified above for multiple conductor cables.
7. Conductor identification
 - a. For twisted pair, the insulation shall be identified as white on one conductor and black on the other.
 - b. Except as otherwise specified, each insulated conductor in other multiple conductor cables shall be identified with a specific number or shall have a different color or tracer color combination.
 - c. Except as otherwise specified in referenced REA specifications, insulated conductors in other multiple conductor cables shall be black with one red conductor in each layer.
8. Identify cables as to manufacturer, year of manufacture, insulation type, conductor size, and voltage rating in accordance with manufacturer's standard method and subject to approval of the Engineer.

H. Power Cable:

1. Power cables shall be sized to carry the design loads and fault currents without exceeding the allowable cable temperatures.
2. Cables shall be stranded copper conductors of minimum size #6 AWG (minimum 3 conductors #6) and shall be ethylene-propylene-rubber insulated in accordance with ICEA S-95-658, NEMA WC8 and ASTM D-2802-78.
3. The insulation level shall be consistent with the system nominal voltage.
4. Cables shall be furnished with heavy duty hypalon jacket and with galvanized steel interlocked armor tape listed by Underwriters Laboratories and in accordance with ICEA S-95-658.
5. Jacket thickness shall be as specified above.
6. All power cables shall include a ground wire.
7. Power cable conductors shall be color coded per ICEA S-95-658.

ARTICLE 3 EXECUTION

3.01 INSTALLATION

- A. All wire and cable shall be installed in accordance with manufacturer's recommendation and applicable codes and standards.
- B. Contractor shall not exceed minimum bending radius recommended by cable manufacturer.

- C. Engineer shall be notified 24 hours prior to cable installation.
- D. Cables for Signal System shall be installed at least 36 inches away from any high voltage cable such as substation cables to feed the catenary, local commercial power cables, or any cable required to carry current at 600 volts or more.
- E. Contractor shall verify raceway conduit is free of obstructions by pulling a suitable wire brush, swab, and mandrel through raceway conduit to remove extraneous matter.
- F. Contractor shall ensure raceway conduit is dry before installation of cable and use lubricant approved by cable manufacturer to facilitate pulling cable.
- G. Maximum cable lengths and pulling tensions shall be determined to avoid excessive pulling tensions or more bends than manufacturer's recommendations.
- H. Exposed cable will not be permitted along the wayside.
- I. Wires shall not be allowed to cross one another when pulled into a conduit. Kinking shall be prevented in conduit fittings or boxes. All cables and wires to be installed in a conduit shall be installed at the same time.
- J. All exposed wires and cables entering or leaving signal equipment housings, junction boxes, relay rooms and cable transition points shall be protected from abrasion. Chase nipples shall be provided in drilled or punched openings in housings and junction boxes. Openings in equipment enclosures and junction boxes shall have split ring plastic grommets.
- K. All openings in equipment enclosures relay rooms, and junction boxes where exposed cables enter the enclosure or box shall be sealed. A resilient sealing compound made expressly for the purpose shall be installed after the cables are in place.
- L. Open wiring between individual equipment shall be neatly arranged, bundled, and tied approximately every 3 inches with nylon straps.
- M. Cable installed in conduit, regardless of length, shall not exceed the maximum fill recommendations of the manufacturer and the requirements of the NEC and local codes. Where the aforementioned codes do not apply, the maximum fill shall not exceed 60 percent.

3.02 SPLICES AND TERMINATIONS

- A. Wires and cables shall be continuous between relay rooms and the intended termination point at the wayside or junction box and between other termination points. Splices shall not be permitted. All terminations shall be made in accordance with the cable manufacturer's recommendations. Termination hardware shall require Engineer approval.

- B. If terminations are not made immediately after installation, ends of cable shall be sealed as recommended by the manufacturer to prevent entrance of moisture.
- C. Testing:
 - 1. All completed cable installation shall be tested as specified in Section 13595, "Signal System Test and Inspection."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13588

RELAYS AND PLUGBOARDS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals, necessary for relays and plugboards, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 01910, "Operations, Maintenance and Repair Data"
- C. Section 13570, "Signal System Requirements"
- D. Section 13574, "Wayside Signal Equipment"
- E. Section 13576, "Circuit Requirements"
- F. Section 13577, "Solid State Equipment"
- G. Section 13579, "Design Requirements"
- H. Section 13580, "Train to Wayside Communications"
- I. Section 13581, "Local Control Panels"
- J. Section 13585, "Installation Requirements"
- K. Section 13587, "Wire and Cable"
- L. Section 13591, "Tags, Locks and Keys"
- M. Section 13595, "Signal System Test and Inspection"

1.03 REFERENCE STANDARDS

- A. AREMA Communications and Signals Manual of Recommended Practices.

1.04 SUBMITTALS

- A. Relay Product Data, Shop Drawings and specifications. Drawings shall show contact stacking arrangements and mounting and supporting arrangements for all relay types.

- B. The Contractor shall submit completed Office Record of Test of DC Electrical Apparatus forms and Field Test Record of DC Electrical Apparatus forms, in accordance with the AREMA Communications and Signals Manual of Recommended Practices, Part 6.4.1 for each vital relay furnished. All information required shall be typed on the specified forms and shall be shop and field verified as the case may be.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Contractor shall ensure that relay operating characteristics have not been altered due to damage during shipping or storage. Relays shall be shipped separately from wired racks in which they are to be installed. They shall be packaged individually, each in a sturdy cardboard carton with the drawing number of the relay printed on the outside of the carton. Relays shall be stored in a protected area until installed.

ARTICLE 2 PRODUCTS

2.01 RELAYS

- A. General
1. All relays shall be plug-in type.
 2. Relays shall be identified with manufacturer's name, model number, contact identification, and serial number.
 3. Relays shall be interchangeable with relays of the same type used elsewhere.
 4. Plug-in type relays shall be equipped with a handgrip or other method for easy removal or insertion into plugboards.
 5. Plug-in type relays shall be equipped with a latching mechanism or other type of fastening arrangement to provide firm attachment in the plugboards.
 6. All vital relays shall be equipped with a minimum of one spare front-back dependent contact for each relay function.
 7. The condition (either energized or de-energized) of all relays shall be easily viewed from the front.
- B. Vital DC Relays shall conform to the following:
1. AREMA Communications and Signals Manual of Recommended Practices, Part 6.2.1 except as otherwise specified or as approved by the Engineer.
 - a. Operable on a nominal voltage in the range of 12 to 28 VDC and capable of continuous operation.
 - b. Moisture resistant transparent dust cover of non-flammable composition.
 - c. Arc suppression for vital coils shall be built into the relay or attached to plugboard.
 2. Various Vital DC Relays shall be of, but not limited to, the following:
 - a. Biased neutral relays
 - 1) A minimum of six front back independent contacts, configured as required.
 - b. Switch Control Relays
 - 1) A biased-neutral controller or relay shall be provided that will provide

- control and overload functions for the operation of the switch.
- 2) Each contact capable of interrupting the normal switch and lock movement current 10,000 times without its resistance exceeding 1.0 ohm measured at five amps.
 - 3) A biased-neutral relay with heavy-duty contacts equipped with magnetic blowout feature to effectively interrupt high currents.
 - 4) All switch operating relays shall be identical. One normal and one reverse switch operating relay shall be provided for each switch machine.
- c. Overload Stick Relays
 - 1) DC neutral relays equipped with two coils, one to be placed in series with the switch machine to detect overload and the other to be used in the stick circuit. One overload relay shall be provided for each switch machine.
 - 2) Equipped with sufficient number of contacts to perform the required functions.
 - 3) Solid State device or function may be submitted for approval as an alternative
 - d. Flasher relays
 - 1) AREMA flashing rates shall be used.
 - a) Signals: 40 per minute, fixed.
 - 2) Current rating of contacts controlling lamps shall exceed the connected lamp load by fifty percent minimum.
 - 3) Built-in arc suppression and surge protection.
 - 4) Solid State devices shall be submitted. Electro-mechanical relays are not permitted.
- C. Vital AC Track Relays shall conform to the following:
- 1. Capable of operating continuously and successfully without resultant damage with a minimum voltage range of 100 volts to 135 volts inclusive applied to local winding, and with a minimum voltage range of 0.75 volts to 5 volts inclusive applied to the control winding.
 - 2. A minimum of two dependent front-back contacts.
 - 3. Plug-in, two-element, 60Hz, vane type induction relays.
 - 4. AREMA Communications and Signals Manual of Recommended Practices, Part 6.1.35 except as otherwise specified.
 - 5. Moisture resistance transparent dust cover of non-flammable composition.
- D. Non-vital DC Relays shall conform to the following:
- 1. General
 - a. Solid-state devices shall be used where possible. Non-vital relays use shall be minimized.
 - b. Non-vital logic relays shall be mounted in racks and shall be furnished with transparent dust-proof covers that will not support combustion.
 - c. Non-vital relays shall be mechanically secured to the relay base.
 - d. Non-vital relays shall have one spare front-back dependent contact.
 - e. Non-vital relays shall be rated for continuous power on with a minimum duty

- cycle of ten million operations.
2. Non-vital DC Relays shall be provided in accordance with the following:
- Logic Relays
 - Operating voltage: as for vital relays.
 - Response of less than 100 milliseconds when energized with 75 percent nominal voltage.
 - Response of less than 50 milliseconds when de-energized from nominal voltage.
 - Arc suppression built into the relay or attached to plugboard.
 - A minimum of six front-back dependent contacts capable of carrying one amp continuously without contact resistance exceeding five ohms.
 - Front or back contacts capable of breaking a load consisting of three vital or non-vital relays connected in parallel at least 10 million times without contact resistance exceeding five ohms measured at 10 milliamps.
 - Constructed to assure that contacts break before make.
 - AREMA Communications and Signals Manual of Recommended Practices, Part 6.3.5 except as otherwise approved by the Engineer.
 - Non-vital Heavy Duty Relays: Meeting the same requirements as non-vital logic relays except as follows:
 - Equipped with a minimum of two front-back contacts capable of carrying and breaking a resistive or inductive load, which does not exceed the following characteristics, one million times without the contact resistance, measured at five amps, exceeding one ohm.
 - Maximum continuous volt-amp load: 200 VA.
 - Maximum volt-amp load while relay contact is opening (transient due to inductive surge): 350 VA.
 - Maximum instantaneous load current: 5 amps.
 - Maximum continuous load current: 5 amps.
 - Maximum instantaneous switched voltage: 100 VDC.
 - Each contact shall also be capable of carrying and breaking a resistive or inductive load, which does not exceed the following characteristics, five million times without the contact resistance, when measured at 0.5 amps, exceeding 1 ohm.
 - Maximum continuous volt-amp load: 50 VA.
 - Maximum volt-amp load while relay contact is opening (transient due to inductive surge): 90VA.
 - Maximum instantaneous load current: 1.25 amps.
 - Maximum continuous load current: 1.25 amps.
 - Maximum instantaneous switched voltage: 100 VDC.
 - Non-vital Timers
 - 120 VAC at 60 Hz operating voltage, or 12 to 28 VDC operating voltage.
 - Timing range from 1 second to 200 seconds with adjustment in one-second intervals or fractional parts thereof.
 - Resetting time less than one second.
 - Repeat accuracy plus or minus 0.25 second.

- 5) Automatic reset.
- 6) Operating Life: one million operations minimum.

2.02 RELAY PLUG BOARDS

- A. A high density plastic plugboard for each plug-in relay shall be furnished. The plugboard shall be fire retardant and shall be of low smoke design and shall be self-extinguishing.
- B. Vital relay plugboards shall be equipped with a registration to prevent relays of the wrong style, contact arrangement, or operating characteristics from being inserted.
- C. Each plugboard shall have a tag, or other approved means of identification, to indicate the nomenclature of the relay for which it is wired.

ARTICLE 3 EXECUTION

3.01 RELAYS

- A. Relays shall be installed on racks in relay rooms.
- B. Relay racks shall be located in the relay rooms.
- C. No relay shall be mounted on the first row above the finished floor. However, this space may be used in determining spare space requirements for the relay rack.
- D. No more than two wires shall be attached to a relay connector.

3.02 PLUGBOARDS

- A. Relay plugboards that are factory mounted and wired shall be provided.
- B. Non-corrosive fasteners shall be used to mount plugboards on relay rack.
- C. All wires terminating at a relay shall have sufficient length to connect to any terminals on the relay.
- D. The wire on each contact shall carry an approved tag as specified in Section 13591, "Tags, Locks and Keys."

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13589
ELECTRICAL AND ELECTRONIC COMPONENTS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for electrical and electronic components, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. General requirements for electrical and electronic components
 - 2. Solid state equipment
 - 3. Semiconductors
 - 4. Electrical devices for use with electronic components
 - 5. Lightening arrestors
 - 6. Surge protection
 - 7. Plug connectors

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements."
- B. Section 01910, "Operations, Maintenance and Repair Data."
- C. Section 13570, "Signal System Requirements,"
- D. Section 13577, "Solid State Equipment."
- E. Section 13579, "Design Requirements."
- F. Section 13580, "Train to Wayside Communications."
- G. Section 13581, "Local Control Panels."
- H. Section 13582, "Safety and Systems Assurance."
- I. Section 13590, "Housings and Housing Equipment."
- J. Section 13593, "Signal Power Distribution."

1.03 REFERENCE STANDARDS

- A. AREMA Communications and Signals Manual of Recommended Practices.
- B. MIL-STD-272C.

C. NEMA.

1.04 SUBMITTALS

- A. Product Data, Shop Drawings and specifications for:
 - 1. Transformers.
 - 2. Printed circuit cards.
 - 3. Integrated circuits.
 - 4. Printed circuit card connectors.
 - 5. Lighting arrestors and suppressors.
- B. Printed circuit card layout Shop Drawings.
- C. Complete Shop Drawings for each type of plug connector to be used shall be submitted to the Project Manager for approval prior to manufacture or procurement of the plug connectors. These drawings shall include complete parts lists and information required to order replacement parts. Drawings shall be required for the following components:
 - 1. Molded plug connector blocks
 - 2. Protective shells for blocks
 - 3. All locking and keying devices
 - 4. Strain-relief clamping devices
 - 5. Extractable pin-and-socket contacts
- D. A complete test report for each of the plug connector tests prescribed shall be provided. These reports shall include the date, location, number and origin of specimens, type of test, test conditions and results of the test.
- E. Three copies of all plug connector test reports shall be submitted to the Engineer within seven days of test performance.

ARTICLE 2 PRODUCTS

2.01 GENERAL

- A. General: Solid-state equipment, including vital and non-vital microprocessor-based equipment shall be provided by the Contractor. Such equipment shall be of the most modern design and meet the highest standards of industry and all applicable requirements of the AREMA Communications and Signals Manual of Recommended Practices.
- B. Isolation and Regulation: Equipment shall be provided complete with the necessary isolation and power regulation devices to assure its performance and reliability under service conditions.
- C. Modularity: Equipment shall be modular. Plug-in type printed circuit boards shall be used wherever possible, and be designed so that a board cannot be installed improperly.

- D. Lightning Protection: Lightning protection devices shall be provided according to the manufacturer's standard. Protection against lightning, surges, spikes, and over-voltage shall be provided. The manufacturer shall protect all input and output lines and any auxiliary equipment as necessary.
- E. All electronic components shall meet the Electromagnetic Interference (EMI) requirements of Section 13579 "Design Requirements".

2.02 SEMICONDUCTORS

- A. Semiconductors shall be silicon type with JEDEC numbers, except as otherwise specified.
- B. Zener diodes used for voltage regulation or reference levels shall not be damaged if the entire load is removed, and have a zener voltage tolerance of plus or minus 5 percent maximum. Zener diodes used for transient protection shall not be damaged in performing their function under all actual conditions encountered in the operating system.
- C. Use of integrated circuits shall be such that manufacturer's ratings are not exceeded under normal operation. Integrated circuits shall be protected against over-voltage and noise in the designed installation.
- D. Optically coupled isolators using gallium arsenide emitters and gallium arsenide phosphide light-emitting diodes will be permitted. Manufacturer's ratings shall not be exceeded under normal operation.

2.03 ELECTRICAL DEVICES FOR USE WITH ELECTRONIC COMPONENTS

- A. Resistors: Resistors shall have a maximum tolerance of plus or minus 5 percent and be rated to dissipate a minimum of 1.5 times the maximum operating peak voltage.
- B. Capacitors
 - 1. Capacitors 10 microfarads or less in value used in electronic modules shall have a maximum tolerance of plus or minus 10 percent and be rated for at least 1.5 times the maximum operating peak voltage.
 - 2. All other capacitors shall have a maximum tolerance of plus 75 percent to minus 50 percent and be rated for at least 1.5 times the maximum peak operating voltage.
- C. Inductors: All inductors used in electronic modules shall have impregnated windings and withstand twice the maximum peak-to-peak voltage of their normal operation.
- D. Transformers: All power transformers used in electronic modules shall have:
 - 1. Minimum interwinding breakdown voltage of 1000 VDC.
 - 2. Emitted audible noise not in excess of 40dB referenced to 0.0002 dynes/square centimeter at a distance of 2 feet while operating at rated voltage and load.

3. Impregnated windings.
- E. Printed Circuit Cards
1. Printed circuit cards shall be of glass epoxy construction meeting the requirements of NEMA Type FR-4.
 2. Printed circuit cards shall have thickness sufficient to permit easy insertion and removal without buckling or breaking.
 3. Circuits shall be formed by etching.
 4. Conductor material shall be copper. Width and thickness of this copper shall be in accordance with MIL-STD-272C. They shall be coated with an approved proofing compound for protection from exposure to air, dust and moisture.
 5. Printed circuit cards shall be marked with the identification of each component adjacent to the place where it is installed. Provide diagrams illustrating the layout and identification of each component on the card for approval by the Engineer.
- F. Printed Circuit Card Connectors: Printed circuit card connectors and associated terminals shall be:
1. Etched on both sides of printed circuit card connections.
 2. Gold plated 0.000050-inch thick minimum, unless otherwise approved by the Engineer.
 3. Insulation resistance greater than 1000 Megohms at 500 VDC.
 4. Temperature rating of 32 to 220 degrees F.
 5. Connector shall withstand card removal/insertion for regular maintenance.
 6. Keyed to accept only those cards intended for that particular position, unless an electrical keying scheme is employed.

2.04 LIGHTNING ARRESTORS

- A. Lighting arrestors shall be provided to protect track circuits and other signaling equipment.
- B. Arrestor Types
1. Signal arrestors shall be specifically designed for railway signaling use.
 2. Vital arrestors shall be designed for vital safety circuits that cannot be grounded without reducing safety.
 3. The primary functions of the signal arrestor shall be to provide line-to-line and line-to-ground protection. This requirement shall not exclude the arrestor from performing other functions.
 4. Arrestors, line-to-ground
 - a. The arrestor shall pass negligible current at rated circuit voltage.
 - b. The arrestor failure mode shall be to open rather than short circuit or partial short circuit.
 - c. The arrestor shall be suitable for use on circuits of 0 to 35 VDC without impedance restrictions.
 - d. The arrestors shall have an average DC breakdown voltage of 1000 VDC or less.

- e. Arrestors shall have a maximum impulse spark-over voltage not exceeding 2000 volts peak for an impulse with a 10 kV/microsecond rise time. The arrestor shall be heavy duty Clearview as manufactured by Safetran Systems Corp., or approved equal.
- 5. Arrestors, line-to-line type
 - a. Arrestors shall pass negligible current at rated circuit voltage.
 - b. Arrestors shall be suitable for use on circuits of 0 to 20 volts without circuit impedance restrictions.
 - c. Arrestors may be used on circuits having voltages higher than 20 volts when the circuit has sufficient impedance to limit the follow-through current after a surge to a value that can be interrupted by the arrestor.
 - d. Arrestors shall have an average breakdown voltage of 200 volts or lower.
 - e. Arrestors shall have a maximum impulse spark-over voltage not exceeding 500 volts peak for an impulse with a 10 kV/microsecond rise time.

2.05 SURGE PROTECTION

- A. Surge Protection: Surge protection shall be a shunting device, which triggers at a specified voltage to protect solid state equipment and other types of signaling and track circuit equipment from surges of AC or DC power.
- B. Application:
 - 1. Surge protection shall be provided on all equipment for protection against AC or DC power line surges. Surge protection shall be similar to those manufactured by Safetran System Corp., Harmon Industries, or approved equal.

2.06 PLUG CONNECTORS

- A. Each plug connector assembly shall consist of the following:
 - 1. A two-part molded plastic connector block equipped to hold an appropriate number of solder less, pin-and-socket contacts.
 - 2. Devices for the mechanical locking and keying of the connector block halves.
 - 3. Protective shells for both connector block halves.
 - 4. A strain relief device for the external wiring portion of the connector assembly.
 - 5. Solder less, extractable pin-and-socket contacts.
 - 6. Where required, embedded wire wrap terminals for the internal wiring portion of the connector block.
 - 7. Connector Blocks
 - a. The connector blocks shall consist of molded dielectric plastic shaped to accept the required number and types of contact pins, contact sockets and locking, keying and mounting devices. The dielectric material shall exhibit a minimum insulation resistance of 100 megohms as measured between adjacent pairs of contacts and between the accessory hardware and the closest contacts in each connector assembly half.
 - b. The contact cavities shall be arranged in a rectangular grid configuration. The opening for each contact shall be uniquely identified by a coordinate molded

- into both the mating and wiring faces of each part of the connector block.
- c. The 28 contact, vital plug connector blocks shall provide a surface leakage distance of not less than 1/4 inch between contacts and between the contacts and any other metallic part of the connector assembly.

B. Locking and Keying

- 1. Each plug connector assembly shall include a device for mechanically locking the two mated parts together.
- 2. Mechanical devices and facilities shall also be provided to allow the mating parts of connector assemblies to be keyed in such a manner that they cannot be coupled except when in the correct position relative to each other and cannot be coupled to the mating parts of other coupler assemblies keyed in a different pattern.

C. Protection and Strain Relief

- 1. Each half of the plug connector block shall be protected by a metal shield which shall extend beyond the mating surface. These two shields shall overlap when the connector halves are coupled.
- 2. The external wiring portion of each plug connector assembly shall be equipped with a device to grip the external wiring firmly in order to prevent strain on the plug connector contacts.

D. Pin-and-Socket Contacts

- 1. The pin-and-socket contacts shall be fabricated from commercial bronze or brass and plated with gold over nickel under plate. The retention springs of the pin-and-socket contacts shall be fabricated from stainless steel.
- 2. The contacts shall be fabricated and classified in the required selection of sizes to accept wire sizes 16 through 22, AWG.
- 3. Contact current rating and termination resistance shall meet the requirements of the following table with properly sized contacts applied to the wire sizes specified.
- 4. Wire Size (AWG) ;
 - a. 16
 - b. 18
 - c. 20
 - d. 22
- 5. Minimum Current Rating (Amperes)
 - a. 3.0
 - b. 10.0
 - c. 7.5
 - d. 5.0
- 6. Maximum Termination Resistance (Milliohms)
 - a. 1.7
 - b. 2.0
 - c. 2.7
 - d. 4.0
- 7. Contact termination resistance shall be measured in accordance with Method 307 of MIL-STD-202 at the rated current specified for each wire size.

ARTICLE 3 EXECUTION

3.01 APPLICATION

- A. The 28-way, vital plug connector assembly shall be required where any vital circuits are to be interconnected and the 50-way, non-vital plug connector assembly shall be used where non-vital circuits are to be interconnected

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13590
HOUSINGS AND HOUSING EQUIPMENT

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for housings and housing equipment, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. General requirements for housings and housing equipment
 - 2. Relay room requirements
 - 3. Switch heater cases
 - 4. Racks
 - 5. Lighting and outlets
 - 6. Cable trays
 - 7. Cable tray channel supports
 - 8. Local control panel
 - 9. Telephone

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 01910, "Operations, Maintenance and Repair Data"
- C. Section 13570, "Signal System Requirements"
- D. Section 13577, "Solid State Equipment"
- E. Section 13580, "Train to Wayside Communications"
- F. Section 13581, "Local Control Panels"
- G. Section 13585, "Installation Requirements"
- H. Section 13587, "Wire and Cable"
- I. Section 13588, "Relays and Plugboards"
- J. Section 13589, "Electrical and Electronic Components"
- K. Section 13590, "Housings and Housing Equipment"
- L. Section 13591, "Tags, Locks and Keys"

M. Section 13593, "Signal Power Distribution"

N. Section 16721, "Telephone System"

1.03 REFERENCE STANDARDS

A. ANSI Standard Z55.1.

B. AREMA Communications and Signals Manual of Recommended Practices.

C. NEC Article 318.

D. NEMA Standard VE1.

1.04 SUBMITTALS

A. Product Data, Shop Drawings and specifications for all housings, housing equipment and components.

1.05 DELIVERY, STORAGE AND HANDLING

A. Instrument Cases and Relay Room Racks shall be factory wired.

B. Plug-in relays and other equipment subject to damage shall be dismounted, placed in shipping cartons, secured and shipped in the house or case.

C. Instrument cases shall be shipped with all entrances plugged, locked, and sealed.

ARTICLE 2 PRODUCTS

2.01 GENERAL

A. The Contractor's work shall include associated equipment such as racks, grounding systems, rack mounted convenience outlets, alarms, and cable trays.

B. All relay room equipment shall be designed to operate correctly and without damage in accordance with the environmental design parameters specified within Section 13579, "Design Requirements."

C. An embossed metal nameplate on the outside shall identify each instrument case and relay room. The nameplate shall include the name of each interlocking or relay room in 5 inch high black letters on a white background.

D. Finishes: Unless specified otherwise, the following requirements shall apply to all instrument cases:

1. Exterior metal surfaces, excluding the floor bottom, shall be painted with one coat of rust inhibiting vinyl primer and at least two finished coats of high solids vinyl. The coating shall be graffiti resistant. Minimum dry film thickness shall be 6 mils.

- Finish color shall be as specified by Authority.
2. Apply coal tar enamel coating to exterior floor bottom and base framing.
 3. Interior metal surfaces, excluding the floor: Apply one coat of rust inhibiting vinyl primer and at least one finish coat of high solids vinyl. Minimum dry film thickness shall be 2 mils. Color shall be manufacturer's standard for the service specified.
 4. Interior floors: Apply one coat of alkyd primer and at least two coats of alkyd resin industrial enamel for a dry film thickness of 6 mils. Color shall be medium light gray No. 49 in accordance with ANSI Z55.1.
 5. Refer to all painting requirements specified within Section 13585, "Installation Requirements."

2.02 RELAY ROOMS

- A. Where a relay room is provided for the Contractor's equipment, the Contractor shall furnish install and test all specified equipment be responsible for the following:
 1. Provide factory wired equipment racks to be installed as shown on the Contract Drawings.
 2. Provide all new signal power distribution equipment as specified within Section 13593, "Signal Power Distribution", and as shown on the Contract drawings.
 3. Provide new entrance racks as may be required at new locations. Provide entrance rack modifications as may be required at modified locations.
 4. Comply with all spacing, sizing, and finishing requirements as indicated within these Specifications.

2.03 SWITCH HEATER CASES

- A. Cases shall be constructed of 12 gauge painted galvannealed steel or aluminum. Interior of cases shall be lined with 1 inch Thermax insulation.
- B. Switch heater cases shall be of sufficient size to provide space for the proposed equipment and wiring, plus 10 percent spare space. A non-corrosive stud bolt for externally grounding the case shall be included. Cable entrance shall be in the bottom of the case with provisions for sealing the entrance, and supports for securing the cables and wiring.
- C. Cases shall be factory wired and tested in accordance with approved circuit and wiring diagrams. Wire, cable, wire and cable termination, cable entrances, and tagging shall be provided in accordance with the Contract Documents. All bundled wire shall be tied approximately every 3 inches with nylon straps in accordance with AREMA Communications and Signals Manual of Recommended Practices recommendations.
- D. Provide passive ventilation as required to maintain the operating environment necessary for signal equipment housed within cases. Fans are not permitted.
- E. Provide a minimum of two ventilating openings in each door, covered with fine

aluminum wire mesh screens and protected by hoods to prevent entrance of precipitation. Each case shall also be equipped with resistive heat elements to control corrosion and prevent buildup of moisture.

2.04 RACKS

- A. Racks shall meet the following requirement:
 - 1. Open frame welded construction.
 - 2. Frame: Minimum 14 gauge cold rolled steel.
 - 3. Base: Minimum 12 gauge cold rolled steel with a nominal height of 3.5 inches.
 - 4. Chassis supports or guides: Minimum 11 gauge cold rolled steel.
 - 5. Maximum height of rack shall be 7 feet, with 31 inch maximum width and 24 inch maximum depth.
 - 6. Racks shall not be of the swing-out type unless approved by the Engineer.
 - 7. Racks shall have a minimum clearance at front and back of 3 feet from all other equipment and walls.

2.05 LIGHTING AND OUTLETS

- A. Relay room lighting and wall mounted convenience outlets shall be provided by others.
- B. The breaker panels in all relay rooms shall be identical except for the number and ratings of breakers. Breakers shall be thermal-magnetic types, UL listed. All circuits shall be identified on the inside of the panel door.
- C. For each snowmelter case, an incandescent light with pull chain socket shall be provided, inside and above each door.
- D. The Contractor shall provide one convenience outlet with GFI in each row of racks. Outlets shall be circuit breaker protected. Wire shall be run in conduit. Each case shall have a minimum of one similar type outlet.

2.06 CABLE TRAYS

- A. Cable trays and accessories required for equipment in the house shall be provided.
- B. Ladder type cable trays with 9 inch rung spacing shall be provided.
- C. Cable trays shall be manufactured of Steel, shall be 3 inch deep minimum, and zinc coated in accordance with NEMA VE1.
- D. Design for NEMA Class II load capacity of 50 pounds per linear foot and test in accordance with NEMA load test VE1-3.01.
- E. Radius of bends: 24 inches.

2.07 CABLE TRAY CHANNEL SUPPORTS

- A. Fabricate from minimum 12 gauge steel channel, 1.5 inches by 1.5 inches with a continuous 0.875 inch wide slot, zinc coated.
- B. Hardware, Fittings, and Brackets: Zinc coated.
- C. Assembled supports, fittings, brackets, and hardware shall be designed to carry the load with a safety factor of safety of three or greater.

2.08 LOCAL CONTROL PANEL (LCP)

- A. The Contractor shall provide a LCP in each Relay Room as specified in Section 13581, "Local Control Panels."

2.09 TELEPHONE

- A. A telephone shall be furnished as specified in Section 16721, "Telephone System."

ARTICLE 3 EXECUTION

3.01 RELAY ROOMS AND CASES

- A. The Contractor shall provide enough level walking space 2 feet minimum around the case (with doors open) for maintenance.
- B. Non-skid, non-groove rubber flooring mats shall be installed to cover the entire floor in each new relay room. Flooring shall be bonded to the floor. Design of the rubber flooring shall be submitted to the Engineer for review and approval.
- C. In each case, main terminal boards shall be mounted facing the front.
- D. Cases shall be installed as specified in Section 13585, "Installation Requirements."

3.02 RACKS

- A. Racks shall be installed as specified in Section 13585, "Installation Requirements."
- B. Racks shall be shock-mounted.
- C. Rack terminals shall be located on upper portion of racks.
- D. A unique white identification number shall be stenciled on each rack top, front, and back.
- E. A minimum of 20 percent spare space shall be provided on each equipment rack for future equipment. The 20 percent shall be equal to or greater than one vital relay row.

3.03 CABLE TRAYS

- A. Cable trays shall be installed in accordance with NEC, Article 318.
- B. Trays shall be supported so maximum deflection after cable installation is 0.25 inch. Maximum spacing of supports shall be 8 feet.
- C. Supports shall be anchored with 0.50 inch minimum bolts.
- D. Tray shall be supported adjacent to and on each side of joints and fittings.
- E. Trays shall be mechanically anchored to supports.
- F. Trays shall be bonded and grounded to the bus plate. Trays shall be isolated from racks to prevent ground loops.
- G. Cable support shall be provided between conduit stub-ups or raceways and the cable trays.

3.04 LOCAL CONTROL PANEL

- A. The LCP shall be mounted on a wall of the Relay Room near the entrance door
- B. The LCP shall be mounted to allow for unrestricted access to the LCP interior.
- C. Location of the LCP shall permit free access for an operator standing in front.
- D. LCP shall be oriented so the operator will face both the panel and the entrance door.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13591

TAGS, LOCKS AND KEYS

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for tags, locks and keys, in accordance with the Contract Documents.
- B. The work of this Section includes, but is not limited to, the following activities:
 - 1. Tags and tagging
 - 2. Locks and keys

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements"
- B. Section 01910, "Operations, Maintenance and Repair Data"
- C. Section 13570, "Signal System Requirements"
- D. Section 13574, "Wayside Signal Equipment"
- E. Section 13581, "Local Control Panels"
- F. Section 13585, "Installation Requirements"
- G. Section 13590, "Housings and Housing Equipment"

1.03 SUBMITTALS

- A. Product Data, Shop Drawings and specifications for all tags, locks, and keys shall be submitted.
- B. The Contractor shall submit a sample of each type of tag, lock, and key for review and approval of the Engineer.
- C. The Contractor shall submit method of equipment identification coding.

ARTICLE 2 PRODUCTS

2.01 TAGS

- A. Tags shall meet the following requirements:
 - 1. Stencils: White enamel paint.

2. Flat Tags
 - a. Laminated phenolic or vinyl plastic, white with black lettering.
 - b. Minimum two holes for screw mounting.
 - c. Minimum thickness 0.050 inch.
3. Wire Tags
 - a. White vinyl plastic with black lettering, protect with a 0.005 inch clear over laminate.
 - b. Minimum 0.020 inch thick.
 - c. All corners rounded to approximately 0.125 inch radius.
 - d. Lettering minimum 0.125 inch high with minimum 0.094 inch spacing between lines.
4. Cable Tags: Same as wire tags except attached to the cable with pre-tied nylon cord loops.
5. Sleeve Tags
 - a. White vinyl plastic with black lettering.
 - b. 0.125 inch lettering.
 - c. Lengths as required, minimum length 0.75 inch.
 - d. Diameter shall be selected for a snug fit on wire.
6. Cast Metal Tags
 - a. Malleable cast metal.
 - b. Painted white.
 - c. Minimum height 3 inches.
 - d. Minimum thickness 0.0625 inch.
7. Brass Tags
 - a. 0.25 inch letters and numbers stamped into tag.
 - b. Sufficient size to contain required information, "Danger 650 Volts," without crowding.
 - c. Minimum thickness 0.03125 inch.

2.02 LOCKS AND KEYS

- A. Locks and keys shall meet the following requirements:
 1. Padlocks
 - a. Same as now in service on the existing LRT system as manufactured by American Lock.
 - b. All by the same manufacturer.
 - c. Solid block of extruded brass.
 - d. Shackle of heavy wrought brass or stainless steel.
 - e. Six-pin cylinder type.
 - f. Suitable for outdoor use.
 2. Keys
 - a. Brass.
 - b. Not commercially duplicable.
 - c. Two keys per lock.
 - d. Coding unique to the Authority LRT system.
 - 1) For all cases, relay room doors, cabinets and switch machines –

- American Lock key # 54832.
- 2) For Local Control Panels (LCP) as specified in Section 13581, "Local Control Panels."
 - 3. Keying Arrangement
 - a. The keying arrangement shall be the same as that used on the existing Authority system.

ARTICLE 3 EXECUTION

3.01 TAGGING

- A. A unique equipment identification code shall be provided and installed for each type of fixed equipment and replaceable element. The identification code shall be up to 10 digits in length and the method of coding shall be submitted for review and approval of the Engineer prior to submittal of wiring diagrams/Shop Drawings.
- B. Sleeve tags shall be installed on each end of all wires showing the origin and destination. Tags shall not obscure connecting links used between terminal binding posts. Tags shall be installed so that they can be read with a minimum of disturbance to the tags and wiring.
- C. Stencil
 - 1. Field cases and junction boxes using 1.5 inch lettering to identify location.
 - 2. Relay and equipment racks and cabinets, using 0.75 inch lettering to identify racks and cabinets.
- D. Install flat tags on:
 - 1. Relay plugboards to show relay designation.
 - 2. Equipment to show equipment designation.
 - 3. Main terminal board to identify cables.
- E. Wire tags with circuit nomenclature, location, and destination shall be installed:
 - 1. On terminal ends of all wires and cable conductors installed.
 - 2. Adjacent to terminals or binding posts.
 - 3. Tags shall not slide off the wire when wire is disconnected from its termination point.
 - 4. Tag shall be applied to cable conductors as conductors are verified during testing. Nomenclature shall be verified at both ends.
- F. Cable tags shall be installed at the entrance of every case, junction box, hand hole, and Relay Room. Cable tags showing cable identification, with pre-tied nylon cord loops on the cable sheath near the pothead shall be provided.
- G. Sleeve tags shall be installed on all wires connected to plugboard contacts.
- H. Brass Tags
 - 1. Use stamped brass tags attached adjacent to impedance bonds as referred to 2.01

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3.02 PADLOCKS

- A. The Contractor shall install padlocks on the following:
 - 1. Wayside field cases and junction boxes.
 - 2. Terminal cases.
 - 3. Signal heads.
 - 4. Switch machines
 - 5. Relay rooms, all doors.
 - 6. Other equipment provided under this contract as deemed necessary by the Engineer.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13593
SIGNAL POWER DISTRIBUTION

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for signal power distribution, in accordance with the Contract Documents.
- B. The work of this section includes, but is not limited to, the following activities:
 - 1. Power supplies
 - 2. Rectifiers
 - 3. Transformers
 - 4. Fuses
 - 5. Circuit breakers
 - 6. Power distribution panels
 - 7. Automatic and manual transfer switches
- C. The Contract Documents provide the performance parameters and design criteria to complete the signal power distribution. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements."
- B. Section 01910, "Operations, Maintenance and Repair Data."
- C. Section 13570, "Signal System Requirements,"
- D. Section 13585, "Installation Requirements,"
- E. Section 13587, "Wire and Cable,"
- F. Section 13589, "Electrical and Electronic Components."
- G. Section 13590, "Housings and Housing Equipment."
- H. Section 13595, "Signal System Test and Inspection."

1.03 REFERENCE STANDARDS

- A. ANSI Standard C2.
- B. NFPA Standard 70.

1.04 SUBMITTALS

- A. The Contractor shall submit calculations of the AC and DC power requirements for each signal equipment location.
- B. The Contractor shall submit all product data, Shop Drawing and specifications for all signal power components.

1.05 DESIGN CRITERIA

- A. The Contractor's work shall include feeders, automatic transfer switches, circuit breaker panels, buses, transformers, power supplies, ground detectors, and associated auxiliary material and equipment.
- B. General
 - 1. Power for the new Gateway Station, North Side Station and Allegheny Station Relay Rooms and the Allegheny Station switch heater contactor control circuit shall be 120 VAC, 60 Hz and shall be provided as shown on the Contract Drawings. Redundant power sources are provided to the relay rooms by others.
 - 2. Power for the signal system shall be applied to AC buses through transformers as required for the various loads to be fed from these buses.
 - 3. Power of 120VAC, 60 Hz will be used for all signal and power supplies and transformers. Relay room lights, air conditioning, heaters, outlets shall be provided by NSC Project Contract Packages 010, 011 and 012 for station finishes. Power for the signal system shall be ungrounded, and shall be fed through an isolation transformer as shown on the Contract drawings.
 - 4. Circuit breaker panels for signal power distribution shall be provided as shown on the Contract Drawings.
- C. Power Calculations
 - 1. The Contractor shall compute the size of the power distribution system required to feed the equipment, and design the complete layout of feeders, transformers, fuses, breakers and buses, based on the locations and sizes of individual signal system loads. All designs shall be subject to approval of the Engineer.
 - 2. The Contractor shall size all feeders to carry the rated load with a voltage drop of not more than 5 percent, except no feeder shall be smaller than No. 6 AWG. Size of feeders shall be able to carry a continuous load equal to 125 percent of the total continuous load that is required by the portion of the system to be fed.

ARTICLE 2 PRODUCTS

2.01 POWER SUPPLIES

- A. General: All DC power supplies furnished under this Contract shall meet the following basic requirements.
 - 1. Internal Transformers: Transformers used in DC power supplies shall not emit audible noise in excess of 50 dB (referenced to 0.0002 dynes/sq. cm.) at a distance

- of 3 feet when operated anywhere within the range of input and output voltages and currents specified.
2. Accessibility of Components
 - a. Power supplies requiring filter capacitors shall be designed so that their filter capacitors can be replaced without removing the power supply from the rack on which it is mounted.
 - b. Regulator boards, diodes and indicators shall be located and mounted so that they can be replaced without removing the supply from the rack.
 3. Electrical Insulation: The power supplies shall be insulated to withstand, for one minute, 600 VAC, 60 Hz applied between the input leads (connected together) and the output leads (connected together).
 4. Cooling
 - a. The power supplies shall be designed for natural convection cooling. Supplementary fans or other cooling devices are not permitted.
 - b. The Contractor's design shall allow for a power supply to be mounted on a rack with other power supplies and ensure the convection area and other components are sized and have dissipation ratings for such installations.
 5. Duty Cycle: The power supplies shall be designed for a continuous duty cycle.
 6. Failure Alarm
 - a. Each DC power supply shall be equipped with failure alarm device, which shall detect any internal failure that would prevent the power supply from delivering its full rated load.
 - b. This device shall be normally energized by a small percentage of the rated load current and cause two separately wired internal contacts to open when a failure is detected.
 - c. One of these contacts shall be independently wired to binding post for an external alarm indication circuit. The second contact shall be used to light an indication lamp or LED indicator mounted on the power supply. The circuit shall function even if the output voltage is maintained by a tandem power supply.
 - d. The power supply shall be so designed that the internal failure indication lamp or LED can be replaced without removing the power supply or any adjacent equipment from the rack.
 7. Input Voltage: The power supplies shall not be damaged by a sustained input voltage varying from 0 to 150 percent of the rated input voltage.
 8. Current Rating: The power supplies shall be sized in such a manner that no individual power supply operates at less than 20 percent of its rated current output during normal operation.
 9. Output Current:
 - a. The power supplies shall self-limit their output current to no more than 200 percent of their rated load unless otherwise specified herein.
 - b. Reverse output current protection shall be provided to prevent shorting or sagging of tandem supplies in the event of filter capacitor failure.
 10. Identification: Each power supply shall be clearly and permanently labeled with the following:

- a. Manufacturer's name.
 - b. Part or model number.
 - c. Serial number.
 - d. Input rating.
 - e. Output rating (continuous or intermittent).
11. Components and Wiring
 - a. Electrical and electronic components used on DC power supplies shall be as specified in Section 13589, "Electrical and Electronic Components."
 - b. Power supplies, which are designed to be repaired in the rack, shall have all components in modular assemblies, which do not require soldering to replace.

B. DC Filtered Power Supplies and Rectifiers

1. Rectifiers for supplying power for the operation of DC equipment in the relay rooms shall be an Engineer-approved silicon rectifier type designed to operate from the local 60 Hz 120/240 VAC power source circuit.
2. Rectifiers shall be capable of supplying the entire connected load plus 50 percent for an indefinite period without overheating or damage.
3. Each rectifier output shall be filtered and regulated such that the supply voltage remains stable.
 - a. The voltage regulation under these conditions shall be sufficient to ensure continuous proper operation of all connected equipment. The Voltage regulation shall not exceed five percent of the nominal output voltage, with line voltages between 105 and 125 VDC.
 - b. Ripple shall not exceed one percent at full rated load.
4. Separate rectifiers shall be provided for the following services:
 - a. Relay circuits within the house or case: Internal Power Supply.
 - b. Relay circuits connected to field apparatus other than track circuits, or to other housing: Line Power Supply.
 - c. Microprocessor based equipment.
 - d. Switch machines
5. All energy distribution shall be the loop method.

2.02 OTHER POWER DEVICES

- A. Fuses provided by Contractor shall meet the following requirements:
 1. Non-renewable, fiber-cased, time lag, fusion type.
 2. Correct size and rating to protect the electrical equipment form overload.
 3. Fuses installed in equipment racks: indicating type with fuse alarm circuits provided to alarm individual fuse failure. Switch actuating indicating fuses shall not be allowed. Fuses shall provide an electrical connection directly to the alarm circuit.
 4. In DC branch circuits, where fusing is impractical, a protective resistance unit shall be provided.
 5. All fuses shall be centrally located on power distribution panels or racks.
- B. Circuit Interrupters (Breakers) provided by Contractor shall meet the following

requirements:

1. Equipment intended to break current at fault levels shall have interrupting rating sufficient for the system voltage and the current with is available at the line terminals of the equipment.
 2. Equipment intended to break current at other than fault levels shall have an interrupting rating at system voltage sufficient for the current to be interrupted.
 3. Circuit interrupters may be required in lieu of fuses at the discretion of the Engineer.
 4. Breakers shall be of single, double or triple pole, molded case type and shall be rated for the voltages as indicated on the Contract Drawings.
 5. Breakers shall have an interrupting current rating of 14,000 amperes symmetrical.
 6. Breakers with inverse-time characteristics shall be secured through use of bimetallic tripping elements supplemented by instantaneous magnetic trip.
 7. Breakers shall be UL and CSA listed, IEC 157-1 rated, meet NEMA standard AB1-latest edition and Federal Specification W-C-375B/GEN, when applicable.
 8. Breakers shall have over center toggle-type mechanisms, providing quick-make, quick-break action.
 9. Breakers shall be calibrated for operation in an ambient temperature of 40 degrees C.
 10. Each breaker shall have trip indication by handle position and shall be trip free.
 11. Two and three pole breakers shall be common trip.
 12. Each breaker shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole.
 13. Breakers shall have removable lugs. Lugs shall be UL listed for copper conductors only. Breakers shall be UL listed for installation of mechanical type lugs.
- C. Transfer Switches (Automatic and Manual):
1. The automatic and manual transfer switches shall be of air break design and shall be three phase, 3-pole type as indicated in the Contract Drawings suitable for 60 Hz application.
 2. Automatic and manual transfer switches shall be rated for 120 volts. The switches shall be designed for a maximum system voltage of 600 volts.
 3. The automatic and manual transfer switches shall be of a double throw design that is inherently mechanically interlocked to prevent simultaneous connection of both power sources.
 4. The main contacts shall be mechanically held and electrically operated for the automatic transfer switch.
 5. The contact shall be capable of making or breaking any load within the rating of the switch.
 6. The automatic and manual transfer switches shall be compatible for use with an emergency generator or an alternate source of power.
 7. The control device of the automatic transfer switch shall provide for a complete automatic test and operation.
 8. The control device of the automatic transfer switch shall sense the voltage in the phase(s) of both sources and initiate a transfer immediately when the voltage of the

- normal source drops below 90% of the nominal voltage, and the secondary source is energized.
9. The automatic retransfer shall occur when the normal source is restored to the nominal voltage and after a user adjustable time delay of 0.5 to 30 minutes.
 10. Internal wiring shall be complete so that only service and load termination are required for field installation.
 11. The transfer switches shall meet or exceed all requirements of Underwriter's Laboratories Standards.
 12. The manufacturer shall conduct a complete test on each transfer switch to verify proper operation prior to shipment. Test reports shall be furnished with the shipments of the switches.

D. Power Distribution Panels:

1. Panelboards shall be metal-enclosed with dead-front distribution.
2. Three phase power distribution panels shall be rated at 208/120 volt, four wire, 60 Hz, and single phase signal power distribution panels shall be rated for 120 volt, ungrounded two wire, 60 Hz service; however, panels shall be designed for maximum system voltage of 600 volts.
3. Panelboards shall be complete with circuit breakers, copper buses, connections for incoming and outgoing cables, wiring and nameplates.
4. Electrical connections shall be bolted, with lock washers and ring tongue type, solderless connectors.
5. Distribution panel bus structure and main breakers shall have suitable current ratings. Such ratings shall be established by heat rise tests, conducted in accordance with UL standard 67.
6. Panelboard bus assembly shall be enclosed in a steel cabinet. The rigidity and gauge of steel to be as specified in UL standard 50 for cabinets. Wiring gutter space shall be in accordance with UL standard 67 for panelboards. The box shall be fabricated from galvanized steel or equivalent rust resistant steel. Each front shall include a door and have a flush, cylinder tumbler-type lock with catch and spring-loaded stainless steel door pull. Fronts shall not be removable with door in the locked position. A circuit directory frame and card with a clear plastic covering shall be provided on the inside of the door.

ARTICLE 3 EXECUTION

3.01 POWER EQUIPMENT

A. Power Supplies

1. Wall mount all power supplies.

B. Transformers

1. Install transformers in accordance with manufacturer's instructions.
2. Conduit Connections: Use flexible metal conduit not less than 18 inches or more than 36 inches in length unless otherwise approved.

3. Comply with NFPA 70, Article 450, and ANSI C2, Section 15.
 4. Verify all circuits are connected as indicated.
 5. Perform insulation and circuit continuity test prior to connecting primary service.
- C. Grounding shall be as specified in Sections 13585, "Installation Requirements," and 13590, "Housings and Housing Equipment."

3.02 POWER SUPPLIES

- A. Mounting height of power supplies, battery charges, and rectifiers shall be restricted to an area between 1.5 feet and 5.5 feet above the finished floor.
- B. An approved method shall be used to mount a typed or machine printed nametag for each power supply, battery charger, rectifier and other power-related devices, on the front plate of the equipment. The nametag shall be easily replaceable, but not come off during normal service.
- C. All power supplies, battery chargers, rectifiers and other power-related devices shall be tested in accordance with the manufacturer's recommendations.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. No separate measurement shall be made for the work of this Section.

4.02 PAYMENT

- A. No separate payment will be made for the work of this Section. Payment for the work shall be included in the payment for related portions of the Work.

END OF SECTION

SECTION 13595

SIGNAL SYSTEM TEST AND INSPECTION

ARTICLE 1 GENERAL

1.01 SUMMARY

- A. The work of this Section includes, but is not limited to, providing all labor, materials, tools, equipment and incidentals necessary for signal system test and inspection, in accordance with the Contract Documents.
- B. The work of this section includes, but is not limited to, the following activities:
 - 1. Test Program Plan
 - 2. Factory test procedures
 - 3. Field test procedures
 - 4. General procedures for factory and field testing
 - 5. Test equipment calibration
 - 6. Site test equipment and materials
 - 7. Factory inspections and tests
 - 8. Factory qualification testing
 - 9. First article inspection testing
 - 10. Environmental testing
 - 11. Factory acceptance test
 - 12. System level factory inspections and tests
 - 13. Field incoming inspections and tests
 - 14. Field inspections and tests
 - 15. LRVs for testing
 - 16. Wayside field installation verification
 - 17. Field functional adjustments and testing
 - 18. Interface testing
 - 19. Signal system integration tests
 - 20. Safe braking testing
 - 21. Signal system demonstration tests
- C. The Contract Documents provide the performance parameters and design criteria to complete the signal system test and inspection. The Contractor shall be responsible to provide a complete design for this portion of the Work.

1.02 RELATED SECTIONS

- A. Section 01300, "Administrative Requirements."
- B. Section 01777, "Construction Certification Program."
- C. Section 01910, "Operations, Maintenance and Repair Data."

- D. Section 13570, "Signal System Requirements."
- E. Section 13574, "Wayside Signal Equipment."
- F. Section 13576, "Circuit Requirements."
- G. Section 13577, "Solid State Equipment."
- H. Section 13579, "Design Requirements."
- I. Section 13580, "Train to Wayside Communications."
- J. Section 13581, "Local Control Panels."
- K. Section 13582, "Safety and Systems Assurance."
- L. Section 13585, "Installation Requirements"
- M. Section 13587, "Wire and Cable."
- N. Section 13588, "Relays and Plugboards."
- O. Section 13589, "Electrical and Electronic Components."
- P. Section 13593, "Signal Power Distribution."

1.03 REFERENCE STANDARDS

- A. AREMA Communications and Signals Manual of Recommended Practices.
- B. Code of Federal Regulations, Part 236 – Rules, Standards and Instructions.

1.04 SUBMITTALS

- A. Each submittal required herein shall be submitted for the approval of the Engineer. The Contractor shall, within 90 days after Notice to Proceed, submit for approval of the Engineer, the following:
 - 1. Test Program Plan:
 - a. The Contractor shall submit a Test Program Plan for the signal system, including the signal power system and the central traffic control system. The purpose of this plan is to ensure that the Contractor has considered all of the testing requirements contained in this and other sections of the Specifications and has made adequate provisions of testing in his overall program plans and schedules. The Test Program Plan shall contain, as a minimum, the following data:
 - (1) A flow diagram indicating the logical sequence of tests, starting with factory assembly tests and concluding with field demonstration tests.

- (2) A list of test procedures by test procedure number to be submitted, preliminary submittal schedule, a preliminary schedule of tests and a brief description of each factory and field test.
 - (3) An outline and format of the procedures and test data sheets for each type of test.
 - (4) Requirements for Authority-furnished material, personnel or equipment.
 - (5) Requirements and recommendations for witnessing.
 - (6) A description of the Contractor's in-plant and field test organizations.
 - (7) Integration of the testing to be performed using Engineer approved plans and procedures.
- 2. A list of factory tests to be performed on each piece of equipment furnished under this Contract.
 - 3. A list of installation inspections to be performed in the field upon installation of signal system equipment.
 - 4. A testing schedule which shall be called the Critical Path Testing Schedule. It shall delineate the order in which the various field tests will be made and show how the Contractor plans to meet the installation and testing dates required by the Contract. Supplementary data to be included with the schedule shall include an estimate of the test and train requirements, number of man-days required for each test, and the number of men the Contractor plans to have available for testing. The Critical Path Testing Schedule shall take into account the number of locations included in the Contract.
 - 5. A field installation test procedure for each of the field installation inspections to be performed.
- B. The Contractor shall, at least 30 days prior to the commencement of manufacture, submit for approval of the Engineer, detailed factory test documents as described herein. These test documents shall conform to the following requirements:
- 1. Include block diagrams depicting the test setup for each test method, test equipment to be used, procedures, and method for recording.
 - 2. The Contractor's factory test documents shall consist of a test procedure and pre-printed data sheets and/or inspection sheets for each test.
 - 3. When completed by the factory test personnel and checked for accuracy and completeness, the sheets shall be submitted as the factory test report.
 - 4. The Contractor shall submit these sheets to the Engineer and receive formal approval thereof before the equipment thereby tested is shipped.
 - 5. When factory tests require specific meter or test instrument readings, the pre-printed data sheet shall show the allowable range of values for each part of the test. The test report shall also contain a check-off system for each action and a blank space adjacent to the expected range of values in which to record the test readings. When tests include observations of pertinent responses that do not require instrument readings, each response shall have its own checkmark. No single checkmark shall be used for groups of responses.

6. If during the factory test, a discrepancy is found, it shall be corrected and any affected portion of the test shall be repeated. No piece of equipment with an uncorrected discrepancy shall be shipped. If a discrepancy is found which cannot be corrected, testing shall be discontinued and the Engineer shall be notified and furnished with the test results and all particulars.
 7. If a discrepancy is found within the vital site specific application firmware and software changes are performed, new firmware will be installed and the entire system shall be retested. Prior to the onset of the retesting procedure, new documentation shall be provided to the Engineer.
 8. At the conclusion of factory testing for a particular location, a checksum verification form for each EEPROM shall be provided to the Engineer.
 9. Each device requiring factory test shall be given a model number to which the test documents are keyed. Any change in the organization or construction of the device shall result in a new model number or, alternatively, the same model number, but a new series number. Each device requiring factory test shall have a serial number which shall be unique for any given model number. These numbers shall appear on the device.
- C. For each field test, including field tests for all interim cutovers, the Contractor shall, at least 30 days prior to the scheduled performance of the test, submit for approval of the Engineer, a detailed test procedure, as described herein. These test procedures shall meet, as a minimum, the following requirements:
 1. Include block diagrams depicting the test setup for each test method, test equipment to be used, procedures and method for recording.
 2. The Contractor's field test documents shall consist of pre-printed data sheets and/or inspection sheets for each test. When completed by the field test personnel and checked for accuracy and completeness, the sheets shall be submitted as the test report.
 3. When field tests require specific meter or test instrument readings, the pre-printed data sheet shall show the allowable range of values for each part of the test. The test report shall also contain a check-off system for each action and blank space adjacent to the expected value in which to record the test readings. When tests include observations of pertinent responses that do not require instrument readings, each response shall have its own checkmark. No single checkmark shall be used for groups of responses.
 4. The field test report shall also contain a final description sheet on which the Contractor shall record discrepancies found and action taken. This documentation shall be furnished to the Project Manager. All test reports shall be dated and signed by the responsible employee of the Contractor, or subcontractor, on the day the test is performed. Space shall also be provided for the signature of the witnessing inspector.
 5. Each step of the test procedure shall be clearly written in a manner that describes the action to be performed and also the purpose of the step.
- D. Prior to each system test cutover, the Contractor shall submit all completed and filled out preliminary testing documentation and installation checklists to include cable megger

- records and relay test values. These completed forms shall be submitted ten (10) days prior to the scheduled system test.
- E. Test procedures shall be clearly worded. A Glossary of Technical Terms shall be provided with each group of test procedures submitted. No technical words shall be used which are not in the Glossary. No words may be used in the test procedures which are not either in the Glossary or in common usage as defined by their inclusion in a commonly used "desk" or "college" edition dictionary. Words shall have their common meaning or a meaning in general use in the signal industry.
 - F. A Glossary of Abbreviations shall be provided with each group of test procedures submitted. No abbreviation may be used in the test procedure which is not included in the Glossary of Abbreviations.
 - G. Test procedures shall not be written for specific locations, but shall be general and apply to all locations of the same general type. Where a particular location has a special feature not usually found in locations of the same general type, the Contractor shall add a special section to the general procedure, clearly designated for that special feature. The Contractor shall provide entry spaces in the data sheets for the entry of the data which makes the general test procedure specific for specific locations. Examples of such data are:
 1. Location designations
 2. Adjacent location designations
 3. Track circuit numbers
 4. Signal numbers
 5. Train numbers
 - H. The Contractor shall record the results of each factory or field test as specified herein. The Contractor shall submit properly executed test documents for each prescribed test within ten (10) days of completion of the individual tests. All test reports shall be checked and approved by the Contractor prior to submittal to the Engineer. Partially completed test documents shall not be submitted without permission of the Engineer. The test report shall be all-inclusive, that is, it shall contain all required data, reference drawings, and explanations to permit evaluation without the necessity of securing this information from other sources by those whose purpose is to evaluate the test report. All superfluous data shall be so marked or eliminated from the test report prior to submittal. The test report shall be legible in its entirety. Test reports which do not meet these requirements will be rejected.

1.05 GENERAL REQUIREMENTS

- A. Tests and inspections shall be for the purpose of verifying design parameters, ensuring proper performance and safe operation of the signal system equipment, and demonstrating compliance with these Specifications. The tests to be performed shall cause each system and subsystem to be sequenced through its required operations, including the impositions of simulated conditions to prove that the installation complies

- with all specified fail-safe requirements.
- B. Tests and inspections shall be conducted according to procedures submitted by the Contractor and approved by the Engineer. Suppliers' existing inspection and factory acceptance test (FAT) procedures may be utilized upon the Engineer's approval.
 - C. Tests and inspections shall be made during the progress of this Contract and after completing the installation of equipment and shall consist of, but not be limited to, factory tests, circuit breakdown tests, wiring verification tests, continuity tests, resistance tests, voltage and current tests, time tests, flame tests, operating tests, simulation tests, and other electrical and mechanical tests and inspections. All subsystems and systems shall be tested completely prior to any operational testing of systems. Test procedures and inspections shall be conducted according to the manufacturer's standards except as otherwise specified.
 - D. The Contractor shall furnish all labor and materials necessary to perform tests, record data, and prepare reports.
 - E. Changes required to bring the system into compliance shall be at no additional cost to the Authority, including costs for additional testing.
 - F. Upon completion of each test, all test equipment and temporary facilities shall be removed and the system restored to full operational status.
 - G. The Contractor shall be responsible for the costs of his personnel and any special equipment and assistance required to conduct all required tests and inspections, and complete the required documentation. When a device or system does not meet the Specification requirements initially, the Contractor shall make the necessary corrections and shall be responsible for the total cost of additional tests and/or inspections required to prove compliance. The Contractor will not be responsible for the costs of train operation; these costs will be borne by the Authority to the extent agreed upon by approval of the Contractor's requirements in the test procedure. Vehicles and vehicle operators required for onsite vehicle-related tests will be provided by the Authority.
 - H. The Authority reserves the right to conduct any or all tests and inspections in the Contractor's plants or other manufacturing facilities. The Authority shall be advised a minimum of two weeks in advance of each factory test. When tests are to be conducted continuously as in a production-line routine, the Authority shall be advised 45 days in advance of the start of the tests to be conducted.
 - I. The Authority shall have the right to conduct any or all field tests conducted. The Authority shall be notified in writing at least two weeks prior to each field test. In the case of in-service testing, both the Authority and the Engineer shall be so notified. No part of the signal system shall be placed in service without an authorized Authority Engineering representative being present and overseeing the in-service tests.

1.06 QUALITY ASSURANCE

- A. The quality of materials, fabrication and finish of all signal components, and their compliance with these Specifications, shall be assured by the factory tests and inspections which the Contractor shall devise and perform. Factory testing shall require that all racks to be installed within a relay room, required to prove the signal aspects controlled from a particular location be wired together at the factory and tested as a complete system.
- B. The Contractor shall pretest all site specific application firmware prior to the factory acceptance test. Documentation of such pre-testing shall be submitted for approval prior to the scheduling of the factory acceptance test.
- C. The quality of the wayside signal system installation shall be assured through the performance by the Contractor of tests and inspections made during the progress of this Contract and after completing the installation of equipment.
- D. The Contractor shall devise and perform field installation inspections to ensure that all signal equipment furnished in association with this Contract is installed in compliance with these Specifications.
- E. The Contractor shall devise and perform such tests as are required by these Specifications to ensure that all wayside signal systems, subsystems, and operating equipment provided under this Contract function in a safe and proper manner.
- F. The validity of each field test shall be demonstrated to the Engineer, either at the factory with simulated equipment or in the field on newly installed equipment. (Simulated tests at the factory for vital equipment such as track circuits will not be acceptable.) The Engineer must be satisfied that the test procedure adequately determines that the equipment is working properly, in a safe manner, and that it meets or exceeds the requirements of the Specifications.

1.07 STATISTICAL SAMPLING PLANS

- A. Sampling plans may be used when tests are destructive, or when quality trend data, inherent characteristics of the product, or the non-critical application of the product indicate that a reduction in testing or inspection can be achieved without jeopardizing quality.
- B. The Contractor shall provide details on any sampling plans and submit the proposed sampling plan to the Engineer for approval prior to its use.
- C. Any sampling plan used shall provide valid confidence and quality levels, as solely determined by the Engineer.

1.08 TEST EQUIPMENT AND CALIBRATION

- A. The Contractor shall supply all test equipment required for factory and field testing.
- B. Test reports shall document the calibration date of each instrument used during the test. Calibration shall be traceable to the National Institute of Standards and Technology (NIST). Recertification shall be conducted every 90 days or less. Out-of-date instruments will be considered non-certified. Tests conducted with non-certified instruments will be rejected. If it is determined that the testing and inspection is invalid, a retest shall be conducted with properly certified test equipment and resubmitted for approval. Any additional testing shall be performed at the Contractor's expense.
- C. All calibrations/certifications shall be recorded and become part of the quality assurance records.

ARTICLE 2 PRODUCTS

2.01 SITE TEST EQUIPMENT AND MATERIALS

- A. All test instruments and equipment necessary to conduct the tests specified herein shall be available, ready-for-use not less than one week in advance of test need. Ready-for-use shall mean properly matched for test parameters, properly calibrated, sufficiently supplied with leads, probes, adapters, and stands necessary to conduct the particular test in a completely professional manner.
- B. All temporary or interim test related materials, special tools, connections, and jumpers shall be furnished and available not less than one week in advance of the test.

ARTICLE 3 EXECUTION

3.01 FACTORY INSPECTIONS AND TESTS

- A. The Contractor shall inspect and test each item to be provided under the Contract. The following inspections and tests shall be included:
 1. Receiving inspection of raw materials or component parts at the factory.
 - a. These inspection measures shall be used to preclude the use of incorrect or deficient products and to ensure that only products which are acceptable and in compliance with the Contract Documents are used and installed.
 - b. All product certifications and Test Reports used as the basis for acceptance by the Contractor shall be preserved.
 2. In process inspections of production operations.
 3. Factory qualifications testing, if applicable, as described here-in.
 4. First article inspection test, if applicable, as described here-in.
 5. Environmental testing, if applicable, as described in here-in.
 6. Factory acceptance tests, as described here-in.
 7. System level inspections and tests as described here-in.
- B. General Requirements for Factory Inspections and Tests

1. Design tests: All subsystems, equipment, and components shall be tested at the factory on the first assembled equipment or system component to demonstrate compliance with specifications and/or industry standards.
 2. Production tests: All systems, subsystems, and equipment shall be 100 percent factory inspected and tested to verify the quality and correctness of the manufacturing and assembly process.
 3. Components used in a failsafe or vital circuits shall be 100 percent inspected and tested.
 4. Other components or units that are not used in a failsafe circuit may be inspected and tested using a sampling plan approved by the Engineer.
 5. The Engineer shall have the right to witness inspections or tests in the Contractor's, Subcontractors', or Suppliers' plants.
 6. The Contractor shall obtain the Engineer's approval of test results prior to making any shipment from its or its Suppliers' plants.
 7. When approved by the Engineer, Suppliers' existing factory test procedures may be used.
- C. Vital Relays
1. All vital relays shall be factory tested in accordance with Section 13588, "Relays and Plug boards," and the AREMA Communication and Signal Manual of Recommended Practices, Parts 6.2.1 and 6.1.5.
 2. Evidence of passing the factory inspection and testing shall be indicated on the relay where practical; otherwise a report submitted with the shipment.
- D. Rack Wiring
1. All factory-installed rack wiring shall be tested before shipment.
 2. The Contractor shall perform point-to-point tests to verify the continuity and connection of each conductor.
- E. Operational Testing
1. All equipment shall be operationally tested as a complete functional assembly prior to shipment.
 2. The Contractor shall test each function by simulating operating conditions.
 3. Where equipment is related to a safety function, each component or subassembly shall be separately inspected and tested.
- F. Notification of Testing
1. In order to have the opportunity to witness testing, the Engineer shall be notified in writing a minimum of 2 weeks in advance of each test.
- G. When tests are to be conducted continuously as a production-line routine, inform Engineer in writing at least 2 weeks in advance of the date of testing and the expected duration.

3.02 FACTORY QUALIFICATIONS TESTING

- A. Vital components, systems, and equipment shall be proven vital through qualifications testing or other means determined by the Engineer.
- B. Qualification testing is required for new or modified components, systems, or equipment to verify that environmental and design requirements of the Contract are met.
- C. Qualifications testing may not be required for service-proven components, systems, or equipment based upon service records or previous qualification test records approved by the Engineer.
- D. Qualifications testing shall include environmental testing (temperature, humidity, vibration, etc.) as well as testing under normal and abnormal conditions.

3.03 FIRST ARTICLE INSPECTION TEST (FAIT)

- A. The Contractor shall perform a comprehensive FAIT on the first interlocking, as well as any component or system that requires qualification testing. The Contractor shall not conduct a FAIT until its drawings are approved by the Engineer.
- B. The FAIT shall be required even for service-proven equipment if the equipment has been modified.
- C. The FAIT shall include all interfaces to assure the complete and proper operation of the equipment.
- D. The FAIT shall require approval of the Engineer before additional systems are manufactured or installed.

3.04 ENVIRONMENTAL TESTING

- A. All equipment shall be proven to operate properly over the temperature, humidity, and mechanical vibration and shock range defined in these specifications.
- B. Environmental testing applies to wayside signal equipment.
- C. Service-proven equipment may not require environmental testing, but shall require evidence of proper performance in previous tests or similar operating environment, subject to Engineer approval.

3.05 FACTORY ACCEPTANCE TESTS

- A. Prior to shipments, the Contractor shall inspect all products to be delivered for installation into the Work or otherwise delivered to Authority to assure completion and conformance to the Contract Documents.
- B. The inspections and preparation for shipment shall be verified by the Contractor's quality control personnel. Engineer's approval shall be required before any shipment is

made.

3.06 SYSTEM LEVEL FACTORY INSPECTIONS AND TESTS

- A. The Contractor shall set up all components for a location at the point of assembly and test the components as a system. The Contractor shall not conduct System Level Factory Inspections and Tests of a location until its drawings are approved by the Engineer. Refer to Section 13579, "Design Requirements."
- B. The following tests shall be conducted as a minimum:
 - 1. Visual inspection
 - a. Physically inspect all equipment to make sure it conforms to approved drawings.
 - 2. Continuity verification test
 - a. Ensure all wiring is complete and connects to the proper points.
 - b. Ensure there are no extraneous wires.
 - c. Verify all wires are tagged as required.
 - 3. Vital application software test
 - a. Any vital software shall be tested to verify conformance to specifications in Section 13577, "Solid-State Equipment."
 - b. Exercise all hardware and software by running diagnostics.
 - 4. Vital relay test and inspection
 - a. All vital relays shall be tested as specified in the AREMA Communications and Signals Manual of Recommended Practices.
 - 5. Power distribution and failure alarm tests
 - a. Power distribution and failure alarms shall be tested to verify conformance to specifications.
 - b. Verify each energy bus is fed from its discrete power supply, free from shorts and opens.
 - c. Verify each power supply operates properly and is effectively protected.
 - d. Verify all racks and equipment is connected to power supplies at correct polarity and magnitude.
 - 6. Track circuits system test
 - a. Connect track circuits as shown on approved drawings, simulating running rails and impedance bonds.
 - b. Test power frequency (PF) track circuits.
 - c. Where applicable, test track circuit polarity by simulating the effects of broken down insulated joints.
 - 7. Operating test for interlockings:
 - a. Install and energize all equipment.
 - b. Simulate all interfaces and check for proper operation.
 - c. Verify the following by using the local control panel or other suitable method:
 - 1) Conflicting routes cannot be established.
 - 2) Route and aspect charts at interlocking locations operate properly.
 - 3) Signal indication locking.

- 4) Traffic locking.
- 5) Route locking.
- 6) Time locking.
- 7) Approach locking.
- 8) Switch locking.
- 9) Switch restoration.
- 10) Switch indication.
- 11) Switch obstruction.
- 12) Manual and automatic switch and route selection control.
- 13) Validation of all Controls and Indications from the Operations Control Center

3.07 FIELD INCOMING INSPECTIONS AND TESTS

- A. The Contractor shall perform receiving inspection at the worksite for incoming products.
 1. Inspection shall preclude the use of incorrect or deficient products and ensure that only products which are acceptable and in compliance with the Contract Documents are used and installed.
 2. All product certifications and Test Reports used as the basis for acceptance by the Contractor shall be preserved.
- B. The Contractor shall maintain a receiving inspection log for all items received at the worksite. The Contractor shall submit the content of the log for the Engineer's approval.

3.08 FIELD INSPECTIONS AND TESTS

- A. The Contractor shall verify the quality of the installation by visual inspection and by tests of continuity, insulation resistance, and resistance of ground connections, vital circuit breakdown, and other tests as required.
- B. All tests required shall be performed to ensure the proper and safe operation of all signal equipment and to prove the adequacy and acceptability of the total installation.
- C. In the case of testing on operational portions of Authority's LRT system, the Contractor shall return the system to operational status after testing.
- D. Tests to be performed shall cause each system and subsystem to be sequenced through all required operations and include simulated conditions to prove the installation is in compliance with failsafe requirements.
- E. The Contractor shall obtain recommended field inspections and tests from all Suppliers for all equipment to be used in this Contract. These manufacturers' recommended field inspections and tests shall be contained in the Inspection and Test Plan.

- F. Procedures for all tests shall be submitted for approval to the Engineer at least 60 days before the scheduled test.
- G. The Engineer shall have the right to witness all field inspections and tests. The Engineer shall be notified in writing a minimum of 2 weeks in advance of each inspection or test.
- H. Test Reports from the Contractor and Suppliers shall be submitted within 10 days after performing tests.
- I. Test Reports shall include any pass/fail history along with any corrective action taken to bring test into compliance, including recommended changes and retesting.
- J. The Contractor shall make every effort not to interfere with existing Authority systems during tests and inspections. Operational tests shall be performed during off-peak hours to the extent possible. If interference with existing Authority systems is unavoidable, arrangements must be made with Authority a minimum of two weeks in advance of the test.

3.09 LRV'S FOR TESTING

- A. Authority will provide LRV's and crews to support the testing program. These shall be scheduled 30 days in advance.
- B. Trains for testing will normally be scheduled 8 hours per day, 7 days per week, preferably after peaks. The first hour of each day will be reserved for track inspection and setting up test limits, and the last 30 minutes reserved to return the operating crew to the SHV Rail Center.

3.10 WAYSIDE FIELD INSTALLATION VERIFICATION

- A. For each location, the Contractor shall install all equipment into its relay/instrument house or case before proceeding with the field tests.
- B. The following tests shall be performed to verify all equipment has been installed correctly.
 1. Equipment Location Verification Test
 - a. Verify all field equipment is located and properly identified as required in specifications.
 2. Clearance Check
 - a. Verify that LRV envelope will clear and clearances to other equipment and structures have been properly maintained.
 3. Wire and Cable Tests
 - a. All wire and copper cable shall be tested after installation to ensure it has been installed according to the plans. Test the following at a minimum:
 - 1) Point-to-point continuity and proper connection.
 - 2) Ensure there are no conductor to conductor shorts.

- b. Insulation Resistance Test
 - 1) Prior to the test, disconnect power sources, running rail connections, direct connection to ground circuits, and any equipment that may be damaged by the voltages of the test instrument unless connection incorporates an isolation link.
 - 2) Connection to ground for the test shall be the most convenient previously verified low resistance connection to ground available.
 - 3) Test all wire and cable installed at the job site for insulation resistance between the conductor and ground, using a direct resistance reading instrument having a self-contained or generating test voltage of 500 to 1000 VDC.
 - 4) Minimum insulation resistance to ground for circuits operating below 600 volts shall be 50 megohms, and for circuits operating at 600 volts and above, 100 megohms. Wires and cable shall be replaced when insulation resistances are below these values. Actual resistance readings shall be recorded on test forms.
 4. Ground Resistance Test
 - a. Test relay/instrument housing ground buses in accordance with a procedure approved by the Engineer to ensure the resistance between each bus and the single point ground source is not greater than 0.5 ohm.
 - b. Resistance between a ground rod driven at least 8 feet from the point under test and each housing, signal head, snowmelter case, terminal case, or junction box shall be less than 15 ohms, or as approved by the Engineer. No chemical salts are permitted to achieve the required ground resistance.
 - c. All connections to the ground bus shall be tested to verify proper and adequate connections.
 - d. The Contractor shall propose test method and test equipment to be used for ground resistance test.
 5. Power and Signal Bonding Test
 - a. Test a sample of signal bonds and power bonds, as selected by the Engineer, to verify that the resistance across the rail connection is not greater than specified in Section 13587, "Wire and Cable."
 6. Insulated Joint Test
 - a. Verify the integrity of any insulated joints as specified in the AREMA Communications and Signals Manual of Recommended Practices, Part 8.6.35.
 7. Switch Machine Appurtenances Insulation Test
 - a. Verify the integrity of the insulation of the switch point detector rod insulated section, basket, lock rods, and gage plate extensions.
 8. Power Distribution Test
 - a. Turn power on with circuit breakers closed, fuses installed, and relays plugged in.
 - b. Check power supply input and output levels.
 - c. Verify that fuses do not blow and circuit breakers do not trip during normal operation.

9. Vital Relays Test and Inspection
 - a. Perform this test after vital relays are installed in their final location.
 - b. Verify the proper operation of each vital relay to verify that no change occurred since factory testing.
 - c. Complete an AREMA Office Records Test Form for each vital relay.
10. Breakdown Test of Vital Circuitry
 - a. Verify that all vital circuits are working properly and as specified.
 - b. Test one circuit at a time.
 - c. Open the circuit at each contact in the control line of the relay (or other device) operated by the circuit to verify that the contact on the controlling relay is in the circuit under test.
 - d. Perform this test without power, with relays not installed, and using jumpers to simulate contacts.

3.11 FIELD FUNCTIONAL ADJUSTMENTS AND TESTING

- A. The Contractor shall perform field functional adjustments and testing to verify proper operation.
- B. The following tests shall be performed:
 1. Interlocking Test
 - a. Circuit Breakdown Test
 - 1) All wiring shall be tested after installation to ensure continuity and proper connection according to the circuit plans.
 - 2) Where parallel circuits exist, test each parallel path independently to ensure the continuity of each path.
 - 3) Each function shall be tested as a complete system or subsystem for the correct operation in response to circuit element or contact closure.
 - b. Test interlocking plant functions for correct performance and safety. Include simulated unusual conditions to determine all equipment will respond in a safe and proper manner.
 - c. Functions to be tested shall include but not be limited to:
 - 1) Signal indication locking.
 - 2) Traffic locking.
 - 3) Route locking.
 - 4) Time locking.
 - 5) Approach locking.
 - 6) Switch locking.
 - 7) Switch restoration.
 - 8) Switch indication.
 - 9) Switch obstruction.
 - 10) Switch motor and hand mode of operation.
 - 11) Manual and automatic switch and route selection control.
 - 12) Validation of all Controls and Indications from the Operations Control Center
 2. Power Frequency Track Circuit Test

- a. Test power frequency track circuits to ensure proper design, installation, and adjustment.
 - b. With a 3 ohm per 1000 feet simulated ballast leakage, the track circuit shall de-energize when shunted with a 0.25 ohm shunt anywhere within the circuit. With the 0.25 ohm shunt removed, track circuit shall operate normally.
 - c. Track circuit shall de-energize when any one of the insulated joints defining track circuit boundaries is shunted.
 - d. Track circuit relay shall be de-energized when the feed end or relay end of the circuit is disconnected. Track circuit relay shall be de-energized when the local reference voltage is de-energized.
 - e. The normal operating parameters and track circuit leakage shall be recorded and submitted to the Engineer.
3. Signal Adjustment Test
 - a. Check signals for proper aspect and lamp voltage.
 4. Line Circuit Test
 - a. Check the integrity of vital and non-vital information sent location to location.
 5. Traffic Circuit Test
 - a. Verify the integrity of traffic circuits between interlocking locations as designed.
 6. Train/Wayside Communications Test
 - a. Verify the operation of the TWC at each location.
 7. Signal Sighting Test
 - a. Verify that the wayside signals can be observed from the vehicle.
 8. Control Line Verification Test

3.12 INTERFACE TESTING

- A. The Contractor shall test each interface to verify that it works properly.
- B. Tests shall include at least the following:
 1. OCC interface.
 2. Power.
 3. Any other interface with existing equipment.

3.13 SIGNAL SYSTEM INTEGRATION TESTS

- A. After the Contractor has completed installation tests and verified system operation within the local limits of work, the Contractor shall perform the following tests, at a minimum, utilizing LRV's and any other Authority system elements as necessary:
 1. Interlocking tests shall be performed to verify system safety through dynamic operation of LRV's.
 - a. Tests shall thoroughly exercise both automatic and manual route clearing, normal and reverse moves, switch machine hand and motor modes of operation, and train to wayside communication (TWC) system initiated

routing.

- B. Test all interlocking routes and movements.

3.14 SAFE BRAKING TESTING

- A. The Contractor shall perform tests to verify the safe braking distances provided meet the requirements of these specifications. Marked control line diagrams indicating the block to be tested and the speed at which the test is to be done, shall be included in the data package for such tests. Tests shall meet the following requirements:
1. Tests shall be performed with an LRV on which the brake rate is adjusted to the values used in safe braking distance calculations.
 2. Tests shall be performed on every block for the normal running direction.
 3. The following items shall be checked utilizing an LRV with a known standardized stopping distance. (The standardized stopping distance must be verified and recorded before each day's testing.) The Contractor shall determine that:
 - a. With LRV operating at Maximum Authorized Speed (MAS) for the location being checked, and with the LRV speed recorder on, at the brake activation point the LRV decelerates to a stop within limits of the control line.
 - b. Actual stopping point, as measured and recorded on the data sheet (front end of LRV to end of control line), is within limits.
 - c. Test has been conducted in the required direction(s) for every track circuit.
 - d. Data sheet shows speed at brake application point, stopping distance, maximum and minimum limits for stopping distance and reaction delay time for every test.
- B. If discrepancies are encountered, they shall be duly recorded on the test documents, corrected if possible, and retested as necessary. If a condition cannot be corrected, a plan of corrective action shall be entered on the data sheet, the test rescheduled, and the Engineer notified.

3.15 SIGNAL SYSTEM DEMONSTRATION TESTS

- A. The Contractor shall demonstrate that the system is fully operational under normal and abnormal conditions by circulating a complement of trains on the North Shore Connector.
- B. The Contractor shall perform a system operational test in which all functions of the completed system are exercised. Functions shall include the following, at a minimum:
1. Detection of all light rail vehicles on signaled mainline tracks.
 2. Maintenance of safe braking distance between vehicles, whether vehicles are running or stationary.
 3. Elimination of conflict arising when two vehicles simultaneously request routing through a particular interlocking.
 4. Safe operation of all wayside hardware for the vehicle prior to permitting any route to be traversed.

5. Automatic, remote, and TWC routing for all routes at terminals.
- C. The Contractor shall perform tests required to demonstrate compliance with the EMI criteria in accordance with Section 13579, "Design Requirements."
- D. The Contractor shall perform tests and inspections needed to verify the requirements of Section 13582, "Safety and Systems Assurance."
- E. The Contractor shall provide labor, tools, and equipment to support demonstration testing.
- F. The Contractor shall verify that the system and interfaces operate properly.

ARTICLE 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Item 13595.001 – Signal System Test and Inspection, shall be measured as a lump sum unit, complete in place.

4.02 PAYMENT

- A. Item 13595.001 - Signal System Test and Inspection, will be paid at the lump sum price and shall include cost of all related work specified in this Section.

END OF SECTION

