2015 EDITION

THE "GREENBOOK"

STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION

"GREENBOOK"

Standard Specifications for Public Works Construction

2015 Edition

Written And Promulgated By

Public Works Standards, Inc.

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..... *By Way Of Explanation*

The Standard Specifications for Public Works Construction, popularly known as the "Greenbook", was originally published in 1967. The 2015 Edition is the 17th edition of this book, which is updated and republished every three years.

The original edition of the Greenbook was the product of almost four years of intensive work by a 400-person task force which then comprised the Joint Cooperative Committee. The City and County of Los Angeles were major contributors to this effort and these two agencies were the first to adopt the Greenbook. To date, more than 200 other cities, counties, and agencies in the area have also adopted it as their standard for public works construction specifications. Interest in the Greenbook has been worldwide, with copies being acquired and studied by public works officials throughout the United States, Canada, and many countries overseas.

Immediately after publication of the Greenbook, a permanent Joint Cooperative Committee, comprised of representatives from cities, counties, utility companies, and contractors throughout Southern California, was established to carry on the work. The function of this committee was to study and update the provisions of these specifications to reflect the constantly changing technology and advanced thinking of the construction industry.

The first 10 editions of the Greenbook were the product of the Joint Cooperative Committee of the Southern California Chapter of the American Public Works Association, and the Southern California Districts of the Associated General Contractors of California.

In December 1995, the Joint Committee formally ceased operations. In January 1996, Public Works Standards, Inc., a mutual benefit corporation, began producing the Greenbook. The Corporation's Board of Directors is comprised of nine members – five representing the American Public Works Association, and the other four from the Associated General Contractors of California, the Engineering Contractors Association, the Southern California Contractors Association, and BNi Publications, Inc. The Board appoints a 25-member Greenbook Committee which carries on the tradition and function of the original Joint Committee. This committee convenes regularly each month to consider new changes.

In each of the two years between publication of a new Greenbook edition, the changes which have been approved by the Greenbook Committee during the preceding year are published in pamphlet form as amendments to the current edition. This program maintains a "living" document in public works specifications. Stripes in the margin of each new edition point out significant changes in the text adopted since the preceding edition.

The original edition of the Greenbook consisted of three parts: General Provisions, Construction Materials, and Construction Methods.

In 1970, 1991, and 1994, Parts 4, 5 and 6 were added to provide specifications for alternate aggregate materials, pipeline system rehabilitation, and modified asphalt products, respectively. In 2012, Part 6 was incorporated into Parts 2 and 3. In 2015, Parts 6, 7, and 8 were added. Part 6 contains specifications formerly in 7-10.1 and 7-10.2; Part 7 those formerly in 209 and 307; and Part 8 those formerly in 212 and 308.

The Greenbook is designed to aid in furthering uniformity of plans and specifications accepted and used by those involved in public works construction and to take such other steps as are designed to promote more competitive bidding by private contractors. The Greenbook provides specifications that have general applicability to public works projects. The Greenbook does NOT test or approve products. It is the function of public agencies and private project owners that utilize the Greenbook to determine whether products proposed by a contractor satisfy the Greenbook specifications or the Special Provisions.

Interested parties who wish to suggest changes or amendments to this book may communicate with Public Works Standards, Inc., c/o Associated General Contractors of California, 1906 W. Garvey Avenue South, Suite 100, West Covina, CA 91790. The change form and further information about the Greenbook Committee are available at www.greenbookspecs.org

In 1984, a companion to the Greenbook entitled the Standard Plans for Public Works Construction was adopted by the Joint Cooperative Committee. Both books are available from BNi Publications, Inc., or other technical bookstores.

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GENERAL PROVISIONS

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1-2 TERMS AND DEFINITIONS.

Addendum – Written or graphic instrument issued prior to the opening of Bids which clarifies, corrects, or changes the Contract Documents. The term "Addendum" shall include bulletins and all other types of written notices issued to potential bidders prior to opening of the Bids.

Agency – The legal entity for which the Work is being performed.

Agreed Price – The cost for new or unforeseen work, or for adjustments in the Contract Unit Price for changes in the character of the work as specified in 3-2.4, established by mutual agreement between the Contractor and the Agency.

Agreement – See Contract.

Assessment Act Contract – A Contract financed by special assessments authorized under a State Act or procedural ordinance of a City or County.

Base – A layer of specified material of planned thickness placed immediately below the pavement or surfacing.

Bid – The offer or proposal of the Bidder submitted on the prescribed form setting forth the prices for the Work.

Bidder – Any individual, firm, partnership, corporation, or combination thereof, submitting a Bid for the Work, acting directly or through a duly authorized representative.

Board – The officer or body constituting the awarding authority of the Agency.

Bond – Bid, performance, or payment bond or other instrument of security.

Caltrans – The State of California Department of Transportation.

Cash Contract – A Contract financed by means other than special assessments.

Certificate of Compliance – A written document signed and submitted by a supplier or manufacturer that certifies that the material or assembled material supplied to the Work site conforms to the requirements of the Contract Documents.

Change Order – A written order to the Contractor signed by the Agency directing an addition, deletion, or revision in the Work, or an adjustment in the Contract Price or the Contract time issued after the effective date of the Contract. A Change Order may or may not also be signed by the Contractor.

Code – The terms *Government Code*, *Labor Code*, etc., refer to codes of the State of California.

Contract – The written agreement between the Agency and the Contractor covering the Work.

Contract Documents – The Contract, Addenda, notice inviting bids, instructions to bidders, Bid (including documentation accompanying the Bid and any post-bid documentation submitted prior to the Notice of Award) when attached as an exhibit to the Contract, the Bonds, permits from jurisdictional regulatory agencies, Special Provisions, Plans, Standard Plans, Standard Specifications, Reference Specifications, Change Orders, and Supplemental Agreements.

Contractor – The individual, partnership, corporation, joint venture, or other legal entity having a Contract with the Agency to perform the Work. In the case of work being done under a permit issued by the Agency, the permittee shall be construed to be the Contractor. The term "prime contractor" shall mean the Contractor.

Contract Price – The total amount of money for which the Contract is awarded.

Contract Unit Price – The amount stated in the Bid for a single unit of an item of work.

County Sealer – The Sealer of Weights and Measures of the county in which the Contract is awarded.

Days – Days shall mean consecutive calendar days unless otherwise specified in the Special Provisions.

Disputed Work – Work in which the Agency and the Contractor are in disagreement.

Electrolier – Street light assembly complete, including foundation, standard, mast arm, luminaire, etc.

Extra Work – New or unforeseen work not covered by a Contract Unit Price or Stipulated Unit Price.

Engineer – The Chief Engineer of the Agency, Director of Public Works, or other person designated by the Board, acting either directly or through authorized agents.

House Connection Sewer—A sewer, within a public street or right-of-way, proposed to connect any parcel, lot, or part of a lot with a mainline sewer.

Luminaire – The lamp housing including the optical and socket assemblies (and ballast if so specified).

Mast Arm – The structural member, or bracket, which, when mounted on a Standard, supports the luminaire.

Modification – Includes Change Orders and Supplemental Agreements. A Modification may only be issued after the effective date of the Contract.

Notice of Award – The written notice by the Agency to the successful Bidder stating that upon its compliance with the required conditions, the Agency will execute the Contract.

Notice to Proceed – A written notice given by the Agency to the Contractor fixing the date on which the Contract time will start.

Operation, Maintenance, and Warranty Instructions – Documents published by manufacturers of pre-manufactured products describing operation, maintenance and any other actions that must be performed by the Agency as a condition for the manufacturer to honor the specified warranty.

Person – Any individual, firm, association, partnership, corporation, trust, joint venture, or other legal entity.

Plans – The drawings, profiles, cross sections, Standard Plans, working drawings, and shop drawings, or reproductions thereof, approved by the Engineer, which show the location, character, dimensions, or details of the Work.

Private Contract – Work subject to Agency inspection, control, and approval, involving private funds, not administered by the Agency.

Proposal – See Bid.

Reference Specifications - The latest edition, including amendments, in effect as of the date of advertisement of the Contract or issuing the permit, unless otherwise specified, of:

a) bulletins,
b) standards,
c) rules,
d) methods of analysis or testing,
e) codes,
f) installation instructions, and
g) specifications of other agencies, engineering societies, manufacturers, or industrial associations referred to in the Contract Documents.

Roadway – The portion of a street reserved for vehicular use.

Service Connection – All or any portion of the conduit cable or duct including meter, between a utility distribution line and an individual consumer.

Service Lateral Connection – The interface of the House Connection Sewer with the host pipe.

Sewer – Any conduit intended for the reception and transfer of sewage and fluid industrial waste.

Shop Drawings – Drawings showing details of manufactured or assembled products proposed to be incorporated into the Work.

Special Provisions – Additions and revisions to the Standard Specifications setting forth conditions and requirements peculiar to the Work.

Specifications – Standard Specifications, Reference Specifications, Special Provisions, and specifications in Change Orders or Supplemental Agreements between the Contractor and the Board.

Standard – The shaft or pole used to support street lighting luminaires, traffic signal heads, mast arms, etc.

Standard Plans – Details of standard structures, devices, or instructions referred to on the Plans or in the Specifications by title or number.

Standard Specifications – The Standard Specifications for Public Works Construction (SSPWC), the "Greenbook."

State – State of California.

Stipulated Unit Price – Unit prices established by the Agency in the Contract Documents.

Storm Drain – Any conduit and appurtenances intended for the reception and transfer of storm water.

Street – Any road, highway, parkway, freeway, alley, walk, or way.

Subbase – A layer of specified material of planned thickness between the base and the subgrade.

Subcontractor – An individual, firm, or corporation having a direct contract with the Contractor or with any other Subcontractor for the performance of a part of the Work.

Subgrade – For roadways, that portion on which pavement, surfacing, base, subbase, or a layer of other material is placed. For structures, the soil prepared to support a structure.

Supervision – Supervision, where used to indicate supervision by the Engineer, shall mean the performance of obligations, and the exercise of rights, specifically imposed upon and granted to the Agency in becoming a party to the Contract. Except as specifically stated

herein, supervision by the Agency shall not mean active and direct superintendence of details of the Work.

Supplemental Agreement – A written amendment of the Contract Documents signed by the Agency and the Contractor.

Surety – Any individual, firm, or corporation, bound with and for the Contractor for the acceptable performance, execution, and completion of the Work, and for the satisfaction of all obligations incurred.

Utility – Tracks, overhead or underground wires, pipeline, conduits, ducts, structures, sewers, or storm drains owned, operated, or maintained in or across a public right of way or private easement.

Work – That which is proposed to be constructed or done under the Contract or permit, including the furnishing of all labor, materials, equipment, and services.

Working Day – Any day within the period between the date of the start of the Contract time as specified in 6-1 and the date of completion of the Work as specified in 6-8.1, other than:

a) Saturday,
b) Sunday,
c) any day designated as a holiday by the Agency,
d) any other day designated as a holiday in a master labor agreement entered into by the Contractor or on behalf of the Contractor as an eligible member of a contractor association,
e) any day the Contractor is prevented from working at the beginning of the workday for cause as specified in 6-6.1, or
f) any day the Contractor is prevented from working during the first 5 hours with at least 60 percent of the normal work force for cause as specified in 6-6.1.

Working Drawings – Drawings showing details not shown on the Plans which are required to be designed by the Contractor.

1-3 ABBREVIATIONS.

1-3.1 General. The abbreviations are applicable to these Standard Specifications and the Special Provisions. Additional abbreviations shall be as shown on the Plans or specified in the Special Provisions.

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1-3.1 General. The abbreviations are applicable to these Standard Specifications and the Special Provisions. Additional abbreviations shall be as specified on the Plans or in the Special Provisions.

1-3.2 Common Usage.

Abbreviation	Word or Words
ABS	Acrylonitrile-Butadiene-Styrene
AC	Alternating Current
ADA	Americans with Disabilities Act of 1990 (Public Law 101-336, 104 Sat. 1990, 42 USC 12101-12213 (as amended))
APC	Air Placed Concrete
ARHM	Asphalt Rubber Hot Mix
ARAM	Asphalt Rubber and Aggregate Membrane
AWG	American Wire Gauge
BMPs	Best Management Practices
BR	Butadiene Rubber
BWG	Birmingham Wire Gauge

Abbreviation	Word or Words
CAB	Crushed Aggregate Base
CAPA	Corrugated Aluminum Pipe Arch
CAP	Corrugated Aluminum Pipe
CBR	California Bearing Ratio
CCFRPM	Centrifugally Cast Fiberglass Reinforced Plastic Mortar
CCR	California Code of Regulations
CCTV	Closed Circuit Television
CHDPE	Corrugated High Density Polyethylene
CIP	Cast Iron Pipe
CIPCP	Cast-In-Place Non-Reinforced Concrete Pipe
CIPP	Cured-In-Place Pipe
CLSM	Controlled Low Strength Material
CMB	Crushed Miscellaneous Base
CMP	Corrugated Metal Pipe
CQS	Cationic Quick-Setting
CRM	Crumb Rubber Modifier
CRS	Cationic Rapid-Setting
CRUMAC	Crumb Rubber Modified Asphalt Concrete
CSEP	Confined Space Entry Plan
CSPA	Corrugated Steel Pipe Arch
CSPB	Cement Stabilized Pulverized Base
CSP	Corrugated Steel Pipe
CSS	Cationic Slow-Setting
CTB	Cement Treated Base
CTM	California Test Method
CT	California Test
CWA	Constant Wattage Attenuator
CW	Constant Wattage
DC	Direct Current
DIP	Ductile Iron Pipe
EAS	Emulsion-Aggregate Slurry
EPDM	Ethylene-Propylene Diene Monomer
EPM	Ethylene-Propylene Monomer
FRPM	Fiberglass Reinforced Polymer Mortar
GG	Gap-Graded
HC	House Connection
HDPE	High Density Polyethylene
HPS	High Pressure Sodium
HRWRA	High Range Water Reducing Admixture
IIPP	Injury and Illness Prevention Program
IPS	Iron Pipe Size
JMF	Job Mix Formula
LCB	Lean Concrete Base

Abbreviation	Word or Words
LED	Light Emitting Diode
LSPB	Lime Stabilized Pulverized Base
LS	Lump Sum
MAC	Modified Asphalt Cement
MC	Medium Curing
Min	Minimum
MTBM	Microtunneling Tunnel Boring Machine
MUTCD	Manual on Uniform Traffic Control Devices
N/A	Not Applicable
NBR	Nitrile-Butadiene Rubber
NEC	National Electric Code
NPDES	National Pollutant Discharge Elimination System
NRCP	Non-Reinforced Concrete Pipe
OBC	Optimum Binder Content
OD	Outside Diameter
PAM	Pneumatically Applied Mortar
PAV	Pressure Aging Vessel
PBM	Pulverized Base Material
PCC	Portland Cement Concrete
PE	Polyethylene
PG	Performance Graded
PLI	Pounds Per Linear Inch
PMB	Processed Miscellaneous Base
PME	Polymer Modified Emulsion
PM	Polymer Modified
PRCB	Precast Reinforced Concrete Box
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
RC	Rapid Curing
R	Resistance Value
RA	Reclaimed Aggregates
RAP	Reclaimed Asphalt Pavement
RCP	Reinforced Concrete Pipe
REAS	Rubberized Emulsion-Aggregate Slurry
RMS	Root Mean Square
RPPCC	Reclaimed Plastic Portland Cement Concrete
RTFO	Rolling Thin Film Oven
RW	Reclaimed Water
S	Hveem Stability
SAPPA	Structural Aluminum Plate Pipe Arch
SAPP	Structural Aluminum Plate Pipe
SBR	Styrene-Butadiene Rubber
SC	Slow Curing

Abbreviation	Word or Words
SCMs	Supplementary Cementitious Materials
SDR	Standard Dimension Ratio
SDS	Safety Data Sheet
SE	Sand Equivalent
SG	Specific Gravity
SI	International System of Units (Metric)
SLC	Service Lateral Connection
SPA	Special Performance Admixture
SS	Slow-Setting
SSPPA	Structural Steel Plate Pipe Arch
SSPP	Structural Steel Plate Pipe
SWPPP	Storm Water Pollution Prevention Plan
TCP	Traffic Control Plan
THN	Thermoplastic, High Heat, Nylon-Coated
THWN	Thermoplastic, Heat and Water Resistant, Nylon-Coated
THW	Thermoplastic, Heat and Water Resistant
TRMAC	Tire Rubber Modified Asphalt Concrete
TR	Tire Rubber
TTC	Temporary Traffic Control
TW	Thermoplastic, Water Resistant
U.S.C.	United States Code
U.S.	United States
UV	Ultraviolet
VCP	Vitrified Clay Pipe
VTCSH	Vehicle Traffic Controls Signal Head
WATCH	Work Area Traffic Control Handbook
WMA	Warm Mix Asphalt
WTAT	Wet Track Abrasion Test
X	By

1-3.3 Institutions.

Abbreviation	Word or Words
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
AREA	American Railway Engineering Association
ASME	American Society of Mechanical Engineers
ASQ	American Society for Quality
ASTM	American Society for Testing and Materials
AWPA	American Wood Preservers Association
AWS	American Welding Society
AWWA	American Water Works Association
EEI	Edison Electric Institute

Abbreviation	Word or Words
EIA	Electronic Industries Alliance
EPA	Environmental Protection Agency
ETL	Electrical Testing Laboratories
FCC	Federal Communications Commission
GRI	Geosynthetic Research Institute
IEEE	Institute of Electrical and Electronics Engineers
IMSA	International Municipal Signal Association
ISSA	International Slurry Surfacing Association
ITE	Institute of Transportation Engineers
NEMA	National Electrical Manufacturers Association
NSF	NSF International
OSHA	Occupational Safety and Health Administration
PPI	Plastics Pipe Institute
RUS	Rural Utilities Service
SAE	Society of Automotive Engineers
SSPC	Society for Protective Coatings
UL	Underwriters' Laboratories Inc.

1-4 UNITS OF MEASURE.

1-4.1 General. The U.S. Standard Measures, also referred to as the U.S. Customary System, is the principal measurement system in these Specifications and shall be used for construction unless otherwise specified in the Special Provisions. The International System of Units, also referred to as SI or the metric system, is included in parenthesis. U.S. Standard Measures units may or may not be exactly equivalent to the SI units in parenthesis. If SI is specified for use in the Contract Documents, then all values used for construction shall be the SI units shown in parenthesis. Certain material specifications and test requirements contained herein use SI units specifically and U.S. Standard Measures have not been included in those circumstances.

Reference is also made to ASTM E380 for definitions of various units of the SI system and a more extensive set of conversion factors.

1-4.2 Units of Measure and Their Abbreviations.

U.S. Customary Unit (Abbreviations)	Equal To	SI Unit (Abbreviations)
1 mil (= 0.001 inch)		25.4 micrometer (μm)
1 inch		25.4 millimeter (mm)
1 inch		2.54 centimeter (cm)
1 foot (ft)		0.3048 meter (m)
1 yard (yd)		0.9144 meter (m)
1 mile (mi)		1.6093 kilometer (km)
1 square foot (ft^2)		0.0929 square meter (m^2)
1 square yard (yd^2)		0.8361 square meter (m^2)
1 cubic foot (ft^3)		0.0283 cubic meter (m^3)
1 cubic yard (yd^3)		0.7646 cubic meter (m^3)
1 acre		0.4047 hectare (ha)

U.S. Customary Unit (Abbreviations)	Equal To	SI Unit (Abbreviations)
1 U.S. gallon (gal)		3.7854 liter (L)
1 fluid ounce (fl. oz)		29.5735 milliliter (mL)
1 pound mass (lb) (avoirdupois)		0.4536 kilogram (kg)
1 ounce mass (oz)		0.02835 kilogram (kg)
1 Ton (= 2000 lb avoirdupois)		0.9072 tonne (= 907 kg)
1 Poise		0.1 pascal · second (Pa · s)
1 centistoke (cs)		1 square millimeters per second (mm^2/s)
1 pound force (lbf)		4.4482 Newton (N)
1 pound per square inch (psi)		6.8948 kilopascal (kPa)
1 pound force per foot (lbf/ft)		1.4594 Newton per meter (N/m)
1 foot-pound force (ft-lbf)		1.3558 joules (J)
1 foot-pound force per second (ft-lbf)		1.3558 watt (W)
1 part per million (ppm)		1 milligram/liter (mg/L)

Temperature Units and Abbreviations

Degree Fahrenheit (°F):
°F = (1.8 x °C) + 32

Degree Celsius (°C):
°C = (°F – 32)/1.8

SI Units (abbreviation) Commonly Used in Both Systems

1 Ampere (A)
1 Volt (V)
1 Candela (cd)
1 Lumen (lm)
1 second (s)

Common Metric Prefixes

kilo (k)	10^3
centi (c)	10^{-2}
milli (m)	10^{-3}
micro (μ)	10^{-6}
nano (n)	10^{-9}
pico (p)	10^{-12}

1-5 SYMBOLS.

%	Percent
'	Feet or minutes
"	Inches or seconds
#	Number
/	per or (between words)
°	Degree
x	Times

SECTION 2 - SCOPE AND CONTROL OF THE WORK

2-1 AWARD AND EXECUTION OF THE CONTRACT. Award and execution of the Contract shall be as provided for in the Special Provisions, Instructions to Bidders, or Notice Inviting Bids.

2-2 ASSIGNMENT. No Contract or portion thereof may be assigned without the consent of the Board, except that the Contractor may assign money due or which will accrue to it under the Contract. If given written notice, such assignment will be recognized by the Board to the extent permitted by law. Any assignment of money shall be subject to all proper withholdings in favor of the Agency and to all deductions provided for in the Contract. All money withheld, whether assigned or not, shall be subject to being used by the Agency for completion of the Work should the Contractor be in default.

2-3 SUBCONTRACTS.

2-3.1 General. Each Bidder shall comply with Division 2, Chapter 4 of the Public Contract Code including Sections 4100 through 4113.

The Bidder shall set forth in the Bid, pursuant to 4104:

"a) The name and location of the place of business of each subcontractor who will perform work or labor or render service to the prime contractor in or about the construction of the work or improvement, or a subcontractor licensed by the State of California who, under subcontract to the prime contractor, specially fabricates and installs a portion of the work or improvement according to detailed drawings contained in the plans and specifications, in an amount in excess of one-half of 1 percent of the prime contractor's total bid, or, in the case of bids or offers for the construction of streets or highways, including bridges, in excess of one-half of 1 percent of the prime contractor's total bid or ten thousand dollars ($10,000), whichever is greater."

"b) The portion of the work which will be done by each such subcontractor under this act. The prime contractor shall list only one subcontractor for each such portion as is defined by the prime contractor in his or her bid."

If the Contractor fails to specify a Subcontractor, or specifies more than one Subcontractor for the same portion of the Work to be performed under the Contract (in excess of one-half of 1 percent of the Contractor's total Bid), the Contractor shall be qualified to perform that portion itself, and shall perform that portion itself, except as otherwise provided in the Code.

Pursuant to Section 4107, no Contractor whose Bid is accepted shall substitute any person as a Subcontractor in place of a Subcontractor listed in the Bid, except for the causes and by the procedures established in Section 4107.5. This section provides procedures to correct a clerical error in the listing of a Subcontractor.

Section 4110 provides that a Contractor violating any of the provisions of Chapter 4 violates the Contract and the Board may exercise the option either to cancel the Contract or assess the Contractor a penalty in an amount of not more than 10 percent of the subcontract involved after a public hearing.

2-3.2 Self Performance. The Contractor shall perform, with its own organization, Contract work amounting to at least 50 percent of the Contract Price except that any designated "Specialty Items" may be performed by subcontract and the amount of any such "Specialty Items" so performed will be deducted from the Contract Price before computing the amount required to be performed by the Contractor with its own organization. "Specialty Items" will be identified by the Agency in the Bid or in the Special Provisions. Where an entire item is subcontracted, the value of work subcontracted will be

based on the Contract Unit Price. When a portion of an item is subcontracted, the value of work subcontracted will be based on the estimated percentage of the Contract Unit Price. This will be determined from information submitted by the Contractor, and subject to approval by the Engineer.

2-3.3 Status of Subcontractors. The Contractor shall give personal attention to the fulfillment of the Contract. The Contractor shall keep the Work under its control.

Subcontractors shall be considered employees of the Contractor, and the Contractor shall be responsible for their work.

In addition to the requirements of 2-3.1, before the work of any Subcontractor is started, the Contractor shall submit to the Engineer for approval a written statement listing the name, contractor license number, and business address of each Subcontractor and a description and value of each portion of the Work to be so subcontracted.

2-4 CONTRACT BONDS. Before execution of the Contract, the Contractor shall file surety bonds with the Agency to be approved by the Board in the amounts and for the purposes specified below. Bonds issued by a surety who is listed in the latest version of U.S. Department of Treasury Circular 570, who is authorized to issue bonds in California, and whose bonding limitation shown in said circular is sufficient to provide bonds in the amount required by the Contract shall be deemed to be approved unless specifically rejected by the Agency. Bonds from all other sureties shall be accompanied by all of the documents enumerated in the Code of Civil Procedure, Section 995.660 a).

Each bond shall incorporate, by reference, the Contract and be signed by both the Bidder and the Surety. The signature of the authorized agent of the Surety shall be notarized.

The Contractor shall provide 2 good and sufficient surety bonds. The "Payment Bond" (material and labor bond) shall be for not less than 100 percent of the Contract Price, to satisfy claims of material suppliers and mechanics and laborers employed by it on the Work. The Bond shall be maintained by the Contractor in full force and effect until the performance of the Contract is accepted by the Agency and until all claims for materials and labor are paid, and shall otherwise comply with the Civil Code.

The "Performance Bond" shall be for 100 percent of the Contract Price to guaranty faithful performance of all work, within the time prescribed, in a manner satisfactory to the Agency, and that all materials and workmanship will be free from original or developed defects. The Bond must remain in effect until the end of all warranty periods set forth in the Contract Documents.

The Contractor shall pay all bond premiums, costs, and incidentals.

Should any bond become insufficient, the Contractor shall renew the bond within 10 Days after receiving notice from the Agency.

Should any surety at any time be unsatisfactory to the Board, notice to that effect will be given to the Contractor. No further payments shall be deemed due or will be made under the Contract until a new surety qualifies and is accepted by the Board.

Changes in the Work or extensions of time, made pursuant to the Contract, shall in no way release the Contractor or the Surety from its obligations. Notice of such changes or extensions shall be waived by the Surety.

2-5 PLANS AND SPECIFICATIONS.

2-5.1 General. The Contractor shall keep at the Work site a copy of the Plans and Specifications, to which the Engineer shall have access at all times.

The Plans, Specifications, and other Contract Documents shall govern the Work. The Contract Documents are intended to be complementary and cooperative. Anything specified in the Specifications and not shown on

the Plans, or shown on the Plans and not specified in the Specifications, shall be as though shown on or specified in both.

The Plans shall be supplemented by such Working Drawings and Shop Drawings as are necessary to adequately control the Work.

The Contractor shall, upon discovering any error or omission in the Plans or Specifications, immediately call it to the attention of the Engineer.

2-5.2 Precedence of the Contract Documents. If there is a conflict between any of the Contract Documents, the document highest in the order of precedence shall control. The order of precedence, from highest to lowest, shall be as follows:

a) Permits issued by jurisdictional regulatory agencies.
b) Change Orders and Supplemental Agreements; whichever occurs last.
c) Contract/Agreement.
d) Addenda.
e) Bid/Proposal.
f) Special Provisions.
g) Plans.
h) Standard Plans.
i) Standard Specifications.
j) Reference Specifications.

Detail drawings shall take precedence over general drawings. The precedence of the notice inviting bids and instructions to bidders shall be as specified in the Special Provisions.

2-5.3 Submittals.

2-5.3.1 General. Submittals shall be provided as specified or when requested by the Engineer. Materials shall neither be furnished nor fabricated, nor shall any work for which submittals are required be performed before the required submittals have been reviewed and accepted by the Engineer. Neither review nor acceptance of submittals by the Engineer shall relieve the Contractor from responsibility for errors, omissions, or deviations from the Contract Documents, unless such deviations were specifically called to the attention of the Engineer in the letter of transmittal. The Contractor shall be responsible for the correctness of the submittals.

The Contractor shall allow a minimum of 20 Working Days for review of submittals unless otherwise specified in the Special Provisions. Each submittal shall be accompanied by a letter of transmittal.

Payment for submittals shall be included in the Contract Unit Price for the various Bid items.

2-5.3.2 Working Drawings. Working Drawings shall be of a size and scale to clearly show all necessary details.

Six copies and one reproducible shall be submitted. If no revisions are required, 3 of the copies will be returned to the Contractor. If revisions are required, the Engineer will return one copy along with the reproducible for resubmission. Upon acceptance, the Engineer will return 2 of the copies to the Contractor and retain the remaining copies and the reproducible.

Working Drawings are required in the subsections shown in Table 2-5.3.2.

TABLE 2-5.3.2

Item	Subsection No.	Title	Subject
1	7-8.5.2	Sanitary Sewers	Sewage Bypass and Pumping
2	7-8.6.3	Water Pollution Control	Storm Water Pollution Prevention Plan
3	7-8.6.4	Water Pollution Control	Dewatering Plan
4	7-10.4.2.2	Safety	Shoring Plan
5	300-3.2	Cofferdams	Structure Excavation & Backfill
6	303-1.6.1	General	Falsework
7	303-1.7.1	General	Placing Reinforcement
8	303-3.1	General	Prestressed Concrete Construction
9	304-1.1.2	Falsework Plans	Structural Steel
10	307-1.1	General	Jacking Operations
11	307-2.1	General	Tunneling Operations
12	307-2.4	Tunnel Supports	Tunneling Operations
13	308-3	Microtunneling	Microtunneling Operations
14	601-2	Work Area Traffic Control	Traffic Control Plan

Working Drawings listed above as Items 4, 5, 6, 8, 9, 10, 11, 12, 13, and 14 shall be prepared by a Civil or Structural Engineer registered by the State of California.

2-5.3.3 Shop Drawings. Shop Drawings are required in the subsections shown in Table 2-5.3.3.

TABLE 2-5.3.3

Item	Subsection No.	Title	Subject
1	207-2.5	Joints	Reinforced Concrete Pipe
2	207-8.4	Joints	Vitrified Clay Pipe
3	207-10.2.1	Joints	Vitrified Clay Pipe
4	304-1.1.1	Shop Drawings	Structural Steel
5	304-2.1	General	Metal Hand Railings
6	700-1	General	Shop Drawings

2-5.3.4 Supporting Information. Supporting information is information required by the Specifications for the purposes of administration of the Contract, analysis for verification of conformance with the Specifications, the operation and maintenance of a manufactured product or system to be constructed as part of the Work, and other information as may be required by the Engineer. Six copies of the supporting information shall be submitted to the Engineer prior to the start of the Work unless otherwise specified in the Special Provisions or directed by the Engineer. Supporting information for systems shall be bound together and include all manufactured items for the system. If resubmittal is not required, 3 copies will be returned to the Contractor.

Supporting information shall consist of the following and is required unless otherwise specified in the Special Provisions:

a) List of subcontractors per 2-3.2.
b) List of materials per 4-1.4.
c) Certificates of Compliance per 4-1.5.
d) Construction schedule per 6-1.
e) Spill Prevention and Emergency Response Plan per 7-8.5.3.
f) Confined Space Entry Program per 7-10.4.5.1.
g) Lean concrete base mix designs per 200-4.
h) Concrete mix designs per 201-1.1.

i) Asphalt concrete job mix formulas and/or mix designs per 203-6.3.

j) Pipeline layout diagrams per 207-2.1.

k) Equipment and materials list per 700-1.

l) Controller cabinet wiring diagrams per 701-17.2.2.

m) Data, including, but not limited to, catalog sheets, manufacturer's brochures, technical bulletins, specifications, diagrams, product samples, and other information necessary to describe a system, product or item. This information is required for irrigation systems, street lighting systems, and traffic signals, and may also be required for any product, manufactured item, or system.

2-5.3.5 Installation Instructions. When installation instructions for a pre-manufactured product are specified or referenced in the Contract Documents, the Contractor shall submit the following:

a) One original or legal copy of the installation instructions referenced.

b) When a manufacturer's installation instructions deviate from the Contract Documents, the Contractor shall submit a written statement from the manufacturer identifying the proposed deviations and the basis for such.

c) Unless the proposed deviations are approved, installation shall conform to the requirements in the Contract Documents.

d) The Engineer may waive the requirement for submitting installation instructions.

2-5.3.6 Manufacturer's Operation, Maintenance, and Warranty Instructions. For each pre-manufactured product covered by a manufacturer's warranty, the Contractor shall submit 3 bound original or legal copies prior to acceptance of the Contract. When no instructions are submitted, the Agency will presume no operational restrictions or maintenance procedures are required by the manufacturer as a condition for the manufacturer to honor the specified warranty.

2-6 WORK TO BE DONE. The Contractor shall perform all work necessary to complete the Contract in accordance with the Contract Documents. Unless otherwise specified, the Contractor shall furnish all materials, equipment, tools, labor, and incidentals necessary to complete the Work.

2-7 SUBSURFACE DATA. Soil and test hole data, groundwater elevations, and soil analyses shown on the Plans or included in the Special Provisions apply only at the location of the test holes and to the depths indicated. Soil test reports for test holes which have been drilled are available for inspection at the office of the Engineer. Additional subsurface exploration may be performed by Bidders or the Contractor at their own expense.

The indicated groundwater elevation is that which existed on the date specified in the data. It is the Contractor's responsibility to determine and allow for the groundwater elevation on the date the Work is performed. A difference in groundwater elevation between what is shown in soil boring logs and what is actually encountered during construction will not be considered as a basis for Extra Work.

2-8 RIGHT-OF-WAY. Rights-of-way, easements, or rights-of-entry for the Work will be provided by the Agency. Unless otherwise specified in the Special Provisions, the Contractor shall make arrangements, pay for, and assume all responsibility for acquiring, using, and disposing of additional work areas and facilities temporarily required. The Contractor shall indemnify and hold the Agency harmless from all claims for damages caused by such actions.

2-9 SURVEYING.

2-9.1 Permanent Survey Markers. Pursuant to Division 3, Chapter 15 of the Business and Professions Code, the Contractor shall not disturb survey monuments that "control the location of subdivisions, tracts, boundaries, roads, streets, or highways, or provide horizontal or vertical survey

control" until they have been tied out by a Registered Land Surveyor or Registered Civil Engineer authorized to practice land surveying within the State of California.

The Contractor shall submit to the Engineer a minimum of 7 Days prior to the start of the Work a list of controlling survey monuments which may be disturbed. The Agency (or the owner on a Private Contract) will:

a) set survey points outside the affected work area that reference and locate each controlling survey monument that may be disturbed,
b) file a Corner Record or Record of Survey with the County Surveyor after setting the survey points to be used for re-establishment of the disturbed controlling survey monuments, and
c) file a Corner Record or Record of Survey with the County Surveyor after re-establishment of the disturbed controlling survey monuments.

2-9.2 Survey Service. Except for Private Contracts, the Engineer will perform and be responsible for the accuracy of surveying adequate for construction. The Contractor shall preserve construction survey stakes and marks for the duration of their usefulness. If any construction survey stakes are lost or disturbed and need to be replaced, such replacement will be performed by the Engineer at the expense of the Contractor.

The Contractor shall notify the Engineer in writing at least 2 Working Days before survey services will be required in connection with the laying out of any portion of the Work. The Contractor shall dig all holes necessary for line and grade stakes.

Unless otherwise specified in the Special Provisions, stakes will be set and stationed by the Engineer for curbs, headers, sewers, storm drains, structures, and rough grade. A corresponding cut or fill to finished grade (or flowline) will be indicated on a grade sheet.

2-9.3 Private Engineers. Surveying by private engineers on the Work shall conform to the quality and practice required by the Engineer.

2-9.4 Line and Grade. The Work shall conform to the lines, elevations, and grades shown on the Plans.

Three consecutive points set on the same slope shall be used together so that any variation from a straight grade can be detected. Any such variation shall be reported to the Engineer. In the absence of such report, the Contractor shall be responsible for any error in the grade of the Work.

Grades for underground conduits will be set at the surface of the ground. The Contractor shall transfer them to the bottom of the trench.

2-10 AUTHORITY OF THE BOARD AND THE ENGINEER. The Board has the final authority in all matters affecting the Work. Within the scope of the Contract, the Engineer has the authority to enforce compliance with the Plans and Specifications. The Contractor shall promptly comply with instructions from the Engineer.

The decision of the Engineer is final and binding on all questions relating to: quantities; acceptability of material, equipment, or work; execution, progress or sequence of work; and interpretation of the Plans, Specifications, or other Contract Documents. This shall be precedent to any payment under the Contract, unless otherwise ordered by the Board.

2-11 INSPECTION. The Work is subject to inspection and approval by the Engineer. The Contractor shall notify the Engineer before noon of the Working Day before inspection is required. Work shall be done only in the presence of the Engineer, unless otherwise approved. Any work done without proper inspection will be subject to rejection. The Engineer and any authorized representatives shall at all times have access to the Work during its construction at shops and yards and while in storage, as well as to the Work site. The Contractor shall provide every reasonable facility for ascertaining that

the materials and workmanship conform to the Contract Documents. Inspection of the Work shall not relieve the Contractor of the obligation to fulfill all conditions of the Contract.

2-12 SPECIAL NOTICES. When specified in the Specifications or directed by the Engineer, any notice required to be served in accordance with this subsection shall be in writing, dated, and signed by the Contractor or the Engineer. Such notices shall be served by any of the following methods:

a) Personal delivery with proof of delivery which may be made by declaration under penalty of perjury by any person over the age of 18 years. The proof of delivery shall show that delivery was performed in accordance with these provisions. Service shall be effective on the date of delivery. Notices given to the Contractor by personal delivery may be made to the Contractor's authorized representative at the Work site; or

b) Certified mail addressed to the mailing address of the recipient postage prepaid; return receipt requested. Service shall be effective on the date of the receipt of the mailing.

Simultaneously, the Agency may send the same notice by regular mail. If a notice that is sent by certified mail is returned unsigned, then delivery shall be effective pursuant to regular mail, provided the notice that was sent by regular mail is not returned.

SECTION 3 - CHANGES IN WORK

3-1 CHANGES REQUESTED BY THE CONTRACTOR.

3-1.1 General. Changes in the Plans and Specifications, requested in writing by the Contractor, which do not materially affect the Work and which are not detrimental to the Work or to the interests of the Agency, may be granted by the Engineer. Nothing herein shall be construed as granting a right to the Contractor to demand acceptance of such changes.

3-1.2 Payment for Changes Requested by the Contractor. If such changes are granted, they shall be made at a reduction in cost or no additional cost to the Agency.

3-2 CHANGES INITIATED BY THE AGENCY.

3-2.1 General. The Agency may change the Plans, Specifications, character of the work, or quantity of work provided the total arithmetic dollar value of all such changes, both additive and deductive, does not exceed 25 percent of the Contract Price. Should it become necessary to exceed this limitation, the change shall be by written Supplemental Agreement between the Contractor and Agency, unless both parties agree to proceed with the change by Change Order.

Change Orders shall be in writing and state the dollar value of the change or establish the method of payment, any adjustment in the Contract time of completion, and when negotiated prices are involved, shall provide for the Contractor's signature indicating acceptance.

3-2.2 Contract Unit Prices.

3-2.2.1 General. If a change is ordered in an item of work covered by a Contract Unit Price, and such change does not involve a substantial change in the character of the work from that shown on the Plans or specified in the Specifications, then an adjustment in payment will be made. This adjustment will be based upon the increase or decrease in quantity and the Contract Unit Price.

If the actual quantity of an item of work covered by a Contract Unit Price and constructed in conformance with the Plans and Specifications varies from the Bid quantity by 25 percent or less,

payment will be made at the Contract Unit Price. If the actual quantity of said item of work varies from the Bid quantity by more than 25 percent, payment will be made per 3-2.2.2 or 3-2.2.3 as appropriate.

If a change is ordered in an item of work covered by a Contract Unit Price, and such change does involve a substantial change in the character of the work from that shown on the Plans or specified in the Specifications, an adjustment in payment will be made per 3-2.4.

3-2.2.2 Increases of More Than 25 Percent. Should the actual quantity of an item of work covered by a Contract Unit Price and constructed in conformance with the Plans and Specifications, exceed the Bid quantity by more than 25 percent, payment for the quantity in excess of 125 percent of the Bid quantity will be made on the basis of an adjustment in the Contract Unit Price mutually agreed to by the Contractor and the Agency, or at the option of the Engineer, on the basis of Extra Work.

The Extra Work basis of payment shall not include fixed costs. Fixed costs shall be deemed to have been recovered by the Contractor through payment for 125 percent of the Bid quantity at the Contract Unit Price.

3-2.2.3 Decreases of More Than 25 Percent. Should the actual quantity of an item of work covered by a Contract Unit Price, and constructed in conformance with the Plans and Specifications, be less than 75 percent of the Bid quantity, an adjustment in payment will not be made unless so requested in writing by the Contractor. If the Contractor so requests, payment will be made on the basis of an adjustment in the Contract Unit Price mutually agreed to by the Contractor and the Agency, or at the option of the Engineer, on the basis of Extra Work; however, in no case will payment be less than would be made for the actual quantity at the Contract Unit Price nor more than would be made for 75 percent of the Bid quantity at the Contract Unit Price.

3-2.3 Stipulated Unit Prices. Stipulated Unit Prices may be used for the adjustment of Contract changes when so specified in the Special Provisions.

3-2.4 Agreed Prices. If mutual agreement can not be reached, the Engineer may direct the Contractor to proceed on the basis of Extra Work, except as otherwise specified in 3-2.2.2 and 3-2.2.3.

3-2.5 Eliminated Items. Should any Bid item be eliminated in its entirety, payment will be made to the Contractor for its actual costs incurred in connection with the eliminated item prior to notification in writing from the Engineer so stating its elimination.

If material conforming to the Plans and Specifications is ordered by the Contractor for use in the eliminated item prior to the date of notification of elimination by the Engineer, and if the order for that material can not be canceled, payment will be made to the Contractor for the actual cost of the material. In this case, the material shall become the property of the Agency. Payment will be made to the Contractor for its actual costs for any further handling. If the material is returnable, the material shall be returned and payment will be made to the Contractor for the actual cost of charges made by the supplier for returning the material and for handling by the Contractor.

Actual costs, as used herein, shall be computed on the basis of Extra Work.

3-3 EXTRA WORK.

3-3.1 General. New or unforeseen work will be classified as Extra Work when the Engineer determines that it is not covered by Contract Unit Prices or Stipulated Unit Prices.

3-3.2 Payment.

3-3.2.1 General. When the cost for Extra Work cannot be agreed upon, the Agency will pay for Extra Work based on the accumulation of costs as provided herein.

3-3.2.2 Basis for Establishing Costs.

3-3.2.2.1 Labor. The cost of labor shall be the actual cost for wages of workers performing the Extra Work at the time the Extra Work is done, plus employer payments of payroll taxes, workers compensation insurance, liability insurance, health and welfare, pension, vacation, apprenticeship funds, and other direct costs, resulting from Federal, State, or local laws, as well as assessments or benefits required by lawful collective bargaining agreements.

The use of a labor classification which would increase the Extra Work cost will not be permitted unless the Contractor establishes the necessity for such additional costs. Labor costs for equipment operators and helpers shall be reported only when such costs are not included in the invoice for equipment rental. The labor cost for foremen shall be proportioned to all of their assigned work and only that applicable to the Extra Work will be paid.

Nondirect labor costs, including superintendence, shall be considered part of the markup specified in 3-3.2.3.1.

3-3.2.2.2 Materials. The cost of materials reported shall be at invoice or lowest current price at which such materials are locally available and delivered to the Work site in the quantities involved, plus sales tax, freight, and delivery.

The Agency reserves the right to approve materials and sources of supply, or to supply materials to the Contractor if necessary for the progress of the Work. No markup shall be applied to any material provided by the Agency.

3-3.2.2.3 Tool and Equipment Rental. No payment will be made for the use of tools which have a replacement value of $200 or less.

Regardless of ownership, the rates to be used in determining equipment rental costs shall not exceed listed rates prevailing locally at equipment rental agencies, or distributors, at the time the Extra Work is performed.

The rental rates paid shall include the cost of fuel, oil, lubrication, supplies, small tools, necessary attachments, repairs and maintenance of any kind, depreciation, storage, insurance, and all incidentals. Necessary loading and transportation costs for equipment used on the Extra Work shall be included.

If equipment is used intermittently and, when not in use, could be returned to its rental source at less expense to the Agency than holding it at the Work site, it shall be returned, unless the Contractor elects to keep it at the Work site, at no expense to the Agency.

All equipment shall be acceptable to the Engineer, in good working condition, and suitable for the purpose for which it is to be used.

The reported rental time for equipment already at the Work site shall be the duration of its use on the Extra Work. This time shall begin when the equipment is first used on the Extra Work, plus the time required to move it from its previous site and back, or to a closer site.

3-3.2.2.4 Other Items. The Agency may authorize other items which may be required on the Extra Work, including labor, services, material, and equipment. These items must be different in their nature from those required for the Work, and be of a type not ordinarily available from the Contractor or Subcontractors.

3-3.2.2.5 Invoices. Vendors' invoices for material, equipment rental and other expenditures shall be submitted with the daily report per 3-3.3. If the daily report is not substantiated by invoices or other documentation, the Agency may establish the cost of the item involved at the lowest price which was current at the time of the report.

3-3.2.3 Markup.

3-3.2.3.1 Work by the Contractor. Unless otherwise specified in the Special Provisions, a reasonable allowance for overhead and profit shall be added to the Contractor's costs as determined under 3-3.2.2 and shall constitute the markup for all overhead and profit on Extra Work done by the

Contractor. The Contractor shall also be compensated as specified in the Special Provisions for the actual increase in the Contractor's bond premium caused by the Extra Work.

3-3.2.3.2 Work by a Subcontractor. When any of the Extra Work is performed by a Subcontractor, the markup established in 3-3.2.3.1 shall be applied to the Subcontractor's costs as determined under 3-3.2.2. Unless otherwise specified in the Special Provisions, a reasonable allowance for the Contractor's overhead and profit shall be added to the sum of the Subcontractor's costs and markup and shall constitute the markup for all overhead and profit for the Contractor on Extra Work done by the Subcontractor.

3-3.3 Daily Reports. When the cost for the Extra Work cannot be agreed upon, the Contractor shall submit a daily report to the Engineer on forms approved by the Agency. Applicable delivery tickets, listing all labor, materials, and equipment involved for that day, and other services and expenditures when authorized shall be included. Failure to submit the daily report by the close of the next Working Day may waive any rights for that day. An attempt shall be made to reconcile the report daily, and it shall be signed by the Engineer and the Contractor. In the event of a disagreement, pertinent notes shall be entered by each party to explain points which cannot be resolved immediately. Each party shall retain a signed copy of the report. Reports by Subcontractors or others shall be submitted through the Contractor.

The report shall:

a) List the names of workers, classifications, and hours worked.

b) Describe and list quantities of materials used.

c) List the type of equipment, size, identification number, and hours of operation, including loading and transportation, if applicable.

d) Describe other services and expenditures in such detail as the Agency may require.

3-4 CHANGED CONDITIONS. The Contractor shall notify the Engineer of the following Work site conditions (hereinafter called "changed conditions"), in writing, upon their discovery and before they are disturbed:

a) Subsurface or latent physical conditions differing materially from those represented in the Contract Documents;

b) Unknown physical conditions of an unusual nature differing materially from those ordinarily encountered and generally recognized as inherent in work of the character being performed; and

c) Material differing from that represented in the Contract Documents which the Contractor believes may be hazardous waste, as defined in Section 25117 of the Health and Safety Code, that is required to be removed to a Class I, Class II, or Class III disposal site in accordance with the provisions of existing law.

The Engineer will investigate conditions which appear to be changed conditions. If the Engineer determines that the conditions are changed conditions and will materially affect costs, a Change Order will be issued adjusting the compensation for such portion of the Work in accordance with 3-2 or 3-3. If the Engineer determines that the conditions are changed conditions and will materially affect performance time, the Contractor, upon submitting a written request, will be granted an extension of time in accordance with 6-6.

If the Engineer determines that the conditions do not justify an adjustment in compensation, the Contractor will be so notified in writing. This notice will also advise the Contractor of its obligation to notify the Engineer in writing if the Contractor disagrees.

If the Contractor disagrees with the decision, it may submit a written notice of potential claim to the Engineer before commencing the disputed work. In the event of such a dispute, the Contractor shall not be excused from any scheduled completion date provided by the Contract and shall proceed with all

work to be performed under the Contract. However, the Contractor shall retain any and all rights provided by either the Contract or by law which pertain to the resolution of disputes and protests between the contracting parties. The Contractor shall proceed in accordance with 3-5.

The Contractor's failure to give notice of changed conditions promptly upon their discovery and before they are disturbed shall constitute a waiver of all claims in connection therewith.

3-5 DISPUTED WORK. If the Contractor and the Agency are unable to reach agreement, the Agency may direct the Contractor to proceed with the Disputed Work. Payment shall be as later determined by 3-2, 3-3, mediation or arbitration, if the Agency and Contractor agree thereto, or as fixed in a court of law.

Although not to be construed as proceeding under 3-3, the Contractor shall keep and furnish records of Disputed Work to the Engineer in accordance with 3-3.

SECTION 4 - CONTROL OF MATERIALS

4-1 MATERIALS AND WORKMANSHIP.

4-1.1 General. Materials, parts, and equipment furnished by the Contractor for the Work shall be new, free of defects, and conform to the requirements in the Contract Documents. Used or secondhand materials, parts, and equipment may be used only if so specified in the Special Provisions.

The quality of materials and workmanship shall be subject to approval by the Engineer. Materials and workmanship of quality not conforming to the requirements of the Specifications shall be considered defective and will be subject to rejection. Defective work or material, whether in place or not, shall be removed immediately from the Work site by the Contractor, at its expense, when so directed by the Engineer.

If the Contractor fails to replace any defective or damaged work or material after reasonable notice, the Engineer may cause such work or materials to be replaced. The replacement expense will be deducted from the amount to be paid to the Contractor.

4-1.2 Protection of Work and Materials. The Contractor shall provide and maintain storage facilities and employ such measures as will preserve the specified quality of materials to be used in the Work. Stored materials shall be reasonably accessible for inspection. The Contractor shall also adequately protect new and existing work and all items of equipment for the duration of the Contract.

The Contractor shall not, without the Agency's consent, assign, sell, mortgage, hypothecate, or remove equipment or materials which have been installed or delivered and which may be necessary for the completion of the Work.

4-1.3 Inspection Requirements.

4-1.3.1 General. Unless otherwise specified in the Special Provisions, inspection is required at the source for asphalt concrete pavement mixtures, structural concrete, metal fabrication, metal casting, welding, concrete pipe manufacture, protective coating application, and similar shop or plant operations. Additional materials and fabricated items which require inspection at the source shall be as specified in the Special Provisions.

Steel pipe in sizes less than 18 inches (450 mm) and vitrified clay and cast iron pipe in all sizes are acceptable upon submittal of a Certificate of Compliance, subject to sampling and testing by the Agency. Standard items of equipment such as electric motors, conveyors, elevators, plumbing fixtures, etc., are subject to inspection at the Work site only. Special items of equipment such as designed electrical panel boards, large pumps, sewage plant equipment, etc., are subject to inspection at the source for

performance testing only. Inspection at the source for other items shall be as specified in the Special Provisions.

4-1.3.2 Inspection by the Agency. The Agency will provide inspection and testing laboratory services within the continental United States within a 50-mile radius of the geographical limits of the Agency. Inspection and testing laboratory services beyond this radius or outside the continental United States shall be provided by the Contractor and approved by the Engineer.

4-1.3.3 Inspection of Items Not Locally Produced. When the Contractor intends to purchase materials, fabricated products, or equipment from sources located more than 50 miles (80 km) outside the geographical limits of the Agency or outside the United States, an inspector or accredited testing laboratory approved by the Engineer, shall be engaged by the Contractor at its expense, to inspect the materials, equipment or process. This approval shall be obtained before producing any material or equipment. The inspector or representative of the testing laboratory shall evaluate the materials for conformance with the requirements of the Plans and Specifications. The Contractor shall forward reports required by the Engineer. No materials or equipment shall be shipped nor shall any processing, fabrication or treatment of such materials be done without proper inspection by the approved agent. Approval by said agent shall not relieve the Contractor of responsibility for complying with the requirements of the Contract Documents.

4-1.4 Test of Materials. Before incorporation into the Work, the Contractor shall submit samples of materials, as the Engineer may require, at no cost to the Agency. The Contractor, at its expense, shall deliver the materials for testing to the place and at the time designated by the Engineer. Unless otherwise specified in the Special Provisions, all initial testing and a reasonable amount of retesting will be performed under the direction of the Engineer, and at no expense to the Contractor. If the Contractor is to provide and pay for testing, it will be so specified in the Special Provisions.

The Contractor shall notify the Engineer in writing, at least 15 Days in advance, of its intention to use materials for which tests are specified, to allow sufficient time to perform the tests. The notice shall name the proposed supplier and source of material.

If the notice of intent to use is sent before the materials are available for testing or inspection, or is sent so far in advance that the materials on hand at the time will not last but will be replaced by a new lot prior to use on the Work, it will be the Contractor's responsibility to re-notify the Engineer when samples which are representative may be obtained.

Third party independent testing and quality control testing shall be performed within the United States.

4-1.5 Certificate of Compliance. A Certificate of Compliance shall be furnished to the Engineer prior to the use of any material or assembled material for which these Specifications so require or if so required by the Engineer.

The Engineer may waive the materials testing requirements of the Specifications and accept a Certificate of Compliance. Material test data may be required by the Engineer to be included with the submittal.

Materials used on the basis of a Certificate of Compliance may be sampled and tested at any time. The submission of a Certificate of Compliance shall not relieve the Contractor of responsibility for incorporating material into the Work which conforms to the requirements of the Contract Documents, and any material not conforming to the requirements will be subject to rejection by the Engineer whether in place or not.

4-1.6 Trade Names or Equals. The Contractor may supply any of the materials specified or offer an equivalent. The Engineer will determine whether the material offered is equivalent to that specified. Adequate time shall be allowed for the Engineer to make this determination.

A listing of materials is not intended to be comprehensive, or in order of preference. The Contractor may offer any material, process, or equipment considered to be equivalent to that indicated. The substantiation of offers shall be submitted as provided in the Contract Documents.

The Contractor shall, at its expense, furnish data concerning items offered by it as equivalent to those specified. The Contractor shall have the material tested as required by the Engineer to determine that the quality, strength, physical, chemical, or other characteristics, including durability, finish, efficiency, dimensions, service, and suitability are such that the item will fulfill its intended function.

Test methods shall be subject to the approval of the Engineer. Test results shall be reported promptly to the Engineer, who will evaluate the results and determine if the substitute item is equivalent. The Engineer's findings shall be final. Installation and use of a substitute item shall not be made until approved by the Engineer.

If a substitute offered by the Contractor is not found to be equal to the specified material, the Contractor shall furnish and install the specified material.

The specified Contract completion time shall not be affected by any circumstance developing from the provisions of this subsection.

4-1.7 Weighing and Metering Equipment. Scales and metering equipment used for proportioning materials shall be inspected for accuracy and certified within the past 12 months by the State of California Bureau of Weights and Measures, by the County Sealer, or by a scale mechanic registered with or licensed by the County.

The accuracy of the work of a scale service agency, except as stated herein, shall meet the standards of the Business and Professions Code and the Code of Regulations pertaining to weighing devices. A Certificate of Compliance shall be presented, prior to operation, to the Engineer for approval and shall be renewed whenever required by the Engineer at no cost to the Agency.

Scales shall be arranged so they may be read easily from the operator's platform or area. They shall indicate the true net weight without the application of any factor. The figures of the scales shall be clearly legible. Scales shall be accurate to within 1 percent when tested with the plant shut down. Weighing equipment shall be so insulated against vibration or moving of other operating equipment in the plant area that the error in weighing with the entire plant running will not exceed 2 percent for any setting nor 1.5 percent for any batch.

4-1.8 Calibration of Testing Equipment. Testing equipment, such as, but not limited to pressure gages, metering devices, hydraulic systems, force (load) measuring instruments, and strain-measuring devices shall be calibrated by a testing agency acceptable to the Engineer at intervals not to exceed 12 months and following repairs, modification, or relocation of the equipment. Calibration certificates shall be provided when requested by the Engineer.

SECTION 5 - UTILITIES

5-1 LOCATION.

5-1.1 General. Known utilities and their respective owners are shown on the Plans or specified in the Special Provisions. Where underground utilities are shown on the Plans, the Contractor shall assume every property parcel will be served by a service connection for each type of utility.

Pursuant to Section 4216 of the Government Code, the Contractor shall contact the appropriate regional notification center and obtain an inquiry identification number at least 2 Working Days, but not

more than 14 Days prior to commencing any excavation required for the Work. Caltrans and certain other agencies are not required to become a member of a regional notification center. The Contractor shall contact non-member agencies directly and request they locate and mark their subsurface installations. Pursuant to Section 4216.2, when any proposed excavation is within 10 feet of a "high priority subsurface installation" the Contractor shall coordinate with the operator.

Before starting the Work, the Contractor shall physically locate subsurface installations within 24 inches of any side of excavations required for the Work. The Contractor shall determine the horizontal and vertical location, alignment, depth, material type, and size of each subsurface installation. Excavation shall be performed pursuant to Section 4216.4. The Contractor shall provide the subsurface installation location data to the Engineer within the time period specified in the Special Provisions.

The Contractor shall notify the Engineer in writing immediately after identifying potential physical conflicts between existing subsurface installations and the Work. The written notification shall include;

a) date of locating,
b) method of locating,
c) type, size, and material of subsurface installation,
d) horizontal location,
e) elevation (or depth from existing pavement or ground surface) of the top and bottom of the subsurface installation, and
f) presumed owner.

The Contractor shall complete excavation, backfill, and placement of temporary resurfacing on the same Day. Backfill shall conform to 306-1.3. Temporary resurfacing shall conform to 306-1.5.1. Permanent resurfacing shall be placed within 10 Working Days unless otherwise specified in the Special Provisions or directed by the Engineer. Permanent resurfacing shall conform to 306-1.5.

5-1.2 Payment. Payment for utility location by the Contractor shall be as specified in the Special Provisions.

5-2 PROTECTION. The Contractor shall not interrupt the service function or disturb the support of any utility without authority from the utility owner or direction from the Engineer. Valves, switches, vaults, and meters shall be maintained readily accessible for emergency shutoff.

Where protection is required to ensure support of utilities located as shown on the Plans or in accordance with 5-1, the Contractor shall, unless otherwise specified on the Plans or in the Special Provisions, furnish and place the necessary protection at its expense.

Upon learning of the existence and location of any utility omitted from or shown incorrectly on the Plans, the Contractor shall immediately notify the Engineer in writing. When authorized by the Engineer, support or protection of the utility will be paid for as provided in 3-2 or 3-3.

The Contractor shall immediately notify the Engineer and the utility owner if any utility is disturbed or damaged. The Contractor shall bear the costs of repair or replacement of any utility damaged if located in accordance with 5-1.

When placing concrete around or contiguous to any non-metallic utility installation, the Contractor shall at its expense:

a) Furnish and install a 2-inch (50 mm) cushion of expansion joint material or other similar resilient material; or

b) Provide a sleeve or other opening which will result in a 2-inch (50 mm) minimum-clear annular space between the concrete and the utility; or

c) Provide other acceptable means to prevent embedment in or bonding to the concrete.

Where concrete is used for backfill or for structures which would result in embedment, or partial embedment, of a metallic utility installation; or where the coating, bedding or other cathodic protection system is exposed or damaged by the Contractor's operations, the Contractor shall notify the Engineer and arrange to secure the advice of the affected utility owner regarding the procedures required to maintain or restore the integrity of the system.

5-3 REMOVAL. Unless otherwise specified in the Special Provisions, the Contractor shall remove all interfering portions of utilities shown on the Plans as "abandoned" or "to be abandoned in place". Before starting removal operations, the Contractor shall ascertain from the Agency whether the abandonment is complete, and the costs involved in the removal and disposal shall be included in the Bid for the items of work necessitating such removals.

5-4 RELOCATION. When feasible, the owners responsible for utilities within the area affected by the Work will complete their necessary installations, relocations, repairs, or replacements before commencement of the Work by the Contractor. When the Plans or Special Provisions indicate that a utility installation is to be relocated, altered, or constructed by others, the Agency will conduct all negotiations with the owners and utility work will be done at no cost to the Contractor, except as otherwise specified in 301-1.6. Utilities which are relocated in order to avoid interference shall be protected in their position and the cost of such protection shall be included in the Bid for the items of work necessitating such relocation.

After award of the Contract, portions of utilities which are found to interfere with the Work will be relocated, altered or reconstructed by the utility owners, or the Engineer may order changes in the Work to avoid interference. Such changes will be paid for in accordance with 3-2 or 3-3.

When the Plans or Special Provisions provide for the Contractor to alter, relocate, or reconstruct a utility, all costs for such work shall be included in the Bid for the items of work necessitating such work. Temporary or permanent relocation or alteration of utilities requested by the Contractor for its convenience shall be its responsibility and it shall make all arrangements and bear all costs.

The utility owner will relocate service connections as necessary within the limits of the Work or within temporary construction or slope easements. When directed by the Engineer, the Contractor shall arrange for the relocation of service connections as necessary between the meter and property line, or between a meter and the limits of temporary construction or slope easements. Payment for the relocation of such service connections shall be in accordance with 3-2 or 3-3. Payment will include the restoration of all existing improvements which may be affected thereby. The Contractor may agree with the owner of any utility to disconnect and reconnect interfering service connections. The Agency will not be involved in any such agreement.

5-5 DELAYS. The Contractor shall notify the Engineer of its construction schedule insofar as it affects the protection, removal, or relocation of utilities. Said notification shall be included as a part of the construction schedule in accordance with 6-1. The Contractor shall notify the Engineer in writing of any subsequent changes in the construction schedule which will affect the time available for protection, removal, or relocation of utilities.

The Contractor will not be entitled to damages or additional payment for delays attributable to utility relocations or alterations if correctly located, noted, and completed in accordance with 5-1.

The Contractor may be given an extension of time for unforeseen delays attributable to unreasonably protracted interference by utilities in performing work correctly shown on the Plans.

The Agency will assume responsibility for the timely removal, relocation, or protection of existing main or trunkline utility facilities within the area affected by the Work if such utilities are not identified in the Contract Documents. The Contractor will not be assessed liquidated damages for any delay caused by failure of the Agency to provide for the timely removal, relocation, or protection of such existing facilities.

If the Contractor sustains loss due to delays attributable to interferences, relocations, or alterations not covered by 5-1, which could not have been avoided by the judicious handling of forces, equipment, or plant, there shall be paid to the Contractor such amount as the Engineer may find to be fair and reasonable compensation for such part of the Contractor's actual loss as was unavoidable and the Contractor may be granted an extension of time.

5-6 COOPERATION. When necessary, the Contractor shall so conduct its operations as to permit access to the Work site and provide time for utility work to be accomplished during the progress of the Work.

SECTION 6 - PROSECUTION, PROGRESS, AND ACCEPTANCE OF THE WORK

6-1 CONSTRUCTION SCHEDULE AND COMMENCEMENT OF THE WORK.

6-1.1 Construction Schedule. After notification of award of the Contract and prior to start of any work, the Contractor shall submit its proposed construction schedule to the Engineer for approval. The construction schedule shall be in the form of a tabulation, chart, or graph and shall be in sufficient detail to show chronological relationship of all activities of the Work. These include, but are not limited to: estimated starting and completion dates of various activities, submission of submittals per 2-5.3, procurement of materials and scheduling of equipment. The construction schedule shall incorporate the requirements of 5-5 and reflect completion of the Work within the specified Contract time and in conformance with the Contract Documents.

If the Contractor desires to make a major change in the method of operations after commencing construction, or if the schedule fails to reflect the actual progress, the Contractor shall submit to the Engineer a revised construction schedule in advance of beginning revised operations.

The Engineer may waive these requirements for work constructed under a permit.

6-1.2 Commencement of the Work. Unless otherwise specified in the Special Provisions, the Contract time shall commence upon the date of issuance of the Notice to Proceed. The Work shall start within 15 Days thereafter, and be diligently prosecuted to completion within the Contract time.

6-2 PROSECUTION OF THE WORK. To minimize public inconvenience and possible hazard and to restore street and other work areas to their original condition and state of usefulness as soon as practicable, the Contractor shall diligently prosecute the Work to completion. If the Engineer determines that the Contractor is failing to prosecute the Work to the proper extent, the Contractor shall, upon orders from the Engineer, immediately take steps to remedy the situation. All costs of prosecuting the Work as specified herein shall be included in the Contract Price. Should the Contractor fail to take the necessary steps to fully accomplish said purposes, after orders of the Engineer, the Engineer may suspend the Work in whole or part, until the Contractor takes said steps.

If the Work is suspended through no fault of the Agency, all expenses and losses incurred by the Contractor during such suspensions shall be borne by the Contractor. If the Contractor fails to properly provide for public safety, traffic, and protection of the Work during periods of suspension, the Agency

may elect to do so, and deduct the cost thereof from monies due the Contractor. Such actions will not relieve the Contractor from liability.

6-3 SUSPENSION OF THE WORK.

6-3.1 General. The Work may be suspended in whole or in part when determined by the Engineer that the suspension is necessary in the interest of the Agency. The Contractor shall comply immediately with any written order of the Engineer. Such suspension shall be without liability to the Contractor on the part of the Agency except as otherwise specified in 6-6.3.

6-3.2 Archaeological and Paleontological Discoveries. If discovery is made of items of archaeological or paleontological interest, the Contractor shall immediately cease excavation in the area of discovery and shall not continue until ordered by the Engineer. When resumed, excavation operations within the area of discovery shall be as directed by the Engineer.

Discoveries which may be encountered may include, but not be limited to, dwelling sites, stone implements or other artifacts, animal bones, human bones, and fossils.

The Contractor shall be entitled to an extension of time and compensation in accordance with 6-6.

6-4 TERMINATION OF THE CONTRACT FOR DEFAULT.

6-4.1 General. If, prior to the acceptance of the Work, the Contractor:

a) becomes insolvent, assigns its assets for the benefit of its creditors, is unable to pay its debts as they become due, or is otherwise financially unable to complete the Work,

b) abandons the Work by failing to report to the Work site and diligently prosecute the Work to completion,

c) disregards written instructions from the Engineer or materially violates provisions of the Contract Documents,

d) fails to prosecute the Work according to the schedule approved by the Engineer,

e) disregards laws or regulations of any public body having jurisdiction, or

f) commits continuous or repeated violations of regulatory or statutory safety requirements, then the Agency will consider the Contractor in default of the Contract.

Notices, and other written communications regarding default between the Contractor, the Agency, and the Surety shall be transmitted in accordance with 2-12.

6-4.2 Notice to Cure. The Agency will issue a written notice to cure the default to the Contractor and its Surety. The Contractor shall commence satisfactory corrective actions within 5 Working Days after receipt.

6-4.3 Notice of Termination for Default. If the Contractor fails to commence satisfactory corrective action within 5 Working Days after receipt of the notice to cure, or to diligently continue satisfactory and timely correction of the default thereafter, then the Agency will recommend to the Board that the Contractor be found in default of the Contract and upon such finding by the Board:

a) will terminate the Contractor's right to perform under the Contract by issuing a written notice of termination for default to the Contractor and its Surety,

b) may use any materials, equipment, tools or other facilities furnished by the Contractor to secure and maintain the Work site, and

c) may furnish labor, equipment, and materials the Agency deems necessary to secure and maintain the Work site.

The provisions of this subsection shall be in addition to all other legal rights and remedies available to the Agency.

6-4.4 Responsibilities of the Surety. Upon receipt of the written notice of termination for default, the Surety shall immediately assume all rights, obligations and liabilities of the Contractor under the Contract. If the Surety fails to protect and maintain the Work site, the Agency may do so, and may recover all costs incurred. The Surety shall notify the Agency that it is assuming all rights, obligations and liabilities of the Contractor under the Contract and all money that is due, or would become due, to the Contractor shall be payable to the Surety as the Work progresses, subject to the terms of the Contract.

Within 15 Working Days of receipt of the written notice of termination for default, the Surety shall submit to the Agency a written plan detailing the course of action it intends to take to remedy the default. The Agency will review the plan and notify the Surety if the plan is satisfactory. If the Surety fails to submit a satisfactory plan, or if the Surety fails to maintain progress according to the plan accepted by the Agency, the Agency may, upon 48 hours written notice, exclude the Surety from the premises, take possession of all material and equipment, and complete the Work in any way the Agency deems to be expedient. The cost of completing the Work by the Agency shall be charged against the Surety and may be deducted from any monies due, or which would become due, the Surety. If the amounts due under the Contract are insufficient for completion, the Surety shall pay to the Agency, within 30 Days after the Agency submits an invoice, all costs in excess of the remaining Contract Price.

6-4.5 Payment. The Surety will be paid for completion of the Work in accordance with 9-3 less the value of damages caused to the Agency by acts of the Contractor.

6-5 TERMINATION OF THE CONTRACT FOR CONVENIENCE. The Board may terminate the Contract if it becomes impossible or impracticable to proceed, or because of conditions or events beyond the control of the Agency.

The Agency will issue a written notice of termination for convenience in accordance with 2-12. Upon receipt, the Contractor shall immediately cease work, except work the Contractor is directed to complete by the Engineer or required to complete for public safety and convenience. The Contractor shall immediately notify Subcontractors and suppliers to immediately cease their work.

The Contractor will be paid without duplication for:

a) work completed in accordance with the Contract Documents prior to the effective date of termination for convenience;

b) reasonable costs incurred in settlement of terminated contracts with Subcontractors, suppliers and others; and

c) reasonable expenses directly attributable to termination.

The Contractor shall submit a final termination settlement proposal to the Agency no later than 90 days from the effective date of termination, unless extended, in writing, by the Agency upon written request by the Contractor.

If the Contractor fails to submit a proposal, the Agency may determine the amount, if any, due the Contractor as a result of the termination. The Agency will pay the Contractor the amount it determines to be reasonable. If the Contractor disagrees with the amount determined by the Agency as being reasonable, the Contractor shall provide notice to the Agency within 30 Days of receipt of payment. Any amount due shall be as later determined by arbitration, if the Agency and the Contractor agree thereto, or as fixed in a court of law.

6-6 DELAYS AND EXTENSIONS OF TIME.

6-6.1 General. If delays are caused by unforeseen events beyond the control of the Contractor, such delays will entitle the Contractor to an extension of the Contract time as provided herein, but the Contractor will not be entitled to damages or additional payment due to such delays, except as otherwise specified in 6-

6.3. Such unforeseen events may include: war, government regulations, labor disputes, strikes, fires, floods, adverse weather or elements necessitating cessation of work, inability to obtain materials, labor or equipment, required Extra Work, or other specific events as may be further described in the Special Provisions.

No extension of time will be granted for a delay caused by the Contractor's inability to obtain materials unless the Contractor furnishes to the Engineer documentary proof. The proof must be provided in a timely manner in accordance with the sequence of the Contractor's operations and the approved construction schedule.

If delays beyond the Contractor's control are caused by events other than those mentioned above, the Engineer may deem an extension of time to be in the best interests of the Agency. The Contractor will not be entitled to damages or additional payment due to such delays, except as otherwise specified in 6-6.3.

If delays beyond the Contractor's control are caused solely by action or inaction by the Agency, such delays will entitle the Contractor to an extension of time per 6-6.2.

6-6.2 Extensions of Time. Extensions of time, when granted, will be based upon the effect of delays to the Work. They will not be granted for non-controlling delays to minor portions of the Work unless it can be shown that such delays did or will delay the progress of the Work.

SEE SSP

6-6.3 Payment for Delays. Pursuant to Section 7102 of the Public Contract Code, the Contractor will be compensated for damages incurred due to delays for which the Agency is responsible. Such actual costs will be determined by the Engineer. The Agency will not be liable for damages which the Contractor could have avoided by any reasonable means, such as judicious handling of forces, equipment, or plant. The determination of what damages the Contractor could have avoided will be made by the Engineer.

6-6.4 Written Notice and Report. If the Contractor desires payment for a delay as specified in 6-6.3 or an extension of time, it shall file with the Engineer a written request and report of cause within 30 Days after the beginning of the delay. The request for payment or extension must be made at least 15 Days before the specified completion date. Failure by the Contractor to file these items within the times specified will be considered grounds for refusal by the Agency to consider such request.

SEE SSP

6-7 TIME OF COMPLETION.

6-7.1 General. The Contractor shall complete the Work within the time specified in the Contract or the Special Provisions. The Contractor shall complete each portion of the Work within the time specified as in the Contract or the Special Provisions for such portion. Unless otherwise specified in the Contract or the Special Provisions, the time of completion of the Contract shall be expressed in Working Days.

SEE 2015 Whitebook/SSP

6-7.2 Not Used.

6-7.3 Contract Time Accounting. The Engineer will make a daily determination of each Working Day to be charged against the Contract time. These determinations will be discussed and the Contractor will be furnished a periodic statement showing the allowable number of Working Days of Contract time, as adjusted, at the beginning of the reporting period. The statement will also indicate the number of Working Days charged during the reporting period and the number of Working Days of Contract time remaining. If the Contractor does not agree with the statement, it shall file a written protest within 15 Days after receipt, setting forth the facts of the protest. Otherwise, the statement will be deemed to have been accepted.

6-8 COMPLETION, ACCEPTANCE, AND WARRANTY.

6-8.1 Completion. The Contractor shall submit a written assertion that the Work has been completed. If, in the Engineer's judgment, the Work has been completed in accordance with the Contract Documents, the Engineer will set forth in writing the date the Work was completed. This will

be the date when the Contractor is relieved from responsibility to protect and maintain the Work and to which liquidated damages will be computed.

6-8.2 Acceptance. Acceptance will occur after all of the requirements contained in the Contract Documents have been fulfilled. If, in the Engineer's judgment, the Contractor has fully performed the Contract, the Engineer will recommend to the Board that the Contractor's performance of the Contract be accepted.

6-8.3 Warranty. The Work shall be warranted by the Contractor against defective materials and workmanship for a period of 1 year. The warranty period shall start on the date the Work was completed as determined by the Engineer.

The warranty period for specific items covered under manufacturers' or suppliers' warranties shall commence on the date they are placed into service at the direction of or as approved by the Engineer in writing.

All warranties, express or implied, from subcontractors, manufacturers, or suppliers, of any tier, for the materials furnished and work performed shall be assigned, in writing, to the Agency, and such warranties shall be delivered to the Engineer prior to acceptance of the Contractor's performance of the Contract.

The Contractor shall replace or repair defective materials and workmanship in a manner satisfactory to the Engineer, after notice to do so from the Engineer, and within the time specified in the notice. If the Contractor fails to make such replacement or repairs within the time specified in the notice, the Agency may perform the replacement or repairs at the Contractor's expense. If the Contractor fails to reimburse the Agency for the actual costs, the Contractor's Surety shall be liable for the cost thereof.

6-9 LIQUIDATED DAMAGES. Failure of the Contractor to complete the Work within the time allowed will result in damages being sustained by the Agency. Such damages are, and will continue to be, impracticable and extremely difficult to determine. For each consecutive calendar day in excess of the time specified for completion of the Work, as adjusted in accordance with 6-6, the Contractor shall pay to the Agency, or have withheld from monies due it, the sum of $250, unless otherwise specified in the Special Provisions.

Execution of the Contract shall constitute agreement by the Agency and Contractor that $250 per day is the minimum value of the costs and actual damage caused by the failure of the Contractor to complete the Work within the allotted time. Such sum is liquidated damages and shall not be construed as a penalty, and may be deducted from payments due the Contractor if such delay occurs.

6-10 USE OF IMPROVEMENT DURING CONSTRUCTION. The Agency reserves the right to take over and utilize all or part of any completed facility or appurtenance. The Contractor will be notified in writing in advance of such action. Such action by the Agency will relieve the Contractor of responsibility for injury or damage to said completed portions of the improvement resulting from use by public traffic or from the action of the elements or from any other cause, except Contractor operations or negligence. The Contractor will not be required to reclean such portions of the improvement before field acceptance, except for cleanup made necessary by its operations. Nothing in this subsection shall be construed as relieving the Contractor from full responsibility for correcting defective work or materials.

In the event the Agency exercises its right to place into service and utilize all or part of any completed facility or appurtenance, the Agency will assume the responsibility and liability for injury to persons or property resulting from the utilization of the facility or appurtenance so placed into service, except for any such injury to persons or property caused by any willful or negligent act or omission by the Contractor, Subcontractor, their officers, employees, or agents.

SECTION 7 - RESPONSIBILITIES OF THE CONTRACTOR

7-1 THE CONTRACTOR'S EQUIPMENT AND FACILITIES.

7-1.1 General. The Contractor shall furnish and maintain in good condition all equipment and facilities as required for the proper execution and inspection of the Work

The Contractor shall provide and maintain enclosed toilets for the use of employees engaged in the Work. These accommodations shall be maintained in a neat and sanitary condition, and regularly pumped out.

7-1.2 Temporary Utility Services. The Contractor shall, at its own expense, make all arrangements necessary for the provision of temporary utility services necessary for its own use during performance of the Work.

The Contractor shall not draw water from any fire hydrant (except to extinguish a fire), without obtaining permission from the water utility owner.

7-1.3 Crushing and Screening Operations. Unless otherwise specified in the Special Provisions, the establishment and operation of portable screens and crushers will not be allowed on or adjacent to the Work site.

7-2 LABOR.

7-2.1 General. The Contractor, its agents, and employees shall be bound by and comply with applicable provisions of the Labor Code and Federal, State, and local laws related to labor.

Any worker found by the Engineer to be incompetent, intemperate, troublesome, disorderly, or otherwise objectionable, or who fails to perform the Work properly and acceptably, shall be immediately removed from the Work site by the Contractor and shall not be reemployed in the performance of the Work.

7-2.2 Prevailing Wages. Pursuant to Section 1773.2 of the Labor Code, the current prevailing rate of per diem wages at the time of the Bid as determined by the Director of the Department of Industrial Relations (DIR) are on file at the office of the Engineer. The Contractor shall post a copy of these rates at the Work site. Pursuant to Section 1774 of the Labor Code, the Contractor and any Subcontractors shall pay not less than the specified prevailing rates of wages to workers employed on the Contract. If the Contract is Federally-funded, the Contractor and any Subcontractors shall not pay less than the higher of these rates or the rates determined by the United States Department of Labor. Pursuant to Section 1775 of the Labor Code, the Contractor and any Subcontractors, shall, as a penalty to the Agency, forfeit the prescribed amounts per calendar day, or portion thereof, for each worker paid less than the prevailing wage rates.

7-2.3 Payroll Records. Pursuant to Section 1776 of the Labor Code the Contractor shall keep, make available, and submit to the Engineer upon request, certified payroll records.

7-2.4 Hours of Labor. Pursuant to Section 1810 of the Labor Code, 8 hours of labor shall constitute a legal day's work. Pursuant to Section 1813 of the Labor Code, the Contractor and any Subcontractors, shall, as a penalty to the Agency, forfeit the prescribed amount per calendar day for each worker required or permitted to work more than 8 hours in any 1 calendar day and 40 hours in any 1 calendar week without being compensated in accordance with Section 1815.

7-3 INSURANCE.

7-3.1 General. The Contractor shall provide and maintain insurance naming the Agency as an insured or additional insured with the Contractor regardless of any inconsistent statement in the policy or any subsequent endorsement whether liability is attributable to the Contractor or the Agency. The insurance provisions shall not be construed to limit the Contractor's indemnity obligations contained in the Contract. Except as otherwise specified in 6-10, the Contractor shall save, keep, and hold harmless

the Agency, its officers, employees, and agents from all damages, costs or expenses in law or equity that may at any time arise to a person or property by reason of or in the course of performing the Work, or which may be caused by a negligent act or omission by the Contractor, the Contractor's employees, or a Subcontractor. The Agency will not be liable for any accident, loss, or damage to the Work prior to completion, except as otherwise specified in 6-10.

With the exception of workers' compensation insurance, the policies furnished by the Contractor shall be issued by an insurance company authorized by the Insurance Commissioner to transact business in the State of California. The insurance company shall have a policy holder rating of "A" or higher and a Financial Class VII or higher as established by A.M. Best, or higher rating established by Moody's or Standard & Poor's.

The Contractor shall notify the Agency in accordance with 2-12 within 5 Days of the date of being notified by its insurance carrier of any changes to or cancellation of the policy.

The Contractor shall submit insurance documents including an additional insured endorsement, certificate of insurance, and waiver of subrogation.

The cost of the defense of any claims against the Agency shall not erode or take away from the specified limits of liability.

No separate payment will be made for insurance. Payment shall be considered as included in the Contract Price.

7-3.2 General Liability Insurance. The policy shall insure the Agency, its officers, employees, and agents while acting within the scope of their duties on the Work, against all claims arising out of or in connection with the Work, except as otherwise specified in 6-10. This policy shall provide coverage for on-going and completed operations. The certificate of insurance submitted to the Agency shall state that the Contractor's insurance is primary and that any other insurance held by the Agency is non-contributory.

The Contractor may file insurance acceptable to the Agency covering more than one contract. The coverage shall provide the following minimum limits:

	Limits of Liability
General Aggregate Limit	$2,000,000
Other than Products/Completed Operations Aggregate	$2,000,000
Products/Completed Operations Aggregate Limit	$2,000,000
Personal Injury Limit	$1,000,000
Each Occurrence	$1,000,000

The policy or policies shall be endorsed to provide that the insurer waives all rights of subrogation against the Agency, and its respective elected officials, officers, employees, agents, and representatives for losses paid under the terms of the policy or policies and which arise from work performed by the named insured for the Agency.

7-3.3 Workers' Compensation Insurance. Pursuant to Sections 1860 and 3700 of the Labor Code, the Contractor shall secure, pay for, and maintain in full force for the duration of the Contract, workers' compensation insurance. The insurance company shall have a policy rating equal to or better than that of the California State Compensation Insurance Fund (SCIF). The Agency, its officers, employees and agents, shall not be held responsible for any claims in law or equity occasioned by failure of the Contractor to comply with this requirement.

Pursuant to Sections 1860 and 1861 of the Labor Code, the Contractor shall submit the following certification to the Engineer prior to execution of the Contract by the Board:

"I am aware of the provisions of Section 3700 of the Labor Code which require every employer to be insured against liability for workers' compensation or to undertake self-insurance in accordance with the provisions of that code, and I will comply with such provisions before commencing the performance of the work of this contract."

The policy or policies shall be endorsed to provide that the insurer will waive all rights of subrogation against the Agency, and its respective elected officials, officers, employees, agents, and representatives for losses paid under the terms of the policy or policies and which arise from work performed by the named insured for the Agency.

7-3.4 Auto Liability Insurance. The Contractor shall provide a certificate of insurance to the Agency showing coverage of at least $1,000,000 for bodily injury and property damage or a combined single limit. This policy shall be for "any auto" or for "all autos either owned, hired, or non-owned."

7-4 Not Used.

7-5 PERMITS. The Agency will obtain, at no cost to the Contractor, all permits necessary to perform the Work in streets, highways, railways or other rights-of-way. The Contractor shall obtain and pay for all costs incurred for permits necessitated by its operations such as, but not limited to, those permits required for night work, overload, blasting, and demolition. For Private Contracts, the Contractor shall obtain all permits incidental to the Work or made necessary by its operations, and pay all costs incurred by the permit requirements.

The Contractor shall pay all business taxes or license fees that are required for the Work.

7-6 THE CONTRACTOR'S REPRESENTATIVE. Before starting the Work, the Contractor shall designate in writing a representative who shall have complete authority to act for it. An alternative representative may be designated as well. The representative or alternate shall be present at the Work site whenever work is in progress or whenever actions of the elements necessitate its presence to take measures necessary to protect the Work, persons, or property. Any order or communication given to this representative shall be deemed delivered to the Contractor. A joint venture shall designate only one representative and alternate. In the absence of the Contractor or its representative, instructions or directions may be given by the Engineer to the superintendent or person in charge of the specific work to which the order applies. Such order shall be complied with promptly and referred to the Contractor or its representative.

In order to communicate with the Agency, the Contractor's representative, superintendent, or person in charge of specific work shall be able to speak, read, and write the English language.

7-7 COOPERATION AND COLLATERAL WORK. The Contractor shall be responsible for ascertaining the nature and extent of any simultaneous, collateral, and essential work by others. The Agency, its workers and contractors and others, shall have the right to operate within or adjacent to the Work site during the performance of such work.

The Agency, the Contractor, and each of such workers, contractors and others, shall coordinate their operations and cooperate to minimize interference.

The Contractor shall include in its Bid all costs involved as a result of coordinating its work with others. The Contractor will not be entitled to additional compensation from the Agency for damages resulting from such simultaneous, collateral, and essential work. If necessary to avoid or minimize such damage or delay, the Contractor shall redeploy its work force to other parts of the Work.

Should the Contractor be delayed by the Agency, and such delay could not have been reasonably foreseen or prevented by the Contractor, the Engineer will determine the extent of the delay, the effect on the Work, and any extension of time.

7-8 WORK SITE MAINTENANCE.

7-8.1 General. Throughout all phases of construction, including suspension of the Work, and until acceptance per 6-8, the Contractor shall keep the Work site clean and free from rubbish and debris. Rubbish and debris collected on the Work site shall only be stored in roll-off, enclosed containers prior to disposal. Stockpiles of such will not be allowed.

When required by the Special Provisions, the Contractor shall provide a self-loading motorized street sweeper equipped with a functional water spray system. The sweeper shall clean all paved areas within the Work site and all paved haul routes at least once each working day

The Contractor shall ensure there is no spillage along haul routes. Any such spillage shall be removed immediately and the area cleaned.

Should the Contractor fail to keep the Work site free from rubbish and debris, the Engineer may suspend the Work per 6-3 until the condition is corrected.

7-8.2 Air Pollution Control. The Contractor shall not discharge smoke, dust, equipment exhaust, or any other air contaminants into the atmosphere in such quantity as will violate any Federal, State, or local regulations. The Contractor shall also abate dust nuisance by cleaning, sweeping and spraying with water, or other means as necessary. The use of water shall conform to 7-8.6.

7-8.3 Noise Control. Noise generated from the Contractor's operations shall be controlled as specified in the Special Provisions.

7-8.4 Storage of Equipment and Materials.

7-8.4.1 General. Materials and equipment shall be removed from the Work site as soon as they are no longer necessary. Before inspection by the Engineer for acceptance, the Work site shall be cleared of equipment, unused materials, and rubbish so as to present a satisfactory clean and neat appearance.

Excess excavated material shall be removed from the Work site immediately unless otherwise specified in the Special Provisions.

Forms and form lumber shall be removed from the Work site as soon as practicable after stripping.

7-8.4.2 Storage in Public Streets. Construction materials and equipment shall not be stored in streets, roads, or highways for more than 5 Days after unloading unless otherwise specified in the Special Provisions or approved by the Engineer. All materials or equipment not installed or used in construction within 5 days after unloading shall be stored at a location approved by the Engineer.

Excavated material, except that which is to be used as backfill in the adjacent trench, shall not be stored in public streets unless otherwise specified in the Special Provisions or approved by the Engineer. Immediately after placing backfill, all excess excavated material shall be removed.

7-8.5 Sanitary Sewers.

7-8.5.1 General. The flow of sewage shall not be interrupted. Should the Contractor disrupt the operation of existing sanitary sewer facilities, or should disruption be necessary for performance of the Work, the Contractor shall bypass the sewage flow around the Work. Sewage shall be conveyed in closed conduits and disposed of in a sanitary sewer system. Sewage shall not be permitted to flow in trenches nor be covered by backfill.

Whenever sewage bypass and pumping is required by the Plans or Specifications, or the Contractor so elects to perform, the Contractor shall submit per 2-5.3 a Working Drawing conforming to 7-8.5.2 detailing its proposed plan of sewage bypass and pumping.

7-8.5.2 Sewage Bypass and Pumping Plan. The plan shall indicate the locations and capacities of all pumps, sumps, suction and discharge lines. Equipment and piping shall be sized to handle the peak flow of the section of sewer line to be bypassed and pumped. Equipment and piping shall conform to 7-10, the Plans, and the Special Provisions. Bypass piping, when crossing areas subject to traffic loads, shall be constructed in trenches with adequate cover and otherwise protected from damage due to traffic. Lay-flat hose or aluminum piping with an adequate casing and/or traffic plates may be allowed if so approved by the Engineer. Bypass pump suction and discharge lines that extend into manholes shall be rigid hose or hard pipe. Lay-flat hose will not be allowed to extend into manholes. The Contractor shall provide a backup bypass pumping system in case of malfunction. The backup bypass system shall provide 100 percent standby capability, and be in place and ready for immediate use. Each standby pump shall be a complete unit with its own suction and discharge piping. In addition to the backup system, the Contractor shall furnish and operate vacuum trucks when required by the Plans or Special Provisions.

7-8.5.3 Spill Prevention and Emergency Response Plan. The Contractor shall prepare and submit per 2-5.3 a spill prevention and emergency response plan. The plan shall address implementation of measures to prevent sewage spills, procedures for spill control and containment, notifications, emergency response, cleanup, and spill and damage reporting.

The plan shall account for all storm drain systems and water courses within the vicinity of the Work which could be affected by a sewage spill. Catch basins that could receive spilled sewage shall be identified. Unless otherwise specified in the Special Provisions, these catch basins shall be sealed prior to operating the bypass and pumping system. The Contractor shall remove all material used to seal the catch basins when the bypass and pumping system operations are complete.

The Contractor shall be fully responsible for containing any sewage spillage, preventing any sewage from reaching a watercourse, recovery and legal disposal of any spilled sewage, any fines or penalties associated with the sewage spill imposed upon by the Agency and/or the Contractor by jurisdictional regulatory agencies, and any other expenses or liabilities related to the sewage spill.

7-8.6 Water Pollution Control.

7-8.6.1 General. The Contractor shall conform to all applicable local, state and Federal regulations and laws pertaining to water pollution control. The Contractor shall conduct and schedule its operations, and follow and implement best management practices in such a manner as to prevent water pollution. The Contractor shall also conform to the following requirements:

a) Sediments shall not be discharged to a storm drain system or receiving waters.

b) Sediments generated on the Work site shall be contained on the Work site using appropriate BMPs.

c) No construction-related materials, waste, spill, or residue shall be discharged from the Work site to streets, drainage facilities, receiving waters, or adjacent property by wind or runoff.

d) Non-storm water runoff from equipment, vehicle washing, or any other activity shall be contained within the Work site using appropriate BMPs.

e) Erosion shall be prevented. Erosion susceptible slopes shall be covered, planted or otherwise protected in a way that prevents discharge from the Work site.

7-8.6.2 Best Management Practices (BMPs). The Contractor shall implement and maintain such BMPs as are relevant to the Work, and as are specifically required by the Plans or Special Provisions.

The Contractor shall be responsible throughout the duration of the Contract for installing, constructing, inspecting, maintaining, removing and disposing of BMPs for wind erosion control, tracking control, erosion and sediment control, non-storm water control, and waste management and materials pollution control. Unless otherwise directed by the Engineer, the Contractor shall be responsible for BMP implementation and maintenance throughout any temporary suspension of the Work.

7-8.6.3 Storm Water Pollution Prevention Plan (SWPPP). When so specified in the Special Provisions, or if so required by a jurisdictional regulatory agency, the Contractor shall prepare and submit per 2-5.3 a storm water pollution prevention plan. The SWPPP shall conform to the requirements specified in the Special Provisions and those of the jurisdictional regulatory agency. The Notice of Intent will be filed by the Agency.

7-8.6.4 Dewatering. Dewatering shall be performed by the Contractor when specifically required by the Plans or Specifications, and as necessary for construction of the Work. Dewatering shall be performed in conformance with all applicable local, state and Federal laws and permits issued by jurisdictional regulatory agencies. Permits necessary for treatment and disposal of accumulated water shall be obtained by the Contractor or the Agency as specified in the Special Provisions. Accumulated water shall be treated prior to disposal if so specified in the Special Provisions or required by a permit. The Contractor shall submit a Working Drawing and related supporting information per 2-5.3 detailing its proposed plan and methodology of dewatering and treatment and disposal of accumulated water.

The plan shall identify the location, type and size of dewatering devices and related equipment, the size and type of materials composing the collection system, the size and type of equipment to be used to retain and, if required, treat accumulated water, and the proposed disposal locations. If the proposed disposal location is a sanitary sewer, the Contractor shall submit to the Engineer written evidence of permission from the owner. If the proposed disposal location is a storm drain system or receiving body of water, the Contractor shall submit written evidence of permission from the owner of the storm drain system and, if not obtained by the Agency, original signed permits from jurisdictional regulatory agencies or written evidence that such permits are not required.

7-8.6.5 Payment. Unless otherwise specified in the Special Provisions, payment for implementation and maintenance of BMPs shall be considered as included in the Contract Unit Price for each item in the Bid.

Payment for dewatering shall be as specified in the Special Provisions.

7-9 PROTECTION AND RESTORATION OF EXISTING IMPROVEMENTS. The Contractor shall be responsible for the protection of public and private property adjacent to the Work and shall exercise due caution to avoid damage to such property.

The Contractor shall repair or replace all existing improvements within the right-of-way which are not designated for removal (e.g., curbs, sidewalks, driveways, fences, walls, signs, utility installations, pavement, structures, etc.) which are damaged or removed as a result of its operations. When a portion of a sprinkler system within the right-of-way must be removed, the remaining lines shall be capped. Repairs and replacements shall be at least equal to existing improvements and shall match them in finish and dimension.

Maintenance of street and traffic signal systems that are damaged, temporarily removed or relocated shall be done in conformance with 701-2.

Trees, lawns, and shrubbery that are not to be removed shall be protected from damage or injury. If damaged or removed due to Contractor's operations, they shall be restored or replaced in as nearly the original condition and location as is reasonably possible. Lawns shall be reseeded and covered with suitable mulch.

The Contractor shall give reasonable notice to occupants or owners of adjacent property to permit them to salvage or relocate plants, trees, fences, sprinklers, and other improvements, within the right-of-way which are designated for removal and would be destroyed because of the Work.

All costs to the Contractor for protecting, removing, and restoring existing improvements shall be included in the Bid.

7-10 SAFETY.

7-10.1 Not Used.

7-10.2 Not Used.

7-10.3 Haul Routes. Unless otherwise specified in the Special Provisions, haul routes shall be determined by the Contractor.

7-10.4 Safety.

7-10.4.1 Work Site Safety.

7-10.4.1.1 General. The Contractor shall provide safety measures as necessary to protect the public and workers within, or in the vicinity of, the Work site. The Contractor shall ensure that its operations will not create safety hazards.

The Contractor shall provide safety equipment, material, and assistance to Agency personnel so that they may properly inspect all phases of the Work.

When asbestos is being removed, the requirements of the CCR Title 8, Div. 1, Chapter 4, Subchapter 4 and Subchapter 7 shall be implemented.

7-10.4.1.2 Work Site Safety Official. The Contractor shall designate in writing a "Project Safety Official" who shall be at the Work site at all times, and who shall be thoroughly familiar with the Contractor's Injury and Illness Prevention Program (IIPP) and Code of Safe Practices. The Project Safety Official shall be available at all times to abate any potential safety hazards and shall have the authority and responsibility to shut down an unsafe operation, if necessary.

7-10.4.2 Safety Orders.

7-10.4.2.1 General. The Contractor shall have at the Work site, copies or suitable extracts of Construction Safety Orders, Tunnel Safety Orders, and General Industry Safety Orders issued by the State Division of Industrial Safety.

Prior to beginning any excavation 5 feet in depth or greater, the Contractor shall submit to the Engineer, the name of the "Competent Person" as defined in CCR, Title 8, Section 1504, in accordance with 2-5.3. The "Competent Person" shall be present at the Work site as required by Cal-OSHA.

7-10.4.2.2 Shoring Plan. Before excavating any trench 5 feet (1.5 m) or more in depth, the Contractor shall submit in accordance with 2-5.3 a detailed Working Drawing (shoring plan) showing the design of the shoring, bracing, sloping, or other provisions used for the workers' protection . If the shoring plan varies from the shoring system standards, the shoring plan shall be prepared by a registered Structural or Civil Engineer. The shoring plan shall accommodate existing underground utilities. No excavation shall start until the Engineer has accepted the shoring plan and the Contractor has obtained a permit from the State Division of Industrial Safety. A copy of this permit shall be submitted to the Engineer in accordance with 2-5.3. If the Contractor fails to submit a shoring plan or fails to comply with an accepted shoring plan, the Contractor shall suspend work at the affected location(s). Such suspended work shall not be the basis of a claim for Extra Work and the Contractor shall not receive additional compensation or Contract time.

7-10.4.2.3 Payment. Payment for shoring shall be included in the Bid item provided therefore. Payment for compliance with the provisions of the safety orders and all other laws, ordinances, and regulations shall be included in the various Bid items.

7-10.4.3 Use of Explosives. Explosives may be used only when authorized in writing by the Engineer, or as otherwise specified in the Special Provisions.

Explosives shall be handled, used, and stored in accordance with all applicable regulations.

Prior to blasting, the Contactor shall comply with the following requirements:

a) The jurisdictional law enforcement agency shall be notified 24 hours in advance of blasting.

b) The jurisdictional fire department shall be notified 24 hours in advance of blasting.

c) Blasting activities and schedule milestones shall be included in the Contractor's construction schedule per 6-1.

For a Private Contract, specific permission shall be obtained from the Agency in writing, prior to any blasting operations in addition to the above requirements.

The Engineer's approval of the use of explosives shall not relieve the Contractor from liability for claims caused by blasting operations.

7-10.4.4 Hazardous Substances. An SDS as described in CCR, Title 8, Section 5194, shall be maintained at the Work site for all hazardous material used by the Contractor.

Material usage shall be accomplished with strict adherence to California Division of Industrial Safety requirements and all manufacturer warnings and application instructions listed on the MSDS and on the product container label.

The Contractor shall notify the Engineer if a specified product cannot be used under safe conditions.

7-10.4.5 Confined Spaces.

7-10.4.5.1 Confined Space Entry Program (CSEP). The Contractor shall be responsible for implementing, administering and maintaining a CSEP in accordance with CCR, Title 8, Sections 5156, 5157 and 5158.

Prior to the start of the Work, the Contractor shall prepare and submit a CSEP in accordance with 2-5.3. The CSEP shall address all potential physical and environmental hazards and contain procedures for safe entry into confined spaces such as the following:

a) Training of personnel.

b) Purging and cleaning the space of materials and residue.

c) Potential isolation and control of energy and material inflow.

d) Controlled access to the space.

e) Atmospheric testing of the space.

f) Ventilation of the space.

g) Special hazards consideration.

h) Personal protective equipment.

i) Rescue plan provisions.

The submittal shall include the names of the Contractor's personnel, including each Subcontractor's personnel, assigned to the Work that will have CSEP responsibilities, their CSEP training, and their specific assignment and responsibility in carrying out the CSEP.

7-10.4.5.2 Permit-Required Confined Spaces. Entry into permit-required confined spaces as defined in CCR, Title 8, Section 5157 may be required as a part of the Work. Manholes, tanks, vaults, pipelines, excavations, or other enclosed or partially enclosed spaces shall be considered permit-required confined spaces until the pre-entry procedures demonstrate otherwise. The Contractor shall implement a permit-required CSEP prior to performing any work in a permit-required confined space. A copy of the permit shall be available at all times for review by the Contractor and the Engineer at the Work site.

7-10.4.5.3 Payment. Payment for the CSEP shall be included in the Bid items for which the CSEP is required.

7-10.5 Security and Protective Devices.

7-10.5.1 General. Security and protective devices shall consist of fencing, steel plates, or other devices as specified in the Special Provisions to protect open excavations.

7-10.5.2 Security Fencing. The Contractor shall completely fence open excavations. Security fencing shall conform to 304-3.5. Security fencing shall remain in place unless workers are present and construction operations are in progress during which time the Contractor shall provide equivalent security.

7-10.5.3 Steel Plate Covers. The Contractor shall provide steel plate covers as necessary to protect from accidental entry into openings, trenches, and excavations.

7-11 PATENT FEES OR ROYALTIES. The Contractor shall absorb in its Bid the patent fees or royalties on any patented article or process furnished or used in the Work. The Contractor shall indemnify and hold the Agency harmless from any legal action that may be brought for infringement of patents.

7-12 ADVERTISING. The names, addresses and specialties of Contractors, Subcontractors, architects, or engineers may be displayed on removable signs. The size and location shall be subject to the Engineer's approval.

Commercial advertising matter shall not be attached to or painted on the surfaces of buildings, fences, canopies, or barricades.

7-13 LAWS TO BE OBSERVED. The Contractor shall keep itself fully informed of State and national laws and County and municipal ordinances and regulations which in any manner affect those employed in the Work or the materials used in the Work or in any way affect the conduct of the Work. The Contractor shall at all times observe and comply with such laws, ordinances, and regulations.

7-14 ANTITRUST CLAIMS. Pursuant to Section 7103.5 of the Public Contract Code:

> "In entering into a public works contract or a subcontract to supply goods, services, or materials pursuant to a public works contract, the contractor or subcontractor offers and agrees to assign to the awarding body all rights, title, and interest in and to all causes of action it may have under Section 4 of the Clayton Act (15 U.S.C. Sec 15) or Cartwright Act (Chapter 2 [commencing with Section 16700] of Part 2 of Division 7 of the Business and Professions Code), arising from purchases of goods, services, or materials pursuant to the public works contract or subcontract. The assignment shall be made and become effective at the time the awarding body tenders final payment to the contractor, without further acknowledgment by the parties."

SECTION 8 - FACILITIES FOR AGENCY PERSONNEL

8-1 GENERAL. Facilities provided for Agency personnel shall be at suitable locations approved by the Engineer. Such facilities must be in a room, building, or trailer provided for this purpose with acceptable means for locking.

A Class "A" Field Office conforming to 8-2.1 shall be provided at any offsite plant facility furnishing pipe subject to Agency inspection during manufacture. A Field Laboratory conforming to 8-3.1 shall be provided at any offsite or Work site plant facility furnishing Portland cement concrete or asphalt concrete pavement. Any other facilities for Agency personnel shall be provided only when required by the Specifications.

Offices and laboratories at plants may be used concurrently by inspection personnel of other agencies provided such use does not seriously conflict with Agency use. When facilities are shared in this manner, at least one locker provided with a hasp for a padlock must be available for the exclusive use of the Agency. Otherwise any facilities furnished are for the exclusive use of the Agency.

Facilities shall conform to the applicable codes, ordinances, and regulations of the local jurisdiction and of the State of California, and shall conform to current practice. The interior shall be paneled or suitably lined to provide a facility of good appearance.

The Contractor shall provide janitorial and other maintenance services in all types of facilities provided. Such services shall include the supply of the appropriate paper products and dispensers. Trash receptacles shall be provided and emptied by the Contractor at weekly intervals or sooner as required. The trash shall be removed from the Work site.

All costs to furnish, maintain, service, and remove the specified facilities at the Work site shall be included in the price in the Bid for such facilities. If no Bid item is provided in the Proposal, costs shall be included in other Bid items.

The first progress payment will not be approved until all facilities are in place and fully comply with the Specifications.

8-2 FIELD OFFICE FACILITIES.

8-2.1 Class "A" Field Office. The office shall have a minimum floor space of 175 square feet (16 m^2), at least one door, and window area of not less than 22 square feet (2 m^2). All doors and windows shall be provided with screens.

Furniture shall be provided as follows: one plan table, one standard 5-foot (1.5 m) long double-pedestal desk with a drawer suitable for holding files, 2 chairs, one drafting stool, and one plan rack.

Electric power shall be provided to include a minimum of 4 duplex convenience outlets. The office shall be illuminated at the tables and desk. An outdoor lighting fixture with a 300W bulb shall be installed.

Heating and air conditioning of sufficient capacity shall be provided at no expense to the Agency. The Contractor shall provide drinking water within the office and integral sanitary facilities directly adjoining. Sanitary facilities shall include a toilet and wash basin with hot and cold running water.

Extended area, non-coin-operated telephone service shall be provided within the office area. The installation shall include sufficient extension cord to serve the plan table and desk.

8-2.2 Class "B" Field Office. The office shall be the same as class "A" except that integrated sanitary facilities and air conditioning are not required. A chemical toilet facility shall be provided adjacent to the office.

8-2.3 Class "C" Field Office. The office shall have a minimum floor space of 120 square feet (11 m^2) of floor area. It shall be equipped with one 3-foot x 5-foot (0.9 m x 1.5 m) table, 4 chairs and one plan rack. It shall be adequately heated, ventilated, and lighted and 2 duplex convenience outlets shall be provided. Air conditioning, telephones, and sanitary facilities are not required.

8-3 FIELD LABORATORIES.

8-3.1 Offsite at Manufacturing Plant. Field laboratories shall conform to the requirements for a Class "C" Field Office specified in 8-2.3 except for the following:

a) Telephone service as specified in 8-2.1.

b) Chair.

c) Work table, 4 feet x 10 feet (1.2 m x 3 m), 3 feet (0.9 m).

d) Sieves per 203-6.

e) Scales and weights.

f) Burner plate for heating samples.

g) Thermometer, with 200 to 400°F (90 to 260°C) degree range (asphalt concrete plants only).

h) Air meter for concrete in accordance with ASTM C231 of the type that indicates the percentage of air directly (precast concrete plants only).

Sampling and testing equipment shall be maintained in satisfactory operating condition by the Contractor or the plant owner. Laboratories shall be located immediately adjacent to and with full view of batching and loading operations.

8-3.2 At the Work Site. Field laboratories shall conform to 8-3.1, except that sieves, scales, weights, burner plates, sampling devices, pans, and thermometers will be furnished by the Agency at no expense to the Contractor. If air entraining admixtures are being used in the concrete on the Work, an air meter of the type specified in 8-3.1 shall be furnished by the Contractor.

8-4 BATHHOUSE FACILITIES. When the Plans or Special Provisions require bathhouse facilities, the following shall be provided:

a) One lavatory with hot and cold water.

b) One toilet in a stall.

c) One 3-foot (1 m) trough-type urinal.

d) One enclosed shower at least 3 feet x 3 feet (1 m x 1 m) with hot and cold water.

e) One bench, 6 feet (2 m) long.

f) Soap dispensers.

g) Toilet paper holders.

h) Paper towel cabinet.

i) Wastepaper receptacle.

These facilities shall be serviced and provided with necessary sanitary supplies.

These facilities shall be for the exclusive use of Agency personnel. However, a separate building need not be provided for this purpose if such facilities are located in a separate room in a building which includes other facilities.

8-5 REMOVAL OF FACILITIES. Field offices, laboratories, and bathhouse facilities at the Work site shall be removed upon completion of the Work. Buildings and equipment furnished by the Contractor at the Work site under the provisions of this subsection shall remain the property of the Contractor.

8-6 BASIS OF PAYMENT. All costs incurred in furnishing, maintaining, servicing, and removing field offices laboratories, or bathhouse facilities required at the Work site shall be included in the Bid item for furnishing such facilities. If such facilities are required by the Plans and no Bid item is provided in the Proposal, the costs shall be included in other Bid items. Such costs incurred in connection with offices and laboratories at plants shall be borne by the plant owners.

SECTION 9 - MEASUREMENT AND PAYMENT

9-1 MEASUREMENT OF QUANTITIES FOR UNIT PRICE WORK.

9-1.1 General. Unless otherwise specified, quantities of work shall be determined from measurements or dimensions in horizontal planes. However, linear quantities of pipe, piling, fencing and timber shall be considered as being the true length measured along longitudinal axis.

Unless otherwise specified in the Special Provisions, volumetric quantities shall be the product of the mean area of vertical or horizontal sections and the intervening horizontal or vertical dimension. The planimeter shall be considered an instrument of precision adapted to measurement of all areas.

9-1.2 Methods of Measurement. Materials and items of work which are to be paid for on basis of measurement shall be measured in accordance with methods stipulated in the particular sections involved.

9-1.3 Certified Weights. When payment is to be made on the basis of weight, the weighing shall be done on certified platform scales or, when approved by the Engineer, on a completely automated weighing and recording system. The Contractor shall furnish the Engineer with duplicate licensed weighmaster's certificates showing actual net weights. The Agency will accept the certificates as evidence of weights delivered.

9-2 LUMP SUM WORK. Items for which quantities are indicated "Lump Sum", "LS", or "Job", shall be paid for at the price indicated in the Bid. Such payment shall be full compensation for the items of work and all work appurtenant thereto.

When required by the Special Provisions or requested by the Engineer, the Contractor shall submit to the Engineer within 15 Days after award of Contract, a detailed schedule in triplicate, to be used only as a basis for determining progress payments on a lump sum contract or designated lump sum Bid item. This schedule shall equal the lump sum Contract Price or Bid item price and shall be in such form and sufficiently detailed as to satisfy the Engineer that it correctly represents a reasonable apportionment of the lump sum.

9-3 PAYMENT.

9-3.1 General. The quantities listed in the Proposal will not govern final payment. Payment to the Contractor will be made only for actual quantities of Contract items constructed in accordance with the Contract Documents. Upon completion of the Work, if the actual quantities show either an increase or decrease from the quantities in the Proposal, the Contract Unit Prices will prevail except as otherwise specified in 3-2.2.

The unit and lump sum prices to be paid shall be full compensation for the items of work and all appurtenant work, including furnishing all materials, labor, equipment, tools, and incidentals.

Payment will not be made for materials wasted or disposed of in a manner not called for under the Contract. This includes rejected material not unloaded from vehicles, material rejected after it has been placed, and material placed outside of the Plan lines. No compensation will be allowed for disposing of rejected or excess material.

Payment for work performed or materials furnished under an Assessment Act Contract will be made as provided in the particular proceedings or legislative act under which such contract was awarded.

Whenever any portion of the Work is performed by the Agency at the Contractor's request, the cost thereof shall be charged against the Contractor, and may be deducted from any amount due or becoming due from the Agency.

Whenever immediate action is required to prevent injury, death, or property damage, and precautions which are the Contractor's responsibility have not been taken and are not reasonably expected to be taken, the Agency may, after reasonable attempt to notify the Contractor, cause such precautions to be taken and shall charge the cost thereof against the Contractor, or may deduct such cost from any amount due or becoming due from the

Agency. Agency action or inaction under such circumstances shall not be construed as relieving the Contractor or its Surety from liability.

Payment shall not relieve the Contractor from its obligations under the Contract; nor shall such payment be construed to be acceptance of any of the Work. Payment shall not be construed as the transfer of ownership of any equipment or materials to the Agency. Responsibility of ownership shall remain with the Contractor who shall be obligated to store any fully or partially completed work or structure for which payment has been made; or replace any materials or equipment required to be provided under the Contract which may be damaged, lost, stolen or otherwise degraded in any way prior to completion of the Work, except as otherwise specified in 6-10.

Warranty periods shall not be affected by any payment.

If, within the time fixed by law, a properly executed notice to stop payment is filed with the Agency, due to the Contractor's failure to pay for labor or materials used in the Work, all money due for such labor or materials will be withheld from payment to the Contractor in accordance with applicable laws.

At the expiration of 35 Days from the date of acceptance of the performance of the Contract by the Board, or as prescribed by law, the amount deducted from the final estimate and retained by the Agency will be paid to the Contractor except such amounts as are required by law to be withheld by properly executed and filed notices to stop payment, or as may be authorized by the Contract to be further retained.

9-3.2 Partial and Final Payment. The Engineer will, after award of the Contract, establish a closure date for the purpose of making monthly progress payments. The Contractor may request in writing that such monthly closure date be changed. The Engineer may approve such request when it is compatible with the Agency's payment procedure.

Each month, the Engineer will make an approximate measurement of the work performed to the closure date and as a basis for making monthly progress payments, estimate its value based on Contract Unit Prices or in accordance with 9-2. When the Work has been satisfactorily completed, the Engineer will determine the quantity of work performed and prepare the final estimate.

From each progress payment, not less than 5 percent will be deducted and retained by the Agency. The Agency will withhold not less than 5 percent of the total Contract amount until acceptance of the performance of the Contract by the Board.

No progress payment made to the Contractor or its Sureties will constitute a waiver of the liquidated damages specified in 6-9.

Pursuant to Section 22300 of the Public Contract Code, the Contractor may substitute securities for any monies withheld by the Agency to ensure performance under the Contract.

9-3.3 Delivered Materials. When provided for in the Special Provisions, and subject to the limitation and conditions therein, the cost of materials and equipment delivered but not incorporated into the Work will be included in the progress estimate.

9-3.4 Mobilization. When a Bid item is included in the Proposal for mobilization and subject to the conditions and limitations in the Special Provisions, the costs of work in advance of construction operations and not directly attributable to any specific Bid item will be included in the progress estimate. When no such Bid item is provided, payment for such costs will be considered to be included in the other items of work.

PART 2
CONSTRUCTION MATERIALS

SECTION 200- ROCK MATERIALS

200-1 ROCK PRODUCTS.

200-1.1 General. Rock products shall be defined as crushed rock, rock dust, gravel, sand, stone for riprap, or any combination thereof. Rock products shall be clean, hard, sound, durable, uniform in quality, and free of any detrimental quantity of soft, friable, thin, elongated or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.

200-1.1.1 Testing. Sieve analysis shall be performed in accordance with California Test 202. Sand equivalent tests shall be performed in accordance with California Test 217. Unless otherwise specified, percentages shall be determined by weight.

200-1.1.2 Statistical Testing. Statistical testing shall conform to the following:

Whenever both individual test results and moving average requirements are specified, materials shall meet both requirements.

Individual samples tested prior to the first use of materials from each source, or prior to the first use of materials after any changes have been made in material processing procedures, shall conform to the limits specified for moving average.

Moving average shall be computed in accordance with 211-5.

200-1.2 Crushed Rock and Rock Dust.

200-1.2.1 General. Crushed rock and rock dust shall be the product of crushing rock or gravel. A minimum of 50 percent of the particles retained on the 3/8 inch (9.5 mm) sieve shall have 3 or more fractured faces. A maximum of 5 percent of the retained particles shall have no fractured faces. Of that portion which passes the 3/8 inch (9.5 mm) sieve but is retained on the No. 4 (4.75 mm) sieve, not more than 10 percent shall be gravel particles.

Crushed rock and rock dust will be specified by nominal size (e.g. "3/4") and shall conform to the gradation requirements shown in Table 200-1.2.1 (A).

TABLE 200-1.2.1 (A)

	Percentage Passing Sieves		
Sieve Size	**1" (25.0 mm)**	**3/4" (19.0 mm)**	**1/2" (12.5 mm)**
1-1/2" (37.5 mm)	100	-	-
1" (25.0 mm)	90-100	100	-
3/4" (19.0 mm)	30-60	90-100	100
1/2" (12.5 mm)	0-20	30-60	90-100
3/8" (9.5 mm)	-	0-20	20-60
No. 4 (4.75 mm)	0-5	0-5	0-15
No. 8 (2.36 mm)	-	-	0-5
ASTM C131 Test Grading	A	B	B

	Percentage Passing Sieves			
Sieve Size	**3/8" (9.5 mm)**	**1/4" (6.3 mm)**	**3/16" (4.75 mm)**	**Rock Dust**
1/2" (12.5 mm)	100	-	-	-
3/8" (9.5 mm)	90-100	-	-	100
1/4" (6.3 mm)	-	100	-	-
No. 4 (4.75 mm)	30-60	75-100	100	90-100
No. 8 (2.36 mm)	0-10	0-25	40-75	-
No. 16 (1.18 mm)	-	0-5	0-10	-
No. 30 (600 µm)	-	-	-	20-60
No. 200 (75 µm)	-	0-2	0-2	5-20
ASTM C131 Test Grading	C	D	D	-

Crushed rock shall conform to the rock quality requirements shown in Table 200-1.2.1 (B).

TABLE 200-1.2.1 (B)

Test	Test Method No.	Requirements in percent
Percentage Wear	ASTM C131	
100 Revolutions		15 Maximum
500 Revolutions		52 Maximum

200-1.2.2 Screenings.

200-1.2.2.1 General. Screenings shall be composed of crushed rock conforming to 200-1.2.1, except the rock quality shall conform to the requirements shown in Table 200-1.2.2.1. Screenings will be specified by the name of the nominal size, e.g. "Medium Fine."

TABLE 200-1.2.2.1

Tests	Test Method No.	Requirements
Percentage Wear (100 revolutions)	ASTM C131	12 Maximum
Percentage Wear (500 revolutions)	ASTM C131	35 Maximum
Film Stripping	California 302	25 Maximum
Cleanness Value	California 227	80 Minimum
California Durability	California 229	52 Minimum

200-1.2.2.2 Screenings for Polymer Modified Emulsified Asphalt Chip Seal Applications. Screenings for use as cover aggregate over polymer modified emulsified asphalt shall conform to the gradation requirements shown in Table 200-1.2.2.2.

TABLE 200-1.2.2.2

Sieve Size	Percentage Passing Sieve			
	Coarse 1/2" x No. 4 (12.5 x 4.75 mm)	Medium 3/8" x No. 6 (9.5 x 3.35 mm)	Medium Fine 5/16" x No. 8 (8.0 x 2.36 mm)	Fine 1/4" x No. 10 (6.3 x 2.00 mm)
3/4" (19.0 mm)	100	-	-	-
1/2" (12.5 mm)	85 -100	100	-	-
3/8" (9.5 mm)	0-30	85-100	100	100
No. 4 (4.75 mm)	0- 5	0-15	0-50	60-85
No. 8 (2.36 mm)	-	0- 5	0-15	0-25
No. 16 (1.18 mm)	-	-	0-5	0-5
No. 30 (600 µm)	-	-	0-3	0-3
No. 200 (75 µm)	0-2	0-2	0-2	0-2

200-1.2.2.3 Pre-Coated, Pre-Heated Screenings for Asphalt Rubber and Aggregate Membrane (ARAM) Applications. Screenings for use as cover aggregate over asphalt rubber binder shall conform to the grading requirements shown in Table 200-1.2.2.3.

TABLE 200-1.2.2.3

Sieve Size	Percentage Passing Sieve	
	Medium Maximum 1/2" (12.5 mm)	Medium 3/8" (9.5 mm)
3/4" (19.0 mm)	100	100
1/2" (12.5 mm)	85 – 90	95 – 100
3/8" (9.5 mm)	0 – 30	70 – 85
No. 4 (4.75 mm)	0 - 5	0 - 15
No. 8 (2.36 mm)	–	0 – 5
No. 200 (75 µm)	0 – 1	0 – 1

Screenings shall be:

a) "Medium" unless otherwise specified in the Special Provisions or shown on the Plans;
b) preheated to between 260°F (127°C) to 325°F (163°C); and
c) coated with 0.70 percent to 1 percent PG 64-10 paving asphalt conforming to 203-1 at a central mixing plant. The exact percentage of paving asphalt shall be recommended by the Contractor and approved by the Engineer.

200-1.3 Gravel. Gravel shall be composed entirely of particles that have no more than one fractured face.

200-1.4 Coarse Aggregate for Portland Cement Concrete. Concrete aggregate shall be composed of gravel, crushed rock, or a blended mixture. Concrete aggregate shall be washed before delivery to the batching plant and shall conform to the following:

TABLE 200-1.4 (A)

Tests	Tests Method No.	Requirements
Cleanness Value	California 227	75 Minimum
Percentage Wear	ASTM C131	
100 revolutions		15 Maximum
500 revolutions		52 Maximum
Specific Gravity (Bulk saturated surface dry)	ASTM C127	2.58 Minimum[1]

1. Not more than 15 percent by weight shall be particles with a bulk specific gravity below 2.50.
2. Moving Average calculated in accordance with 211-5; no individual test result used shall be less than 71.

Concrete aggregate will be designated by number and shall conform to the following gradations:

TABLE 200-1.4 (B)

Sieve Size	Percentage Passing Sieve		
	No. 2	No. 3	No. 4
2" (50 mm)	100	-	-
1-1/2" (37.5 mm)	90-100	100	-
1" (25.0 mm)	5-40	90-100	-
3/4" (19.0 mm)	0-15	55-85	100
3/8" (9.5 mm)	0-5	8-20	85-100
No. 4 (4.75 mm)	-	0-5	0-30
No. 8 (2.36 mm)	-	0-5	0-10
No. 200 (75 µm)	0-2	0-2	0-2
ASTM C131 Test Grading	A	B	C

200-1.5 Sand.

200-1.5.1 General. Sand shall consist of natural or manufactured granular material, or a combination thereof, free of deleterious amounts of organic material, mica, loam, clay, and other substances not suitable for the purpose intended.

200-1.5.2 Sand for Asphalt Concrete. The sand shall conform to the gradation specified for asphalt concrete in 200-1.5.5.

200-1.5.3 Sand for Portland Cement Concrete. Sand for Portland cement concrete shall be washed and shall conform to the gradation specified for Portland cement concrete in 200-1.5.5 and the following quality requirements:

TABLE 200-1.5.3

Tests	Test Method No.	Requirements in percent
Organic Impurities	ASTM C40	Satisfactory[1]
Sand Equivalent	California 217	75 Minimum
Moving Average[3]		75 Minimum
Soundness[2]	California 214	10 Maximum

1. The resultant color of the testing solution shall not be darker than the ASTM C40 standard.
2. The soundness requirement will be waived, provided that the durability index, Df, is 60 or greater, when determined by California Test 229.
3. Moving Average calculated in accordance with 211-5; no individual test result used shall be less than 70.

200-1.5.4 Sand For Air-Placed Concrete. Sand for air-placed concrete shall be washed and conform to the gradation for Portland cement concrete in 200-1.5.5. The amount of deleterious substances shall not exceed the limits prescribed in ASTM C33.

200-1.5.5 Sand Gradations. Sand shall conform to the following gradations:

TABLE 200-1.5.5

Sieve Size	Percentage Passing Sieve		
	Asphalt Concrete	Portland Cement Concrete	Mortar
3/8" (9.5 mm)	100	100	-
No. 4 (4.75 mm)	-	95-100	100
No. 8 (2.36 mm)	75-100	75-90	95-100
No. 16 (1.18 mm)	-	55-75	70-95
No. 30 (600 µm)	-	30-50	35-70
No.50 (300 µm)	-	10-25	5-35
No. 100 (150 µm)	-	2-10	0-10
No. 200 (75 µm)	0-8[1]	0-5	0-5

1. May be exceeded to permit a maximum of 12 percent, provided the sand equivalent of the asphalt concrete sand is 35 or greater.

200-1.6 Stone for Riprap.

200-1.6.1 General. Stone for riprap shall be quarrystone or cobblestone. Quarrystone shall be angular and cobblestone shall be rounded. Flat or elongated shapes will not be accepted unless the thickness of the individual pieces is at least 1/3 of the length.

Stone shall be sound, durable, hard, resistant to abrasion and free from laminations, weak cleavage planes, and the undesirable effects of weathering. Stone shall be of such character that it will not disintegrate from the action of air, water, or the conditions to be met in handling and placing. Stone shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings.

200-1.6.2 Grading Requirements. Stone for riprap shall be designated by class and conform to the following gradations:

TABLE 200-1.6.2

Rock Size	Percentage Larger Than			
	500 lb. (225 kg) Class	375 lb. (170 kg) Class	Light (90 kg) Class	Facing (35 kg) Class
1000 lbs (450 kg)	0-5	-	-	-
700 lbs (320 kg)	-	0-10	-	-
500 lbs (225 kg)	50-100	10-50	0-5	-
200 lbs (90 kg)	-	85-100	50-100	0-5
75 lbs (35 kg)	90-100	95-100	90-100	50-100
25 lbs (10 kg)	95-100	-	95-100	90-100
2.2 lbs (1 kg)	-	-	-	95-100

Note: The amount of material smaller than the smallest size shown in the table for any class shall not exceed the percentage limit as determined on a weight basis. Compliance with the percentage limits shown in the table for all other sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified size compared to the total number of individual pieces larger than the smallest size listed in the table for that class.

200-1.6.3 Quality Requirements. Visual evaluation of the quarry, including examination of blast samples and diamond drill core samples, suitable tests and service records may be used to determine the acceptability of the stone. The Contractor shall notify the Agency in writing of the intended source of stone at least 60 Days prior to use. To ensure the required quality, stone may be subject to petrographic analysis or X-ray diffraction.

Stone for riprap shall conform to the following requirements:

TABLE 200-1.6.3

Tests	Test Method No.	Requirements in percent
Apparent Specific Gravity	ASTM C127	2.50 Minimum
Absorption[1]	California 206	4.20 Maximum
Durability[1]	California 229	52 Minimum
Percentage Wear	ASTM C131	45 Maximum

1. Based on the formula below, absorption may exceed 4.2 percent if the Durability Absorption Ratio (DAR) is greater than 10. Durability may be less than 52 if DAR is greater than 24.

$$DAR = \frac{\text{Coarse Durability Index}}{\%\ \text{Absorption} + 1}$$

200-2 UNTREATED BASE MATERIALS.

200-2.1 General. Materials for use as untreated base or subbase shall be classified in the order of preference as follows:

a) Crushed Aggregate Base

b) Crushed Miscellaneous Base

c) Pulverized Miscellaneous Base

d) Processed Miscellaneous Base

e) Select Subbase

When base material without further qualification is specified, the Contractor shall supply crushed aggregate base. When a particular classification of base material is specified, the Contractor may substitute any higher classification, following the order of preference listed above, of base material for that specified. All processing or blending of materials to meet the grading requirement will be performed at the plant or source. The materials shall compact to a hard, firm, unyielding surface and shall remain stable when saturated with water.

200-2.2 Crushed Aggregate Base.

200-2.2.1 General. Crushed aggregate base shall consist entirely of crushed rock and rock dust conforming to the requirements of 200-1.1 and 200-1.2.

200-2.2.2 Grading. The aggregate shall be uniformly graded and shall conform to the following gradation:

TABLE 200-2.2.2

Sieve	Percentage Passing Sieve
1-1/2" (37.5 mm)	100
3/4" (19.0 mm)	90-100
3/8" (9.5 mm)	50-80
No. 4 (4.75 mm)	35-55
No. 30 (600 µm)	10-30
No. 200 (75 µm)	2-9
ASTM C131 Test Grading	B

200-2.2.3 Quality Requirements. The material shall conform to the following:

TABLE 200-2.2.3

Tests	Test Method No.	Requirements
R-value[1]	California 301	80 Minimum
Sand Equivalent	California 217	50 Minimum
Percentage Wear	ASTM C131	
100 revolutions		15 Maximum
500 revolutions		52 Maximum
Specific Gravity (Bulk saturated surface dry)	ASTM C127	2.58 Minimum[2]

1. The R-value requirement will be waived, provided the material has an SE of 55 or more.
2. Not more than 15 percent by weight shall be particles with a bulk specific gravity below 2.50.

The Engineer may waive percentage wear and specific gravity requirements, provided that the material has a minimum durability of 40 in accordance with California Test 229.

200-2.3 Not Used.

200-2.4 Crushed Miscellaneous Base.

200-2.4.1 General. Crushed miscellaneous base shall consist of broken and crushed asphalt concrete or Portland cement concrete and may contain crushed aggregate base or other rock materials. The material shall be free of any detrimental quantity of deleterious material as defined in 200-1.1. The material retained on the No. 4 (4.75 mm) sieve shall contain no more than 15 percent gravel particles as defined in 200-1.3. The material may contain no more than 3 percent brick by weight as determined by California Test 202 modified as follows: Brick material retained on a No. 4 (4.75 mm) sieve shall be identified visually and separated manually. Brick quantification shall be based on total weight of dry sample.

200-2.4.2 Grading. The material shall be uniformly graded and shall conform to one of the following gradations:

TABLE 200-2.4.2

Sieve Size	Percentage Passing Sieve	
	Coarse	Fine
2" (50.0 mm)	100	
1-1/2" (37.5 mm)	85-100	100
3/4" (19.0 mm)	50-85	85-100
3/8" (9.5 mm)		55-75
No. 4 (4.75 mm)	25-45	35-60
No. 30 (600 µm)	10-25	10-30
No. 200 (75 µm)	2-9	2-9
ASTM C131 Test Grading	A	B

When there is a difference in specific gravity (bulk saturated surface dry per ASTM C127) of 0.2 or more between that portion retained and that portion passing a No. 4 (4.75 mm) sieve, the grading will be modified by California Test 105.

200-2.4.3 Quality Requirements. The material shall conform to the following:

TABLE 200-2.4.3

Tests	Test Method No.	Requirements
R-value[1]	California 301	78 Minimum
Sand Equivalent	California 217	35 Minimum
Percentage Wear	ASTM C131	
100 revolutions		15 Maximum
500 revolutions		52 Maximum

1. The R-value requirement may be waived, provided the material has an SE of 40 or more.

The Engineer may waive the percentage wear requirements, provided the material has a minimum durability of 40 in accordance with California Test 229.

200-2.5 Processed Miscellaneous Base.

200-2.5.1 General. Processed miscellaneous base shall consist of broken or crushed asphalt concrete, Portland cement concrete, railroad ballast, glass, crushed porcelain material, crushed rock, rock dust, or natural material. The material retained on the No. 4 (4.75 mm) sieve shall contain no more than 75 percent gravel particles as defined in 200-1.3. The material shall be free of any detrimental quantity of deleterious material as defined in 200-1.1. The material may contain no more than 3 percent brick by weight as determined by California Test 202 modified as follows: Brick material retained on a No. 4 (4.75 mm) sieve shall be identified visually and separated manually. Brick quantification shall be based on total weight of dry sample.

200-2.5.2 Grading. The material shall be uniformly graded and shall conform to 200-2.4.2.

200-2.5.3 Quality Requirements. The material shall conform to the following in Table 200-2.4.3:

The Engineer may waive the percentage wear requirements, provided the material has a minimum durability of 35 in accordance with California Test 229.

200-2.6 Select Subbase

200-2.6.1 General. Select subbase shall consist of soil, mineral aggregates, asphalt concrete, Portland cement concrete, or blends of these.

200-2.6.2 Grading. The material shall be uniformly graded and shall conform to one of the following gradations:

TABLE 200-2.6.2

Sieve Size	Percentage Passing Sieve	
	Coarse	Fine
1-1/2" (37.5 mm)	100	-
1" (25.0 mm)	-	100
No. 4 (4.75 mm)	55-75	70-100
No. 16 (1.18 mm)	30-75	40-90
No.50 (300 µm)	15-40	20-60
No. 200 (75 µm)	0-25	0-30

200-2.6.3 Quality Requirements. The material shall also conform to the following requirements:

TABLE 200-2.6.3

Tests	Test Method No.	Requirements
R-value[1]	California 301	60 Minimum
Sand Equivalent	California 217	20 Minimum

1. The R-value requirement may be waived, provided the material has an SE of 30 or more.

200-2.7 Disintegrated Granite.

200-2.7.1 General. Disintegrated granite shall be free from vegetable matter and other deleterious substances and shall be of such nature that it can be compacted readily under water and rolling to form a firm, stable base.

Disintegrated granite shall be any igneous rock, which has been weathered in place, or any sedimentary material principally derived from igneous rock.

200-2.7.2 Grading. The percentage composition by weight shall conform to Table 200-2.7.2.

TABLE 200-2.7.2

Sieve Size	Percent Passing
1-1/2 in (37.5 mm)	100
1 in (25.0 mm)	90-100
No. 4 (4.75 mm)	50-100
No. 30 (600 µm)	25-55
No. 200 (75 µm)	5-18

200-2.7.3 Quality Requirements. Disintegrated granite shall also conform to Table 200-2.7.3.

TABLE 200-2.7.3

Test	Test Method No.	Requirements
R-value	California 301	73 Minimum
Sand Equivalent	California 217	30 Minimum

200-2.8 Pulverized Miscellaneous Base.

200-2.8.1 General. Pulverized miscellaneous base shall consist of asphalt concrete or Portland cement concrete pavement that has been pulverized in place to the dimensions shown on the Plans. Pulverized miscellaneous base may contain underlying base material or subgrade soil. The material shall be free of any detrimental quantity of deleterious material as specified in 200-1.1.

Pulverized miscellaneous base, if produced in place, shall only be produced through the operation of a machine specifically designed for pulverizing, stabilizing and blending of this material. Pulverized miscellaneous base shall not be produced by the operation of self-propelled drop hammers ("stompers"), breakers, steel padded rollers, or by ripping or excavation equipment.

200-2.8.2 Testing. The Agency will collect samples of the pulverized material in accordance with California Test 125. The Agency will perform a minimum of one gradation and one sand equivalent test per 500 cubic yards of material pulverized. The Contractor shall allow the Agency a minimum of 48 hours to complete each test and inform the Contractor of the results.

200-2.8.3 Grading. The material shall be uniformly graded and shall conform to Table 200-2.8.3:

TABLE 200-2.8.3

Sieve Size	Percentage Passing Sieves
2" (50 mm)	100
1" (25 mm)	-
3/4" (19 mm)	85-100
3/8" (9.5 mm)	55-80
No. 4 (4.75 mm)	35-60
No. 30 (600 µm)	10-30
No. 200 (75 µm)	2-9
ASTM C131 Grading	B

If, after testing by the Agency, the pulverized material does not conform to the gradation specified in Table 200-2.8.3, a maximum of 35 percent rock products conforming to 200-1 may be blended into the pulverized material to correct the gradation. The Contractor shall determine the amount of rock products to be blended. The rock products shall be uniformly spread and blended over the area requiring correction of the gradation. The equipment used for blending shall conform to 200-2.8.1. The Agency will retest the corrected area in accordance with 200-2.8.2.

When there is a difference in specific gravity (bulk saturated surface dry conforming to ASTM C127) of 0.2 or more between that portion retained and that portion passing a No. 4 sieve, a modified grading will be required. The grading will be modified in accordance with California Test 105. The Agency will provide the Contractor with the modified grading required.

200-2.8.4 Quality Requirements. This material shall conform to the following:

TABLE 200-2.8.4

Tests	Test Method No.	Requirements
Sand Equivalent	California 217	40 Minimum
Percentage Wear	ASTM C131	
100 Rev		15 Maximum[1]
500 Rev		52 Maximum[1]
R-Value	California 301	78 Minimum[2]

1. The Engineer may waive the percentage wear requirements, provided the material has a minimum durability of 40 in accordance with California Test 229.
2. The R-Value may be waived if the SE is 45 or greater.

200-3 Not Used.

200-4 LEAN CONCRETE BASE (LCB).

200-4.1 General. LCB shall consist of a mixture of:

a) cement,

b) aggregate,

c) water, and

d) at the option of the Contractor, water reducing and/or air-entraining admixtures.

The proportions of cement, water and other materials shall be determined by the Contractor.

The Contractor shall submit a mix design with laboratory results in accordance with 2-5.3. The mix design shall show the amount and type of cement, and the amount of water, the aggregate grading and source, and the type and manufacturer of any proposed admixtures.

The amount of cement shall not to exceed 300 pounds per cubic yard (178 kg/m^3). The compressive strength, when tested in accordance with California Test 548, shall be a minimum of 700 pounds per square inch (4.8 MPa) at 7 Days.

200-4.2 Materials.

200-4.2.1 Cement. Cement shall be Type II/V Portland cement conforming to 201-1.2.1, added at a rate of 270 pounds per cubic yard (160 kg/m^3). SCMs shall not be substituted for Portland cement.

200-4.2.2 Aggregate.

200-4.2.2.1 General. Aggregate shall conform to 200-2. Should the Contractor change the source or grading, the Contractor shall notify the Engineer, in writing, of the new source or grading. The Contractor shall make the aggregate available for sampling and testing at least 45 Days prior to its intended use.

The 1-1/2 inch (37.5 mm) maximum or the 1 inch (25 mm) maximum may be used. Once a grading is selected, the grading shall not be changed without the Engineer's written approval.

200-4.2.2.2 Combined Aggregate Gradation. The combined aggregate gradation for the grading selected shall conform to Table 200-4.2.2.1. The percentage retained shall be determined by California Test 202, modified by California Test 105 when there is a difference in specific gravity of 0.2 or more between the coarse and fine aggregate.

TABLE 200-4.2.2.2

Sieve Sizes	Percent Passing[1]			
	1-1/2" (37.5 mm) Maximum		1" (25.0 mm) Maximum	
	Moving Average[2]	Individual Test Results	Moving Average[2]	Individual Test Results
2" (50.0 mm)	100	100	---	---
1 ½" (37.5 mm)	90 -100	87-100	100	100
1" (25.0 mm)	—	—	90 – 100	87 – 100
3/4" (19.0 mm)	50 – 85	45 – 90	50 – 100	45 – 100
3/8" (9.5 mm)	40 – 75	35 – 80	40 – 75	35 – 80
No. 4 (4.75 mm)	25 – 60	20 – 65	35 – 60	30 – 65
No. 30	10 – 30	6 – 34	10 – 30	6 – 34
No. 200	0 – 12	0 – 15	0 – 12	0 – 15

1. Coarse aggregate is material retained on the No. 4 (4.75 mm) sieve and fine aggregate is material passing the No. 4 (4.75 mm) sieve.
2. Statistical testing shall conform to 200-1.1.

200-4.2.2.3 Sand Equivalent. Aggregate shall not be treated with lime, cement or other chemicals before being tested. Aggregate shall have a sand equivalent value of not less than that shown in Table 200-4.2.2.2.

TABLE 200-4.2.2.3

Moving Average[1]	30
Individual Test Results	27

1. Statistical testing shall conform to 200-1.1.

The 1-1/2 inch (38 mm) maximum or the 1 inch (25 mm) maximum may be used. Once a grading is selected, the grading shall not be changed without the Engineer's written approval.

If the test results of the tests for either or both aggregate grading and sand equivalent tests do not meet the requirements specified for the "moving average" but meet the "individual test" requirements, placement of the LCB may be continued for the remainder of the working day. Work shall not resume until tests indicate that the aggregate to be used complies with the requirements specified for the "moving average."

No single aggregate grading or sand equivalent test shall represent more than 500 cubic yards (400 m^3) or one day of production, whichever is smaller.

200-4.2.3 Water. Water shall conform to 201-1.2.3.

200-4.2.4 Chemical Admixtures. Chemical admixtures shall conform to 201-1.2.4. Water reducing admixtures shall be Type A or Type F.

The air content of LCB shall not exceed 4 percent. An air-entrainment reducing admixture shall be used when aggregate is produced from reclaimed material containing asphalt concrete or other material which would cause the air content to exceed 4 percent.

200-4.3 Proportioning, Mixing and Transporting. Proportioning shall conform to 201-1.3, except that the dividing of aggregate into sizes will not be required and the slump shall not exceed 3 inches (75 mm).

Mixing and transporting shall conform to 201-1.4 and 201-1.5.

SECTION 201 - CONCRETE, MORTAR, AND RELATED MATERIALS

201-1 PORTLAND CEMENT CONCRETE.

201-1.1 Requirements.

201-1.1.1 General. Concrete shall consist of cement, concrete aggregates, water, and when specified or approved for use, chemical admixtures, and/or SCMs, fibers, color, and/or reclaimed concrete material. Concrete shall be specified by class, alternate class, special exposure, or compressive strength.

Concrete specified by compressive strength shall be designed by the Contractor in accordance with 201-1.1.4.

Chemical admixtures shall be used in accordance with 201-1.2.4 and at the manufacturer's specified dosage rate. Additional cement or SCMs may be used to obtain high early strength in concrete, except that the total amount of cement shall not exceed 700 pounds per cubic yard (415 kg/m^3) unless otherwise approved by the Engineer.

Colored concrete shall conform to 303-7.

Fiber reinforcement shall conform to 201-2.3 and be added at the rate specified in the Special Provisions.

Reclaimed concrete material conforming to 201-1.2.6 may be incorporated into concrete mixtures when so specified in the Special Provisions or approved by the Engineer.

When concrete is specified by class, alternate class, or special exposure, a mix design shall be submitted to the Engineer for approval in accordance with 2-5.3. The mix design shall specify the proportions of aggregate, water, and when applicable, SCMs, chemical admixtures, and reclaimed concrete material. The mix design shall also include the gradation and source of aggregate, the type and source of cement and SCMs, the brand and designation of chemical admixtures, and slump requirement. If fiber reinforcement is to be added, the fiber type, fiber manufacturer, and rate of addition shall be included with the mix design. If so specified in the Special Provisions, the color manufacturer, amount of color, and the type of construction for which the concrete is to be used shall also be included with the mix design.

201-1.1.2 Concrete Specified by Class and Alternate Class. When the specified by class, concrete will be designated by a number, one or two letters, and a number. The first number is the weight of Portland cement conforming to 201-1.2.1 in pounds per cubic yard (kg/m^3), the first letter is the combined aggregate gradation conforming to 201-1.3.2 and the second letter (W) designates the required use of a water reducing admixture conforming to 201-1.2.4. The last number is the minimum compressive strength at 28 Days in pounds per square inch (MPa). A water reducing admixture conforming to 201-1.2.4 may be used in any concrete specified by class and is required in all 4000 psi (28 MPa) compressive strength concrete specified by class.

When specified by alternate class, concrete will be designated by a number, three letters, and a number. The first number is the weight of cementitious material in pounds per cubic yard (kg/m^3) which consists of 85 percent Portland cement conforming to 201-1.2.1 and 15 percent SCMs by weight. The first letter is the combined aggregate gradation, conforming to 201-1.3.2, the second letter (F) designates the required use of SCMs conforming to 201-1.2.5, the third letter (W) designates the required use of a water reducing admixture conforming to 201-1.2.4. The last number is the minimum compressive strength at 28 Days in pounds per square inch (MPa).

The concrete class, alternate class, and maximum slump for the various types of construction shall be as shown in Table 201-1.1.2.

TABLE 201-1.1.2

Type of Construction	Concrete Class [5,6,7] U.S. Standard Measures (Metric Units)	Alternate Class U.S. Standard Measures (Metric Units)	Maximum Slump Inches (mm)
Street Surface Improvements			
Concrete Pavement (not integral with curb)	520-A-2500 (310-A-17)	494-AFW-2500 (295-AFW-17)	3 (75)
Curb, Integral Curb and Pavement, Gutter, Walk, Alley Aprons	520-C-2500 (310-C-17)	494-CFW-2500 (295-CFW-17)	4 (100)
Curb, Integral Curb and Pavement, Gutter, Walk, Alley Aprons	520-C-2500P[1] (310-C-17P[1])	494-CFW-2500P[1] (295-CFW-17P[1])	4 (100)
Extruded Curb, Curb and Gutter [8]	520-C-2500 (310-C-17) 520-D-2500 (310-D-17)	494-CFW-2500 (310-CFW-17) 494-CFW-2500 (310-CFW-17)	2 (50) 2 (50)
Sewer & Storm Drainage Facilities			
Pipe Collars, Beam Support for Pipe, Pre-Cast Manhole Components, Catch Basins, Sidewalk Culverts	560-C-3250[2] (330-C-23[2]) 565-C-3250P[1] (335-C-23P[1])	532-CFW-3250[2] (315-CFW-23[2]) 537-CFW-3250P[1] (320-CFW-23P[1])	5 (125) 4 (100)
Sidehill Surface Drainage Facilities	500-C-2500 (295-C-17) 520-C-2500P[1] (310-C-17P[1]) 560-E-2500P[1] (330-E-17P[1])	475-CFW-2500 (280-CFW-17) 494-CFW-2500P[1] (295-CFW-17P[1]) 532-EFW-2500P[1] (315-EFW-17P[1])	3 (75) 4 (100) 4 (100)
Pipe Bedding and Encasement, Anchors and Thrust Blocks, Wall Support for Pipe[3]	450-C-2000[2] (265-C-14[2]) 565-E-2000P[1] (335-E-14P[1])	 537-EFW-2000P[1] (320-EFW-14P[1])	4 (100) 6 (150)
Tunnel Backfill	480-C-2000 (285-C-14) 490-C-2000P[1] (290-C-14P[1])		5 (125) 5 (125)
Trench Backfill	100-E-100 (60-E-0.7)		5 (125)
Reinforced Structures			
Bridges, Buildings, Retaining Walls, and Tunnels	560-C-32502 (330-C-232) 565-C-3250P1 (335-C-23P1) 650-CW-40005 (385-C-285) 660-CW-4000P1, 5 (390-CW-28P1, 5)	532-CFW-32502 (315-CFW-232) 537-CFW-3250P1 (320-CFW-23P1) 650-CFW-40005 (385-CFW-281) 660-CFW-4000P1,5 (390-CFW-28P1,5)	4 (100) 4 (100) 4 (100) 4 (100)
Cast-In-Place piles	560-C-32502 (330-C-232) 565-C-3250P1 (335-C-23P1)	532-CFW-32502 (315-CFW-232) 537-CFW-3250P1 (320-CFW-23P1)	4 (100) 4 (100)

TABLE 201-1.1.2 *(Continued)*

Type of Construction	Concrete Class[5,6,7] U.S. Standard Measures (Metric Units)	Alternate Class U.S. Standard Measures (Metric Units)	Maximum Slump Inches (mm)
Reinforced Structures (Cont.)			
Channels and Boxes, Inverts	560-B-3250 (330-B-23) 565-B-3250P1 (335-B-23P1) 650-BW-40005 (385-BW-285) 660-CW-4000P1, 5 (390-CW-28P1, 5)	532-BFW-3250 (315-BFW-23) 537-BFW-3250P1 (320-BFW-23P1) 650-BFW-40005 (385-BFW-285) 660-CFW-4000P1,5 (390-CFW-28P1,5)	4 (100) 4 (100) 4 (100) 4 (100)
Reinforced Structures (Cont.)			
Walls and Deck	560-C-3250 (330-C-23) 565-C-3250P[1] (335-C-23P[1,5]) 650-CW-4000[5] (385-CW-28[5]) 660-CW-4000P[1, 5] (390-CW-28P[1, 5])	532-CFW-3250 (315-CFW-23) 537-CFW-3250P[1] (320-CFW-23P[1,5]) 650-CFW-4000[5] (390-CFW-28[5]) 660-CFW-4000P[1,5] (390-CFW-28P[1,5])	5 (125) 5 (125) 4 (100) 4 (100)
Miscellaneous			
Street Light and Traffic Signal Foundations, Survey Monuments	560-C-3250 (330-C-23)	532-CFW-3250 (315-CFW-23)	4 (100)
Fence and Guardrail Post Foundations	500-C-2500 (295-C-17)	475-CFW-2500 (280-CFW-17)	5 (125)
Concrete Not Otherwise Specified	560-C-3250 (330-C-23) 565-C-3250P[1] (335-C-23P[1])	532-CFW-3250 (315-CFW-23) 537-CFW-3250P[1] (320-CFW-23P[1])	5 (125) 4 (100)
Air Placed Concrete, Method B	650-D-3250P[1] (385-D-23P[1]) 650-E-3250P[1] (385-E-23P[1])	650-DFW-3250P[1] (385-DFW-23P[1]) 650-EFW-3250P[1] (385-EFW-23P[1])	4 (100) 4 (100)
Coarse Masonry Grout	610-E-2000G[4] (360-E-14G[4])	610-EF-2000G[4] (360-EF-14G[4]) 580-EFW-2000G[4] (345-EFW-14G[4])	10 (250) 10 (250)

1. Concrete mixes followed by a "P" have been designed to accommodate placement by a concrete pump using a 4-inch line. When placing conditions require use of a smaller line pump, a "CSP" gradation may be substituted for the "C" gradation with the approval of the Engineer. A pump mix may be substituted for a similar Class or Alternate Class mix and placed utilizing standard placement methods by the Contractor at its option. Said substitution, if made, shall be at the Contractor's expense.
2. Use "B" aggregate gradation when placing conditions permit.
3. Use limited to bedding concrete over which backfill will be placed not less than 40 hours after placement. For backfill after 24 hours, add 3 pints per 100 pounds of cement (31 milliliters per kilogram of cement) of calcium chloride. For backfill after 16 hours and removal of sheeting after 18 hours, use 660-C-3750 (390-C-26) with 3 pints per 100 pounds of cement (31 milliliters per kilogram of cement) calcium chloride solution.
4. Concrete mixes followed by a "G" have been designed to accommodate the grout requirements of 202.
5. A water reducing admixture conforming to 201-1.2.4 may be used in any concrete specified by class and is required in all 4000 psi (28 MPa) compressive strength concrete specified by class.
6. Fibers conforming to 201-2.3 may be used in any concrete specified by class.
7. Color conforming to 303-7 may be added to any concrete specified by class.
8. Air-entraining or viscosity modifying admixtures conforming to 201-1.2.4 may be used.

201-1.1.3 Concrete Specified by Special Exposure. Concrete specified by special exposure, shall be designated by a number, followed by 3 letters and a number. The first number is the minimum weight of cementitious material in pounds per cubic yard (kg/m^3) as specified in Table 201-1.1.3. The first letter is the combined aggregate gradation conforming to 201-1.3.2. The second and third letters (LE, ME, or SE) designate the level of exposure (Low Exposure, Moderate Exposure or Severe Exposure). The last number is the minimum compressive strength at 28 Days in psi (MPa).

Concrete specified by special exposure shall contain Class F fly ash or other SCMs conforming to 201-1.2.5 and a water-reducing admixture conforming to 201-1.2.4, and shall conform to the water-cementitious material ratio specified in Table 201-1.1.3.

Concrete specified by special exposure shall be proportioned in accordance with ACI 318, Chapter 4, Durability Requirements. Air entraining admixtures may be incorporated at the manufacturer's recommended rates to produce 4 percent ± 1 percent air content in the concrete mix. Admixtures containing calcium chloride are prohibited for use in concrete exposed to sulfates. The level of protection shall be as specified in the Special Provisions or shown on the Plans. A mix of more severe exposure may be substituted for a mix of less severe exposure.

TABLE 201-1.1.3

Special Exposure Mixes	Maximum Water – Cementitious Ratio[2]	Special Exposure U.S. Standard Measure (Metric Units)	Cementitious Material Requirement
LOW EXPOSURE – (% water soluble SO_3 in soil samples 0.10 to 0.20) (Sulfate SO_4 in water samples, PPM – 150 to 1,500)	0.50	650-BLE-4000P[1] (385-BLE-28P[1]) 650-CLE-4000P[1] (385-CLE-28P[1]) 740-DEL-4000P[1] (440-DLE-28P[1])	80% Type II or V Portland cement with 20% Class F fly ash
MODERATE EXPOSURE – (% water soluble SO_3 in soil samples 0.20 to 2.00) (Sulfate SO_4 in water samples, PPM – 1500 to 10,000)	0.45	658-BME-4500P[1] (390-BME-31P[1]) 658-CME-4500P[1] (390-CME-31P[1]) 815-DME-4500P[1] (480-DME-35P[1])	80% Type II or V Portland cement with 20% Class F fly ash
SEVERE EXPOSURE – (% water soluble SO_3 in soil samples 2.00 or more) (Sulfate SO_4 in water samples, PPM –10,000 or more)	0.40	750-BSE-5000P[1] (450-BSE-35P[1]) 750-CSE-5000P[1] (450-CSE-35P[1]) 875-DSE-5000P[1] (520-DSE-35P[1])	80% Type II or V Portland cement with 20% Class F fly ash

1. Concrete mixes followed by a "P" have been designed to accommodate placement by a concrete pump using a 4-inch line.
2. Maximum slump is determined by placement conditions so long as water-cementitious ratio is not exceeded.

201-1.1.4 Concrete Specified by Compressive Strength. The Contractor shall determine the mix proportions of concrete specified in the Special Provision or shown on the Plans by its 28-Day compressive strength within the minimum cement, maximum size coarse aggregate and admixture limitations specified herein or otherwise specified in the Special Provisions. Concrete specified by compressive strength shall contain not less than 560 pounds of cement, or cement and SCMs per cubic yard (330 kg of cement, or cement and SCMs per m^3), in accordance with 201-1.2.5, for concrete

strengths of 3,250 psi (23 MPa) or greater. The Contractor may submit mix designs specified by compressive strength in excess of 28 Days with the approval of the Engineer. Such mix designs are not subject to the SCMs limitations of 201-1.2.5.

Calcium chloride may be used only with the approval of the Engineer. Admixtures proposed for use shall be evaluated in accordance with 201-1.2.4.

The proposed mix design shall be evaluated from tests of a field trial batch conforming to the size of load, materials, proportions, slump, mixing and placing equipment, and procedures to be used in the actual work or, with the approval of the Engineer, tests of a laboratory trial batch conforming to the materials, proportions, and slump to be used in the actual work. The trial batch procedure may be waived when test data of prior performance of the proposed mix design is presented by the Contractor and approved by the Engineer. The Contractor may utilize any strength data on file with the Agency for this purpose.

When approved by the Engineer, field trial batches may be placed in the Work at designated locations where concrete of a lower quality is specified. Concrete so placed will be considered for purpose of payment to be the type of concrete specified at that location.

Ten test cylinders shall be molded from the trial batch containing the maximum water content indicated by the mix design. Five of the cylinders shall be tested at 7 Days in order to establish 7-Day average compressive strength information, and the remaining 5 cylinders shall be tested at no more than 28 Days after molding. The average compressive strength of the 5, 28-Day cylinders for field trial tests shall be at least 600 psi (4 MPa) greater than the specified strength. The average compressive strength of the 5, 28-Day cylinders for laboratory trial batch tests shall be at least 1000 psi (7 MPa) greater than the specified strength for specified strengths less than 3000 psi (21 MPa), 1200 psi (8 MPa) greater than the specified strength for specified strengths between 3000 psi and 5000 psi (21 MPa and 36 MPa), and 1400 psi (10 MPa) greater than the specified strength for specified strengths greater than 5000 psi (36 MPa). The minimum strength of any one cylinder shall not be less than the specified strength.

The placing of concrete specified by compressive strength shall not begin until the mix design has qualified in accordance with the aforesaid test criteria. Should the source of materials or established procedures change, new trial batches may be required.

201-1.1.5 Tests for Portland Cement Concrete. Portland cement concrete shall be sampled and tested in accordance with the following ASTM and California Tests:

a) Sampling Fresh Concrete C172
b) Obtaining Drilled Cores C42
c) Molding and Curing Specimens C31
d) Compressive Strength C39
e) Flexural Strength C78
f) Slump C143
g) Air Content ..... C173 or C231
h) Unit Weight Yield C138
i) Setting of Mortar ..... C191 or C266
j) Mortar Cube Test ..... California Test 515
k) Drying Shrinkage (with admixture) ..... California Test 530

A compressive strength test shall consist of the average strength of 2 cylinders fabricated from a single load of concrete, except that if any cylinder shows evidence of improper handling, molding, or testing, it shall be discarded and the strength test shall consist of the strength of the remaining cylinder.

The Engineer will determine the frequency of sampling. The Contractor shall afford the Engineer all reasonable access, without charge, for the procurement of samples of fresh concrete at time of placement.

Concrete compressive strength tests representing concrete that has been placed shall attain the following 28-Day strength: The average of any 3 consecutive strength tests shall be equal to or greater than the specified 28-Day strength. Not more than 10 percent of the tests shall be less than the specified 28-Day strength. No test shall be less than 85 percent of the specified 28-Day strength.

Concrete represented by compressive strength tests that fail to meet the requirements of this subsection shall be removed from the Work. However, with the approval of the Engineer, the concrete represented by the failing compressive strength tests may be cored for strength testing. Coring shall commence within 5 Days of notification by the Engineer. Drilled cores shall be obtained by the Contractor in the presence of the Engineer and tested at the Contractor's expense in accordance with ASTM C42 by a laboratory acceptable to the Engineer. A minimum of 3 cores shall be taken in each area represented by the failing 28-Day compressive strength tests. If the average of 3 cores is at least 85 percent of the specified 28-Day strength and no single core is less than 75 percent of the specified 28-Day strength, the concrete represented may be accepted with no further action required. Additional testing of cores extracted from locations represented by erratic core strength results shall be permitted by the Engineer.

201-1.1.6 Pervious Concrete.

201-1.1.6.1 General. Pervious concrete shall consist of Portland cement, coarse concrete aggregate, water, and when approved by the Engineer or specified in the Special Provisions, chemical admixtures, fly ash, sand, or reclaimed concrete material.

201-1.1.6.2 Materials. Materials shall consist of:

a) Type II or Type V Portland cement conforming to 201-1.2.1, Type II, unless otherwise specified in the Special Provisions;
b) coarse concrete aggregate conforming to 200-1.4, No. 4, unless otherwise specified in the Special Provisions;
c) water conforming to 201-1.2.3;
d) hydration stabilizing (Type B or D), air-entraining, and/or specific performance chemical admixtures conforming to 201-1.2.4;
e) fly ash conforming to 201-1.2.5.3, the content shall be less than 25 percent;
f) sand for Portland cement concrete conforming to 200-1.5.3; and
g) reclaimed concrete material conforming to 201-1.2.6.

201-1.1.6.3 Mix Design. A mix design shall be submitted in accordance with 2-5.3. The minimum cementitious material content shall be 540 pounds per cubic yard (320 kg/m^3). The fly ash content shall not be greater than 25 percent of the total weight of cementitious materials.

The mix design shall show the mix identification number and the applicable proportions, weights, and quantities of Portland cement, aggregate, water, and when specified or approved, fly ash, chemical admixtures, sand, and reclaimed concrete material. The mix design submittal shall also include the size and source of concrete aggregates, the type and source of Portland cement and fly ash, the brand and designation of chemical admixtures, the percent voids, and the intended type of construction.

201-1.2 Materials.

201-1.2.1 Cement. Cement shall be:

a) Portland Cement. Portland cement shall be:

1) Type II or Type V Portland cement conforming to ASTM C150 and the optional requirements of ASTM C150, Table 2 for maximum equivalent alkalis ($Na_2O + 0.658K_2O$) of 0.60 percent.

2) Type III Portland cement conforming to ASTM C150 and the optional requirements of ASTM C150, Table 2 for maximum equivalent alkalis ($Na_2O + 0.658K_2O$) of 0.60 percent may be used when approved by the Engineer.

b) Blended Cement. Blended cement shall be Type IP (MS) Portland-pozzolan cement conforming to ASTM C595, unless otherwise specified. Type IP (MS) cement shall meet the optional mortar expansion requirements of ASTM C595, Table 2 and contain no more than 25 percent pozzolan.

c) Rapid Hardening Hydraulic Cement. Rapid hardening hydraulic cement shall conform to ASTM C1600.

The Contractor shall furnish a Certificate of Compliance.

Cement shall be stored to protect against contamination and moisture. Should any cement show evidence of contamination or be otherwise unsuitable, the Engineer may reject it and require that it be removed from the site.

Cement used in concrete for any individual structure shall be of the same brand and type unless otherwise approved by the Engineer.

201-1.2.2 Aggregates. Aggregates shall conform to 200-1. Aggregate shall be of such character that it will be possible to produce workable concrete within the limits of slump and water content in 201-1.1.2 and 201-1.3.3.

Methods of handling materials resulting in segregation, degradation, or the combining of materials which results in failure to meet specifications shall not be permitted. The free moisture content of sand shall not exceed 8 percent at the time of batching.

Aggregates shall be nonreactive when tested in accordance with ASTM C289 and evaluated in accordance with Appendix X-1 of ASTM C33. Aggregates found to be potentially reactive may be used only upon written approval of the Engineer.

201-1.2.3 Water. Water used for concrete shall not contain deleterious substances. Water shall not contain an amount of impurities that will cause a change in the time of setting of Portland cement of more than 25 percent nor a reduction in relative mortar strength at 7 and 28 Days of more than 10 percent compared to results obtained with distilled water.

In conventionally reinforced concrete work, water shall not contain more than 1,000 mg/L (ppm) of chlorides calculated as Cl, nor more than 1,000 mg/L (ppm) of sulfates calculated as SO_4.

In prestressed concrete work, water shall not contain more than 650 mg/L (ppm) of chlorides calculated as Cl, nor more than 800 mg/L (ppm) of sulfates calculated as SO_4.

In nonreinforced concrete work, water shall not contain more than 2,000 mg/L (ppm) of chlorides calculated as Cl, nor more than 1,500 mg/L (ppm) of sulfates calculated as SO_4.

201-1.2.4 Chemical Admixtures. Chemical admixtures specified or approved by the Engineer shall conform to ASTM standards unless otherwise specified in the Special Provisions. Chemical admixtures shall be compatible with all other ingredients of the concrete mixture. Chemical admixtures shall be dispensed in liquid form and the quantity dispensed shall not vary more than 5 percent from the quantity specified. Approval to use an admixture shall not relieve the Contractor of the specified concrete

requirements. Use of chemical admixtures shall conform to the trial batch requirements of 201-1.1.4, except for concrete specified by class, by alternate class, or by special exposure.

a) **Water-Reducing, Set-Retarding, and Hydration Stabilizing Admixtures.** Water-reducing (Type A), water-reducing set-retarding (Type D), and hydration stabilizing (Type B or D) admixtures shall conform to ASTM C494.

b) **Accelerating Admixtures.** When calcium chloride is approved for use, it shall conform to ASTM D98. Calcium chloride shall not be used in concrete containing prestressing steel. Calcium chloride shall not be used in concrete containing any reinforcing metal products, unless approved by the Engineer. Other accelerating admixtures shall conform to ASTM C494, accelerating (Type C), or water reducing and accelerating (Type E) admixtures.

c) **High Range, Water-Reducing Admixtures (HRWRA).** HRWRA, i.e., superplasticizers, shall conform to ASTM C494, water-reducing, high range admixtures (Type F), or water-reducing, high range, and retarding admixtures (Type G). The use of HRWRA shall conform to the manufacturer's recommendation for dosage, redose, and point of addition for each specific admixture. HRWRA may be added at the batch plant or at the Work site, as approved by the Engineer.

d) **Air-Entraining Admixtures.** Air-entraining admixtures shall conform to ASTM C260. Concrete containing air-entraining admixtures shall be sampled and tested in accordance with 201-1.1.5. The air content, at the point of discharge shall be within a tolerance of 1.5 percent of the value specified in ASTM C94. Testing for air content may be waived by the Engineer when air-entrainment is used solely in concrete for extruded curb, or curb and gutter as shown in Table 201-1.1.2.

e) **Specific Performance Admixtures (SPA).** SPA shall conform to ASTM C494, specific performance admixtures (Type S). The use of SPA shall conform to the manufacturer's recommendation for dosage, redose, and point of addition. SPA may be added at the batch plant or at the Work site, as approved by the Engineer.

201-1.2.5 Supplementary Cementitious Materials.

201-1.2.5.1 Definitions.

SCMs - Materials that are by products of other processes or natural materials. SCMs may or may not be furthered processed for use in concrete and distribute pozzolanic and/or cementitious reactions.

Pozzolans - Materials that possess little or no cementitious value, but are capable of reacting chemically with calcium hydroxide at ambient temperatures to form compounds with cementitious properties.

Cementitious Materials - Materials that react in the presence of water or calcium hydroxide to form complex silicates having the characteristics of cements.

201-1.2.5.2 General. SCMs shall be cementitious and/or pozzolanic materials as specified in the Special Provisions.

Bulk SCMs shall be stored in silo storage facilities. SCMs shall be stored in such a manner as to permit ready access for the purposes of inspection, and sampling and provide suitable protection against contamination or moisture. The Engineer may reject SCMs that show evidence of contamination or are otherwise unsuitable, and require that they be removed from the storage site. Facilities shall be provided to discharge the SCMs into the cement hopper in accordance with 201-1.3.1.

SCMs used in concrete for any individual structure shall be from the same source in combination with the same source and type of cement, unless otherwise approved by the Engineer.

201-1.2.5.3 Fly Ash. Fly ash shall be incorporated into the alternate class mixes specified in 201-1.1.2, and special exposure mixes specified in 201-1.1.3. Fly ash may also be used in other mixes when approved by the Engineer. The amount of fly ash and cement used shall be based upon trial batches in accordance with 201-1.1.4.

The Contractor shall furnish a Certificate of Compliance conforming to 4-1.5 signed by the supplier. The certificate shall identify the type of fly ash, and state that the fly ash conforms to ASTM C618 and the Specifications. Supporting test data shall be furnished when requested by the Engineer. Testing and sampling procedures shall conform to ASTM C311.

a) Class F Fly Ash. Class F fly ash shall conform to ASTM C618 and the following:

Loss of ignition	4% maximum
SO_3 content	3% maximum
Moisture content	1% maximum

Test results for special exposure mixes shall be submitted to the Engineer in accordance with 2-5.3. The test results shall show the fly ash to be used is effective in contributing to sulfate resistance in conformance with ASTM C618, Table 3 (optional requirements) as tested in accordance with ASTM C1012. The data submitted shall be less than 6 months old.

Class F fly ash, as a percent by weight of total cementitious material, may exceed 20 percent, when approved by the Engineer.

b) Class C Fly Ash. Class C fly ash shall conform to ASTM C618 and the following:

Loss of ignition	2% maximum
SO_3 content	4% maximum
Moisture content	1% maximum

Class C fly ash, as a percent by weight of total cementitious material, shall not exceed 30 percent, unless otherwise approved by the Engineer.

Class C fly ash shall not be used where sulfate resistant concrete is required.

201-1.2.5.4 Class N Pozzolans. Class N pozzolans shall comply with the applicable requirements for the class specified herein and conform to ASTM C618.

Class N pozzolans are:

a) some diatomaceous earths;

b) opaline cherts and shales;

c) tuffs and volcanic ashes or pumicites, calcined or uncalcined; and

d) various materials requiring calcination to induce satisfactory properties, such as some clays and shales.

Class N pozzolans may be used in any mix when approved by the Engineer.

The Contractor shall submit a Certificate of Compliance signed by the supplier. The certificate shall identify the type of pozzolan, and state that the pozzolan conforms to ASTM C618 and the Specifications. Supporting test data shall be furnished when requested by the Engineer. Testing and sampling procedures shall conform to ASTM C311.

Class N pozzolan, as a percent by weight of total cementitious material, may exceed 20 percent when approved by the Engineer.

Special exposure mixes specified in 201-1.1.3 shall be proportioned in accordance with ACI 318, Chapter 4. Class N pozzolan shall comply with ASTM C618 Table 3. All test data shall be made available upon the Engineer's request.

In any other mix, the amount of Class N pozzolan and Portland cement used shall be determined by trial batches in accordance with 201-1.1.4.

201-1.2.6 Reclaimed Concrete Material. Reclaimed concrete material may be either:

a) Reclaimed plastic Portland cement concrete (RPPCC)

or

b) Reclaimed non-plastic Portland cement concrete materials

The Contractor is required to maintain suitable equipment to classify reclaimed concrete material and document its use in the proportioning of concrete mixtures. The addition and characteristics of reclaimed concrete material will be monitored to ensure the final Portland cement concrete composite conforms to the specifications for its Class and use.

All mixtures incorporating reclaimed concrete material will be represented by mix designs in accordance with section 201-1.1.1. The Contractor shall evaluate all mix designs by laboratory or field trial batches. Each trial batch shall conform to the materials, proportions, and slump as proposed by the mix design. When approved by the Engineer, field trial batches may be placed in the Work at designated locations where concrete of lower quality is specified. Concrete so placed will be considered for the purpose of payment to be the type of concrete specified at that location. A minimum of 10 test cylinders shall be molded from the trial batch containing the maximum water content indicated by the mix design. Five of the cylinders shall be tested at 7 Days to establish 7-Day average compressive strength information. The remaining 5 cylinders shall be tested at no more than 28 Days after molding. For field trial batches the average 28-Day compressive strength shall be at least 600 psi (4 MPa) greater than the specified strength. For laboratory trial batches the average 28-Day compressive strength shall be at least 1000 psi (7 MPa) greater for specified strengths less than 3000 psi (21 MPa), 1200 psi (8 MPa) greater for specified strengths between 3000 psi and 5000 psi (21 MPa and 36 MPa) and 1400 psi (10 MPa) greater for specified strengths greater than 5000 psi (36 MPa). The minimum strength of any one cylinder shall not be less than the specified strength. Changes in the source of materials or established procedures may require new trial batches. Changes in the quality of materials or failure to comply with the compressive strength requirements of 201-1.1.4 shall require new trial batches unless otherwise approved by the Engineer.

Reclaimed concrete material may not be used in special exposure mixtures or in architectural concrete specifications.

a) Reclaimed Plastic Portland Cement Concrete (RPPCC). A maximum of 15 percent by volume of reclaimed plastic Portland cement concrete may be incorporated into fresh Portland cement concrete. Each weighmaster certificate shall show the exact volume of RPPCC in addition to the weighmaster certificate requirements of section 201-1.4.3.

RPPCC may be any un-hardened Portland cement concrete provided its design strength is 2000 psi (14 MPa) or greater, its constituent material conforms to section 201-1.2, and it has not attained or has been delayed from attaining initial set either by time or by the incorporation of set-delaying chemical admixtures. When set-delaying chemical admixtures are used, they shall be used at the manufacturer's recommended dosage rates and have a proven history of specifically maintaining and extending both plasticity and set. The Contractor shall maintain process documentation, mix designs, and supportive concrete test data and shall provide the information to the Engineer upon request.

RPPCC shall be proportioned by volume in accordance with section 201-1.3. RPPCC may be added at any point during the proportioning process that results in a consistent, uniform, and homogeneous final product. For design and proportioning purposes, all RPPCC shall be

considered as a 2000 psi (14 MPa) mixture, consisting of 470 pounds (280 kg) of cementitious material. Additional cement shall be added to achieve the minimum cement content and/or strength as required for a mixture's Class and use. The quantity and/or constituent materials of the RPPCC shall be monitored and proportioned such that the final combined gradation conforms to the requirements of 201-1.3.2.

b) **Reclaimed Non-Plastic Portland Cement Concrete Materials.** Non-plastic Portland cement concrete materials shall consist of an individual amount of or a combination of materials resulting from the reclaiming of Portland cement concrete. Before reclamation, these materials shall conform to 201-1.2. The materials shall be designated as either reclaimed aggregates (RA) or reclaimed water (RW).

RA shall consist of crushed and graded concrete aggregates and/or a reclaimed naturally occurring aggregate. A maximum of 30 percent RA by weight of total aggregate may be incorporated into fresh Portland cement concrete. Reclaimed naturally occurring aggregates may contain minor residual amounts of Portland cement concrete components as a result of reclamation. When crushed Portland cement concrete is used as aggregate it shall, when combined with the non-reclaimed aggregate at the proposed percentage of use, conform to 201-1.2.2. When 15 percent or less RA by weight of total aggregate is used, the requirements of 201-1.2.2 may be waived by the Engineer provided the final combined gradation conforms to the requirements of 201-1.3.2.

RW may consist of non-deleterious amounts of hydrated and un-hydrated Portland cement, admixtures, minor amounts of fly ash and fine aggregate. The reclamation process for RW shall include a mechanism to ensure uniformity and homogeneity of the RW. A maximum of 35 percent RW by weight of batch water may be incorporated into fresh Portland cement concrete.

RA and RW shall be proportioned by weight in accordance with 201-1.3. RA and RW may be added at any point during the proportioning process that results in a consistent, uniform, and homogeneous final product. The quantity and/or constituent materials of the RA shall be monitored and proportioned such that the final combined gradation conforms to the requirements of 201-1.3.2.

201-1.3 Proportioning.

201-1.3.1 General. Aggregates and cement shall be proportioned by weight except that when the amount of concrete required for any one contract is 10 cubic yards (8 m^3) or less, the materials may be measured by volume. Materials that are proportioned by volume shall be measured in containers of known capacity.

Weigh hoppers shall be charged from bins located directly over them or from conveyor belts. When conveyor belts are used, there shall be a separate belt for each size aggregate. There shall be a moisture meter installed, accurate within 1 percent of actual moisture content, to indicate moisture in the sand.

Bulk cement shall be weighed in an individual hopper and kept separate from the aggregates until ingredients are released for discharge. The cement hopper shall be attached to a separate scale for individual weighing.

The amount of water added to the mixture shall be measured into the mixing drum through a valve with a positive cutoff. When water is measured by weight, it shall be weighed on a separate scale.

Whenever a portable batch plant is set up at a new location the scale assemblies shall be inspected and certified regardless of the date the scales were last tested.

Scales utilized in proportioning shall be either springless dial, multiple beam, or solid-state digital strain gage transducer. Scale graduation shall be no greater than the following:

Aggregate Scales ..... 25 lbs (10 kg)
Cement Scales ..... 5 lbs (2 kg)
Water Scales ..... 5 lbs (2 kg)

If a multiple beam type scale is used, the scale shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or under weight. The indicator shall be so designed that it will operate during the addition of the last 400 pounds (200 kg) of any weighing. The over-travel of the indicator hand shall be at least 1/3 of the loading travel. Indicators shall be enclosed against moisture and dust.

Weighing equipment shall be insulated against vibration and movement of other operating equipment in the plant. When the entire plant is running, the scale reading at cutoff shall not vary from the weight designated by more than 1 percent for cement, 1 percent for water, 1-1/2 percent for any size of aggregate, nor 1 percent for the total aggregate in any batch.

201-1.3.2 Combined Aggregate Gradings. The aggregates, when proportioned and combined in accordance with an approved mix design, shall conform to the gradings shown in Table 201-1.3.2. If the combined aggregate grading conforms to the grading of its specified class, the mix proportions shall be considered satisfied and the individual gradations required by 200-1.4 and 200-1.5 may be waived by the Engineer.

TABLE 201-1.3.2

Sieve Size	Percentage Passing Sieves					
	Grading A	Grading B	Grading C	Grading CSP	Grading D	Grading E
2" (50 mm)	100	100	-	-	-	-
1-1/2" (37.5 mm)	95-100	95-100	100	100	-	-
1" (25.0 mm)	64-80	80-96	95-100	98-100	-	-
3/4" (19.0 mm)	55-71	64-80	77-93	85-98	100	100
3/8" (9.5 mm)	37-53	40-52	50-70	67-80	92-100	90-100
No. 4 (4.75 mm)	32-42	35-46	39-51	46-65	42-60	60-80
No. 8 (2.36 mm)	25-35	28-38	31-41	38-54	33-47	50-70
No. 16 (1.18 mm)	18-28	21-31	22-32	27-40	22-38	33-53
No. 30 (600 µm)	10-18	10-20	12-22	15-27	17-25	19-35
No.50 (300 µm)	3-9	3-10	3-15	3-15	6-15	5-15
No. 100 (150 µm)	0-4	0-4	0-5	0-7	1-6	2-7
No. 200 (75 µm)	0-2	0-2	0-2	0-3	0-3	0-4

201-1.3.3 Concrete Consistency. The amount of water added at the mixer shall be regulated to take into account the free water in aggregates. Free water is defined as the total water minus the water absorbed by the aggregate in a saturated surface-dry condition.

The amount of water used in the mixture shall not exceed the amount necessary to permit practical placement and consolidation of the concrete. Total free water in the mixture shall not exceed an amount producing the maximum slump specified in 201-1.1.2, and shall not exceed amounts shown in the following:

TABLE 201-1.3.3

Pounds (Kg) Per Cubic Yard (Cubic Meter) of Concrete					
Aggregate Grading[1]	Slump Inches (mm)				
	1" (25 mm)	2" (50 mm)	3" (75 mm)	4" (100 mm)	5" (125 mm)
A	270 (160)	280 (166)	290 (172)	300 (178)	310 (184)
B	275 (163)	285 (169)	295 (175)	305 (181)	315 (187)
C	290 (172)	300 (178)	310 (184)	320 (190)	330 (196)
D	320 (190)	335 (199)	350 (208)	365 (216)	375 (222)
E	335 (199)	350 (208)	365 (216)	380 (225)	395 (234)

1. When the coarse aggregate is composed solely of crushed rock, the above values may be increased up to 20 pounds (12 kg) of water per cubic yard (cubic meter).

When adverse or difficult conditions affect the placement of concrete, the Engineer may authorize a greater slump to be used, provided the cement is increased. Water shall be added at a ratio not to exceed 32 percent of added cement per cubic yard (m^3) of concrete, and such additional water and cement shall be provided at the Contractor's expense.

201-1.4 Mixing.

201-1.4.1 General. Machine mixing will be required in all cases other than those in which it would obviously prove to be impractical, in which case hand mixing is permitted. Mixing shall be commenced as soon as possible after the cement is placed in contact with the aggregates, but in no event shall the intervening period exceed 30 minutes.

All concrete mixers shall be of such design and construction and so operated to provide a properly mixed concrete with uniform distribution of ingredients. Mixers shall be maintained properly and be in working order and not have any aluminum parts which will have direct contact with concrete.

201-1.4.2 Paving and Stationary Mixers. Paving and stationary mixers shall be equipped with an accurate automatic timing device so designed and constructed as to lock the discharge lever. The regulation setting of this device shall be under the supervision of the Engineer. Water control equipment shall also be provided with each concrete mixer.

The proper proportions of aggregate, cement, and water for each batch of concrete shall be placed in the mixer and mixed for a period of not less than 1 minute (1-1/2 minutes for reinforced concrete).

The rotating speed at which the mixer shall be operated shall conform to that recommended by the manufacturer. The total volume of materials in any one batch shall not exceed the water level capacity of the mixer or the manufacturer's specified capacity of the mixer.

201-1.4.3 Transit Mixers. The type, capacity, and manner of operation of the mixing and transporting equipment for ready-mix concrete shall conform to the current "Standards for Operation of Truck Mixers and Agitators of the National Ready-Mixed Concrete Association" and the "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau." Transit mix concrete trucks shall be equipped with an automatic device for recording the number of revolutions of the drum during the mixing period. Each mixer and agitator shall have attached thereto in a prominent place, a metal plate or plates, installed by the manufacturer. The plate(s) shall be plainly marked with the manufacturer's designated capacity of the drum in terms of the volume of mixed concrete and the speed of rotation for the agitating and mixing speeds of the mixing drum or blades.

Each mixer shall have an identification number painted on it that can be easily read from the batching platform.

The total volume of materials introduced into the mixer shall not exceed the manufacturer's specified mixing capacity. If the concrete so mixed does not meet the uniformity requirements of 210-1.4.1, the amount of materials introduced into the mixer shall be reduced.

The drum of the mixer shall be completely emptied of any previously mixed load. The proper proportions of the required ingredients for each load of concrete shall be placed in the mixer and shall be mixed between 70 and 100 revolutions at the manufacturer's designated mixing speed unless otherwise approved by the Engineer. Additional revolutions of the drum shall be at the manufacturer's designated agitating speed.

When concrete is produced for pavement or concrete structures, all wash water shall be emptied from the mixer before any portion of the succeeding load is introduced, unless it has been measured. For all other work, the mixer shall be empty or may carry up to 10 gallons (40 L) of water in the drum. This amount may be exceeded if the water is measured to an accuracy of 1 percent of the required total mixing water. Adequate control of ready-mixed concrete may require additional added water mixed into the batch at the discharge point. This water shall be mixed for a minimum of 30 revolutions at the manufacturer's designated mixing speed. Water shall not be added to the load during transit.

The total elapsed time between introduction of water at the batch plant and completely discharging the load shall not exceed 90 minutes. The Engineer may waive this limitation if the concrete is of such slump after the 90 minute time limit has been reached that it can be placed without the addition of water to the batch. Under conditions contributing to quick stiffening of the concrete a time limit less than 90 minutes may be specified by the Engineer.

The Engineer shall be provided with a legible certified weighmaster certificate which shall contain the following information:

a) Name of vendor.

b) Name of Contractor.

c) Work location.

d) Number of cubic yards in the load.

e) Concrete Class, Alternate Class, or Special Exposure mix designation.

f) Amount of water added at the plant (including water in fine aggregates).

g) Maximum allowable water.

h) Time and date of batching.

When concrete is specified by compressive strength, or when required by the Engineer, the certificate shall contain the following additional information:

i) Actual weights of cementitious materials and of each size of aggregate.

j) Brand and type of cement.

k) Brand, type and amount of admixture.

Space shall be provided on the certificate so that amount of water added at the Work site may be indicated.

201-1.4.4 Hand Mixing. Hand mixing is permitted when the amount of concrete required is less than 1 cubic yard (cubic meter). Hand-mixed concrete shall be mixed on a watertight platform or in a mortar box in batches not to exceed 1/3 cubic yard (cubic meter) each. The aggregates shall be spread in a uniform layer over which the required quantity of cement shall be evenly distributed. The entire batch shall be turned with shovels until the ingredients are thoroughly blended before adding water. After adding the proper amount of water, the batch shall again be turned with shovels until a uniform consistency is obtained. Methods of hand mixing which allow the loss of mixing water will not be permitted.

201-1.5 Transporting Batched Materials and Mixed Concrete. The compartments of trucks or other equipment used for the purpose of transporting proportioned dry aggregate and cement, or mixed concrete, shall be suitably constructed to protect and prevent loss or leakage of contents during charging, transit, or discharging.

201-2 REINFORCEMENT FOR CONCRETE.

201-2.1 General. Bar, wire, welded wire, and fiber reinforcement shall conform to the dimensions, quantity, and details shown on the Plans or specified in the Special Provisions.

Before use, reinforcement shall be clean and free of deleterious substances.

201-2.2 Steel Reinforcement.

201-2.2.1 Reinforcing Steel. Unless otherwise specified, reinforcing steel shall be either Grade 40 (300) or Grade 60 (400) billet steel conforming to ASTM A615/A615M. Steel bending processes shall conform to the requirements of the Manual of Standard Practice of the Concrete Reinforcing Steel Institute. Bending or straightening shall be performed in a manner that will not result in the steel being damaged. Kinked bars shall not be used.

201-2.2.2 Wire Reinforcement. Wire reinforcement shall conform to ASTM A82.

201-2.2.3 Welded Wire Reinforcement. Welded wire reinforcement shall conform to ASTM A185. The gage of the wire and the dimensions of the mesh shall be as shown on the Plans or specified in the Special Provisions. Welded wire reinforcement shall retain its original shape and form during handling. The effective cross-sectional area of the wire shall be equal to that specified.

201-2.3 Fiber Reinforcement.

201-2.3.1 General. Fiber reinforcement for fiber reinforced concrete or air placed concrete, method B, shall conform to ASTM C1116. The Contractor shall submit a Certificate of Compliance for each type of fiber reinforcement used in the Work.

201-2.3.2 Type I Reinforcement. Type I reinforcement shall be composed of steel fibers conforming to ASTM A820.

201-2.3.3 Type II Reinforcement. Type II reinforcement shall be composed of alkali-resistant glass fibers.

201-2.3.4 Type III Reinforcement. Type III reinforcement shall be composed of synthetic fibers conforming to ASTM D7508. Fibers shall be tested in accordance with ASTM C1399, ASTM C1609 or ASTM C1550.

201-2.4 Samples for Testing.

201-2.4.1 General. No reinforcing steel will be accepted until it has been approved by the Engineer. Samples shall be taken from bars selected by the Engineer and cut in the Engineer's presence. The Contractor shall furnish a certified mill test report for each heat or size of steel when required by the Engineer.

201-2.4.2 Reinforcing Steel Bars. Two sample bars, cut from different bars and 3 feet (1 m) in length for sizes No. 3 (10M) through No. 5 (16M) and 5 feet (1.5 m) in length for size No. 6 (19M) and larger, shall be taken from each bar size and heat number delivered to the Work site on a cumulative tonnage basis in accordance with the following schedule:

TABLE 201-2.4.2

U.S. Standard Bar Sizes (Metric Sizes)	Bar Size Delivered To the Work Site Tons (tonnes)
2 (6M)	0.5 (1/2)
3 (10M)	1 (1)
4 (13M)	2 (2)
5 (16M)	3 (3)
6 (19M)	4 (4)
7 (22M)	5 (5)
8 (25M)	7 (6)
9 (29M)	9 (8)
10 (32M)	11 (10)
11 (36M)	13 (12)
14 (43M)	20 (18)
18 (57M)	35 (32)

At least 2 sample bars shall be taken from each bar size.

201-2.4.3 Wire Reinforcement. One sample consisting of two pieces, each 3 feet (1 m) long, shall be taken from each lot of 2 tons (2 tonnes) or less for each size of wire delivered to the Work site.

201-2.4.4 Welded Wire Reinforcement. Two samples of a size suitable for testing shall be taken from each 3,000 square feet (280 m^2) of fabric or fraction thereof.

201-3 EXPANSION JOINT FILLER AND JOINT SEALANTS.

201-3.1 General. This section specifies joint fillers and sealants to be used for treating joints in Portland cement concrete.

All joints which are to be sealed shall be formed with filler. The filler shall be placed in correct position before concrete is placed against it. Holes or joints in the filler shall be filled with mastic to prevent the passage of mortar or concrete from one side of the joint to the other.

201-3.2 Premolded Joint Filler. Premolded joint filler material shall consist of premolded strips of a durable resilient material.

Unless otherwise specified, premolded joint filler shall be one of the following:

Preformed Expansion Joint Filler (Bituminous) ASTM D994

Nonextruding and Resilient Filler (Bituminous) ASTM D1751

Nonextruding and Resilient Filler (Non-bituminous) ASTM D1752

201-3.3 Polystyrene Joint Filler. Commercial quality expanded polystyrene foam blocks and planks shall be furnished by the Contractor and installed in-place as shown on the Plans. The foam shall be composed of non-interconnecting cells. Expanded polystyrene shall have a flexural strength of 35 pounds per square inch (240 kPa) and a compressive yield strength of between 16 and 40 pounds per square inch (110 kPa and 275 kPa) at 5 percent compression.

Surfaces of expanded polystyrene against which concrete is to be placed shall be faced with hardboard. Hardboard shall be 1/8 inch (3 mm) minimum thickness conforming to Federal Specifications LLL-B-810, any type. Other facing materials may be used, provided they furnish equivalent protection. All boards shall be held in place by nails, waterproof adhesive, or other means approved by the Engineer.

201-3.4 Type "A" Sealant (Two-Part Polyurethane Sealant). The sealant shall be a polyurethane sealant furnished and placed in accordance with the Specifications for "Two-Component Machine-Mixed Polyurethane Sealant" (State Specification 8030-61J-01).

Polyethylene foam shall be commercial quality, with a continuous impervious, glazed top surface, suitable for retaining the liquid polyurethane sealant in the joint while hardening.

A primer, furnished by the manufacturer of the sealant, shall be applied to the sides of the groove and to all exposed vertical surfaces in the joint prior to placing the polyurethane sealant. The primer shall be dry prior to placing sealant. Contamination of the completed primer with foreign material will be cause for rejection of the primed surface.

201-3.5 Type "B" Sealant (Preformed Elastomeric Sealant). The sealant shall be a preformed elastomeric joint seal conforming to specifications of ASTM D268 and the following requirements:

The manufacturer shall designate the minimum uncompressed width of each size of seal to be furnished. Any seal which has a minimum uncompressed width, measured at any point in the height of the seal, less than that designated by the manufacturer shall not be used.

Seals delivered to the Work site that have dimensional or shape tolerances of such magnitude that the seal will not function as specified shall not be used.

The seal shall consist of a multi-channel, nonporous, homogeneous material furnished in a finished extruded form, and shall be furnished full length for each joint with no more than one shop splice in any 60 foot (18 m) length of seal. Field splices shall not be used.

The adhesive used to splice the seal shall be an effective bonding agent and shall be resistant to water and ozone. The lubricant adhesive shall conform to State Specification 701-80-30. All abutting surfaces of shop splices shall be bonded together with adhesive. Shop splices shall have no visible evidence of bond failure.

After the seal has been installed in the joint, shop splices shall have no visible offset of the exterior surfaces and there shall be no evidence of bond failure at the abutting surfaces of the splices.

At all open ends of the seal, each cell of the elastomeric joint seal shall be filled to a depth of 4 inches (100 mm) with commercial quality open cell polyurethane foam, or closed by other methods subject to Engineer approval.

Tests of elastomeric joint seals will be conducted in accordance with California Test 673.

201-3.6 Type "C" Sealant (Asphalt-Latex Emulsion Joint Sealant). Asphalt-latex emulsion joint sealant shall be designated for mixing and application by hand methods and shall be suitable for use at temperatures above 50°F (10°C). The sealing compound shall be an emulsion consisting of paving asphalt, emulsified with rubber latex in a suitable emulsifying agent. Rubber latex shall be natural rubber or synthetic latex containing approximately 40 percent solids. The resulting emulsion shall consist of a minimum of 55 percent paving asphalt and a minimum of 36 percent rubber latex.

A setting agent shall be provided in the form of a paste to be added at the rate of approximately 3 fluid ounces per gallon (25 mL/L) of emulsion.

The joint sealant shall comply with the requirements of Table 201-3.6.

TABLE 201-3.6

Determination	Test Method No.	Requirements	Remarks
Furol Viscosity at 77°F (25°C)	ASTM D88	80-250 Secs.	Before adding setting agent.
Sieve Test	ASTM D244	1% maximum	Before adding setting agent.
Penetration[1] at 77°F (25°C)	California 418	50-150	Immediately after mixing, the material is poured into a 6-ounce (175 mL) deep ointment can and the specimen allowed to stand in air at a temperature of 77° ± 2°F (25° ± 1°C) for a period of 24 hours. It is then penetrated with a grease cone under a total load of 150 g in accordance with ASTM D217.
Elasticity[1]	California 418	70% minimum	Immediately after mixing, the material is placed in an aluminum pan and cured for 24 hours at 115° ± 2°F (46° ± 1°C). Specimen shall be tested in modified ductility mold per test method.
Total Solids[2]	California 418	70% minimum	3 to 5 g of freshly mixed material is placed in an aluminum pan and dehydrated in a suitable oven maintained at a temperature of 200° ± 3°F (93° ± 2°C) for a period of three hours.
Setting Time[2]	California 418	60 Min. Max.	Material is poured into a 6-ounce (175 mL) deep ointment can and penetration checked each 15 minutes. Time is recorded when penetration is less than 200.

1. Mixing ratio of material: Add 10 ± 0.1 g of sodium fluosilicate powder to 200 g of emulsion component.
2. Mixing ratio of material: Add 12 mL of setting agent component and 8 fluid ounces (24 mL) of emulsion component.

201-3.7 Type "D" Joint Sealant (Hot-Poured Rubber-Asphalt Joint Sealant). Hot-poured rubber asphalt joint sealants shall conform to requirements of ASTM D1190. They shall be applied in accordance with the manufacturer's recommendation and 303-1.8.7.

201-3.8 Type "E" Joint Sealant (Polysulfide Polymer and Rubber Rod). Polysulfide polymer type joint sealant shall be a two-component, plastic, rubber-like, cold-applied joint sealant. This material shall resist the intrusion of foreign materials into the joint throughout repeated cycles of expansion and contraction.

The joint sealant shall be packaged in sealed containers identified by the name of the manufacturer, lot number, and date, and bear instructions for mixing and application. Accelerator containers shall be marked "A", and polysulfide containers shall be marked "B". The weight of component "A" in the mixture shall not be less than 10 percent of component "B". Minimum polysulfide content of the mixture shall be 20 percent by weight.

Upon opening the container, component "B" shall not exhibit more than a slight degree of "skinning" on the surface of the material.

The joint sealant shall conform to the following requirements when laboratory mixed materials are tested in accordance with California Test 413:

TABLE 201-3.8 (A)

Determination	Requirements
Viscosity, 5 minutes after mixing, poises (Pa·s)	200 to 350 (20 to 35)
Application time (pot life or time to reach 2000 poises [200 Pa·s] at 77°F [25°C], hours minimum)	1
Penetration at 77°F (25°C) after aging 24 hours at 77°F (25°C)	150 maximum
Nonvolatile content, percent	88 minimum

The following tests shall be performed on the mixed material after 96 hours of aging at 77°F (25°C) :

TABLE 201-3.8 (B)

Determination	Requirements
Penetration at 77°F (25°C)	50 to 120
Penetration at 158°F (70°C)	175 maximum
Resilience at 77°F (25°C), percent	70 min., 60 min.[1]
Resilience at 158°F (70°C), percent	60 min., 50 min.[1]
Bond to concrete, 100% extension, dry at -20°F (-29°C)	No failure
Bond to concrete, 50% extension, wet at -20°F (-29°C)	No failure

1. This requirement applied if the penetration at 77°F (25°C), after 96 hours aging at 77°F (25°C) is 100 to 129.

The following test shall be performed on the sample from the resilience test above, oven-aged for 7 Days at 158°F (70°C):

TABLE 201-3.8 (C)

Determination	Requirements
Resilience of oven-aged sample after 7 Days at 77°F (25°C), percent	70 min., 60 min.[1]

1. This requirement applied if the penetration at 77°F (25°C), after 96 hours aging at 77°F (25°C) is 100 to 129.

The rubber rod shall be a cellular synthetic rubber, either butyl or neoprene, of circular cross section with continuous skin impervious to water. It must comply with the following requirements:

TABLE 201-3.8 (D)

Determination	Requirements
Specific gravity (Bulk)	0.30 to 0.50
Surface hardness, Durometer (Fig. 1) ASTM D2240	60 to 85
Water absorption, by weight, 1 inch (25 mm) head at 75°F (24°C), for 24 hours, percent	5 maximum
Resistance to ozone, ASTM D470, except 30 minutes exposure, at 70 ± 10 mg/L ozone, at 85°F (29°C)	No cracks

201-3.9 Test Report and Certification. When requested by the Engineer, the Contractor shall provide at delivery time, certified copies of the vendor's test report. This shall indicate the vendor name, type of joint sealant, date and point of delivery, quantity, ticket number, lot number, and results of the required test. The test report shall be signed by an authorized representative of the vendor.

201-4 CONCRETE CURING MATERIALS.

201-4.1 Membrane Curing Compounds.

201-4.1.1 General. Curing compound shall consist of a liquid which, when applied to fresh concrete, will form a continuous membrane over the exposed surfaces of the concrete.

Curing compounds shall conform to the requirements of ASTM C309 Class B (Resin Type Only), except the loss of water shall not exceed 0.15 kilogram per square meter in 24 hours nor 0.45 kilogram per square meter in 72 hours when tested in accordance with ASTM C156.

Concrete curing compounds are designated by type as follows:

Type 1 - Clear or translucent without dye.

Type 1-D - Clear or translucent with fugitive dye.

Type 2 - White pigmented

Unless otherwise stated on the Plans or in the Specifications, Type 1-D shall be used, except that Type 2 shall be used for the top surface of bridge decks. Curing compounds which contain such coloration as to be easily visible following application shall be considered as meeting the fugitive dye requirement.

All compounds shall be furnished by the Contractor and shall be delivered ready-mixed in sealed original containers labeled in accordance with ASTM C309 and with the date of the manufacture. At the time of use, pigmented curing compounds shall be maintained in a thoroughly mixed condition. Containers of curing compound shall remain air-tight when not in use.

201-4.1.2 Application. Curing compound shall be applied in 2 coats according to the manufacturer's directions and 303-1.10. The direction of application of the second coat shall be perpendicular to the first. The second coat shall be applied when the first coat is dry to the touch, but not later than 4 hours after the first coat was applied.

The rate of application shall be such that the compound forms a continuous, unbroken film when applied to the work and shall not be less than the rate used when tested for water retention.

Application of the curing compound to the concrete shall commence as soon as the finished surface of the concrete reaches a uniformly damp appearance with no free water on the surface. At any point, the application rate shall be within 50 square feet per gallon (1.2 m^2/L) of the nominal rate and the average application rate shall be within 25 square feet per gallon (0.6 m^2/L) of the nominal rate specified when tested in accordance with California Test 535.

201-4.2 Sheet Curing Materials.

201-4.2.1 General. Sheet curing materials are designated by type as follows:

Type 1 - Waterproof Paper

Type 2 - Polyethylene Film

Type 3 - White-Burlap-Polyethylene Sheet

Type 4 - Burlap

Types 1, 2, and 3 sheet curing materials shall conform to the requirements of ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

201-4.2.2 Burlap. Burlap shall weigh not less than 10 ounces per linear yard, 40 inches wide (305 g/m^2).

201-4.3 Test Report and Certification. The Contractor shall provide, when requested by the Engineer, certified copies of the vendor's test report showing compliance with ASTM C309 and these specifications.

201-5 CEMENT MORTAR.

201-5.1 General. Cement mortar shall consist of cement, sand, and water. Cement and sand shall first be combined in the proper proportions, and then thoroughly mixed with the required amount of water.

Cement mortar shall be designated by class and proportioned by loose volume as shown in Table 201-5.1.

TABLE 201-5.1

Mortar Designation Class	Proportions	
	Parts Cement	Parts Sand
A	1	1
B	1	1-½
C	1	2
D	1	2-½
E	1	3
F	1	3-½

The quantity of water to be used in the preparation of mortar shall be only that required to produce a mixture sufficiently workable for the purpose intended.

Mortar shall be used as soon as possible after mixing and shall show no visible signs of setting prior to use. Retempering of mortar will not be permitted.

201-5.2 Cement. Cement shall conform to 201-1.2.1.

201-5.3 Sand. Sand shall conform to requirements of 200-1.5.3. In proportioning the sand it shall be measured loose (without shaking or compacting) in measuring boxes or other suitable containers of known capacity.

201-5.4 Water. Water shall conform to 201-1.2.3.

201-5.5 Admixtures. No admixture shall be used in mortar unless approved by the Engineer.

201-6 CONTROLLED LOW STRENGTH MATERIAL (CLSM).

201-6.1 Requirements.

201-6.1.1 General. CLSM shall consist of cement, aggregates, water, and fly ash. Chemical admixtures and other mineral admixtures may be used when approved by the Engineer.

The actual mix proportions and flow characteristics shall be determined by the producer of the CLSM to meet the Work site conditions and shall be approved by the Engineer. The mixture shall be workable and non-segregating. When air-entrainment is specified, it shall be evaluated with the actual materials to be used in the Work.

CLSM that is to be hand excavatable, shall contain aggregate no larger than 3/8 inch (9.5 mm) and the 3/8 inch (9.5 mm) aggregate shall comprise no more than 30 percent of the total aggregate content.

When minimum and/or maximum compressive strength is required, the strength shall be as shown on the Plans.

201-6.2 Materials

201-6.2.1 Cement. Cement shall conform to the requirements of 201-1.2.1.

201-6.2.2 Aggregates. Aggregates shall conform to the requirements of 201-1.2.2, except as noted below. Aggregates shall be pretested in CLSM mixtures similar to those anticipated for the Work, confirming their ability to perform as required for the specific application. Aggregates not in conformance with 201-1.2.2 may be used when approved by the Engineer, providing the material has a minimum sand equivalent of 20, the percentage passing the No. 200 (75 mm) sieve does not exceed 12 percent, and the fines are non-plastic.

201-6.2.3 Water. Water shall conform to the requirements of 201-1.2.3.

201-6.2.4 Admixtures. Chemical admixtures shall conform to the requirements of 201-1.2.4, and may consist of air-entraining agents, water-reducing admixtures, and other chemical additives. Chemical admixtures shall be approved by the Engineer.

Mineral admixtures other than fly ash may be used when approved by the Engineer.

201-6.2.5 Fly Ash. Fly ash shall conform to the requirements of 201-1.2.5, except it shall not be limited to 20 percent by weight of the total cementitious material. Class C fly ash shall not be used.

201-6.3 Proportioning.

201-6.3.1 General. Proportioning shall conform to requirements of 201-1.3.1. When CLSM is used underneath a paved public right of way, the mixture shall contain a minimum of 25 pounds per cubic yard (15 kg/m^3) of cement when using washed concrete sand.

201-6.4 Mixing.

201-6.4.1 General. Mixing shall conform to the requirements of 201-1.4, except the 90-minute time limit specified in 201-1.4 shall not apply. Unless otherwise specified, under conditions contributing to quick setting the Engineer may specify a time limit, not to exceed 2-1/2 hours.

201-6.5 Testing. CLSM shall be tested for plastic unit weight. Plastic unit weight shall not deviate more than ± 10 percent of theoretical unit weight shown on the approved mix design. Unit weight shall be determined in accordance with ASTM C138. When a compressive strength is specified on the Plans, a compressive strength test shall be performed as directed by the Engineer.

201-6.6 Placement.

201-6.6.1 General. CLSM may be placed by chutes, conveyors, buckets, pumps or tremies depending upon the application and accessibility.

For trench backfill, CLSM shall be placed continuously. To contain CLSM when filling long open trenches or open-ended structures in stages, the end points shall be adequately bulkheaded to prevent movement. Methods may include bulkheading with sandbags, earth dams, forms, or stiffer mixtures of CLSM.

For bedding, CLSM shall be placed in a manner to prevent flotation or displacement of the embedded item. Methods of preventing flotation or displacement may include placement of CLSM in lifts or, at strategic locations, placing sandbags, straps anchored into soil, faster setting CLSM, or lower slump CLSM over the embedded item.

201-6.7 Replacing Pavement.

201-6.7.1 General. Pavement may be placed directly upon the CLSM as soon as the surface will withstand the paving process without displacement or disruption. If the placement of the CLSM is not completed in time to allow permanent paving to be completed the same day, the Contractor shall prevent traffic contact with the CLSM until paving is completed.

201-7 NON-MASONRY GROUT.

201-7.1 General. Non-masonry grouts are composed of hydraulic cement, fine aggregate, and other ingredients. Quick-setting grouts may be used for setting posts and anchors in concrete or masonry. Non-shrink grout is typically used for setting bearing plates.

201-7.2 Quick-Setting Grout. Quick-setting grout shall be a high strength nonstaining grout approved by the Engineer. It shall reach an initial set within 90 minutes at 70°F (21°C) and reach minimum compressive strength of 2,500 psi (17.2 MPa) within 24 hours. Shrinking shall be less than 0.1 percent when tested, using the test procedures of ASTM C596. The grout shall be mixed, handled and placed in accordance with manufacturer's instructions.

201-7.3. Non-Shrink Grout. Non-shrink grout shall be a high strength nonstaining grout approved by the Engineer and meeting the requirements of ASTM C1107. The grout shall be mixed, handled and placed in accordance with the manufacturer's instructions.

201-8 SOIL-CEMENT.

201-8.1 General. Soil-cement shall consist of a mixture of soil, Portland cement, and water mixed at a central mixing plant, in-place, or off-road. The required 7-Day compressive strength shall be as shown on the Plans or specified in the Special Provisions.

201-8.2 Materials.

201-8.2.1 Soil. Unless otherwise specified, soil shall conform to the following requirements when tested in accordance with ASTM C136:

a) 100 percent shall pass the 2-inch (50 mm) sieve.

b) Not less than 95 percent shall pass the 1 inch (25 mm) sieve.

c) Not less than 55 percent shall pass the No. 4 (4.75 mm) sieve.

d) Not more than 20 percent shall pass the No. 200 (75 µm) sieve.

e) The SE shall be 15 or greater when tested in accordance with ASTM D2419.

201-8.2.2 Portland Cement. Portland cement shall be Type II/V conforming to 201-1.2.1. Supplementary cementitious materials shall not be substituted for any portion of the required Portland cement content.

201-8.2.3 Water. Water shall conform to 201-1.2.3.

201-8.3 Mix Design(s). The materials shall be tested and the mix design(s) developed in accordance with ASTM D558. Compressive strength shall be determined in accordance with ASTM D1633, Method A.

The mix design(s) shall show:

a) the amount and gradation of the soil to be treated,

b) the amount and type of Portland cement,

c) the amount of water, and

d) the 7-Day compressive strength attained.

Unless otherwise specified in the Special Provisions, the mix design(s) will be prepared by the Agency.

201-8.4 Mixing.

201-8.4.1 General. Mixing shall be performed at a central mixing plant, in-place, or off-road.

The quantity of water added shall be adjusted to produce a moisture content between 1 percent below and 3 percent above the optimum moisture content.

The soil and Portland cement shall be sufficiently mixed so as to prevent balls from being formed when water is added. Mixing shall continue until a homogeneous mixture of uniformly distributed and coated soil-cement of unchanging appearance is produced. After mixing has been completed, no additional water shall be added to the soil-cement mixture unless otherwise approved by the Engineer.

201-8.4.2 Central Mixing Plant.

201-8.4.2.1 General. Central mixing plants shall be either batch-type rotary-drum plants or continuous pugmill plants.

Each plant shall be equipped with a screen or other device capable of removing any oversized material greater than 3 inches (75 mm) and facilities for weighing samples to be used for calibrating gate openings.

Central mixing plants shall be equipped with weighing and metering devices capable of introducing the soil, Portland cement, and water into the mixer in the proportions conforming to the mix design, combining the materials into a uniform mixture, and discharging the mixture without segregation.

Weighing and metering devices shall be electronically controlled, computer-interlocked and synchronized so as to maintain a constant ratio between the soil, Portland cement, and water.

Water shall be so proportioned and recorded such that the Engineer can readily verify the amount or rate of the flow of water being used. Water shall not be weighed or measured cumulatively with the soil or Portland cement.

The weight of soil, Portland cement, and water shall be within 3 percent of the amounts specified in the approved mix design.

201-8.4.2.2 Storage and Handling. The soil to be treated, Portland cement and water shall be stored separately and proportioned by weight.

The soil to be treated and Portland cement shall be:

a) handled so as to not cause segregation or degradation,
b) stored in bins and tight containers such that the materials will not overflow into adjacent bins, and
c) drawn from storage bins by means of separately adjustable calibrated gates and openings.

201-8.4.2.3 Batch-Type Rotary-Drum Plants. Batch-type rotary-drum plants shall be equipped with automatic proportioning devices and a proportioning control system. All weight increments required for a batch shall be pre-set on the controls at the same time. Bin discharge shall be interlocked so that only one bin can discharge onto a given scale at one time and that a new batch may not be started until all weigh hoppers are empty, the scales are at zero, and the discharge gates are closed. Gates shall be arranged so that the amount of each material can be separately adjusted. The interlock shall prevent the weigh box from discharging until the required quantities of materials are weighed and filled. The charge shall not exceed the manufacturer's recommendations and shall produce a complete and homogeneous mixture.

201-8.4.2.4 Continuous Pugmill Plants. Each material shall be uniformly, continuously and simultaneously introduced into a continuous pugmill plant. The materials shall be drawn from storage bins, hoppers or silos by means of a continuous feeder through adjustable calibrated gates, belts, augers or other material transfer devices. The proportioning devices shall be such that the rate of feed for the soil, Portland cement, and water can be determined while the plant is in operation. A positive signal system shall be provided to indicate when the level of material in each bin approaches the "strikeoff" capacity of the feed gate. The plant shall not be operated unless this signal system is in working condition. The rate of feed shall not exceed the manufacturer's recommendations and shall produce a complete and homogeneous mixture.

201-8.4.3 In-Place and Off-Road Mixing. In-place and off-road mixing shall conform to 301-3.2.6.3.

201-8.5 Transporting. Unless otherwise specified, soil-cement shall be transported in dump trucks. Dump truck beds shall be equipped with a retractable cover and not allow seepage of water from the mixture. Each load shall be covered. The haul time shall not exceed 45 minutes.

201-8.6 Acceptance. Acceptance of soil-cement mixtures produced at a central mixing plant will be based on conformance to the Specifications.

201-9 CEMENT TREATED BASE (CTB).

201-9.1 General. CTB shall consist of a mixture of untreated base material, Portland cement, and water mixed at a central mixing plant or in-place. The required 7-Day compressive strength shall be as shown on the Plans or as specified in the Special Provisions.

201-9.2 Materials.

201-9.2.1 Untreated Base Material. Untreated base material to be treated shall be crushed aggregate base conforming to 200-2.3, crushed miscellaneous base conforming to 200-2.4, or pulverized miscellaneous base conforming to 200-2.5, except the sand equivalent shall be a minimum of 18 when tested in accordance with ASTM D2419.

201-9.2.2 Portland Cement. Portland cement shall be Type II/V conforming to 201-1.2.1. Supplementary cementitious materials shall not be substituted for Portland cement.

201-9.2.3 Water. Water shall conform to 201-1.2.3.

201-9.3 Mix Design(s). The materials shall be tested and the mix design(s) developed in accordance with ASTM D1557. Compressive strength shall be determined in accordance with ASTM D1633, Method A, except:

a) Test specimens shall be compacted in accordance with ASTM D1557, Method A or B.

b) Test specimens shall be cured by sealing each specimen with 2 layers of plastic at least 4 mils thick. The plastic must be tight around the specimen. All seams shall be sealed with duct tape. Sealed specimens shall be placed in an oven for 7 Days at 100 ± 5°F (38 ± 3°C). At the end of the cure period, specimens shall be removed from the oven and air-cooled. Duct tape and plastic wrap shall be removed before capping. Specimens shall not be soaked before testing.

The mix design(s) shall show:

a) the amount and gradation of the base material to be treated,

b) the amount and type of Portland cement,

c) the amount of water, and

d) the 7-Day compressive strength attained.

Unless otherwise specified in the Special Provisions, the mix design(s) will be prepared by the Agency.

201-9.4 Mixing. Mixing shall conform to 201-8.4.

201-9.5 Transporting. Transporting shall conform to 201-8.5.

201-9.6 Acceptance. Acceptance of cement treated base mixtures produced at a central mixing plant will be based on conformance to the Specifications.

SECTION 202 - MASONRY MATERIALS

202-1 BRICK.

202-1.1 General. Brick shall be whole, sound, hard, burned, give a clear ringing sound when struck together, and be uniform in quality. Brick shall be culled or sorted before delivery to the Work site. Mortar used in brick construction shall be Class "D" conforming to 202-3.1. Grout used in brick construction shall conform to 202-3.2. Fine grout shall be used in spaces less than 2 inches (50 mm) clear in any dimension. Coarse grout shall be used in spaces 2 inches (50 mm) or larger in all horizontal directions.

202-1.2 Manhole Brick. Sewer manhole brick shall conform to ASTM C62, Grade MW, modified as follows:

a) The average compressive strength of 5 bricks shall not be less than 4,000 psi (28 MPa) and the compressive strength of any individual brick shall not be less than 3,500 psi (24 MPa).

b) The absorption of any individual brick shall not be more than 16 percent when submerged 24 hours in cold water.

c) Dimensions shall conform to the following:

TABLE 202-1.2

	Depth inches (mm)	Width inches (mm)	Length inches (mm)
Standard Size	2-1/2 (64)	3-7/8 (98)	8-1/4 (210)
Allowed Variation	± 1/4 (± 6)	± 3/8 (± 10)	± 1/2 (± 13)

d) Plaster for brick sewer structures shall be Class "D" mortar conforming to 201-5.1.

202-1.3 Building Brick. Building brick shall conform to ASTM C62, Grade MW. The size and texture shall be as shown on the Plans, as specified in the Special Provisions, or as approved by the Engineer.

202-1.4 Facing Brick. Facing brick shall conform to ASTM C216, Grade MW, Type FBS. The size, color, and texture shall be as shown on the Plans, as specified in the Special Provisions, or as approved by the Engineer.

202-2 CONCRETE BLOCK.

202-2.1 General. Mortar used in concrete block construction shall be Class "D" or "E" conforming to 202-3.1. Grout used in concrete block construction shall conform to 202-3.2. Fine grout shall be used in spaces less than 4 inches (100 mm) clear in any dimension. Coarse grout shall be used in spaces 4 inches (100 mm) or larger in all horizontal directions.

202-2.2 Masonry Units. Masonry units shall be made with sand-gravel aggregate and conform to ASTM C90. The net size of the units shall be as indicated on the Plans. Unless otherwise specified in the Special Provisions, all units shall be of the normal weight classification (oven-dry weight of concrete 125 pounds per cubic foot (2000 kg/m^3) or more).

202-3 Mortar, Grout, and Water.

202-3.1 Mortar. Mortar shall be as specified in 201-5.1 to which 1/4 to 1/2 part hydrated lime or lime putty has been added to Portland cement mixtures. Mortar shall attain a minimum compressive strength of 1,800 psi (13 MPa) in 28 Days when tested in accordance with ASTM C109.

202-3.2 Grout.

202-3.2.1 General.

a) Grout shall attain a minimum compressive strength of 2,000 psi (14 MPa) in 28 Days.

b) Grout shall be tested in accordance with ASTM C1019.

202-3.2.2 Site-Mixed Grout.

a) Site-mixed grout shall be proportioned by volume.

b) Fine grout shall be 1 part cement and 2-1/4 to 3 parts sand to which 1/10 part hydrated lime may be added.

c) Coarse grout used in brick construction shall be 1 part cement, 2 to 3 parts sand, and not more than 2 parts No. 4 concrete aggregate.

d) Coarse grout used in concrete block construction shall be 1 part cement, 2 to 3 parts sand, and 1-3/4 to 2 parts No. 4 concrete aggregate.

202-3.2.3 Ready-Mixed Grout.

a) Ready-mixed grout shall conform to 201-1.

b) Fine grout shall consist of a minimum of 750 pounds per cubic yard (445 kg/m^3) of cement, sand, and sufficient water to achieve a 10-inch (250 mm) slump. Admixtures may be used as specified in the Special Provisions or as approved by the Engineer.

c) Coarse grout shall conform to Table 201-1.1.2 for "Coarse Masonry Grout."

202.-3.3 Water. Water shall conform to 201-1.2.3. The quantity of water to be used in the preparation of the mortar or grout shall be the minimum required to produce a mixture sufficiently workable for the purpose intended.

SECTION 203 - BITUMINOUS MATERIALS

203-1 PAVING ASPHALT.

203-1.1 General. Paving asphalt shall be steam-refined asphalt produced from crude asphaltic petroleum or a mixture of refined liquid asphalt and refined solid asphalt. It shall be homogeneous and free from water and residues from distillation of coal, coal tar, or paraffin oil.

203-1.2 Testing Requirements. Paving asphalt shall be specified by performance grade and shall conform to the requirements shown in Table 203-1.2.

TABLE 203-1.2 (A)

Grade	AASHTO Test	PG 64-10	PG 64-16	PG 64-28		PG 70-10
Original Binder						
Flash Point, °C, minimum	T48	230	230	230		230
Solubility, %, minimum	T44	99.0	99.0	99.0		99.0
Viscosity, 135°C, Pa·s, maximum[1]	T316	3.0	3.0	3.0		3.0
Dynamic Shear Test Temperature, °C	T315	64	64	64		70
Dynamic Shear, 10 rad/s, G*/Sinδ, kPa, minimum	T315	1.00	1.00	1.00		1.00
RTFO Aged Binder (T240)						
Mass Loss, %, maximum	T240	1.00		1.00	1.00	1.00
Dynamic Shear Test Temperature, °C	T315	64		64	64	70
Dynamic Shear, 10 rad/s, G*/Sinδ, kPa, minimum	T315	2.20		2.20	2.20	2.20
Ductility, 25°C, 5 cm/min, cm, minimum	T51	75		75	75	75
RTFO and PAV Aged Binder (R28)						
PAV Aging Temperature, °C	R28	100		100	100	110
Dynamic Shear Test Temperature, °C	T315	31[2]		28[2]	22[2]	34[2]
Dynamic Shear, 10 rad/s, G*/Sinδ, kPa, maximum	T315	5000		5000	5000	5000
Bending Beam Test Temperature, °C	T313	0		-6	-18	0
Creep Stiffness, MPa, maximum	T313	300		300	300	300
m-value, minimum	T313	0.300		0.300	0.300	0.300

1. This requirement may be waived by the Engineer if the supplier warrants that the paving asphalt can be adequately pumped and mixed at temperatures that meet all applicable safety standards.
2. If the PAV aged binder exceeds 5000 kPa at the designated test temperature, it will be deemed acceptable if it is less than 5000 kPa when tested at a 3°C higher test temperature.

203-1.3 Test Reports and Certification. Paving asphalt shall be supplied by Caltrans or other State Department of Transportation approved vendors unless otherwise specified in the Special Provisions. At delivery time, the supplying vendor shall deliver to the purchaser a certified copy of the test report. This report shall indicate the vendor's name, grade of paving asphalt delivered, date and point of delivery, quantity delivered, ticket number, purchase order number, and results of specified tests. The certified test report and the testing required in connection with the report shall be submitted to the Agency in accordance with 2-5.3.4.

Until the certified test report and samples of the material have been reviewed by the Engineer to determine their conformity with the specified requirements, the material to which such report relates and any work in which it may have been incorporated as an integral component, will be only tentatively accepted by the Agency. Final acceptance will be dependent upon the determination by the Engineer that the material involved conforms to the Specifications.

203-1.4 Temperatures. Paving asphalt shall not be heated during its manufacture, storage, or during construction so as to cause formation of carbonized particles. At no time shall the temperature be higher than 10°F (5°C) below the actual flash point of the paving asphalt, nor shall it be raised above 375°F (190°C) after loading into a tank car or truck for transport.

Unless otherwise specified in the Special Provisions, the various grades of paving asphalt shall be applied within the temperature range indicated in Table 203-1.4.

TABLE 203-1.4

ASPHALT GRADE	PLANT MIXING TEMPERATURE °F (°C)		DISTRIBUTION APPLICATION TEMPERATURE °F (°C)	
	Minimum	Maximum	Minimum	Maximum
PG 70-10	300 (150)	350 (175)	285 (140)	350 (175)
PG 64-28	275 (135)	325 (160)	285 (140)	350 (175)
PG 64-16	275 (135)	325 (160)	285 (140)	350 (175)
PG 64-10	275 (135)	325 (160)	285 (140)	350 (175)

Paving asphalt shall be heated in such a manner that no steam or hot oils will be introduced into the paving asphalt during heating. The Contractor shall furnish and keep on-site an accurate thermometer suitable for determining the temperature of the paving asphalt.

203-1.5 Distributing Equipment. Distributing equipment shall conform to 203-2.5.

203-1.6 Measurement and Payment. For all volumetric quantities to be paid for at a Contract Unit Price, the unit of measurement shall be U.S. gallon (L) at a temperature of 60°F (15°C).

In converting weight to volume, computations shall be based on Table 203-1.6.

TABLE 203-1.6

Grade of Material	Gallons Per Ton At 60°F (L/tonne At 15°C)	Lbs. Per Gallon At 60°F (g/L At 15°C)
PG 70-10	235 (981)	8.51 (1020)
PG 64-28	235 (981)	8.51 (1020)
PG 64-16	235 (981)	8.51 (1020)
PG 64-10	235 (981)	8.51 (1020)

203-2 LIQUID ASPHALT.

203-2.1 General. Liquid asphalt shall conform to the following classifications:

a) Slow curing products, designated by the letters SC, shall consist of natural crude oils or residual oils from refining of crude asphaltic petroleum, or products resulting from fluxing of a paving asphalt with a light oil.

b) Medium curing products, (MC), shall consist of a paving asphalt conforming to provisions in 203-1, fluxed or blended with a kerosene-type solvent.

c) Rapid curing products (RC), shall consist of a paving asphalt conforming to provisions in 203-1, fluxed or blended with a naphtha solvent.

203-2.2 Test Reports and Certifications. Test reports and certifications will be furnished in accordance with 203-1.3.

203-2.3 Temperatures. The asphalt shall not be heated during its manufacture, storage, or during construction so as to cause the formation of carbonized particles.

At no time after loading for transportation from the refinery to the purchaser, unless authorized by the Engineer, shall the temperature of the asphalt be raised above that given in the last column of the following table and in no case shall the temperature be higher than 10°F (5°C) below flash point. Unless authorized by the Engineer, no asphalt, except tack coats, shall be applied when the air temperature is lower than 40°F (5°C).

Unless otherwise specified, the various grades of asphalt shall be applied within the temperature range shown in Table 203-2.3.

TABLE 203-2.3

All Type of Liquid Asphalt	Pugmill Mixing Temp. for MC & SC Liquid Asphalts, °F (°C)		Distributor Application Temperature, °F (°C)	
	Minimum	Maximum	Minimum	Maximum
70	90 (30)	155 (70)	105 (40)	175 (80)
250	125 (50)	200 (90)	140 (60)	225 (110)
800	160 (70)	225 (105)	175 (80)	225 (125)
3000	200 (95)	260 (125)	215 (100)	290 (145)

The asphalt shall be heated in such a manner that no steam or hot oils will be introduced into the asphalt. The Contractor shall furnish and keep on the site an accurate thermometer suitable for determining the temperature of the asphalt.

203-2.4 Test Requirements. Liquid asphalt shall conform to the requirements shown in the following tables:

TABLE 203-2.4 (A): SLOW CURING PRODUCTS

Test Description	ASTM Test No.	GRADE			
		SC 70	SC 250	SC 800	SC 3000
Flash Point, C.O.C. °F (°C), Min.	D92	150 (65)	175 (80)	200 (90)	225 (105)
Viscosity at 140°F (60°C) Kinematics, mm^2/s (cSt)	D2170	70-140	250-500	800-1600	3000-6000
Distillation Total Dist. to 680°F (360°C) Vol. %	D402	10-30	4-20	2-12	0-5
Kinematic Viscosity on Residue at 140°F (60°C) mm^2/s (cSt)	D2170	400-7000	800-8500	2002-14000	4000-35000
Asphalt Residue of 100 Pen., % Min.	D243	50	60	70	80
Ductility of Asphalt Residue at 77°F (25°C) mm, Min.	D113	1000	1000	1000	1000
Solubility in trichloroethylene, % Min.	D2042	99.5	99.5	99.5	99.5
Water, % Max.	D95	0.5	0.5	0.5	0.5
Heptane Xylene Equivalent, % Max. (AASHTO T102)		35	35	35	35

TABLE 203-2.4 (B): MEDIUM CURING PRODUCTS

Test Description	ASTM Test No.	GRADE			
		MC 70	MC 250	MC 800	MC 3000
Flash Point (Tag Open Cup) °F (°C) Min.	D3143	100 (40)	150 (65)	150 (65)	150 (65)
Viscosity at 140 °F (60 °C) Kinematic, mm^2/s (cSt)	D2170	70-140	250-500	800-1600	3000-6000
Distillation Distillate [% of total distillate to 680°F (360°C)]	D402				
To 437°F (225°C)		0-20	0-10	0-3	0-2
To 500°F (260°C)		20-60	15-55	0-35	0-75
To 600°F (315°C)		65-90	60-87	45-80	15-75
Residue from distillation to 680°F (360°C) Volume percent by difference, Min.		55	67	75	80
Tests on Residue from Distillation Penetration at 77°F (25°C), 0.1 mm	D5	120-250	120-250	120-250	120-250
Ductility, 77°F (25°C) mm, Min.[1]	D113	1000	1000	1000	1000
Solubility in trichloroethylene, % Min.	D2042	99.5	99.5	99.5	99.5
Water, % Max.	D95	0.2	0.2	0.2	0.2
Heptane Xylene Equiv., % Max. (AASHTO T102)	—	35	35	35	35

1. If penetration of residue is more than 200 and its ductility at 77°F (25°C) is less than 1000, the material will be acceptable if the ductility at 60°F (15°C) is greater than 1000 mm.

TABLE 203-2.4 (C): RAPID CURING PRODUCTS

Test Description	ASTM Test No.	GRADE			
		RC 70	RC 250	RC 800	RC 3000
Flash Point (Tag Open Cup) °F (°C), Min.	D3143	—	80 (27)	80 (27)	80 (27)
Viscosity at 140°F (60°C) Kinematic mm^2/s (cSt)	D2170	70-140	250-500	800-1600	3000-6000
Distillation Distillate [% of total distillate to 680°F (360°C), Min.]	D402				
To 374°F (190°C)		10	—	—	—
To 437°F (225°C)		50	35	15	—
To 500°F (260°C)		70	60	45	25
To 600°F (315°C)		85	80	75	70
Residue from Distillation to 680°F (360°C) Volume percent by difference, Min.		55	65	75	80
Tests on Residue from Distillation Penetration at 77°F (25°C), 0.1 mm	D5	80-120	80-120	80-120	80-120
Ductility, 77°F (25°C) mm, Min.[1]	D113	1000	1000	1000	1000
Solubility in trichloroethylene, % Min.	D2042	99.5	99.5	99.5	99.5
Water, % Max.	D95	0.2	0.2	0.2	0.2
Heptane Xylene Equiv., % Max. (AASHTO T102)	—	35	35	35	35

203-2.5 Distributing Equipment. Distributors shall be of the pressure type with insulated tanks and shall be equipped with the following:

a) A tachometer of the auxiliary wheel type which registers speed in feet (m) per minute.
b) Charts and devices to provide for accurate and rapid determination and control of the amount of asphalt being applied.
c) A hose and nozzle attachment to be used for areas inaccessible to the spray bar.
d) A pressure gage for determining application pressure.
e) A thermometer for determining temperature of the asphalt.

Distributors and booster tanks shall be so maintained as to prevent dripping of asphalt from any part of the equipment.

Spray bars shall have a minimum length of 9 feet (2.7 m). Spray bars and extensions shall be the full circulating type and be adjustable to permit varying height above the surface to be treated.

The nozzles attached to the bar shall be either conical or flat slotted. The distance center to center shall not exceed 6 inches (150 mm). The valves which control the flow from nozzles shall be of a positive acting design so as to provide a uniform unbroken spread of asphalt. Valves shall be operated so that all may be simultaneously opened or closed. Each valve shall also be capable of similar independent control.

Spreading equipment shall be so designed and articulated that uniform application of the asphalt may be made ranging from 0.02 to 1.0 gallon per square yard (0.1 L/m^2 to 4.5 L/m^2) of surface and with a range of pressure from 25 to 75 psi (170 kPa to 515 kPa).

Equipment which fails to produce a satisfactory distribution of asphalt, as determined by the Engineer, shall not be used.

Application of asphalt will not be permitted when, as determined by the Engineer, the surface to be treated is damp or weather conditions are unsuitable.

203-2.6 Measurement and Payment. For all volumetric quantities to be paid for at Contract Unit Price, the unit measure shall be the U.S. gallon (L) at a temperature of 60°F (15°C).

In converting weight to volume, computations are based on the following:

TABLE 203-2.6

Grade of Material	Gallons per Ton (L/tonne) @ 60°F (15°C)	Pounds per Gallon (g/L) @ 60°F (15°C)
70	253 (1056)	7.90 (947)
250	249 (1039)	8.03 (962)
800	245 (1022)	8.16 (978)
3000	241 (1006)	8.30 (995)

All types SC, MC, and RC of the same grade shall be considered to have equal weights per volume.

203-3 EMULSIFIED ASPHALT.

203-3.1 General. Emulsified asphalt shall be composed of a paving asphalt base emulsified with water. Emulsified asphalt may also contain crumb rubber and/or latex. Emulsified asphalt shall remain homogeneous during storage.

203-3.2 Water. Water used in emulsifying paving asphalt shall be potable, free from harmful soluble salts and compatible with the other components.

203-3.3 Latex. Latex shall conform to 203-10.2.2.

203-3.4 Physical Properties.

203-3.4.1 General. Emulsified asphalt shall be anionic, cationic, or rubberized polymer modified emulsion (RPME).

203-3.4.2 Anionic Emulsified Asphalt. Anionic emulsified asphalt shall conform to the requirements shown in Table 203-3.4.2.

TABLE 203-3.4.2

Test Description	ASTM Test Method No.	Rapid Setting				Slow Setting			
		RS-1		RS-2		SS-1		SS-1h	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Furol Viscosity at 77°F (25°C), sec.	D7496	20	100			20	100	20	100
Furol Viscosity at 122°F (50°C), sec.	D7496			75	400				
Settlement[1] 5 Days, %	D6930		5		5		5		5
Storage Stability[2] 1 Day	D6930		1		1		1		1
Demulsibility[3] (5 mL 0.02 N $CaCl_2$), %	D6936	60		60					
Sieve Test (Retained on No. 20 (850 µm),%	D6933		0.10		0.10		0.10		0.10
Cement Mixing Test, %	D6935						2.0		2.0
Residue from Distillation, %	D6997	55		63		57		57	
Penetration of residue at 77°F (25°C), 0.1 mm[4]	D5	100[4]	200	100[4]	200	100	200	40	90
Solubility of residue,%	D2042	97.5		97.5		97.5		97.5	
Ductility of residue at 77°F (25°C), mm	D113	400		400		400		400	

1. The test requirements for settlement may be waived when the emulsified asphalt is used in less than 5 days time, or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 Days.
2. The 24-hour (1 Day) storage stability test may be used instead of the 5-Day settlement test.
3. The demulsibility test shall be made within 30 Days from the date of shipment.
4. A harder base asphalt meeting current paving asphalt specifications may be specified with the provision that the test requirements on the residue from distillation test be waived.

203-3.4.3 Cationic Emulsified Asphalt. Cationic emulsified asphalt shall conform to the requirements shown in Table 203-3.4.3.

TABLE 203-3.4.3

Test Description	ASTM Test Method No.	Rapid Setting		Medium Setting			Slow Setting		Quick Set
		CRS-1 Min. Max.	CRS-2 Min. Max.	CRS-2 Min. Max.	CMS-2 Min. Max.	CMS-2h Min. Max.	CSS-1 Min. Max.	CSS-1h Min. Max.	CQS-1h Min. Max.
Furol Viscosity at 77°F (25°C), sec.	D7496						20 100	20 100	15[6] 100[6]
Furol Viscosity at 122°F (50°C), sec.	D7496	20 100	100 400	50 450	50 450	50 450			
Storage Stability Test[1] 5 Day %	D6930	5	5	5	5	5	5	5	5
Storage Stability Test[2] 1 Day %	D6930	1	1	1	1	1	1	1	1
Demulsibility[3] 35 mL 0.8% sodium dactyl sulfosuccinate, %	D6936	40	40						
Sieve Test (Retained on No. 20 [850 µm])	D6933	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Coating ability and water resistance:	D244								
Coating, dry aggregate				Good	Good	Good			
Coating, after spraying				Fair	Fair	Fair			
Coating, wet aggregate				Fair	Fair	Fair			
Coating, after spraying				Fair	Fair	Fair			
Particle Charge Test	D7402	Positive	Positive	Positive	Positive	Positive	Positive	Positive[5]	Positive
Cement Mixing Test, %	D6935						2.0	2.0	
Oil distillate by vol. of emulsion, %	D6997	3	3	20	12	12			
Residue from Distillation, %	D6997	60	65	60	65	65	57	57	60
Penetration of residue, at 77°F (25°C), 0.1 mm[4]	D5	100[4] 250	100[4] 250	100 250	100 250	40 90	100 250	40 90	45 80
Solubility of residue, %	D2042	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5
Ductility of residue 77°F (25°C), mm	D113	400	400	400	400	400	400	400	400

1. The test requirements for settlement may be waived when the emulsified asphalt is used in less than 5 Days time or the purchaser may require that the settlement test be run from the time the sample is received until it is used if the elapsed time is less than 5 days.
2. The 24-hour (1 Day) storage stability test may be used instead of the 5-Day settlement test.
3. The demulsibility test shall be made within 30 Days from the date of shipment.
4. A harder base asphalt meeting current paving asphalt specifications may be specified with the provision that the requirements on the Residue from Distillation test be waived.
5. Must meet pH requirements of 6.7 maximum (ASTM E70) if the Particle Charge Test results are inconclusive.
6. Viscosity does not apply to latex or polymer modified emulsion.

203-3.4.4 Rubberized Polymer Modified Emulsion (RPME).

203-3.4.4.1 General. RPME shall consist of a mixture of emulsified asphalt, crumb rubber, and latex. RPME shall contain between 0.55 pounds per gallon (66 g/L) and 0.65 pounds per gallon (78 g/L) of crumb rubber. Latex shall constitute a minimum of 2 percent by weight of RPME.

Crumb rubber shall:

a) be granulated scrap tire rubber free from fabric, wires, and other contaminants

b) be dry and free flowing;

c) have a specific gravity between 1.15 and 1.20; and

d) have a gradation of 100 percent passing the No. 16 (1.18 mm) sieve, 95 percent passing the No. 20 (900 µm) sieve, and a maximum of 1 percent passing the No. 200 (75 µm) sieve.

Calcium carbonate or talc may be added to a maximum of 4 percent by dry weight of crumb rubber to prevent the rubber particles from sticking together.

203-3.4.4.2 Composition. RPME shall conform to the requirements shown in Table 203-3.4.4.2.

TABLE 203-3.4.4.2

Tests	ASTM Test Method	Requirement	
		Min.	Max.
Viscosity, 77°F (25°C), Brookfield, Model RVT #6 Spindle @ 10 RPM (Centipoise) @ 60 sec.	D2196	4,000	12,000
Residue by Evaporation % (including fillers)	D6934	50	55
Sieve Test (% retained on No. 20 (850 µm) sieve)	D6933	---	2.0[1]
Penetration of Residue, 77°F (25°C), 0.1 mm,	D5	15	30
Solubility of Residue	D2042	75	---
Weight lbs/gallon (g/L) 77°F± 1°F (25°C ± 5°C)	D1475	8.33 lbs/gal (1000 g/L)	8.75 lbs/gal (1050 g/L)
Asphalt Content[2]	------	40	-----

1. Sieve test of original emulsion is 0.10 max.
2. Asphalt Content shall be determined by multiplying Residue by Evaporation by Solubility of Residue.

203-3.5 Certificate of Compliance. If so specified in the Special Provisions or requested by the Engineer, a Certificate of Compliance conforming to 4-1.5 shall be sent with each load of emulsified asphalt.

203-3.6 Temperature. Emulsified asphalt may be reheated, but at no time after loading shall the temperature be raised above 160°F (70°C). During reheating, emulsified asphalt shall be agitated to prevent localized overheating. Emulsified asphalt shall not be permitted to cool to a temperature less than 40°F (5°C).

Unless otherwise specified in the Special Provisions, emulsified asphalt shall be mixed and applied within the temperature range shown in Table 203-3.6.

TABLE 203-3.6

Grade of Emulsified Asphalt	Pug Mill Mixing Temperature °F (°C)		Application Temperature °F (°C)	
	Min.	Max.	Min.	Max.
CQS-1h	50 (10)	130 (55)	77 (25)	130 (55)
RS-1, CRS-1			77 (25)	130 (55)
RS-2, CRS-2			110 (45)	160 (70)
SS-1, CSS-1	50 (10)	130 (55)	77 (25)	130 (55)
SS-1h, CSS-1h	50 (10)	130 (55)	77 (25)	130 (55)
CMS-2, CMS-2S, CMS-2h	50 (10)	140 (60)	100 (40)	160 (70)
RPME	60 (15)	140 (60)	—	—

The Contractor shall furnish and keep on the Work site a thermometer capable of accurately determining the temperature.

203-3.7 Distribution Equipment. Distribution equipment shall conform to 203-2.5 except that hand spraying by means of a hose or bar through a gear pump or air tank is acceptable for uniform application rates up to 0.10 gallon per square yard (0.45 L/m^2) for work on flat surfaces or tacking of vertical edges.

203-3.8 Volumetric Measurement. For volumetric quantities, the unit of measurement shall be the U.S. gallon (L) at a temperature of 60°F (15°C).

In converting weight to volume, computations shall be based on the following, for all grades of emulsified asphalt, except RPME:

Gallons per ton = 240 (L/tonne = 1002)

Pounds per gallon = 8.33 (L/tonne = 998)

For RPME:

Gallons per ton = 235 (L/tonne = 962)

Pounds per gallon = 8.5 (L/tonne = 1018)

203-4 Not Used.

203-5 SLURRY SEAL.

203-5.1 General. Slurry seal shall be either emulsion-aggregate slurry (EAS) conforming to 203-5.4 or rubberized emulsion-aggregate slurry (REAS) conforming to 203-5.5.

203-5.2 Mix Design. The Contractor shall submit a mix design in accordance with 2-5.3.4 for each combination of emulsified asphalt grade and aggregate gradation to be used in the Work. Each mix design shall conform to ASTM D3910. Laboratory reports supporting each mix design shall be included with the submittals. Laboratory reports shall identify the aggregate source and supplier, emulsified asphalt supplier and all of the test results required in ASTM D3910 except for the cohesion test. When the use of slow-set emulsion is specified in the Special Provisions, the "set time" test is not required. In addition, each mix design shall include the following:

a) amount of emulsified asphalt or RPME in gallons (L) per ton (tonne) of aggregate,

b) amount of added water in gallons (L) per ton (tonne) of aggregate,

c) quantity and type of set control agents,

d) percent of latex, if so specified in the Special Provisions, and the

e) loose unit weight of aggregate (ASTM C29 with 0.1 cubic foot (3 L) bucket).

When a mix design is more than 30 Days old, it shall be supplemented with a Certificate of Compliance conforming to 4-1.5 that states the combined aggregate gradation is within ± 3 percent of the reference mix design based on a 30-Day moving average or the average of a minimum of 10 of the most current laboratory results, whichever is greater. A mix design shall be reformulated if it is more than one year old or whenever the combined aggregate gradation changes from that in the previously submitted mix design by ± 3 percentage points on any sieve size shown in Table 203-5.3.2. If the source of any aggregate or emulsified asphalt is changed, or the mix design or supporting laboratory reports are over one year old, a new mix design shall be submitted to the Engineer in accordance with 2-5.3.4.

Mix designs shall be based on the following:

a) for Type Fine, the content of RPME and water needed to produce a slurry seal with a maximum wet track abrasion test loss of 50 grams per square foot (540 g/m^2) when tested in accordance with ASTM D3910;

b) for Type I, the content of emulsified asphalt and water needed to produce a Type I slurry seal with a maximum wet track abrasion test loss of 50 grams per square foot (540 g/m^2) when tested in accordance with ASTM D3910; or,

c) for Type II or Type III, the content of emulsified asphalt and water needed to produce a slurry seal with a maximum wet track abrasion test loss of 60 grams per square foot (650 g/m^2) when tested in accordance with ASTM D3910.

ASTM D3910 shall be modified to include the aggregate retained on the No. 4 (4.75 mm) sieve for Type II and Type III slurry seals. Type III slurry seals shall use the 3/8 inch (9.5 mm) template.

203-5.3 Aggregate.

203-5.3.1 General. Aggregate shall be 100 percent crushed rock conforming to 200-1.1, 200-1.2, and the requirements shown in Table 203-5.3.1.

TABLE 203-5.3.1

Tests	ASTM Test Method	Requirements
Percentage Wear at 500 Revolutions[1]	C131	40% Maximum
Sand Equivalent	D2419	55 Minimum
Soundness(5 Cycles)[1]	C88	15% Maximum

1. To be run on the material retained on the No. 4 (4.75 mm) sieve graded from the source.

203-5.3.2 Grading. The combined aggregate gradation shall be determined in accordance with ASTM C136 and conform to the requirements shown in Table 203-5.3.2.

TABLE 203-5.3.2

	Percentage Passing Sieves							
	Type Fine		Type I		Type II		Type III	
Sieve Size	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
3/8 inch (9.5 mm)	100	---	100	---	100	---	100	---
No. 4 (4.74 mm)	100	---	100	---	90	100	70	90
No. 8 (2.36 mm)	95	100	90	100	65	90	45	70
No. 16 (1.18 mm)	75	92	65	90	45	70	28	50
No. 30 (600 µm)	50	75	40	60	30	50	19	34
No. 50 (300 µm)	35	50	25	42	18	36	12	25
No. 100 (150 µm)	15	30	15	30	10	24	7	18
No. 200 (75 µm)	10	20	10	20	5	15	5	15

203-5.4 Emulsion-Aggregate Slurry (EAS).

203-5.4.1 General. EAS shall be a stable mixture of cationic emulsified asphalt, aggregate, water, a set control agent, and when so required, latex. EAS shall be specified by combined aggregate gradation and emulsified asphalt grade, i.e. Type II-CQS-1h-EAS. The combined aggregate gradation and emulsified asphalt grade shall be as specified in the Special Provisions or shown on the Plans.

203-5.4.2 Materials.

203-5.4.2.1 Aggregate. Aggregate shall be Type I, Type II, or Type III conforming to 203-5.3.

203-5.4.2.2 Emulsified Asphalt. Emulsified asphalt shall be slow-set or quick-set, and, if so specified in the Special Provisions or shown on the Plans, contain latex. Slow-set emulsified asphalt shall be CSS-1h conforming to 203-3 unless otherwise specified in the Special Provisions or shown on

the Plans. Quick-set emulsified asphalt shall be CQS-1h conforming to 203-3 unless otherwise specified in the Special Provisions or shown on the Plans.

The percentage of emulsified asphalt and residual asphalt content shall conform to the requirements shown in Table 203- 5.4.2.2.

TABLE 203-5.4.2.2

	Test Method	Type I	Type II	Type III
Emulsified Asphalt %, by weight of dry aggregate.	—	17-20	14-18	11-15
Residual Asphalt Content, %by weight of dry aggregate[1].	ASTM D6307 or CT 382[1]	10 min.	7.5 min.	6.5 min.

1. Sample size shall be 500 g minimum.

203-5.4.2.3 Water. Water shall conform to 203-3.2.

203-5.4.2.4 Latex. The addition and exact percentage of latex to be added shall be as specified in the Special Provisions or shown on the Plans. Latex for cationic emulsified asphalt shall conform to 203-3.3 except contain 65 ± 5 percent rubber solids.

203-5.4.2.5 Set Control Agents. Set control agents shall be either Type II or Type V Portland cement conforming to 201-1.2.1, aluminum sulfate, or other material approved by the Engineer.

203-5.4.3 Mixing. Mixing shall conform to 302-4.

203-5.5 Rubberized Emulsion Aggregate Slurry (REAS).

203-5.5.1 General. REAS shall be a stable mixture of RPME, aggregate, water, and Portland cement. REAS shall be specified by combined aggregate gradation, i.e. Type II-REAS. The combined aggregate gradation shall be as specified in the Special Provisions or shown on the Plans.

203-5.5.2 Materials.

203-5.5.2.1 Aggregate. Aggregate shall be Type Fine, Type I, Type II, or Type III conforming to 203-5.3.

203-5.5.2.2 Rubberized Polymer Modified Emulsion. RPME shall conform to 203-3.4.5. The percentage of RPME and residual RPME solids shall conform to the requirements shown in Table 203-5.5.2.2.

TABLE 203-5.5.2.2

Test	Test Method	Type Fine		Type I		Type II		Type III	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
RPME % by weight of dry aggregate[1]	ASTM D6307[2] or CT 382[2]	61	85	50	57	33	40	28	35
Residual RPME Solids[3]		31	47	26	31	17	22	15	19

1. Must meet Residual RPME Solids.
2. Sample size shall be 500 g minimum.
3. Residual RPME Solids shall be determined by multiplying RPME % (ASTM D6307 or CT 382) by Residue by Evaporation of RPME % (ASTM D6934).

203-5.5.2.3 Water. Water shall conform to 203-3.2.

203-5.5.2.4 Portland Cement. Portland cement may be added to modify the viscosity and curing characteristics accordance with the approved mix design.

Portland cement shall be Type I/II or II/V conforming to 201-1.2.1 and shall not exceed 1.5 percent of the dry weight of the aggregate.

203-5.5.3 Central Plant Mixing.

203-5.5.3.1 General. Mixing at a central mixing plant shall conform to the following requirements:

a) Component materials conforming to 203-5.5.2 shall be stored separately at the plant.

b) Aggregate shall neither be stored nor transported in such a way that may cause segregation, degradation, or intermingling of different size aggregates.

c) Materials shall be proportioned by weight into the mixing tank. Volumetric proportioning will not be permitted.

d) The mixing tank shall be equipped with scales. The zero tolerance for the tank scales shall be 0.5 percent based on the total batch weight. The scales shall be calibrated and certified on a yearly basis in accordance with 4-1.7 or after every modification or repair.

e) The mixing tank shall be equipped with a full sweep mixer/agitator with blades or paddles of a sufficient size and number and operated at a speed sufficient to produce a homogeneous mix. Should the blades, paddles, or other parts of the mixer/agitator become worn to such an extent to adversely affect the quality of the mix they shall be promptly replaced. Insufficient mixing or agitation within the mixing tank shall be corrected by either a reduction in the volume of component materials or other adjustments.

f) Each batch shall be continuously mixed for 3 minutes or until all of the component materials are thoroughly blended, whichever is longer. The mixing time shall begin upon the introduction of the last component material. If the Engineer determines that the mixture is not thoroughly blended, the mixing time shall be increased.

g) Mixed REAS shall be stored at the central mixing plant site in storage tanks equipped with an agitator of a similar configuration to the agitator in the mixing tank. The agitator shall be capable of continuous operation.

203-5.5.3.2 Transporting. REAS shall be transported from the central mixing plant to the Work site in trucks specifically designed for this purpose equipped with an agitator. REAS shall be continuously agitated during transport.

203-5.5.4 Work Site Mixing. Mixing at the Work site in continuous-flow mixers shall conform to 302-4.

203-6 ASPHALT CONCRETE.

203-6.1 General. Asphalt concrete shall be the product of mixing mineral aggregate and up to 20 percent reclaimed asphalt pavement (RAP) with asphalt binder at a central mixing plant.

When so specified in the Special Provisions, asphalt concrete may contain greater than 20 percent RAP and/or be produced using a warm mix asphalt (WMA) technology.

Unless otherwise specified in the Special Provisions or shown on the Plans, asphalt concrete mixtures shall conform to 203-6.4.

203-6.2 Materials.

203-6.2.1 Asphalt Binder. Asphalt binder shall be paving asphalt conforming to 203-1 or liquid asphalt conforming to 203-2.

203-6.2.2 Rock Products for Asphalt Concrete Mixtures. Coarse aggregate shall be crushed rock conforming to 200-1.2. Rock dust shall conform to 200-1.2. Sand shall conform to 200-1.5.2. Fine aggregate shall be sand, rock dust, mineral filler, or a blend of these materials.

203-6.2.3 Rock Products for Type III Asphalt Concrete Mixtures. Coarse aggregate shall be defined as material retained on the No. 4 (4.75 mm) sieve. Fine aggregate shall be defined as material passing the No. 4 (4.75 mm) sieve.

Aggregate for alternate asphalt concrete mixtures shall conform to 203-6.2.2 except as follows:

a) Coarse and fine aggregate shall consist of one or a mixture of the following:
   1) Broken or crushed rock or crushed gravel.
   2) Natural material having sufficient roughness to conform to the stabilometer requirements when confined within the grading limits shown in Table 203-6.5.4 (B).
b) The percentage by weight of crushed particles, as determined in accordance with California Test 205, shall be:
   1) For coarse aggregate, a minimum of 25 percent.
   2) For fine aggregate, a minimum of 20 percent for the portion passing the No. 4 (4.75 mm) sieve and retained on the No. 8 (2.36 mm) sieve.
c) The weight loss, as determined in accordance with ASTM C131, shall neither exceed 15 percent during 100 revolutions nor exceed 52 percent during 500 revolutions.

203-6.2.4 Mineral Filler. Mineral filler shall consist of Portland cement or mechanically reduced rock. Mechanically reduced rock shall conform to the grading shown in Table 203-6.2.4 when tested in accordance with ASTM D422.

TABLE 203-6.2.4

Particle Size	Percentage
Passing 75 µm Sieve	75 - 100
Finer than 50 µm	65 - 100
Finer than 20 µm	35 - 65
Finer than 10 µm	26 - 35
Finer than 5 µm	10 – 22

203-6.2.5 Reclaimed Asphalt Pavement (RAP).

203-6.2.5.1 General. RAP shall be defined as asphalt concrete pavement which has been processed to a maximum of 1-1/2 inches (37.5 mm) in size and is free of contaminants.

203-6.2.5.2 Stockpiles. Stockpiles of processed RAP shall be:

a) constructed on a base which provides drainage,
b) uniformly layered, and
c) kept clean and free from contaminants.

203-6.2.5.3 Fractionation. Fractionation is the processing of RAP into 2 or more sizes. Unless otherwise specified in the Special Provisions, fractionation will not be required.

203-6.2.5.4 Testing. Testing shall be performed at a frequency of 1 test per 1000 tons of processed RAP. A minimum of 1 test per stockpile per month shall be performed.

The following tests shall be performed on RAP in processed stockpiles:

a) Sand-equivalent on un-extracted RAP in accordance with California Test 217.
b) Asphalt binder content in accordance with one of the test methods listed in 203-6.4.4.
c) Gradation on extracted aggregate obtained in accordance with ASTM D2172 or AASHTO T 308.

When using greater than 25 percent RAP, the following additional tests shall be performed:

a) On asphalt binder and solvent resulting from ASTM D2172, asphalt binder recovered in accordance with AASHTO T 319 or ASTM D1856.
b) Asphalt binder performance grade in accordance with AASHTO M 323.

203-6.2.5.5 Quality. The minimum sand-equivalent value of un-extracted RAP shall be 80 when determined in accordance with California Test 217.

203-6.2.5.6 Quality Control Records. Quality control records (records) shall be established and maintained for a minimum of the last 6 test results. The records shall be submitted with the mix design and be made available to the Engineer upon request.

203-6.2.6 Recycling Agents. Recycling agents shall conform to the requirements shown in Table 203-6.2.6.

TABLE 203-6.2.6[1]

TEST	ASTM Test Method (s)	RA 5	RA 25	RA 75	RA 250	RA 500
Kinematic Viscosity at 140°F, cSt (60°C, mm^2/s). Min./Max.	D2170 or D2171	200/800	1000/4000	5000/10000	15000/35000	40000/60000
Flash Point, COC °F (°C), Min.	D92	400 (205)	425 (215)	450 (230)	450 (230)	450 (230)
Saturated Wt. %, Max.	D2007	25	25	25	25	25
Residue from RTFO Oven Test at 325°F (163°C)	D2872					
Viscosity Ratio[2] Max.	-	3	3	3	3	3
RTFO Oven Weight Change, ±, %	D2872	4	4	2	2	2
Specific Gravity	D70 or D1298	Report	Report	Report		

1. The acceptance of any recycling agent is subject to its ability to develop a RAC binder which will comply with the paving asphalt grade specified.
2. Viscosity Ratio = RTFO Viscosity at 140°F, cSt (60°C, mm^2/s) / Original Viscosity at 140°F, cSt (60°C, mm^2/s)

203-6.3 Job Mix Formula (JMF) and Mix Designs.

203-6.3.1 General. The Contractor shall submit in accordance with 2-5.3 a JMF that summarizes each asphalt concrete mix design for each class and grade of asphalt concrete required to construct the Work. Supporting information for the warm mix asphalt (WMA) technology and/or recycling agent, if included in a mixture, shall also be submitted.

The JMF shall identify the source and the individual grading of each material used to produce the mix design (including the percentage and individual gradation of any manufactured or natural sands), the combined gradation, the optimum binder content (OBC), void content, reclaimed asphalt pavement (RAP) percentage, RAP gradation, RAP binder content, stability value, plant identification, mix number, WMA technology, and the source and performance grade of the paving asphalt. Upon request, the mix design test data represented by the JMF shall be immediately made available to the Engineer.

When greater than 25 percent RAP is to be included in a mixture, a mix design shall be submitted. The submittal shall include supporting information showing the viscosity of the individual binders (both the virgin paving asphalt grade and that of the binder recovered from the RAP); and the amount of recycling agent, if any, and the blended final viscosity in accordance with AASHTO M 323.

For all mixtures, the asphalt binder content shall be defined as the total bituminous material present in the mix consisting of the blend of virgin paving asphalt, residual paving asphalt from RAP, and recycling agent.

When a mix design is more than 30 Days old, the JMF must indicate that the combined gradation is ± 3 percent from the referenced mix design based on a 30-Day moving average or a minimum of the 10 most current results. If the combined aggregate gradation is not within ± 3 percentage points of the gradation shown on the referenced mix design on any sieve, if the source of any aggregate is changed, the performance grade of paving asphalt is changed, or the mix design is over 2 years old, a new mix design shall be prepared and a new JMF shall be submitted to the Engineer for approval.

203-6.3.2 Hveem Mix Design Method. Unless otherwise specified in the Special Provisions, mix designs shall be prepared in accordance with Asphalt Institute publication MS-2. The OBC shall be determined in accordance with California Test 367.

Mix designs for asphalt concrete mixtures shall conform to Table 203-6.4.4 for the class shown on the Plans or specified in the Special Provisions. The minimum Hveem stability ("S-value) shown shall be used for mix design only. The target S-value, at the OBC for the mix design, shall be at least 2 points above the minimum shown.

Mix designs for alternate asphalt concrete mixtures shall conform to Tables 203-6.5.4 (A) and 203-6.5.4 (B) for the class and grade shown on the Plans or specified in the Special Provisions.

Unless viscosity and blending charts developed in accordance with AASHTO M 323 show otherwise, mix designs for mixtures containing more than 25 percent RAP shall drop the high temperature requirement of the virgin paving asphalt by one performance grade and drop the low temperature requirement by a minimum of one performance grade, e.g. a specified "PG 64-10" shall become a "PG 58-22 or "PG 58 – XX."

203-6.4 Asphalt Concrete Mixtures.

203-6.4.1 Class and Grade. Asphalt concrete mixtures shall be specified by class of combined aggregate gradation and performance grade of paving asphalt, e.g. "C2-PG 64-10." The class and grade shall be as shown on the Plans or specified in the Special Provisions.

Job mix formulas, mix designs, and weight tickets shall have the following suffixes added to the class and grade:

a) No suffix if the mixture contains RAP in an amount up to 20 percent.
b) "R0" if the mixture does not contain RAP, e.g. "C2-PG 64-10-R0".
c) "RXX" and the percentage of RAP when the mixture contains greater than 20 percent, e.g. "C2-PG 64-10-R25."
d) "WMA" if the mixture uses a warm mix asphalt technology, e.g. "C2-PG 64-10-WMA" or "B-PG 70-10-R25-WMA."

203-6.4.2 Hveem Stability ("S-Value"). The Hveem stability ("S-value") shall be determined in accordance with California Tests 304 and 366. When mixtures contain a WMA additive, stability shall be determined by curing the mix in an oven for 15 to 18 hours at 140 ± 5 °F or for 2 to 3 hours at 295 ± 5 °F in accordance with California Test 304 prior to testing. Mixtures containing a WMA additive may be cooled to room temperature prior to such curing.

The moving average shall be computed in accordance with 211-5 except that no individual test result will be accepted if it is more than 3 points below the minimum S-value shown in Table 203-6.4.4.

The individual S-value test result shall be the average of 3 tests from one sample representing 1000 tons or a single day of paving on the Work site, whichever is less. If the range for the 3 tests is more than 10, then the sample shall be discarded and a new sample shall be obtained and retested.

203-6.4.3 Combined Aggregates and Reclaimed Asphalt Pavement (RAP). The combined aggregates and RAP shall conform to the following requirements after processing and prior to the addition of asphalt binder, mineral filler and, if so specified, a warm mix asphalt additive and/or recycling agent.

a) The combined aggregates shall have a minimum sand equivalent of 50 when tested in accordance with California Test 217.

b) When there is a difference in specific gravity (bulk saturated surface dry determined in accordance with ASTM C127 and C128) of 0.2 or more between that portion retained on and that portion passing a No. 4 (4.75 mm) sieve, the grading shall be modified in accordance with California Test 105.

c) The combined aggregate gradation shall be determined in accordance with ASTM C136 and C117 or California Test 202.

d) The combined aggregate gradation shall be uniform from coarse to fine.

e) When the mixture contains greater than 20 percent RAP, a RAP correction factor determined in accordance with 211-6 shall be used in determining the combined aggregate and RAP gradation.

f) If the fine aggregate is deficient in material passing the No. 200 (75 µm) sieve, mineral filler conforming to 203-6.2.4 shall be added as necessary to conform to the required combined grading.

g) If the combined aggregate grading conforms to the grading of its class as shown in Table 203-6.4.4, the individual grading required by 200-1.2 may be waived.

h) Percentages for the combined gradings, within the specified limits, shall be of such uniformity that the material passing the indicated sieves during any day of production does not exceed the maximum variation specified in 203-6.4.4.

203-6.4.4 Composition and Grading. Asphalt concrete mixtures shall conform to Table 203-6.4.4 in which the percentages shown are based on the weight of the dry aggregate only.

TABLE 203-6.4.4

Sieve Size	Percentage Passing Sieves							
	A	B	C1	C2	D1	D2	E	F
	Dense Coarse	Dense Medium Coarse	Coarse Medium	Dense Medium	Coarse Fine	Dense Fine	Extra Fine	Channel Liner
1-1/2" (37.5 mm)	100							
1" (25 mm)	90-100	100						
3/4" (19.0 mm)	78-90	87-100	100	100				
1/2" (12.5 mm)	64-78	70-87	90-100	95-100	100	100		
3/8" (9.5 mm)	54-68	55-76	72-88	72-88	90-100	95-100	100	100
No. 4 (4.75 mm)	34-48	35-52	40-54	46-60	40-54	58-72	65-85	95-100
No. 8 (2.36 mm)	25-35	22-40	18-34	28-42	20-32	34-48	45-65	70-84
No. 30 (600 µm)	12-22	8-24	8-20	15-27	6-18	18-32	22-38	36-50
No.50 (300 µm)	8-16	5-18	4-14	10-20	2-12	13-23	16-28	23-35
No. 200 (75 µm)	3-6	0-7	1-6	2-7	0-5	2-9	6-12	6-12
Asphalt Binder %	4.5-5.7	4.5-6.5	4.6-6.0	4.6-6.0	4.8-6.5	4.8-6.5	5.8-7.8	8.0-10.0
Hveem Stability "S Value" (min.)	35	35	33	33	30	30		
Air Voids[1]	4%	4%	4%	4%	4%	4%		

1. Per CTM 367.

When the aggregate is highly absorptive (a 2.0 percent combined absorption value when determined in accordance with AASHTO T84 and T85), the maximum percentage for asphalt binder may be increased up to 2.0 percentage points over the values shown.

Maximum variation during any day of production shall not exceed the following:

No. 4 (4.75 mm) Sieve - 6 percentage points

No. 30 (600 µm) Sieve - 5 percentage points

No. 200 (75 µm) Sieve - 3 percentage points

The gradations in the above tabulations represent the limits which shall determine the suitability of aggregate for use from the sources of supply.

Determination of the asphalt binder content shall be by extraction of the paving asphalt from the mixture performed in accordance with any of the following test methods or other published test methods approved by the Engineer:

AASHTO T 164

AASHTO T 308

AASHTO T 319

ASTM D2172

ASTM D4125

ASTM D6307

California Test Method 382

Gradations determined during asphalt binder content testing shall be provided for information only.

203-6.5 Type III Asphalt Concrete Mixtures.

203-6.5.1 Class and Grade. Type III asphalt concrete mixtures shall be designated by type (III), class of combined aggregate gradation and performance grade of paving asphalt, e.g. "III-C2-PG 64-10." The type, class, and grade shall be as shown on the Plans or specified in the Special Provisions.

Job mix formulas, mix designs, and weight tickets shall have the following suffixes added to the type, class and grade:

a) No suffix if the mixture contains RAP in an amount up to 20 percent.
b) "R0" if the mixture does not contain RAP, e.g. "III-C2-PG 64-10-R0".
c) "R" and the percentage of RAP if the mixture contains greater than 20 percent, e.g. "III-C2-PG 64-10-R25."
d) "WMA" if the mixture uses a warm mix asphalt technology, e.g. "III-C2-PG 64-10-WMA" or "III-B-PG 70-10-R25-WMA."

203-6.5.2 Combined Aggregates and Reclaimed Asphalt Pavement (RAP). The combined aggregates and RAP shall conform to 203-6.4.3 except as follows:

a). The combined aggregates shall have a minimum sand equivalent of 45 when determined in accordance with California Test 217.
b) Subparagraphs "a", "g", and "h" shall not apply.

203-6.5.3 Hveem Stability ("S-Value"). Hveem stability shall be determined in accordance with 203-6.4.2.

203-6.5.4 Composition and Grading. Alternate asphalt concrete mixtures shall conform to Tables 203-6.5.4 (A) and 203-6.5.4 (B). The percentages shown in Table 203-6.5.4 (A) are based on the weight of the dry aggregate only.

TABLE 203-6.5.4 (A)

CLASS	B2		B3	
Sieve Size	Individual Test Result	Moving Average	Individual Test Result	Moving Average
1" (25.0 mm)	100	100	100	100
3/4" (19.0 mm)	87 – 100	90 - 100	90 - 100	95 - 100
3/8" (9.5 mm)	50 – 80	60 - 75	60 - 84	65 - 80
No. 4 (4.75 mm)	30 – 60	40 - 55	40 - 60	45 - 60
No. 8 (2.36 mm)	22 – 44	27 - 40	24 - 50	30 - 45
No. 30 (600 µm)	8 – 26	12 - 22	11 - 29	15 - 25
No. 200 (75 µm)	1 – 8	3 - 6	1 - 9	3 - 7
Asphalt Binder %	4.6 - 6.0		4.6 - 6.0	
CLASS	**C2**		**C3**	
Sieve Size	**Individual Test Result**	**Moving Average**	**Individual Test Result**	**Moving Average**
3/4" (19.0 mm)	100	100	100	100
1/2" (12.5 mm)	89 – 100	95 - 100	89 - 100	95 - 100
3/8" (9.5 mm)	70 – 94	75 - 90	74 - 100	80 - 95
No. 4 (4.75 mm)	44 – 72	50 - 67	50 - 78	55 - 72
No. 8 (2.36 mm)	30 – 54	35 - 50	32 - 60	38 - 55
No. 30 (600 µm)	10 – 34	15 - 30	14 - 38	18 - 33
No. 200 (75 µm)	2 – 10	4 - 7	2 - 10	4 - 8
Asphalt Binder %	4.8 - 6.5		4.6 - 7.0	
CLASS	**D**		**F**	
Sieve Sizes	**Combined Average**		**Combined Average**	
1/2" (12.5 mm)	100		–	
3/8" (9.5 mm)	95 - 100		100	
No. 4 (4.75 mm)	65 - 85		95 - 100	
No. 8 (2.36 mm)	50 - 70		70 - 80	
No. 30 (600 µm)	28 - 40		35 - 50	
No. 200 (75 µm)	5 - 14		7 - 16	
Asphalt Binder %	6.0 - 8.0		8.0 - 10.0	

Table 203-6.5.4 (B)

Aggregate Gradings	California Test	Hveem Stability S Value
B and C	304 and 366	35 Min.
D and F		30 Min.

Determination of the asphalt binder content shall be by extraction of the paving asphalt from the mixture performed in accordance with any of the following test methods or other published test methods approved by the Engineer:

AASHTO T 164
AASHTO T 308
AASHTO T 319
ASTM D2172
ASTM D4125
ASTM D6307
California Test Method 382

Gradations determined during asphalt binder content testing shall be provided for information only.

203-6.5.5 Statistical Testing. Statistical testing shall conform to 200-1.1.2 and the following:

Whenever the results of an individual test for any property of a material does not comply with the limits specified for an individual test and if the moving average would not comply with the limit specified for the moving average should the next test be of the same value as that of the test being considered, the production of that material shall be suspended until corrective changes have been made and tests indicate that the quality of the material proposed for use in the Work complies with that specified for the moving average.

203-6.6 Not Used.

203-6.7 Production.

203-6.7.1 General. Asphalt concrete mixtures shall be produced by either the batch plant method or the dryer-drum method.

The temperature of paving asphalt shall be within the range shown in Table 203-1.4 when added to the aggregate and reclaimed asphalt pavement (RAP).

The temperature of liquid asphalt shall be within the range shown in Table 203-2.3 when added to the aggregate. The temperature of the aggregate at the time of adding liquid asphalt shall not exceed the maximum pugmill mixing temperature shown in Table 203-2.3.

A temperature indicating device capable of reading up to 500°F (260°C) and accurate to within 10°F (5°C) shall be fixed in the asphalt binder and recycling agent feed lines or storage tanks. The indicator shall be located and maintained where the proportioning operations are controlled.

The discharge end of the asphalt binder and recycling agent circulating pipe shall extend to within 1 foot (0.3 m) of the bottom of the storage tank.

The binder and recycling agent feed lines connecting the plant storage tanks to the asphalt binder weighing system or spray bar shall be equipped with a sampling valve. The sampling valve shall consist of a 1/2 inch (12.5 mm) or 3/4 inch (19 mm) valve constructed in such a manner that a 1 quart (1 L) sample may be withdrawn slowly at any time during plant operations, and shall be placed in a safe location. A drainage receptacle shall be provided for flushing the valve prior to sampling. One gallon (4 L) shall be drawn from the sampler prior to taking the sample.

203-6.7.2 Warm Mix Asphalt (WMA) Technologies. Asphalt concrete mixtures may be produced using a WMA technology if so specified in the Special Provisions.

The WMA technology and mixing and placement temperatures shall be as specified on the approved mix design.

The plant shall be equipped or modified as necessary to produce warm mix asphalt in accordance with the WMA technology supplier's recommendations and the approved mix design.

203-6.7.3 Batch Plant Method.

203-6.7.3.1 Aggregate and Reclaimed Asphalt Pavement (RAP) Storage, Drying, and Screening. Each size of aggregate and RAP shall be stored separately. When handling or transporting, no method shall be used which may cause segregation, degradation, or intermingling of different sizes.

When RAP is included in the mixture, the batch plant shall be equipped to introduce RAP using a separate storage facility with direct access to the weigh hopper. RAP may be introduced into the plant by direct access into the weigh hopper, into the hot aggregate elevator, or by another method approved by the Engineer. The RAP and the virgin aggregates shall be weighed together in the weigh hopper prior to introduction into the pugmill and dry mixed for 10 seconds, or longer if necessary, to effectuate the heat transfer. Aggregates shall be heated and dried for a period of time sufficient to result in a moisture content not exceeding 1 percent when tested in accordance with California Test 310 or 370.

The dryer shall be equipped with a device capable of displaying the temperature of the aggregate and RAP leaving the dryer. The heat indicating device shall be independently mounted from other plant components, be accurate to the nearest 10°F (5°C), and shall be installed in such a manner that a fluctuation of 10°F (5°C) in the aggregate and RAP temperature will be indicated within 1 minute. The temperature indicator shall be located and maintained where the proportioning operations are controlled.

After drying, the aggregates and, when included, RAP shall be evenly fed to the screens in such quantities as to maintain, in separate bins, a uniform grading of materials and proper balance in the amount of material. The operation of the screens shall be so controlled as to secure a thorough separation of aggregate sizes.

Screens having clear openings shall be used to separate and classify materials for the hot storage bins. The aggregate and RAP passing these screens shall be separately stored in individual bins until proportioned into the mixer.

TABLE 203-6.7.3.1 (A)

Size of Openings	Bin No.
4-Bin Plants	
100% passing 1-1/2" (37.5 mm) sieve	4
100% passing 5/8" (16.0 mm) sieve	3
100% passing 3/8" (9.5 mm) sieve	2
100% passing No. 4 (4.75 mm) sieve	1
5-Bin Plants	
100% passing 1-1/2" (37.5 mm) sieve	5
100% passing 7/8" (22.4 mm) sieve	4
100% passing 5/8" (16.0 mm) sieve	3
100% passing 3/8" (9.5 mm) sieve	2
100% passing No. 4 (4.75 mm) sieve	1

The No.1 bin shall not contain more than 10 percent of material retained on the No. 8 (2.36 mm) sieve. The remaining bins shall not contain more than 10 percent of material passing through the sieve sizes shown in Table 203-6.7.3.1 (B).

TABLE 203-6.7.3.1 (B)

Bin. No.	Sieve Size
2	No. 8 (2.36 mm)
3	No. 4 (4.75 mm)
4	3/8" (9.5 mm)
5	3/8" (9.5 mm)

Each bin shall be equipped with an opening to prevent overflow into adjacent bins. Overflow material shall be discarded or returned to its respective storage area. All material fed to the No. 4 bin shall pass through the screen over that bin. Oversize rock shall be discarded or returned to its respective storage area.

Discharged material may be returned to a storage area that contains aggregates of the approximate grading of the discharged material. Discharged material containing RAP shall be returned to a separate stockpile for reprocessing.

203-6.7.3.2 Proportioning. All materials shall be proportioned by weight. The zero tolerance for aggregate and RAP scales, asphalt binder scales, and, when used, mineral filler scales shall be 0.5 percent based on the total batch weight of the aggregate.

The indicated weight of any material drawn from storage shall not vary from the preselected setting by more than the following percentages based on the total batch weight of the aggregate:

Aggregate	1.0 percent
RAP	1.0 percent
Mineral Filler	0.5 percent
Asphalt Binder	0.1 percent
Recycling Agent	0.1 percent

Automatic proportioning devices shall be operated so that all weight increments required for a batch are preset on the controls at the same time. The discharge mechanism of each bin shall be interlocked so that only one bin can discharge onto a given scale at a time and that a new batch may not be started until all of the weigh hoppers are empty, the scales are at zero, and the discharge gate is closed. The interlock system shall prevent the weigh box from discharging until the required quantity of each bin and the other weighing devices have been properly filled and weighed. The proportioning controls shall be equipped with means for inspection of the interlock tolerance settings. Instructions for determining these settings shall be posted at the control panel for the Engineer's use.

Bag house fines or mineral filler shall be proportioned by weight by a method that uniformly feeds the material to within 10 percent of the required amount.

When introducing the RAP into the hot aggregate elevator, the conveyors shall be equipped with belt scales with rate-of-flow indicators to show the rates of delivery of each size of aggregate. The belt scales shall be interlocked with the belt scale for aggregate entering the dryer to maintain the proper proportion of RAP to aggregate.

203-6.7.3.3 Mixing. Aggregates, asphalt binder, RAP, and when included, recycling agent and/or warm mix asphalt (WMA) additive, shall be thoroughly mixed.

The mixer shall be of the twin-shaft pugmill type and operated at the speed recommended by the manufacturer. The mixer shall be equipped with paddles of sufficient size and number to produce and deliver

a uniform mixture. Paddles or other parts of the pugmill which become worn to such an extent as to adversely affect the quality of mixing or allow leakage from the discharge gate shall be promptly replaced.

The mixer, weigh hopper, and sampling platforms shall be of ample size to provide safe and convenient access to the mixer and other equipment. Weigh box housings shall be equipped with gates of ample size to permit ready sampling of the discharged aggregates from each of the plant bins.

The total weight of material that may be mixed per batch shall not exceed the manufacturer's rated capacity of the mixer, nor exceed that which will permit complete mixing of all the materials. Dead areas in the mixer shall be corrected either by reducing the total weight of materials or by other adjustments.

Each batch shall be continuously mixed until all of the materials are thoroughly blended. The batch mixing time shall begin on the charging stroke of the weigh hopper dump mechanism and shall end when discharge from the mixer begins. The mixer shall be equipped with a time lock mechanism which locks the mixer discharge gate for the mixing period and actuates an indicator light by the charging stroke of the weigh hopper charging mechanism. The indicator light shall be so located as to be visible from where the mixing operations are controlled.

The minimum mixing time shall be 35 seconds, of which 5 seconds shall be drop time for the aggregate, RAP, paving asphalt, and, if included, recycling agent and/or WMA additive, into the mixer. If the drop time exceeds 5 seconds, the additional time shall be added to the 35 seconds. If the Engineer determines that the mixture is not thoroughly blended, the mixing time shall be increased.

The temperature of the mixture, without a WMA additive, at the point of discharge from the plant shall be between 275°F (135°C) and 325°F (163°C). The temperature of the mixture at the Work site shall be as specified in 302-5.5. When a WMA technology is used, the minimum and maximum plant discharge temperatures and the acceptable temperature range at the Work site shall be as specified on the approved job mix formula or mix design.

203-6.7.4 Dryer-Drum Method.

203-6.7.4.1 Aggregate and Reclaimed Asphalt Pavement (RAP) Storage and Drying. Each size of aggregate and RAP shall be stored separately. When handling or transporting, no method shall be used which may cause segregation, degradation, or intermingling of aggregates of different size.

RAP shall be introduced into the dryer-drum and combined with the hot aggregate in such a manner that the RAP is protected from direct contact with the burner flame. Asphalt binder shall be introduced after the RAP and the aggregate have been combined.

Except for mixtures produced with a warm mix asphalt (WMA) technology, mixtures shall not contain more than 1 percent moisture when tested in accordance with California Test 310 or 370.

The dryer-drum shall be equipped with a device which indicates the temperature of the mixed material leaving the drum. The device shall be accurate to within 10°F (5°C) and shall be installed in such a manner that a temperature change of 10°F (5°C) in the mixed material will be shown within 1 minute. The temperature indicator shall be located and maintained at the location where the proportioning operations are controlled.

203-6.7.4.2 Proportioning. Asphalt binder, RAP, and when included, recycling agent and/or warm mix asphalt (WMA) additive, shall be measured by a meter certified in accordance with 4-1.7. The meter shall automatically compensate for changes in the asphalt binder temperature. The meter and feed lines shall be heated and insulated. The storage tanks for the asphalt binder, and when included, recycling agent and/or WMA additive, shall be equipped with a device for automatic plant cutoff when the fluid level in the tank is low enough to expose the pump suction line. The metering system shall be capable of varying the rate of delivery of asphalt binder, recycling agent and WMA additive proportionately with the rate of delivery of

aggregate and RAP while the plant is in full operation. During any day of production, the temperature of the asphalt binder shall not vary more than 50°F (30°C).

Bag house fines or mineral filler, if used, shall be:

a) proportioned by weight or by volume,
b) uniformly fed into the mixer at an amount within 10 percent of the required amount, and
c) discharged into the mixer in proximity to where the asphalt binder is introduced.

The combined aggregates and RAP shall be weighed on separate belt scales. The belt scales shall be of such accuracy that, when the plant is operating between 30 and 100 percent of belt capacity, the average difference between the indicated weight of the material delivered and the actual weight does not exceed 1 percent of the actual rate for 3, 3-minute runs. For any of the 3 individual 3-minute runs, the indicated weight of the material delivered shall not vary from the actual weight by more than 2 percent of the actual weight. The actual weight of material delivered shall be determined by a vehicle platform scale.

The individual belt scales for the combined aggregates and RAP, the proportioning meters for the asphalt binder, and when included, recycling agent and WMA additive and the other proportioning devices shall be interlocked in such a manner that the rates of feed automatically adjust and maintain the required proportions. The plant shall not be operated unless this system is fully operational and accurate.

Belt scales and proportioning meters shall be equipped with rate of flow indicators showing the rates of delivery of aggregates, RAP, asphalt binder, and if included, recycling agent and WMA additive, and shall have resettable totalizers for determining the actual weight of each. Rate of flow indicators and totalizers for like materials shall be accurate to within 1 percent when compared directly. The asphalt binder, recycling agent and WMA additive totalizers shall not register when the metering system is not delivering material to the mixer, and shall not be reset unless so approved by the Engineer. The bins containing fine aggregate and mineral filler shall be equipped with a vibrating unit or other equipment capable of preventing any "hang-up" of material while the plant is operating. Before the quantity of material in any one bin reaches the strike-off capacity of the feed gate, a device shall automatically shut down the plant.

The moisture content of the aggregate and RAP shall be determined in accordance with California Test 310 or 370 at least once during every 2 hours of production. Moisture control equipment shall be adjusted accordingly.

A sampling device capable of providing 60-pound to 80-pound (25 kg to 40 kg) samples of the RAP and of the combined aggregates while the plant is in full operation shall be located in advance of the point where these materials enter the mixer.

When bag house fines or mineral filler is used, a sampling device shall be installed in each feed line or surge tank preceding the proportioning device.

203-6.7.4.3 Mixing. Aggregates, asphalt binder, RAP, and when included, recycling agent and/or WMA additive, shall be thoroughly mixed.

Mixing shall continue for a sufficient amount of time and at a sufficiently high temperature, that, at discharge from the mixer, aggregate size is uniformly distributed through the mixture and all particles are thoroughly and uniformly coated with asphalt binder.

After mixing, the mixture shall be discharged from the drum into a silo. The Contractor shall provide a means of diverting the flow of material away from the silo when starting and stopping the plant production in order to prevent unmixed or partially mixed portions of the mixture from entering.

The temperature of the mixture, without a WMA additive, at the point of discharge from the plant shall be between 275°F (135°C) and 325°F (163°C). The temperature of the mixture at the Work site shall be as specified in 302-5.5. When a WMA technology is used, the minimum and maximum plant discharge temperatures and the acceptable temperature range at the Work site shall be as specified on the approved job mix formula or mix design.

203-6.8 Storage. Asphalt concrete shall be:

a) transferred from the mixer by a method that does not cause segregation, and
b) stored in insulated silos with heated discharge cones, unless the silo is being used for surge purposes. Silos shall be equipped to prevent segregation during filling.

203-6.9 Transportation. Truck beds shall be coated with a release agent before loading. Visible pools of release agent shall be removed prior to loading.

The temperature of asphalt concrete discharged into truck beds shall not vary more than 20°F (10°C) for successive loads. When the hauling time from the plant to the Work site exceeds 2 hours, when the atmospheric temperature is below 50°F (10°C), or when rain is falling along the haul route, asphalt concrete shall be completely covered with a tarpaulin secured to the truck bed during transport.

Asphalt concrete shall be delivered to the Work site without segregation and within the temperature range specified in 302-5.5.

203-6.10 Sampling. Asphalt concrete shall be sampled in accordance with California Test 125.

Samples of RAP shall be from processed stockpiles, or from collector belts.

Aggregate samples for batch plants shall be taken from the hot bins. Aggregate samples for dryer-drum plants shall be taken in advance of the dryer-drum using devices conforming to 203-6.7.4.2.

203-6.11 Acceptance. Acceptance of asphalt concrete mixtures will be based upon conformance to the gradation, asphalt binder content, and minimum stability values shown in Table 203-6.4.4. Acceptance of alternate asphalt concrete mixtures will be based upon conformance to the gradation, binder content, and minimum stability values shown in Tables 203-6.5.4 (A) and 203-6.5.4 (B). The asphalt binder content shall be within + 0.5 percent of that shown on the respective job mix formula or mix design. Air void values will not be used as an acceptance criterion.

Should plant gradation test results be unavailable, gradation may be determined in accordance with ASTM D2172 or by AASHTO T 308 with adherence to the aggregate correction factor therein. In the case of a continued dispute, final acceptance of plant produced mixtures may be based upon binder content and stability.

When dissimilar surface course mix characteristics are the result of production and delivery from multiple plants, the Engineer may require production and delivery from only one plant during any one day of production.

203-7 Not Used.

203-8 ASPHALT PAINT. Shall conform to ASTM D41 or D43 and be furnished and applied to concrete surfaces as required and shown on the Plans.

203-9 SEALCOAT - ASPHALT BASED.

203-9.1 General. This specification applies to sealcoat intended to be used for sealing miscellaneous areas such as asphalt parking lots, playgrounds, and similar areas. Sealcoat material shall be a plant blended product composed of mineral aggregates uniformly distributed in a petroleum-based asphalt emulsion. The asphalt emulsion shall conform to 203-3. The sealcoat material shall contain non-asbestos fibers.

203-9.2 Testing Requirements. Sealcoat materials, undiluted except as noted, shall conform to the following requirements:

TABLE 203-9.2

Test	Specifications
Weight lbs per gallon (grams per liter)	9.5 (1139) Min.
Nonvolatile component (%)[1]	60% Min. by weight
Mineral aggregate component	No. 20 (850 µm) sieve – 100% passing
Working viscosity, diluted 4 parts product to 1 part water – ASTM D562	75 KREBS Min.
Dried film color	Black
Asphalt content	25% - 35% of nonvolatiles by weight

1. Weigh 10 grams of homogeneous product into a previously tarred, small ointment can lid. Place in a constant temperature oven at 325°F (163°C) for 1-1/2 hours. Cool, reweigh, and calculate nonvolatile components.

203-10 LATEX MODIFIED ASPHALT CONCRETE.

203-10.1 General. Latex modified asphalt concrete shall be the product of mixing latex, asphalt cement, and aggregate. Latex modified asphalt shall conform to 203-6 and the following requirements.

203-10.2 Materials.

203-10.2.1 Paving Asphalt. Paving asphalt shall be PG 64-10 conforming to 203-1, or as specified in the Special Provisions.

203-10.2.2 Latex. Latex shall be a water-based emulsified suspension of styrene butadiene rubber (SBR) in liquid form. The ratio of styrene butadiene shall be 70 to 30. The rubber solids shall be 70 ± 5 percent of the emulsified material unless otherwise directed by the Engineer.

At the time of delivery of each shipment of latex emulsion, the vendor supplying the material shall deliver to the purchaser a Certificate of Compliance which includes, but is not limited to, the following information:

Actual percent of rubber solids

Ratio of styrene to butadiene

Temperature range or limits for product use

Unit weight of the emulsion

Recommended storage conditions

203-10.2.3 Aggregates. Aggregates shall conform to 203-6.3.2.

203-10.2.4 Composition and Grading. The class shall be C2 unless otherwise specified on the Plans or in the Special Provisions.

The amount of latex to be added shall provide 2 percent dry rubber solids, unless otherwise directed by the Engineer. The percentage of dry rubber solids shall be based on the weight of asphalt cement.

The exact proportions of aggregate and the amount asphalt binder for the mixture shall be determined by Contractor so as to incorporate the specified amount of latex.

If the mix design and/or its individual components have no previous record of use by the Agency, the Contractor shall submit a mix design with supporting test data at least 10 Working Days prior to initial use.

203-10.3 Proportioning. Latex may be added to the mixture by any method approved by the Engineer that will assure uniform distribution and accurate measurement of quantity of latex introduced. The latex shall be introduced to the mix at the same time as the introduction of asphalt.

The latex emulsion temperature at the time it is introduced to the mixture shall be as recommended by the manufacturer.

203-10.4 Mixing. The wet-mixing cycle for batch plant production shall be 50 seconds minimum.

Production rates of continuous mix plants shall be carefully regulated by the Contractor to ensure complete and uniform mixing.

203-10.5 Storage. Latex emulsion shall be stored in a closed bottom-draw vessel and agitated as recommended by the manufacturer's Certificate of Compliance.

A latex sampling outlet shall be provided in conformance to the requirements of 203-6.9.

203-10.6 Placement. Latex modified asphalt concrete placement shall conform to the requirements of 302-5 with the exception that pneumatic-tired rollers shall not be used.

203-11 ASPHALT RUBBER HOT MIX (ARHM).

203-11.1 General. Asphalt Rubber Hot Mix shall consist of a mixture of paving asphalt, asphalt modifier, crumb rubber modifier (CRM), and aggregate mixed in a central mixing plant.

203-11.2 Materials. The Contractor shall submit test reports and Certificates of Compliance conforming to 4-1.5 for the paving asphalt, asphalt modifier, and CRM to be used. When requested by the Engineer, the Contractor shall also submit samples of the tested material.

203-11.2.1 Paving Asphalt. Paving asphalt used for asphalt-rubber shall be PG 64-16, conforming to 203-1. Performance graded paving asphalts other than PG 64-16 may be used if so specified in the Special Provisions.

203-11.2.2 Asphalt Modifier. The asphalt modifier shall be a resinous, high flash point, aromatic hydrocarbon compound and shall conform to the requirements shown in Table 203-11.2.2. The asphalt modifier may be eliminated if approved by the Engineer.

TABLE 203-11.2.2

Property	ASTM Test Method	Value
Flash Point, C.L.O.C., °F (°C)	D92	405 (207) min
Viscosity, cSt @ 212°F (100°C)	D445	X ± 3*
Molecular Analysis		
Asphaltenes, percent by mass	D2007	0.1 max
Aromatics, percent by mass	D2007	55 min

* The symbol "X" is the viscosity of the asphalt modifier the Contractor proposes to furnish. The value "X" which the Contractor proposes shall be between the limits of 19 and 36 and shall be submitted in writing to the Engineer. Any proposed change requested by the Contractor in the value "X" shall require a new asphalt-rubber binder design.

203-11.2.3 Crumb Rubber Modifier (CRM).

203-11.2.3.1 General. CRM shall consist of a combination of scrap tire CRM and high natural CRM. Scrap tire CRM shall consist of ground or granulated rubber derived from any combination of automobile tires, truck tires or tire buffings. The high natural CRM shall consist of ground or granulated rubber derived from materials that utilize high natural rubber sources. Whole scrap tire CRM shall be derived from whole scrap tires generated within the State boundaries of the user agencies. The Certificate of Compliance shall contain a statement confirming conformance with this requirement. The high natural CRM may consist of blended CRM.

CRM shall be ground or granulated at ambient temperature. Cryogenically produced CRM particles which can pass through the grinder or granulator without being ground or granulated shall not be used. Cryogenic separation, if utilized, shall be performed separately from and prior to grinding or granulating. Steel and fiber separation may employ any method.

CRM shall not contain more than 0.01 percent of wire by weight and shall be free of all other contaminants, except fabric. Fabric shall not exceed 0.05 percent by weight of CRM. A Certificate of Compliance certifying these percentages shall be furnished to the Engineer.

CRM shall be dry and free-flowing and not produce foaming when combined with the blended paving asphalt and asphalt modifier mixture. Calcium carbonate or talc may be added up to a maximum of 3 percent by weight of CRM to prevent CRM particles from sticking together. CRM shall have a specific gravity range from 1.1 minimum to 1.2 maximum as determined by ASTM D297. Scrap tire CRM and high natural CRM shall be delivered to the production site in separate bags and shall be sampled and tested separately. Scrap tire CRM material shall conform to the chemical analysis requirements shown in Table 203-11.2.3.1 (A).

TABLE 203-11.2.3.1 (A):

CHEMICAL REQUIREMENTS FOR SCRAP TIRE CRM

Test	ASTM Test Method	Minimum	Maximum
Acetone Extract	D297	6.0%	16.0%
Ash Content	D297	—	8.0%
Carbon Black Content	D297	28.0%	38.0%
Rubber Hydrocarbon	D297	42.0%	65.0%
Natural Rubber Content	D297	22.0%	39.0%

Scrap tire CRM shall be mixed at the production site with high natural CRM so that 75 percent ± 2 percent of the product used is derived from scrap tires and 25 percent ± 2 percent from materials that utilize high natural rubber sources. High natural rubber CRM may consist of blended CRM which, after blending, conforms to the chemical analysis requirements shown in Table 203-11.2.3.1 (B).

TABLE 203-11.2.3.1 (B):

CHEMICAL REQUIREMENTS FOR HIGH NATURAL CRM

Test	ASTM Test Method	Minimum	Maximum
Acetone Extract	D297	4.0%	16.0%
Rubber Hydrocarbons	D297	50.0%	–
Natural Rubber Content	D297	40.0%	48.0%

With the approval of the Engineer, high natural CRM may be eliminated. If high natural rubber is not used, then the full amount of required CRM shall be scrap tire CRM. Asphalt rubber binder without high natural CRM shall be designated as Type I and ARHM manufactured with Type I binder shall be designated as ARHM-I.

203-11.2.3.2 CRM Gradations. CRM gradations shall conform to the requirements shown in Table 203-11.2.3.2 when tested in accordance with ASTM C136, amended as follows:

Split or quarter 100 grams ± 5 grams from the representative CRM sample and dry to a constant weight at a temperature of not less than 135°F (57°C) nor more than 145°F (63°C) and record the dry sample weight. Place the CRM sample and 5.0 grams of talc (or calcium carbonate) in a 1 pint jar. Seal the jar and shake it by hand for a minimum of one minute to mix the CRM and the talc (or calcium carbonate). Continue shaking or open the jar and stir until particle agglomerates and clumps are broken and the talc (or calcium carbonate) is uniformly mixed.

A Rotap (or equivalent) test shaker shall be used for the sieve analysis. Place one rubber ball on each sieve. Each ball shall have a weight of 8.5 ± 0.5 grams, have a diameter of 24.5 ± 0.5 mm, and shall have a Shore Durometer "A" hardness of 50 ± 5 in accordance with ASTM D2240. After shaking the combined material for 10 minutes ± 1 minute, disassemble the sieves. Any material adhering to the bottom of a sieve shall be brushed into the next finer sieve. Weigh and record the weight of the material retained on the No. 8 (2.36 mm) sieve and leave this material on the scale or balance. Any observed fabric balls shall remain on the scale or balance and shall be placed together on the side of the scale or balance to prevent the fabric balls from being covered or disturbed when placing the material from finer sieves onto the scale or balance. The material retained on the next finer sieve shall be added to the scale or balance. Weigh and record that weight as the accumulative weight retained on that sieve. Continue weighing and recording the accumulated weight retained on the remaining sieves until the accumulated weight retained in the pan has been determined. Prior to discarding the CRM sample, separately weigh and record the total weight of fabric balls in the sample.

Determine the weight of material passing the No. 200 (75 µm) sieve (or weight retained in the pan) by subtracting the accumulated weight retained on the No. 200 (75 µm) sieve from the accumulated weight retained in the pan. If the material passing the No. 200 (75 µm) sieve (or weight retained in the pan) has a weight of 5 grams or less, cross out the recorded number for the accumulated weight retained in the pan and copy the number recorded for the accumulated weight retained on the No. 200 (75 µm) sieve and record that number (next to the crossed out number) as the accumulated weight retained in the pan. If the material passing the No. 200 (75 µm) sieve (or weight retained in the pan) has a weight greater than 5 grams, cross out the recorded number for the accumulated weight retained in the pan, subtract 5 grams from that number and record the difference next to the crossed out number. The adjustment to the accumulated weight retrained in the pan is made to account for the 5 grams of talc (or calcium carbonate) added to the sample. For calculation purposes, the adjusted total sample weight is the same as the adjusted accumulated weight retained in the pan. Determine the percent passing based on the adjusted total sample weight and record to the nearest 0.1 percent.

TABLE 203-11.2.3.2:

GRADING REQUIREMENTS FOR CRM

Sieve Size	Scrap Tire CRM Percent Passing	High Natural CRM Percent Passing
No. 8 (2.36 mm)	100	100
No. 10 (2.00 mm)	98 – 100	100
No. 16 (1.18 mm)	45 – 75	95 – 100
No. 30 (600 µm)	2 – 20	35 – 85
No. 50 (300 µm)	0 – 6	10 – 30
No. 100 (150 µm)	0 – 2	0 – 4
No. 200 (75 µm)	–	0 – 1

* CRM from more than one source may be used provided the combined CRM gradation meets the specified limits. No particles shall exceed a length of 3/16 inch (5 mm) as measured on any axis.

203-11.2.4 Aggregate. The aggregate for ARHM shall meet the quality requirements specified in 200-1 for asphalt concrete.

203-11.3 Composition and Grading. Asphalt-rubber hot-mix gap-graded (ARHM-GG) shall be designated by type and class, i.e., ARHM-GG-C, and shall conform to the requirements shown in Table 203-11.3.

TABLE 203-11.3

SIEVE SIZE	CLASS		
	GG-B Min.- Max.	GG-C Min.- Max.	GG-D Min.- Max.
1" (25 mm)	100	–	–
3/4" (19.0 mm)	90-100	100	–
1/2" (12.5 mm)	–	90-100	–
3/8" (9.5 mm)	60-75	78-92	100
No. 4 (4.5 mm)	28-42	28-42	28-42
No. 8 (2.36 mm)	15-25	15-25	15-25
No. 30 (600 µm)	5-15	5-15	5-15
No. 200 (75 µm)	0-5	2-7	2-7
% Asphalt Rubber Binder by Weight of Dry Aggregate[1]	7.5-8.4	7.5-8.7	7.5-8.7
Air Voids % California Test 367	3-6	3-6	3-6
Stabilometer Value Min. California Test 304 and 366	25	23	23
Voids in Mineral Agg. Percent Min.[2]	18	18	18

1. Once the percent asphalt rubber binder is determined by the mix design, the production tolerance shall be ± 0.5% as determined by California Test Method 362, 379, or 382.
2. Percent voids in the mineral aggregate (VMA) is to be determined during the mix design process only and is to be calculated on the basis of ASTM bulk specific gravity as described in the Asphalt Institute MS-2 manual.

203-11.4 Mixing Asphalt and CRM. The paving asphalt and asphalt modifier shall be combined into a blended mixture that is chemically compatible with the crumb rubber modifier to be used. The blended mixture is considered to be chemically compatible when it conforms to the requirements for asphalt rubber binder (after reacting) shown in Table 203-11.4.

The asphalt modifier shall be proportionately added to the paving asphalt at the production site where the asphalt-rubber binder is blended and reacted. Asphalt modifier shall be added at an amount of 2.5 percent to 6.0 percent by weight of the paving asphalt based on the recommendation of the asphalt rubber binder supplier. The paving asphalt shall be at a temperature of not less than 375°F (190°C) nor more than 440°F (226°C) when the asphalt modifier is added. If the asphalt modifier is combined with the paving asphalt before being blended with the CRM, the combined paving asphalt and asphalt modifier shall be mixed by circulation for not less than 20 minutes. This premixing of asphalt modifier and the paving asphalt will not be required when all ingredients of the asphalt rubber binder are proportioned and mixed simultaneously. Asphalt modifier and paving asphalt shall be measured for proportioning with meters conforming to 203-6-6.

The proportions of the materials, by total weight of asphalt-rubber binder, shall be 80 percent ± 2 percent combined paving asphalt and asphalt modifier, and 20 percent ± 2 percent CRM. The temperature of the blended asphalt and modifier shall be between 375°F (190°C) and 440°F (226°C) when the CRM is added. The temperature shall not exceed 10°F (6°C) below the actual flash point of the mixture. The CRM shall be combined and mixed together in an asphalt-rubber mechanical blender conforming to 203-11.5. The combined asphalt and CRM shall be pumped into a storage/reaction tank or distributor truck conforming to meeting the requirements of 203-11.5. The required mixing/reaction time shall be 45 minutes minimum. The temperature of the asphalt-rubber mixture shall be between 375°F (190°C) to 425°F (218°C) during the reaction period. After reacting, the asphalt rubber binder shall conform to the requirements shown in Table 203-11.4.

TABLE 203-11.4:

REQUIREMENTS FOR ASPHALT RUBBER BINDER

Test Parameter	Test Method	Specification Limit	
		Minimum	Maximum
Haake Field Viscosity @ 375°F (191°C), (Centipoise)	See 211-4	1500	4000
Cone Penetration @ 77°F (25°C),mm	ASTM D217	25	70
Resilient @ 77°F (25°C), % Rebound	ASTM D3407	18	—
Field Softening Point, °F (°C)	ASTM D36	52 (125)	74 (165)

The reacted asphalt rubber binder shall be maintained at a temperature of not less than 375°F (190°C) nor more than 425°F (218°C). If any of the material in a batch of asphalt rubber binder is not used within 4 hours after the 45-minute reaction period, heating of the material shall be discontinued. Any time the asphalt rubber binder cools below 375°F (190°C), and is then reheated, shall be considered a reheat cycle. The total number of reheat cycles shall not exceed 2. The material shall be uniformly reheated to a temperature of not less than 375°F (190°C)) nor more than 425°F (218°C) prior to use. Additional scrap tire CRM may be added to the reheated binder and reacted for a minimum of 45 minutes. The cumulative amount of additional scrap tire CRM shall not exceed 10 percent of the total binder weight. Reheated asphalt rubber binder shall conform to requirements shown in Table 203-11.4.

When permitted by the Engineer, asphalt-rubber binder produced on a contract for another agency and defined here as "hold over material", may be used in the Work if the initial agency certifies the following:

a) The total weight and type of material being held over.

b) The amount of CRM contained within the holdover load on a percentage basis.

c) The grade of paving asphalt and asphalt modifier used and its source.

d) Date of original mixing.

e) Number of reheat cycles.

In no case, will more than 20 tons (18 tonnes) of holdover material be allowed to be transferred from one project to another. In all cases, the holdover material when blended with new asphalt-rubber binder, shall conform to the requirements shown in Table 203-11.4.

203-11.5 Equipment for Production of Asphalt-Rubber. The Contractor shall utilize the following equipment for production of asphalt-rubber binder:

a) Asphalt Heating Tank. An asphalt heating tank equipped to heat and maintain the blended paving asphalt and asphalt modifier mixture at the necessary temperature before blending with the CRM. This unit shall be equipped with a thermostatic heat control device and a temperature reading device and shall be accurate to within ± 5°F (± 3°C) and shall be of the recording type.

b) Blender Equipment. A mechanical mixer for the complete, homogeneous blending of paving asphalt, asphalt modifier, and CRM. Paving asphalt and asphalt modifier shall be introduced into the mixer through meters. The blending system shall be capable of varying the rate of delivery of paving asphalt and asphalt modifier proportionate with the delivery of CRM. During the proportioning and blending of the liquid ingredients, the temperature of paving asphalt and the asphalt modifier shall not vary more than ± 25°F (± 14°C). The paving asphalt feed, the asphalt modifier feed and CRM feed, shall be equipped with devices by which the rate of feed can be determined during the proportioning operation. Meters used for proportioning individual ingredients shall be equipped with rate-of-flow indicators to show the rates of delivery and

resettable totalizers so that the total amounts of liquid ingredients introduced into the mixture can be determined. The liquid and dry ingredients shall be fed directly into the mixer at a uniform and controlled rate. The rate of feed to the mixer shall not exceed that which will permit complete mixing of the materials. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected by a reduction in the volume of material or by other adjustments. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly blended asphalt-rubber binder is produced. The Contractor shall provide a safe sampling device capable of delivering a representative sample of the completed asphalt-rubber binder of sufficient size to perform the required tests.

c) **Storage/Reaction Tank.** An asphalt-rubber binder storage/reaction tank equipped with a heating system that is equipped with a temperature reading device to maintain the proper temperature of the asphalt-rubber binder and an internal mixing unit capable of maintaining a homogeneous mixture of paving asphalt, asphalt modifier and CRM.

d) **Viscometers.** The Contractor shall supply a Haake Viscometer (or equivalent) conforming to 211-4 for use by the Engineer to verify the viscosity of the asphalt-rubber binder wherever a field laboratory is used. All asphalt concrete plants are required to have a field laboratory for use by the Engineer per 8-3.

The equipment shall be approved by the Engineer prior to use.

203-11.6 Mix Designs and Certifications. The optimum binder content for ARHM-GG mixes shall be determined by California Test Method 367 except that Step 2 regarding surface flushing shall not be used. Optimum binder content shall be determined by using a void content between 3 percent minimum to 6 percent maximum as approved by the Engineer. Compaction shall be in accordance with California Test Method 304 except for the following:

Mixing Temperatures:

Asphalt-rubber = 325°F to 360°F (163°C to 182°C)

Aggregate = 290°F to 325°F (143°C to 163°C)

Compaction Temperature = 290°F to 300°F (143°C to 149°C)

In addition to the formulations and certifications required in 203-11.2, 203-11.3 and 203-11.4 for asphalt-rubber, the Contractor shall furnish to the Engineer a mix design and samples of all materials to be used at least 10 Working Days before construction is scheduled to begin. The mix design and certifications shall include, but are not limited to, the following:

a) Combined aggregate gradation.
b) Individual bin gradations (hot for batch, cold for drum plant).
c) Percentage of each bin.
d) Asphalt rubber binder content.
e) Density.
f) Air Voids.
g) Voids in Mineral Aggregates (VMA).
h) Stability.
i) Aggregate source
j) Asphalt binder source

203-11.7 Mixing Binder With Aggregate. Mixing of the asphalt rubber binder with aggregate shall conform to 203-6.7 except that the temperature requirements of ARHM shall supercede the requirements in 203-6.7.

203-11.8 Storage. Storage of ARHM shall conform to 203-6.8.

203-11.9 Miscellaneous Requirements. Miscellaneous requirements shall conform to 203-6.9 except that the temperature of the asphalt rubber binder shall be 375°F (190°C) to 425°F (218°C) when added to the aggregate. The temperature of the aggregate at the time of adding the asphalt-rubber binder shall be 300°F (149°C) to 330°F (166°C).

203-12 ASPHALT RUBBER AND AGGREGATE MEMBRANE (ARAM).

203-12.1 General. ARAM consists of the application of asphalt rubber binder followed by the spreading of pre-coated, pre-heated screenings.

203-12.2 Asphalt Rubber Binder. Asphalt rubber binder shall conform to 203-11.

203-12.3 Pre-Coated, Pre-Heated Screenings. Pre-coated, pre-heated screenings shall conform to 200-1.2.2.3.

203-13 CRUMB RUBBER MODIFIED ASPHALT CONCRETE GAP GRADED (CRUMAC-GG).

203-13.1 General. CRUMAC-GG shall be the product of mixing mineral aggregate, paving asphalt and crumb rubber modifier (CRM) at a central mixing plant. The Contractor shall submit test reports and certificates of compliance for the paving asphalt and the CRM at the time of delivery to the Work site.

203-13.2 Materials.

203-13.2.1 Paving Asphalt. Paving asphalt shall be PG 64-16 conforming to 203-1.

203-13.2.2 Crumb Rubber Modifier.

203-13.2.2.1 General. CRM shall be scrap tire CRM conforming to 203-11.2.3.

203-13.2.2.2 Gradation. The CRM gradation shall conform to 203-11.2.3.1 and Table 203-13.2.2.2. The class of CRM gradation shall be the same as the class of aggregate gradation, i.e. CRM (CRUMAC-B) shall be specified with aggregate gradation CRUMAC-GG-B.

TABLE 203-13.2.2

SIEVE SIZE	CLASS	
	CRUMAC-B Min.-Max.	CRUMAC-C Min.-Max.
No. 10 (2.00 mm)	98-100	100
No. 16 (1.18 mm)	30-50	50-70
No. 30 (600 µm)	3-13	10-20
No.50 (300 µm)	0-6	3-8
No. 100 (150 µm)	0-2	0-3

203-13.2.3 Aggregate. Aggregate for CRUMAC-GG shall conform to 203-6.3.2.

203-13.3 Composition and Grading. CRUMAC-GG will be designated by type and class, i.e., CRUMAC-GG-C. The grading of the combined aggregates shall conform to Table 203-11.3.

203-13.4 Mix Designs. Mix designs shall conform to 203-11.6. The proportions of paving asphalt and CRM, by weight, shall be 82 ± 2 percent paving asphalt and 18 ± 2 percent CRM. Once the total percent of paving asphalt and CRM is determined by the mix design, the production tolerance for the combined materials shall be ± 0.5 percent as determined by California Test 382.

203-13.5 Aggregate Storing, Drying, and Screening. Aggregate storing, drying, and screening shall conform to 203-6.5.

203-13.6 Proportioning. Proportioning shall conform to 203-6.6, except that proportioning of CRM shall be performed using an automatic batching system. The CRM feeder gate shall be operated by a switch or starter. The CRM feeder system shall be able to deliver CRM to the mixer at an accuracy of 0.1 percent of the total weight of mix. The Contractor shall submit to the Engineer, in writing, the method proposed to deliver the CRM to the mixture in accordance with 2-5.3. The method and equipment proposed for use shall be so designated and accessible that the Engineer can visually observe the materials being incorporated into the mixture. When batch-type plants are used, the CRM shall be proportioned by weight. When dryer-drum plants are used, the systems provided shall maintain positive interlock between the flow of CRM, paving asphalt and aggregate.

203-13.7 Mixing. Mixing shall conform to 203-6.7, except that the aggregate and the CRM shall be combined and mixed thoroughly for a minimum of 5 seconds prior to introducing the paving asphalt. The paving asphalt, aggregate, and CRM shall be mixed for a minimum of 35 seconds. If the Engineer determines that the mixture is not thoroughly mixed or that the aggregate and CRM are not fully coated with paving asphalt, the mixing time shall be increased. The temperature of the mix at discharge shall be a minimum of 320 °F (161 °C) and a maximum of 350 °F (177°C).

203-13.8 Storage. Storage shall conform to 203-6.8.

203-13.9 Miscellaneous Requirements. Miscellaneous requirements shall conform to 203-6.9, except that CRUMAC shall be delivered to the Work site without segregation and within the temperature requirements specified in 302-11.2. No mix shall be delivered with segregation.

203-13.10 Acceptance. Acceptance of plant produced mixtures will be based upon gradation, combined paving asphalt and CRM content, and minimum stability values per Table 203-11.3. Air voids will not to be used as an acceptance criteria. Sampling and S-value moving average requirements shall conform to 203-6.4.1.

203-14 TIRE RUBBER MODIFIED ASPHALT CONCRETE (TRMAC).

203-14.1 General. TRMAC shall be the product of mixing mineral aggregate and tire rubber modified paving asphalt at a central mixing plant.

203-14.2 Materials.

203-14.2.1 Tire Rubber Modified Paving Asphalt. Tire rubber modified paving asphalt shall consist of paving asphalt containing ground scrap tire rubber. The scrap tire rubber shall be incorporated into the paving asphalt such that a smooth and homogeneous composition results. Tire rubber modified paving asphalt shall be designated as MAC-10TR or MAC-15TR and shall conform to the requirements shown in Table 203-14.2.1.

TABLE 203-14.2.1

Properties	Test Method No.	MAC-10TR	MAC-15TR
TESTS ON ORIGINAL ASPHALT:			
Minimum Recycled Whole Scrap Tire Rubber Content, %	CERTIFICATION	10.0	15.0
Penetration, at 25°C, 0.1 mm, 100 grams, 5 seconds	ASTM D5	40-60	40-60
Penetration, at 4°C, 0.1 mm, 200 grams, 60 seconds, Min.	ASTM D5	20	15
Dynamic Viscosity, at 140°F (60°C), Poise, Min.	ASTM D2171	5000	5000
Kinematic Viscosity, at 275°F (135°C), Centistokes, Max.	ASTM D2170	1000	1200
Flash Point, Cleveland Open Cup, °F (°C), Min.	ASTM D92	450 (232)	450 (232)
Softening Point, °F (°C), Min.	ASTM D36	127 (53)	127 (53)
Solubility in Trichloroethylene, %, Min.	ASTM D2042	97.5	97.5
TESTS ON RESIDUE FROM RTFO PROCEDURE:			
Penetration, at 25°C, 0.1 mm, 100 grams, 5 seconds	ASTM D5	20-40	20-40
Penetration, at 4°C, 0.1 mm, 200 grams, 60 seconds, Min.	ASTM D5	14	10
Dynamic Viscosity, at 140°F (60°C), Poise, Min.	ASTM D2171	20,000	20,000
Kinematic Viscosity, at 275°F (135°C), Centistokes, Max.	ASTM D2170	1500	2000
Percent of Original Penetration, at 25°C, 0.1 mm, 100 grams, 5 seconds, Min.	ASTM D5	50	50

The Contractor shall submit in accordance with 2-5.3 a Certificate of Compliance conforming to 4-1.5.

203-14.2.2 Aggregate. Aggregate shall conform to 203-6.3.2.

203-14.2.3 Mineral Filler Mineral filler shall conform to 203-6.3.3.

203-14.3 Composition and Grading. TRMAC will be designated by class and tire rubber content for dense-graded mixes (i.e., "C2-TRMAC-10"); and by tire rubber content and type for gap-graded mixes (i.e., "TRMAC-15-GG-C").

The composition and grading of dense-graded mixes shall conform to 203-6.4.3.

Gap-graded mixes shall conform to the composition requirements shown in Table 203-14.3 and the requirements for the grading of the combined aggregates shown in Table 203-11.3.

TABLE 203-14.3

Properties	Requirements
% MAC-10TR or MAC-15TR by Weight of Dry Aggregate*	5.0 – 7.0
Air Voids % California Test 367	3 – 6
Stabilometer Value per California Test 304 and 366, Min.	23
Voids in Mineral Aggregate Percent, Min.	16

*Once the percent MAC-10TR or MAC-15TR is determined by the mix design, the production tolerance shall be ± 0.5% as determined by California Test method 362, 379, or 382.

203-14.4 Mix Designs. Mix designs for dense-graded mixes shall conform to 203-6.2. Mix designs for gap-graded mixes shall conform to 203-6.2 and the composition and grading requirements specified in 203-14.3.

203-14.5 Aggregate Storing, Drying, and Screening. Aggregate storing, drying, and screening shall conform to 203-6.5.

203-14.6 Proportioning. Proportioning shall conform to 203-6.6.

203-14.7 Mixing. Mixing shall conform to 203-6.7 except that the temperature of the aggregates at the time of adding tire rubber modified paving asphalt shall not exceed 350°F (176°C) nor be less than 300°F (149°C).

203-14.8 Storage. Storage shall conform to 203-6.8.

203-14.9 Miscellaneous Requirements. Miscellaneous requirements shall conform to 203-6.9.

203-14.10 Acceptance. Acceptance of plant-produced mixtures will be based upon gradation, tire rubber modified paving asphalt content, and the minimum stabilometer value shown in Table 203-14.3. Air voids will not be used as an acceptance criteria. Sampling and S-value moving average requirements shall conform to 203-6.4.1.

203-15 POROUS ASPHALT CONCRETE.

203-15.1 General. Porous asphalt concrete shall be the product of mixing open-graded mineral aggregate with paving asphalt at a central mixing plant.

203-15.2 Materials.

203-15.2.1 Paving Asphalt. Paving asphalt shall:

a) conform to 203-1,

b) be one performance grade higher than that established by the State of California for the climate region of the Work site unless otherwise specified in the Special Provisions, and

c) contain 0.5 percent liquid antistrip by weight of paving asphalt.

203-15.2.2 Aggregate. Aggregate shall conform to 203-6.3.2.

203-15.2.3 Mineral Filler. Mineral filler shall conform to 203-6.3.3.

203-15.2.4 Liquid Antistrip. Liquid antistrip storage and method of introduction shall conform to the manufacturer's recommendations. Liquid antistrip shall be introduced into the paving asphalt by the paving asphalt producer. Liquid antistrip shall not be substituted for paving asphalt. Only one type or brand may be used at any one time during production. The total amine value shall be 325 minimum when tested in accordance with ASTM D2074.

203-15.3 Composition and Grading. The grading of the combined aggregates shall conform to the requirements shown in Table 203-15.3 (A) unless otherwise specified in the Special Provisions.

TABLE 203-15.3 (A)

Sieve Size	Percentage Passing Sieves
3/4 in (19.0 mm)	100
1/2 in (12.5 mm)	95-100
3/8 in (9.5 mm)	74-93
No. 4 (4.75 mm)	24-41
No. 8 (2.36 mm)	3-22
No. 16 (1.18 mm)	0-10
No. 200 (75 µm)	0-3

Porous asphalt concrete shall conform to the requirements shown in Table 203-15.3 (B).

TABLE 203-15.3 (B)

Properties	Requirements
Paving Asphalt, %	6.0 % min.
Air Voids, %, California Test 309 *	18% min.
Draindown, ASTM D6390 or CT 368	0.30% max.

* Compact specimen and determine bulk specific gravity in accordance with CT 308 Method B.

203-15.4 Job Mix Formula (JMF) and Mix Designs. JMFs and mix designs shall conform to 203-6.2 and 203-15.3.

203-15.5 Aggregate Storing, Drying, and Screening. Aggregate storing, drying, and screening shall conform to 203-6.5.

203-15.6 Proportioning. Proportioning shall conform to 203-6.6.

203-15.7 Mixing. Mixing shall conform to 203-6.7.

203-15.8 Storage. Storage shall conform to 203-6.8. Porous asphalt concrete shall not be stored in a silo in excess of 2 hours.

203-15.9 Miscellaneous Requirements. Miscellaneous requirements shall conform to 203-6.9. Porous asphalt concrete shall be completely covered with tarpaulins during transport. The material temperature at the time of delivery to the Work site shall not exceed 275° F (135° C).

203-15.10 Acceptance. Acceptance will be based upon gradation and paving asphalt content.

SECTION 204 - LUMBER AND TREATMENT WITH PRESERVATIVES

204-1 LUMBER AND PLYWOOD.

204-1.1 Kinds.

204-1.1.1 General. Structural lumber shall be of the kinds and grades indicated on the Plans or in the Special Provisions. Proper allowance for shrinkage in the lumber shall be made by the Contractor where it is necessary to meet definite dimensions shown on the Plans. All sizes refer to nominal sizes. Rough and dressed sizes shall conform to the sizes set forth in the American Lumber Standards.

204-1.1.2 Douglas Fir. Unless otherwise specified, all lumber shall be Douglas fir and shall be selected as to grade and shall conform in all particulars to the Standard Grading Rules for Western Lumber, published by the Western Wood Products Association and approved by the American Lumber Standards Committee.

204-1.1.3 Redwood. Redwood lumber shall conform in all particulars to the Standard Specifications for Grades of California Redwood of the Redwood Inspection Service.

204-1.1.4 Plywood. Plywood shall be manufactured and graded in accordance with the rules of the American Plywood Association and the latest Product Standard for Softwood Plywood, Construction and Industrial, of the National Bureau of Standards.

204-1.2 Lumber Uses and Grades. Unless otherwise specified, lumber quality for the uses listed shall not be less than the grades in Table 204-1.2.

TABLE 204-1.2

USES	GRADES
Major permanent construction, such as bridges.	"Select Structural" for main structural members. "No. 1" for beams, stringers, joists, and planks. "Select Structural" when redwood is specified.
Minor permanent construction, such as bulkheads, retaining structures, headers for bituminous pavement, wooden warning rails, posts for metal beam guard rails.	"No.1" for posts, joists and planks. "Construction" for boards.
Wooden warning rail posts, guide posts, sign posts.	"Select Structural" redwood. (No. 1 grade Douglas fir optional for wooden warning rail posts.)
Studs, headers, and wales for formwork. Form sheathing for non-showing surfaces of concrete.	"Standard", "No. 4 Common", or "No. 3"; any exterior-type grade of plywood optional for form sheathing.
All exposed surfaces of bridges, viaducts, over-crossing; soffits and sides of beams and girders; slabs between beams and girders; headwalls and endwalls of culverts or covering conduits; form sheathing for showing surfaces of retaining walls, channel walls, etc.	"Exterior B-B" (concrete form) grade of plywood.

204-1.3 Grade Marking.

204-1.3.1 Lumber. All lumber shall be grade marked by a lumber grading agency certified by the American Lumber Standards Committee.

204-1.3.2 Plywood. Each sheet of plywood shall bear the official stamp of a quality control agency stating the grade of the sheet.

204-2 TREATMENT WITH PRESERVATIVES.

204-2.1 General. Wood shall be conditioned, seasoned, prepared, and treated by the pressure process in accordance with the applicable standards in the AWPA Book of Standards.

All cutting, adzing, boring, chamfering, framing, graining, surfacing, and trimming shall be done prior to treatment.

With the exception of southern yellow pine and ponderosa pine, all lumber and timber with a nominal thickness of 2 inches (50 mm) and over shall be incised on all sides to ensure penetration in accordance with AWPA Standards. Lumber edge-worked to pattern (such as T&G) other than S4S need not be incised on the edges.

204-2.2 Wood Preservatives. The preservative used shall be one of the following:

a) Oil-borne preservatives;

b) Water-borne preservatives;

c) Fire-retardant treatment (either exterior or interior type).

Preservatives and the selection of preservatives shall conform to the requirements in the AWPA Book of Standards for the AWPA Use Category System specified in the Special Provisions. The retention and penetration for each preservative shall be equal to, or greater than, the minimums specified.

Fire-retardant treated wood shall conform to NFPA 703-Standard for Fire Retardant Impregnated Wood.

Unless otherwise specified in the Special Provisions, preservatives used for wood in contact with ground or fresh water shall be limited to:

a) Copper Napthenate

b) Alkaline Copper Quaternary (ACQ) Compounds

c) Copper Azole (CA-B)

Unless otherwise specified in the Special Provisions, preservatives used for wood subjected to marine (salt water) exposure shall be limited to:

a) Ammoniacal Copper Zinc Arsenate (ACZA)

b) Chromated Copper Arsenate (CCA)

c) Creosote

d) Pentachlorophenol

204-2.3 Field Treatment of Cut Surfaces. When cutting or drilling becomes necessary after plant treatment, the cut or drilled surfaces shall be given protection by field treatment in accordance with provisions of AWPA Standard M4.

204-2.4 Quality Control. All materials treated shall be subject to inspection. The inspection and marking shall be in accordance with AWPA Standard M2.

Inspection shall be performed by an American Lumber Standard Committee accredited agency.

A manufacturer's Certificate of Compliance and explanation of the markings or codes shall be submitted with each delivery to the Work site.

204-2.5 Handling and Protection of Treated Materials. Care shall be exercised to not damage the edges or abrade the surfaces to the extent of reducing the depth of treated wood or exposing any wood not penetrated. Cant hooks, peavies, sharp-pointed tools, and the use of metal slings without protective guards shall not be used for the handling of treated lumber. Treated piling may be handled with pointed tools, provided that side surfaces are not penetrated over 1/2 inch (12.5 mm). Handling tools and loading devices shall not be used in the groundline area of poles. All damage such as abrasions, nail and spike holes, shall be thoroughly saturated with the field treating solution in accordance with AWPA Standard M4.

Material that is stored at the Work site prior to its use shall be stacked neatly on skids, and shall be protected from the sun and weather.

SECTION 205 - PILES

205-1 TIMBER PILES.

205-1.1 General. Timber piles shall be Douglas fir, unless otherwise shown on the Plans or specified in the Special Provisions.

205-1.2 Quality. Piles shall conform to ASTM D25 for Class B piles and the requirements contained herein. Piles shall be cut from sound, live, close-grained trees and shall be free from large, loose, or unsound knots, scars, decay, holes, insect damage, barnacles, limnoria, or other forms of sea life, and other defects or imperfections that would materially impair their strength or durability.

All piles shall be machine-peeled and all inner skin shall be removed. All branch stubs and partially overgrown knots shall be neatly trimmed flush with the surface, and the butts and tips shall be sawed square with the longitudinal axis of the pile.

No cracks will be permitted in any pile. Splits, shakes, and checks will be permitted only to the extent provided herein. A crack is defined as a break across the grain of the wood extending from surface to surface through the pile; a shake is defined as a separation of the wood along the annual rings; and a check is defined as a lengthwise separation of the wood across the rings of annual growth. A

through check or compound check is defined as a check extending from surface to surface, either through the pith center or shunted around by a shake.

Splits in piles shall not be longer than the butt diameter. The length of any shake or combination of shakes in the outer half of the radius of the butt of the pile, when measured along the curve of the annual ring, shall not exceed one-third of the circumference of the butt of the pile.

Any check that would impair the strength of the pile will be cause for rejection, but in no case will any check exceeding 3/4 inch (19 mm) in width be allowed. Any compound or through check, regardless of length, will be cause for rejection.

Spiral grain shall not exceed one-half of a complete twist in any 20 feet (6 m) of length.

Sound knots in piles 50 feet (15 m) or less in length, and in 3/4 of the length from the butt of piles longer than 50 feet (15 m), shall be no longer than 4 inches (100 mm) or 1/3 of the diameter of the pile at the point where they occur, whichever is smaller. Sound knots in the remaining 1/4 of the length of piles longer than 50 feet (15 m) shall be no larger than 5 inches (125 mm) or 1/2 of the diameter of the pile at the point where they occur, whichever is the smaller. The size of a knot shall be its diameter measured at right angles to the length of the pile.

Unsound knots or knot clusters will not be permitted. A knot cluster is two or more knots grouped together, the fibers of the wood being deflected around the entire unit. A group of single knots, with fibers deflected around each knot separately, is not a cluster, even though the knots may be in close proximity. The sum of sizes of all knots in any foot of length of the pile shall not exceed twice the size of the largest single knot permitted.

Holes less than 1/2 inch (12.5 mm) in average diameter will be permitted in piles, provided the sum of the average diameters of all holes in any 1 square foot (0.1 m^2) of pile surface does not exceed 1-1/2 inches (38 mm).

The presence of invisible internal checks, and shattering or water-burses, shall be determined by sounding with a suitable hammer, and a resultant hollow or shattered sound will be sufficient cause for rejecting the pile.

The requirements prescribed herein relative to cracks, splits, shakes, and checks shall apply equally to treated and untreated piles, and any such defects that develop or occur as a result of any treating operation may be cause for rejection.

No nails, spikes, or other metal shall be present in any timber pile unless specifically authorized by the Engineer.

205-1.3 Dimensional Requirements. The diameter of a pile at any section shall be considered as the average diameter at such section measured at right angles to the longitudinal axis of the pile; but in determining an average diameter, no single diameter that is more than 10 percent greater than the least diameter at the same section shall be used. The butt and tip diameters shall be such as to conform with the requirements indicated in the following tabulation and the diameter 3 feet (1 m) from the butt shall not be smaller than 1 inch (25 mm) less than that at the butt.

TABLE 205-1.3

Length Feet (Meters)	3 Ft (1 m) From Butt				All Tip Minimum	
	Minimum		Maximum			
	Circumference inches (mm)	Approx. Dia. inches (mm)	Circumference inches (mm)	Approx. Dia. inches (mm)	Circumference inches (mm)	Approx. Dia. inches (mm)
Under 40 (12)	38 (965)	12 (305)	63 (1600)	20 (510)	25 (635)	8 (203)
40-54 (12-16)	38 (965)	12 (305)	63 (1600)	20 (510)	22 (559)	7 (178)
55-74 (17-22)	41 (1040)	13 (330)	63 (1600)	20 (510)	22 (559)	7 (178)
75-90 (23-27)	41 (1040)	13 (330)	63 (1600)	20 (510)	19 (483)	6 (152)
Over 90 (27)	41 (1040)	13 (330)	63 (1600)	20 (510)	16 (406)	5 (127)

The average diameter of the heartwood at the butt of Douglas fir piles that are to be treated shall be not less than 70 percent, and of those that are to be used untreated not less than 75 percent, of the average outside butt diameter of the pile.

A straight line from the center of the butt to the center of the tip pile shall lie entirely within the body of the pile.

Piles shall be free from short crooks in which the deviation from straightness in any 5 feet (1.5 m) of length anywhere exceeds 2-1/2 inches (63 mm). Short crooks shall also comply with the requirements for straightness.

The individual lengths in which timber piles are to be furnished shall be as stipulated by the Plans, Specifications, requisition, or purchase order issued in connection therewith. Unless otherwise prescribed, as many as 30 percent of the number furnished on any single order or in any single lot may run as much as 2 feet (0.6 m) longer than the specified lengths.

205-2 STEEL PILES.

205-2.1 General. Steel piles furnished under this specification shall consist of structural steel shapes that fulfill the requirements prescribed for such material in ASTM A36 and shall conform to the details and dimensions shown on the Plans and Special Provisions relating directly thereto.

Splices in steel piles shall be made by a full penetration butt weld of the entire cross section. Care shall be taken to properly align adjacent sections so that the axis of the pile will be straight. The number of splices in the length of the pile shall be limited to 2. Splices in the top 10 feet (3 m) of the piles will not be permitted. The locations of pile lugs, when used, shall be subject to the approval of the Engineer. All weldings shall be performed by qualified welding operators in accordance with 304-1.9.

205-2.2 Manufacturing Requirements. Material for steel piles shall not be made by the acid Bessemer process.

Steel sheet piling shall consist of standard interlocking sheet pile sections having positive interlocks in both longitudinal and transverse directions which are continuous throughout the entire length of the piece.

205-3 CONCRETE PILES.

205-3.1 General. The types of concrete piles covered by these specifications are precast, cast-in-place, and prestressed piles. The type to be used or furnished shall be as shown on the Plans or in the Special Provisions. Steel and concrete shall be placed in accordance with 303-1. Portland cement concrete and reinforcing steel shall conform to the provisions of 201-1 and 201-2.

Compressive strength tests for precast and pre-stressed piles shall be performed in accordance with 201-1.1.5.

205-3.2 Precast Piles. Precast concrete piles shall be of such quality that the finished piles can be handled and driven to required bearing without cracking or other damage which would impair their strength or durability. Concrete shall have a minimum strength of 4,000 psi (27.6 MPa) at 28 Days.

Concrete for precast concrete piles shall be cast in smooth, mortar-tight forms so supported as to prevent deformation or settlement during concrete placement or curing. The piles after being cast shall be cured by water, steam, curing compound, or other such methods of curing as may be approved by the Engineer. Curing shall be continued until specimens of the concrete from which the piles were cast attain a compressive strength of at least 4,000 psi (27.6 MPa). Piles shall not be driven until completion of the specified curing.

The piles shall present true, smooth, even surfaces, free from honeycombs or voids and shall be sufficiently straight that a line stretched from butt tip along any face will not deviate nor be deflected for more than 1 inch (25 mm) in 50 feet (15 m) at any point. Defects in any pile may be accepted if repaired to the satisfaction of the Engineer.

Concrete piles may be cast the full length of the reinforcing bars provided that, after the piles have been driven, the concrete is removed to expose the steel as shown on the Plans.

205-3.3 Cast-in-Place Concrete Piles.

205-3.3.1 Metal-Cased Cast-in-Place Concrete Piles. Piles shall be cast in steel shells that have been previously driven to the penetration or bearing value required by the Engineer.

The shell shall be cylindrical and may be fluted, step-tapered, or uniformly tapered from butt to tip.

Shells that are driven without a mandrel shall be equipped with steel driving tips and shall be constructed of material conforming to the requirements prescribed in ASTM A252, Grade 2. They shall be of sufficient thickness (9 gage (3.8 mm) minimum), strength, and rigidity to withstand distortion from driving, soil pressure, or the driving of adjacent piles. Continuous welds shall be used at all shell splices to develop the full strength of the section.

After being driven, but prior to placing of the reinforcing steel and concrete, the shells shall be examined for collapse or reduced diameter. The Contractor shall have available at all times a suitable light for the inspection of the shell throughout the entire length. Shells that are improperly driven, broken, or show partial collapse shall be replaced by and at the expense of the Contractor. Partial collapse of shells shall be interpreted to mean any collapse which reduces any diameter to less than 80 percent at any point. The replacement of the shell shall be made by withdrawing the entire shell and driving another in its place. Driving one shell within a shell is not permitted. If the withdrawal of the defective shell is impossible or impractical, as determined by the Engineer, the Contractor shall fill the defective shell with concrete and shall replace the defective pile with another pile driven alongside. Any enlargement of the footing required to accommodate such piling shall be at Contractor's expense.

Driven shells shall be clean and free of water before reinforcing steel and concrete are placed therein. Concrete shall be vibrated to within 5 feet (1.5 m) of the tip of the shell.

205-3.3.2 Piles Cast in Drilled Holes. All holes for concrete piles cast in drilled holes shall be drilled dry to the tip elevations and diameter shown on the Plans or to the elevation determined by the Engineer. Any hole which shows less than 1/2 the diameter of the hole at the bottom shall be rejected. Suitable casings shall be furnished and placed when required to prevent caving of the hole before concrete is placed therein.

All loose material and water, existing at the bottom of the hole after drilling operations have been completed, shall be removed before placing concrete in the hole.

If the casing is to be removed, it shall be removed from the hole as concrete is placed therein. The bottom of the casing shall be maintained not more than 5 feet (1.5 m) nor less than 1 foot (0.3 m) below the top of the concrete during withdrawal and placing operations, unless otherwise permitted by the Engineer. Damage to the concrete during withdrawal and placing operations shall be avoided by hammering or vibrating the casing.

The Contractor shall ensure that the concrete in the hole is dense and homogeneous. Vibration of the concrete during placing will not be permitted. However, rodding may be required. After the hole has been filled with concrete, the concrete in the top 10 feet (3 m) of the hole or for the length of the reinforcing, whichever is the greater, shall be vibrated.

The Contractor shall ensure that the concrete in the hole is dense and homogeneous. Vibration of the concrete during placing will not be permitted. However, rodding may be required. After the hole has been filled with concrete, the concrete in the top 10 feet (3 m) of the hole or for the length of the reinforcing, whichever is the greater, shall be vibrated.

205-3.4 Prestressed Concrete Piles.

205-3.4.1 General. The manufacture of prestressed piles shall be performed in accordance with 303-3. Concrete shall have a minimum strength at 28 Days of 5,000 psi (34.5 MPa). Piles shall be of such quality that the finished piles can be handled and driven to required bearing without cracking or other damage which would impair their strength or durability. Piles shall present true, smooth, even surfaces free from honeycombs or voids and shall be sufficiently straight that a line stretched from butt to tip along any face will not deviate more than 1 inch (25 mm) in 50 feet (15 m) at any point. Piles showing defects in the upper 10 feet (3 m) which reduce the cover over the steel to less than required, will be rejected. Defects in the remainder of the pile may be accepted if repaired in a manner satisfactory to the Engineer.

Prestressed forces shall not be transferred to the piles until the concrete has attained a strength of 3,500 psi (24.1 MPa).

205-3.4.2 Handling and Driving. Prestressed concrete piles shall be lifted or supported only at the points shown on the approved Shop Drawings. Piles shall not be driven until they have attained a minimum compressive strength of 5,000 psi (34.5 MPa) as determined by tests on concrete cylinders cast and cured under the same conditions as the piles.

SECTION 206 - MISCELLANEOUS METAL ITEMS

206-1 STRUCTURAL STEEL, RIVETS, BOLTS, PINS, AND ANCHOR BOLTS.

206-1.1 Requirements.

206-1.1.1 General. All steel, the class of which is not definitely designated herein, in the Special Provisions, or on the Plans, shall be structural steel and shall conform to the requirements of ASTM A36. Steel manufactured by the acid Bessemer process shall not be used.

206-1.1.2 Certification. The Contractor shall furnish to the Engineer, before fabrication, a mill certified report (in duplicate) of the tests for each heat of steel or iron from which the material is to be fabricated. The certification shall contain the results of chemical and physical tests required by ASTM standards for materials.

206-1.1.3 Additional Tests. The Agency reserves the right to require or make additional mill and laboratory tests. The number of such additional tests will be limited as follows, except that in case of failure of the material to comply with the ASTM requirements, more tests may be made or the material rejected:

a) Structural steel - One complete test for each heat number or each 10 tons (9 tonnes) of identifiable stock

b) Rivets - One complete test for each size

c) Bolts - One complete test for each lot

"Identifiable stock" is material for which authentic records of the chemical and physical properties are available.

Test specimens shall be furnished cut and machined in accordance with the ASTM standards for the material to be tested, as referred to herein.

206-1.1.4 Stock Material. When the Contractor proposes to use material already in stock, it shall notify the Engineer of such intention at least 10 Days in advance of beginning fabrication.

206-1.1.5 Mill Tolerance. Rolling and cutting tolerances, permissible variations in weight and dimensions, defects, and imperfections shall not exceed the limits contained in ASTM A6.

206-1.2 Structural Steel.

206-1.2.1 Stock Materials. The Contractor shall select the material intended for use from stock and place it in location apart from other stock material and accessible for inspection and sampling. It shall also select the material from as few heat numbers as possible and shall furnish certified mill test reports for each of the heat numbers. Two samples shall be taken by the Engineer from each heat number; one for the tension test and one for the cold-bend test. If the heat numbers cannot be identified, the Engineer may select random test specimens from the unidentifiable heats.

206-1.2.2 High-Strength Low-Alloy Structural Steel. The material shall conform to the requirements of ASTM A242, A440, A441, A606, A607, or A446 (Grades C, D, or E) as specified.

206-1.2.3 Copper Bearing Structural Steel. Copper bearing structural steel shall conform to requirements of ASTM A36, A440, A446, A570 or A611 as specified.

206-1.3 Rivets.

206-1.3.1 Stock Material. Rivets taken from identifiable stock may be accepted by the Engineer based on certified mill test reports.

Rivets from unidentifiable stock shall not be used except where shown on Shop Drawings.

206-1.3.2 High-Strength Structural Steel Rivets. The material shall conform to the requirements of ASTM A502.

206-1.3.3 Structural Steel Rivets. The material shall conform to the requirements of ASTM A502, except that the test specimen shall be bent upon itself when performing the bend test.

206-1.4 Bolts.

206-1.4.1 Unfinished Bolts. The bolts shall have square heads and square nuts unless otherwise specified. The bolts shall be long enough to extend entirely through the nut but not more than 1/4 inch (6 mm) beyond. Washers shall not be furnished unless specified. Bolts shall be of steel conforming to the requirements of ASTM A307.

206-1.4.2 High-Strength Bolts. Shall conform to ASTM A325.

206-1.4.3 Anchor Bolts. Shall be manufactured from steel conforming to ASTM A36 or A307.

206-1.5 Mild Steel Forgings for Structural Purposes.

Steel forgings shall conform to the requirements of ASTM A325. They shall be Class C forgings with a maximum carbon content of 0.35 percent and shall be given a thorough annealing. The metal shall have a minimum Brinell hardness of 130 and a maximum of 190, when tested in accordance with ASTM E10.

206-2 STEEL CASTINGS.

206-2.1 General. Steel castings shall be true to pattern in form and dimension and free from defects that would affect the service value of the casting. Minor defects which do not impair the strength of the casting may be repaired with the approval of the Engineer. Castings which have been repaired without the permission of the Engineer may be rejected. Chemical analysis shall be performed in accordance with ASTM E30.

206-2.2 Test Specimens. When required by the Agency, test coupons shall be poured monolithically with the castings. If, in the opinion of the manufacturer, the design of the casting is such that test coupons should not be attached thereto, the test coupons shall be cast attached to separate blocks. Two coupons shall be cast to represent each lot. A lot shall be considered as all castings from a melt which constitutes a part of a charge. Coupons shall remain attached until properly identified by the Engineer. Where test coupons are cast separately from the castings, the Engineer shall be notified of the time of pouring so as to permit him to identify both coupons and castings. Coupons cast separately from the castings shall not be detached from the block to which they are fastened until identified by the Engineer.

Test specimens shall be furnished and machined in accordance with ASTM A370 at the Contractor's expense.

If the results of the tests for any lot do not conform, the entire lot will be rejected.

206-2.3 High-Strength Steel Castings for Structural Purposes. Castings shall conform to ASTM A148, Grade 80-50, except that the steel shall contain not less than 0.60 percent of manganese and not less than 0.20 percent of silicon.

206-2.4 Mild-to-Medium Carbon-Steel Castings for General Application. Castings shall conform to ASTM A27, Grade 65-35. The metal shall have a minimum Brinell hardness number of 130 when tested in accordance with ASTM E10.

206-3 GRAY IRON AND DUCTILE IRON CASTINGS.

206-3.1 General. This subsection provides material specifications for gray and ductile iron castings. Castings shall be coated or uncoated as specified in the Special Provisions or shown on the Plans.

206-3.2 Materials.

206-3.2.1 Castings for Vehicular Traffic Areas. Vehicular traffic areas shall be defined as streets, highways, alleys, parking lots, bike lanes, driveways and other areas intended for use by motor vehicles.

Gray iron castings shall conform to ASTM A48/A48M, Class 35B, or AASHTO M105, Class 35B. Ductile iron castings shall conform to ASTM A536/A536M, grade 80-55-06.

206-3.2.2 Castings for Non-Vehicular Traffic Areas. Non-vehicular traffic areas shall be defined as sidewalks, bike paths, and other areas intended for use by pedestrians and bicyclists.

Gray iron castings shall conform to ASTM A48/A48M, Class 30B, or AASHTO M105, Class 30B. Ductile iron castings shall conform to ASTM A536/A536M grade 65-45-12 or grade 80-55-06.

206-3.2.3 Railings, Railing Posts, and Wheel Guards. Gray iron castings shall conform to ASTM A48/A48M, Class 40B, or AASHTO M105, Class 40B. Ductile iron castings shall conform to the requirements specified in the Special Provisions or shown on the Plans.

206-3.2.4 Rockers, Rocker Plate Bearings, and Bearing Plates for Bridges. Gray iron castings shall conform to ASTM A48/A48M, Class 50B, or AASHTO M105, Class 50B.

206-3.3 Manufacturing and Finishing.

206-3.3.1 General. The dimensions of the finished casting shall be as shown on the Plans. The as-cast dimensions may vary by 1/2 the maximum shrinkage of the metal or ± 1/16 inch per foot (± 5 mm/m).

206-3.3.2 Manhole Frame and Cover Sets and Grates. Manhole covers and grates shall seat into the frame such that the top surface of the cover or grate is flush with the top surface of the frame. The cover or grate shall sit within 1/8 inch (3 mm) of the frame at any point.

Circular manhole frames shall be fabricated with a machined horizontal bearing surface. Covers and grates shall seat firmly into the frame and not rock when rotated to any position in the frame. The cover or grate shall not sit higher than 1/16 inch (1.5 mm) above the frame for a distance greater than 1/4 of the frame circumference.

Square and rectangular frames shall be fabricated with an as-cast bearing surface.

206-3.3.3 Railings, Railing Posts, and Wheel Guards. Castings shall be machined and finished as specified in the Special Provisions or shown on the Plans.

206-3.3.4 Rockers, Rocker Plate Bearings, and Bearing Plates for Bridges. Castings shall be machined and finished as specified in the Special Provisions or shown on the Plans.

206-3.4 Testing.

206-3.4.1 General. Tensile testing, proof-load testing, or both shall be performed as specified in the Special Provisions. No separate payment will be made for the material specimens, test bars, machining, testing, and inspection required in these specifications.

206-3.4.2 Tensile Testing.

206-3.4.2.1 General. Test bars shall be tested at a laboratory approved by the Engineer. The Engineer shall be notified of the time of the melt and the time of testing to permit identification of both the test bars or coupons and the castings. The Engineer may select the test bars to be tested and may be present during testing. The Contractor shall submit in accordance with 2-5.3 a Certificate of Compliance with laboratory test results.

206-3.4.2.2 Gray Cast Iron Castings. Testing shall be performed in accordance with ASTM A48/A48M.

Test bars shall be provided and machined by the manufacturer to the dimensions specified for Type B test bars in AASHTO M105 Specimen B or ASTM A48/A48M.

Test bars cast on and with a casting shall be cast such that when removed, the breakage pattern remains on the member. Test bars shall be of sufficient size for the manufacturer to produce a machined test specimen with the dimensions specified for "Type B" test bars as shown in Table 3 of AASHTO M105 or ASTM A48/A48M. For lots of 30 or less, a minimum of 3 test bars shall be tested. For lots greater than 30, 10 percent of all the test bars shall be tested.

Test bars cast separately from the casting shall be machined and tested at the laboratory approved by the Engineer. The Certificate of Compliance shall state that the test bar was cast integral with the casting it represents and that the testing and results were obtained as specified.

206-3.4.2.3 Ductile Iron Castings. Testing shall be performed in accordance with ASTM A536/A536M as modified herein.

Test bars shall be machined by the manufacturer to the dimensions specified in ASTM A536/A536M. The size of the test bars shall be as specified in the Special Provisions. Test bars shall be marked for identification of the casting represented by the coupons and test bars.

At the time of manufacture, test bars shall be cast from the same melt. Test bars shall be machined and tested at the laboratory approved by the Engineer. The Contractor shall submit in accordance with 2-5.3 a Certificate of Compliance conforming to 4-1.5 with laboratory test results. The Certificate of Compliance shall

state that the test bar was cast integral with the casting it represents and that the testing and results were obtained as specified.

206-3.4.2.4 Test Results. If any of the test bars fail, 3 additional test bars shall be tested. The Engineer may select the test bars. If any of the additional test bars fail, the lot shall be rejected.

206-3.4.3 Proof-Load Testing.

206-3.4.3.1 General. Proof-load testing shall be performed in accordance with AASHTO M306 as modified in these specifications. Testing shall be performed at a facility approved by the Engineer. The Engineer shall be notified a minimum of 14 Days before the scheduled date of testing and may elect to be present.

Castings shall be loaded to the proof-load specified in the Special Provisions or shown on the Plans. The loads shall be concentrated on a 9-inch x 9-inch x 1 inch (225 mm x 225 mm x 25 mm) minimum thickness steel plate placed on a 9-inch x 9-inch x 1/4 inch (225 mm x 225 mm x 6 mm) thick rubber pad, with a shore D hardness of 30, centered on the assembled castings. Castings shall be supported in the same manner as they would be when placed in use. The specified load shall be applied by a calibrated testing machine and held for a period of 1 minute. Upon removal of the load, the castings shall be examined for cracks and permanent deformation. Castings subjected to proof-load testing shall be destroyed.

Additionally, for each lot of gray iron castings supplied with cast-on test bars, 3 assembled castings shall be proof-load tested. The castings may be selected by the Engineer. A lot shall be defined as consisting of no more than 100 complete units from the same foundry facility.

206-3.4.3.2 Test Results. The Contractor shall submit test results signed by a Registered Civil Engineer showing the ultimate strength of the castings conforms to the requirements of AASHTO M306.

In addition, each lot of gray iron castings with cast-on test bars shall conform to the following:

a) If each of the 3 assembled castings pass the test, the entire lot will be considered as complying with the load requirements.

b) If any of the 3 assembled castings fail to pass the test, then 5 additional assembled castings from the same lot shall be selected for testing.

c) If each of the 5 additional assembled castings pass the test, the remainder of the lot will be considered as complying with the Specifications, except for the previously failed casting(s).

d) If any of the 5 additional assembled castings fail, the entire lot will be rejected.

206-3.5 Workmanship. Before castings are removed from the foundry, they shall be smooth and cleaned by shot blasting and parting lines, gates, and risers ground flush. Castings that show injurious defects revealed by X-ray or machining operations shall be rejected.

Castings shall be rejected if an examination reveals cracks or permanent deformations exceeding 1/8 inch (3 mm).

Castings shall be true to pattern in form and dimension, and properly fit together. Castings shall be filleted boldly at angles and the risers shall be sharp and true. Parting lines, gates, and risers shall be ground flush.

Castings with minor defects may be reworked and resubmitted for approval by the Engineer. Castings that have been repaired without the permission of the Engineer shall be rejected. Welding plugs shall not be used.

206-3.6 Weight and Dimensions. Castings shall be inspected for conformance to the required weight and dimensions. The weight of each component shall not vary by more than ± 5 percent from the weight specified in the Special Provisions or shown on the Plans.

Castings that fail to conform to the required weight or dimensions shall be rejected. All remaining castings in the lot shall be inspected and shall conform to the Specifications.

206-3.7 Acceptance. The basis of acceptance will be the test results from the tensile testing, proof-load testing or both, as specified in the Special Provisions, and conformance to the required workmanship and weights and dimensions.

If so specified in the Special Provisions, a Certificate of Compliance shall be submitted to the Engineer in accordance with 2-5.3 in lieu of testing. The certificate shall state that the samples representing each lot have been tested, inspected, and conform to the Plans and Specifications. The certificate shall also state the country of origin of the castings. In addition, acceptance will be based on conformance to the required workmanship.

Castings that have been damaged prior to installation will be rejected.

206-4 BRONZE CASTINGS.

206-4.1 General. Bronze castings shall be true to pattern in form and dimension and free from defects that would affect the service value of the casting. Minor defects may be repaired with Engineer approval. Castings which have been repaired without Engineer approval may be rejected. Castings that show injurious defects revealed by machining operations or by X-ray will be rejected.

206-4.2 Testing Requirements. Chemical analysis shall be made in accordance with ASTM E54.

When required by the Agency, test coupons shall be provided as specified in 206-2.2 except specimens shall be prepared in accordance with ASTM B208.

206-4.3 Expansion and Bearing Plates. Expansion and bearing plates shall conform to the requirements of ASTM B22, Alloy C. The sliding contact faces shall be machined smooth to true planes. If practical, one plate shall be machined at right angles to other plates in the set.

206-4.4 Ornamental Tablets and Miscellaneous Castings.

206-4.4.1 General. Ornamental tablets, railings, miscellaneous ornaments, and fixtures shall conform to the chemical requirements of ASTM B584 Copper Alloy UNS No. C90300.

206-4.4.2 Bearing Plates. The letters shall be heavily raised and spaced carefully to secure a uniform and balanced effect over the entire area of the panel. The background of the letter panel shall have a finely pebbled surface. The model of the tablet shall be submitted to the Engineer for approval.

Castings shall be boldly filleted at angles, and the arises shall be sharp and true.

The faces and edges of all lettering and ornaments shall be tooled sharp and clean. Beveled edges shall be tooled smooth and true. Outside borders shall be straight and true and thoroughly polished. Filling and other tool marks shall be removed.

Ornaments, lettering, and the beveled edges shall be given a fine satin, hand finish. Lettering, bevels, and rosettes shall be highlighted; leaves and scrolls slightly highlighted, but well-polished. The pebble background shall be finished in dark statuary bronze and polished.

206-5 METAL RAILINGS.

206-5.1 Metal Hand Railings Materials. The fabrication of metal hand railings shall be in accordance with 304-2.

Steel railing material shall be welded or seamless steel pipe conforming to ASTM A53, structural steel conforming to ASTM A36, or tubular sections of hot rolled-mild steel, conforming to ASTM A501.

The base metal for aluminum railing shall be ASA alloy designation 6063-T6. Pipe and tubing shall be extruded conforming to requirements of ASTM B429, plates and sheets shall be rolled conforming to ASTM B209, and rods, bars, or shapes shall be extruded conforming to ASTM B221.

206-6 CHAIN LINK FENCE.

206-6.1 General. All materials and fittings shall be new and all ferrous materials shall be coated in accordance with 210-3. Class 1A steel pipe shall additionally be coated in accordance with 210-4. When specified, Class 1 or Class 1A materials shall additionally be clad coated with PVC in accordance with 210-5. The base material for the manufacture of steel pipe used for posts, braces, top rails, and gate frames shall conform to the requirements of ASTM F1083, Schedule 40, for Class 1 or ASTM A569 for Class 1A. Class 1A steel shall have a minimum yield strength of 50,000 pounds per square inch (345 MPa). All unit weights shall be subject to the standard mill tolerance of plus or minus 5 percent.

Posts shall be fitted with caps designed to fit securely over the posts and carry a top rail where specified. Posts shall have a total length of not less than the depth of the concrete footing, as specified herein, plus the length required above ground. Where no top rail is required, pipe posts shall be fitted with suitable caps. Caps will not be required for "C" or "H" section posts.

Top rails shall be furnished in random lengths of approximately 20 feet (6 m) where required.

Barbed wire shall be installed on the fence only when specifically required by the Plans or Special Provisions. When required, it shall be installed on extension arms of a type specified under 206-6.6.

206-6.2 Materials for Posts, Rails and Braces. Materials for posts, rails, and braces shall conform to Table 206-6.2.

206-6.3.1 Galvanized Fabric. Chain link fabric shall conform to the requirements of ASTM A392. The fabric shall be 11-gage (3.1 mm) for all fence 60 inches (1500 mm) or less in height and shall be 9-gage (3.8 mm) for all fence over 60 inches (1500 mm) in height, unless otherwise specified.

All chain link fabric shall be woven into approximately 2-inch (50 mm) mesh and galvanized either prior to or after fabrication, unless otherwise specified by the Contract Documents. Fabric 60 inches (1500 mm) or less in width shall have knuckled finish on the top and bottom edges. Fabric greater than 60 inches (1500 mm) in width shall have knuckled finish on the top edges and twisted and barbed finish on the bottom edge. Barbing shall be done by cutting the wire on the bias.

206-6.3.2 Polyvinyl Chloride (PVC) Coated Fabric. This specification covers PVC coated chain link fabric coated before weaving. PVC coated fabric shall conform to ASTM F668. Fabric may be produced in two classes of wire defined as follows: Class 1 shall consist of PVC extruded or extruded and adhered to zinc-coated steel wire. Class 2 shall consist of PVC fusion-bonded to zinc-coated steel wire. PVC coating thickness shall be a minimum 15 mils (380 μm) for Class 1 and 7 mils (180 μm) for Class 2. The core wire for the fabric shall be 0.120 inches (3.0 mm) for all fence 60 inches (1500 mm) or less in height and shall be 0.148 inches (3.76 mm) for all fence over 60 inches (1500 mm) in height unless otherwise specified. The specified diameter is the metallic core wire diameter and the PVC coating shall not be considered when determining the diameter.

All chain link fabric shall be woven into approximately 2-inch (50 mm) mesh. All fabric widths shall have knuckled finish on the top and bottom edges. At the time of fabrication, cut ends shall be covered with acrylic enamel. Acrylic enamel shall be a PVC resin in solution, consisting of high-level pigments, ultraviolet absorbers and solvent blends applied by brush or dabbing applicator.

206-6.4 Tension Wires and Fabric Ties. Tension wires shall be at least 7-gage (4.5 mm) galvanized coil spring steel wire.

Ties used to fasten the fabric to posts, rails, and gate frames shall be not smaller than 11-gage (3.1 mm) galvanized steel, 6-gage (4.9 mm) aluminum wire, or approved noncorrosive metal bands.

Tension bars used in fastening fabric to end and corner posts and gate frames shall be galvanized high carbon steel bars not smaller than 3/16 inch (9.5 mm) by 3/4 inch (19 mm).

TABLE 206-6.2

Use	Nominal[1] Type And Size	Actual O.D. inches (mm)	Weight lbs/ft (kg/m)	
			Class 1	Class 1A
End, corner, slope, and gate posts for single gates 6 feet (1.8 m) or less in width and double gates 12 feet (3.6 m) or less in width for fences less than 72 inches (1.8 m) in height.	2 NPS	2.375 (60.3)	3.65 (5.43)	3.12 (4.64)
End, corner, slope, and gate posts for single gates 6 feet (1.8 m) or less in width and double gates 12 feet (3.6 m) or less in width for fences 72 inches (1.8 m) or higher.	2-1/2 NPS	2.875 (73.0)	5.79 (8.62)	4.64 (6.91)
Gate posts for single swing gates over 13 ft (4 m) but not over 18 ft (5.5 m) in width and double swing gates over 26 ft (8 m) but not over 36 ft (11 m) in width.	3-1/2 NPS	4.0 (101.6)	9.11 (13.56)	— —
	3 NPS	3.5 (88.9)	— —	5.71 (8.50)
Gate posts for single swing gates over 13 feet (4 m) but not over 18 feet (5.5 m) in width and double swing gates over 26 feet (8 m) but not over 36 feet (11 m) in width.	6 NPS	6.625 (168.3)	18.97 (28.23)	—
Gate posts for single swing gates over 18 feet (5.5 m) in width and double-swing gates over 36 feet (11 m) in width.	8 NPS	8.625 (219.1)	24.70 (36.76)	—
Line posts for fences 72 inches (1.8 m) or higher.	2 NPS	2.375 (60.3)	3.65 (5.43)	3.12 (4.64)
	1-7/8 x 1-5/8 in (48 x 41 mm) C	—	2.15 (3.20)	— —
	2-1/4 x 1-7/8 in (57 x 48 mm) H	—	4.10 (6.10)	
Line posts for fences less than 72 inches (1.8 m) in height.	1-1/2 NPS	1.90 (48.3)	2.72 (4.05)	2.28 (3.39)
	17/8 x 1-5/8 in (48 x 41 mm) H	— —	1.85 (2.75)	
	17/8 x 1-5/8 in (48 x 41 mm) H	— —	2.80 (4.17)	—
Use	**Nominal[1] Type And Size**	**Actual O.D. inches (mm)**	**Weight lbs/ft (kg/m)**	
Top rails and braces.	1-1/4 NPS	1.660 (42.2)	2.27 (3.39)	1.83 (2.72)
	1-5/8 x 1-1/4 in (41 x 32 mm) C	— —	1.35 (2.01)	— —
	1-1/2 x 1-1/4 in (38 x 32 mm) H	— —	2.20 (3.27)	— —
Frames for gates.	1-1/2 NPS	1.900 (48.3)	2.72 (4.05)	2.28 (3.39)
Stiffeners for gates.	1-1/4 NPS	1.660 (42.2)	2.27 (3.39)	1.83 (2.72)

1. Nominal Pipe Size (NPS), a non-dimensional unit as defined in ASTM F1083.

206-6.3 Chain Link Fabric. Unless otherwise specified, shall conform to 206-3.1 or 206-6.3.2.

206-6.5 Truss or Tension Rods. Truss or tension rods used in trussing gate frames and line posts adjacent to end, corner, slope or gate posts shall be adjustable 3/8 inch (9.5 mm) diameter galvanized steel rod. When used in trussing line posts, adjustment shall be provided by means of galvanized turnbuckles or other suitable tightening devices.

206-6.6 Fittings. All required fittings and hardware shall be galvanized.

Couplings to connect the individual lengths of top rail shall be of the outside sleeve type and at least 7 inches (175 mm) long. The bore of the sleeves shall be sufficiently true to maintain adjacent lengths of rail in alignment.

Extension arms for barbed wire shall be of a type that can be attached to the tops of the posts and carry three wires at approximately 5-1/2 inches (138 mm) centers in a plane approximately 45 degrees from the vertical, inclined as shown on the Plans or as directed by the Engineer.

206-6.7 Barbed Wire. Barbed wire shall be 4-point pattern, composed of two strands of 12-1/2 gage (2.5 mm) galvanized steel wire with barbs spaced 5 inches (125 mm) apart and shall confirm to ASTM A121.

206-6.8 Repair of Damaged Coatings. All welds made after galvanizing shall be ground smooth and wire brushed to remove loose or burned zinc coating, after which the cleaned areas shall be prepared and neatly coated with 50-50 solder or as prescribed in 210-3.5. Repairs to abraded or otherwise damaged zinc coating shall be made in a similar manner.

206-6.9 Security Fencing. Security fencing shall be 5 feet (1.5 m) high. Security fencing material shall be chain link fabric or welded wire fabric (6x6-W9xW9 minimum) and constructed using:

a) Tensioned fencing material with top and bottom tension wires securely fastened to driven steel posts or other equally rigid elements at a maximum spacing of 12 feet (3.7 m); or

b) Untensioned fencing materials securely fastened to extended trench shoring elements at a maximum spacing of 8 feet (2.4 m) and fastened to continuous top and bottom rails including toe plates constructed of nominal 2-inch x 4-inch (50 mm x 100 mm) lumber or equally rigid material.

Framed panels with suitable supporting elements fastened together to form a continuous fence may also be used.

SECTION 207 – GRAVITY PIPE

207-1 NONREINFORCED CONCRETE PIPE.

207-1.1 General. Nonreinforced concrete pipe to be furnished shall be as shown on the Plans, or as specified under the Bid item of work for the Contract.

Concrete pipe shall be extra-strength unless otherwise specified, shall be manufactured from Portland cement concrete, and shall be so constructed that it will conform to the requirements described herein.

207-1.2 Materials. Materials used in manufacturing the pipe shall be as specified in ASTM C14/C14M with the following exceptions:

a) Cement shall conform to 201-1.2.1.

b) At least 28 percent of the aggregate by weight shall be larger than 9/10 inch (23 mm) for pipes 12 inches (300 mm) and larger in diameter.

c) Aggregates shall conform to 201-1.2.2.

207-1.3 General Requirements. The plane of the ends of the pipe, except for special shapes, shall be perpendicular to the longitudinal axis of the pipe. The interior surface shall be smooth and well-finished. Joints shall either be of the socket and spigot type or the tongue and groove type, as approved by the Engineer, and so constructed that, when laid, the pipe will form a continuous conduit with a smooth and uniform interior surface.

When shown on the Plans, the pipe shall have a gasketed joint. The gasket shall be seated in an accurately shaped groove on the spigot end of the pipe section and the gasket shall be of suitable cross section and size. Alternate joint details may be used with Engineer approval. The gasket shall be considered as the principal element in making the joint watertight. The gasket shall be manufactured from a synthetic rubber of neoprene base and shall conform to the requirements of 208-1.2 and 208-2.2.

The completed pipe shall be free from fractures, large or deep cracks, laminations, and surface roughness. Specimens which, when placed in a vertical position, do not give a metallic ring when struck with a hammer, or which exhibit any of the following defects, will be subject to rejection:

a) Indications of honeycomb or open texture or of imperfect mixing or molding.

b) Fractures or cracks passing through the wall or socket, except a single end crack less than 3 inches (75 mm) measured transversely or 2 inches (50 mm) measured longitudinally will not be deemed cause for rejection unless such defects appear in more than 5 percent of the number of sections inspected; in which event, the defective sections will be rejected.

c) Cracks sufficient to impair the strength, durability or serviceability of the pipe; a single crack in the body of the pipe, extending through one-half of the thickness of the wall and over 3 inches (75 mm) in length; or 2 or more such cracks regardless of length.

d) Variations in dimensions in excess of those permissible, as set forth in the following tables.

e) Failure to meet the test requirements set forth herein.

f) In pipe designed to be straight, deviations greater than 3/8 inch per linear foot (30 mm/m).

The deviation shall be measured from a straight-edge on the concave side of the pipe.

207-1.4 Dimensions. Each straight pipe of all sizes and classes shall be not less than 3 feet (0.9 m) in length unless otherwise specified for special purposes. The minimum length of 6-inch (150 mm) Y's and T's shall be 18 inches (450 mm) and 24 inches (600 mm) for 8-inch (200 mm) and larger Y's and T's. Other dimensions of pipe shall conform to the following tables:

TABLE 207-1.4 (A):

STANDARD STRENGTH CONCRETE PIPE

1 Nominal Size inches (mm)	2 Thickness of Wall inches (mm)	3 Depth of Socket inches (mm)	4 Minimum Annular Space[1] inches (mm)
6 (150)	3/4 (19)	2-1/4 (57)	5/8 (16)
8 (200)	7/8 (22)	2-1/2 (64)	5/8 (16)
10 (250)	1 (25)	2-1/2 (64)	5/8 (16)
12 (300)	1-1/8 (29)	2-3/4 (70)	5/8 (16)
15 (375)	1-3/8 (35)	2-3/4 (70)	5/8 (16)
18 (450)	1-1/2 (38)	3 (76)	5/8 (16)
21 (525)	1-3/4 (44)	3-1/2 (89)	3/4 (19)

1. Applies to socket ends only.

TABLE 207-1.4 (B):
EXTRA-STRENGTH CONCRETE PIPE

1 Nominal Size inches (mm)	2 Thickness of Wall inches (mm)	3 Depth of Socket inches (mm)	4 Minimum Annular Space [2] inches (mm)
6 (150)	3/4 (19)	2-1/4 (57)	5/8 (16)
8 (200)	7/8 (22)	2-1/2 (64)	5/8 (16)
10 (250)	1 (25)	2-1/2 (64)	5/8 (16)
12 (300)	1-1/2 (38)	2-3/4 (70)	5/8 (16)
15 (375)	1-7/8 (48)	2-3/4 (70)	5/8 (16)
18 (450)	2-3/8 (60)	3 (76)	5/8 (16)
21 (525)	2-3/4 (70)	3-1/2 (89)	3/4 (19)

1. The annular space is the space between the inside of the socket and the outside of the spigot of the pipe as placed in the socket. The minimum annular space, as shown in column 4, is measured at the outer end of the socket. The space at the bottom of the socket, known as the caulking space, shall be not less than 1/4 inch (6 mm).
2. Applies to socket ends only.

TABLE 207-1.4 (C):
LIMITS OF PERMISSIBLE VARIATION IN STANDARD STRENGTH AND EXTRA-STRENGTH CONCRETE PIPE

Nominal Size inches (mm)	Variation from Indicated Length (±) inches (mm)	Depth of Socket (–) inches (mm)	Thickness of Wall (–) inches (mm)	Inside Diameter of Bore inches (mm)		Length of Two Opposite Sides inches (mm)
				Minimum	Maximum	
6 (150)	1/2 (13)	1/4 (6)	1/16 (2)	5-13/16 (150)	6-3/16 (160)	3/8 (10)
8 (200)	1/2 (13)	1/4 (6)	1/16 (2)	7-13/16 (200)	8-1/4 (210)	3/8 (10)
10 (250)	1/2 (13)	1/4 (6)	1/16 (2)	9-13/16 (250)	10-1/4 (260)	3/8 (10)
12 (300)	1/2 (13)	1/4 (6)	1/16 (2)	11-13/16 (300)	12-5/16 (312)	3/8 (10)
15 (375)	1/2 (13)	1/4 (6)	1/8 (3)	14-3/4 (375)	15-5/16 (390)	3/8 (10)
18 (450)	1/2 (13)	1/4 (6)	1/8 (3)	17-3/4 (450)	18-3/8 (465)	3/8 (10)
21 (525)	1/2 (13)	1/4 (6)	1/8 (3)	20-11/16 (525)	21-7/16 (545)	3/8 (10)

The minus sign (–) alone indicates the plus variation is not limited; the plus and minus sign (±) indicates variations in both excess and deficiency.

207-1.5 Marking. Each pipe shall be marked clearly and legibly to show the class of pipe, date of manufacture, and the name or trademark of the manufacturer.

207-1.6 Test Requirements.

207-1.6.1 General. Before pipe is delivered to the Work site for use in any work, test pipe shall meet the requirements of the hydrostatic pressure test and the loading test described herein. Tests shall be made at the point of manufacture and shall be made under the supervision of the Engineer.

All testing equipment shall be calibrated by an agency approved by the Engineer at intervals not to exceed 6 months.

207-1.6.2 Selection of Test Pipes. Each lot of non-reinforced concrete pipe is defined as not more than 450 sections of pipe of one size and class. All the pipe shall be manufactured from the same mix of concrete, have the same cure, and be from 1 day's manufacture.

The Engineer will select at random and have tested one pipe for each 50 pipes or fraction thereof in each lot. The minimum number of pipes tested for any lot shall be 5. The pipes selected for test shall be sound and have dimensions consistent with these specifications.

The Contractor shall furnish the test pipes without charge and shall provide adequate equipment and facilities for conducting tests. Unless otherwise specified, the Contractor shall bear all costs.

207-1.6.3 Hydrostatic Pressure Test. The hydrostatic pressure test shall precede the loading test by not more than 3 hours.

When the pipe is subjected to an internal hydrostatic pressure of 10 pounds per square inch (70 kPa) for the time shown in the following table, the accumulated moisture on the exterior surface shall not run down the sides in such quantity that will exceed 0.34 fluid ounce (10 mL). Each 10 square inches (6500 mm^2) of moisture appearing on the exterior surface shall be considered to be 0.03 fluid ounce (1 mL) of runoff.

TABLE 207-1.6.3

Thickness of Wall	Testing Time (Minutes)
Up to and including 1 inch (25 mm)	7
Over 1 inch (25 mm) and including 1-1/2-inch (38 mm)	9
Over 1-1/2 inches (38 mm) and including 2-inch (50 mm)	12
Over 2 inches (50 mm) and including 2-1/2-inch (63 mm)	15
Over 2-1/2 inches (64 mm) and including 3-inch (75 mm)	18
Over 3 inches (75 mm)	21

207-1.6.4 Loading Test. The loading test shall be the three-edge bearing conforming to ASTM C14.

TABLE 207-1.6.4

pounds per linear foot (kN/m)		
Size Inches (mm)	Standard Strength	Extra Strength
6 (150)	1100 (16.1)	2000 (29.2)
8 (200)	1300 (19.0)	2000 (29.2)
10 (250)	1400 (20.4)	2000 (29.2)
12 (300)	1500 (21.9)	2250 (32.8)
15 (375)	1750 (25.5)	2750 (40.1)
18 (450)	2000 (29.2)	3300 (48.2)
21 (525)	2200 (32.1)	3850 (56.2)

The net inside length of pipe from the bottom of the socket to the spigot end of the pipe shall be used as the divisor to calculate the load per unit length.

207-1.6.5 Acceptance or Rejection of Pipe. When all the pipe tested passes the required tests, the entire lot of pipe will be acceptable. When 2 test pipes fail, the entire lot will be rejected.

When only one test pipe of the first group selected fails, 5 additional pipes shall be tested. If none of the additional pipes fail, the entire lot will be acceptable. If one fails, the entire lot will be rejected.

207-1.7 Perforated Pipe. Perforated pipe shall conform to the requirements of this section except the hydrostatic pressure test will not be required, and the strength requirements shall be reduced 10 percent from the values given in 207-1.6.4.

The pipe shall be shop perforated with perforations symmetrically located within a maximum arc of 160 degrees. Perforations shall have a total open area of at least 0.3 square inches per linear foot (630 mm^2/m) of pipe, with a minimum of one perforation per linear foot (3 perforations per linear meter) ; except for joint areas. Perforations shall be either holes or slots. Diameter of the holes may vary from 1/4 inch (6 mm) minimum to 3/8 inch (9.5 mm) maximum; the width of the slots may vary from 3/16 inch (5 mm) minimum to 5/16 inch (8 mm) maximum; the length of the slot shall not exceed 4 inches (100 mm).

207-1.8 Curing.

207-1.8.1 General. The manufacturer shall provide adequate steam plant, enclosures, piping, and other facilities for curing the pipe. The enclosures shall be such that the humidity shall be maintained so as to keep the pipe surfaces moist at all times. The temperature shall be maintained continuously between 120°F and 150°F (50°C and 65°C).

207-1.8.2 Curing Requirements. The pipe shall be cured under either of the following methods:

a) After the pipe has been manufactured, it shall be placed in enclosures and saturated steam applied for at least 6 hours, starting not sooner than 1 hour nor more than 10 hours, after completion of manufacture. Starting not later than 1 working day after completion of the steam curing, the pipe shall be kept constantly and thoroughly wet for at least 7 Days. When an approved temperature-time recorder is used, 1 hour of steam may be substituted for each 4 hours of the required water cure.

b) Starting not later than 24 hours after the pipe has been manufactured, it shall be kept constantly and thoroughly wet for at least 14 Days.

207-1.9 Inspection. Sections of pipe to be inspected shall be so situated at the manufacturer's plant as to provide the Engineer with free accessibility for inspection and marking. In no case shall the pipe be stacked for inspection to a height that would require the Engineer to climb or use a ladder.

At the place of manufacture, the Engineer will indicate acceptance of the pipe for delivery to the Work site by marking the pipe with the Agency's stamp. Such acceptance, however, shall be considered a tentative acceptance. Final acceptance will be made only when the project has been completed.

If pipe is rejected subsequent to its manufacture, the mark placed thereon by the Engineer shall be defaced.

207-2 REINFORCED CONCRETE PIPE (RCP).

207-2.1 General. These specifications apply to reinforced concrete pipe intended to be used for the construction of storm drains, sewers, and related structures.

The size, type, and D-load of the concrete pipe to be furnished shall be as shown on the Plans or in the Special Provisions.

Prior to the manufacture of the RCP, 3 sets of prints of the pipeline layout diagrams shall be furnished to the Engineer per 2-5.3, except transparencies will not be required. Catch basin connector pipes need not be included in the layout; but, in lieu thereof, a list of catch basin connector pipes shall accompany the layout. The connector pipe list shall include size and D-load of pipe, station at which pipe joins mainline, number of sections of pipe, length of sections, and type of sections (straight, horizontal bevel, vertical bevel, etc.). The diagrams and lists submitted will be used by the Agency for reference only, and their use shall in no way relieve the Contractor of its responsibility for correctness. The Engineer may waive the pipeline layout and connector pipe list requirement.

Unless otherwise specified, RCP shall be either wet-cast, spun, or machine-made.

Plants and processes not previously qualified by the Agency may require initial qualification by the Agency using any or all of the following tests described in ASTM C497/C497M and as listed below. Upon qualification, no additional tests will be required unless changes have been made in the equipment and procedures, or an increase in the largest aggregate size is made from the previous approved mix designs. The manufacturer shall provide qualifying data upon request by the Engineer:

a) **Three-Edge Bearing Test.** Two tests minimum on each of three different pipe sizes per 207-2.9.2.

b) **Core Strength Test.**

1) Minimum allowable adjusted compressive strength: 4,000 pounds per square inch (27.6 MPa).
2) Number of tests: 2 each from 3 different pipes.
3) Unit weight to be used as a baseline for future reference.

c) **Absorption Test Per ASTM C497/ASTM, C497M, Section 7, Method A.**

1) Obtain 2 core samples (one each from the middle area of two pipes for each mix design).
2) Maximum allowable absorption value: 9 percent.

d) **Hydrostatic Test.** One test sample selected by the Engineer shall meet the following criteria:

1) 24-hour presoak (manufacturer's option).
2) Hydrostatic pressure of 13 pounds per square inch (90 kPa) minimum shall be maintained for 20 minutes.
3) End bulkheads or internal plugs may be used at the manufacturer's option. Leakage at the bulkhead of plugs is allowed if leakage does not interfere with the test.
4) Allowable leakage: none. Moisture appearing on the exterior surface of the pipe in the form of beads adhering to the surface will not be considered leakage. The tests may be repeated after the 24-hour presoak at the manufacturer's option to determine if test pipe stops leaking. Pipe which stops leakage after the presoak will be considered to have passed.

e) **Visual Inspection.** Pipe inspection shall include the following:

1) 207-2.5 (Joints).
2) Interior surface finish and textures.
3) Reinforcing steel placement and twist, per 207-2.4.2 and 207-2.4.3. Concrete from a portion of one piece of green pipe shall be stripped or raked to determine cage twist, location, clearance, and voids. Voids around reinforcing steel cage caused by cage twist will not be acceptable. Cage twist resulting from pipe production in excess of 1/4 inch (6 mm) in 8 feet (2.4 m) will not be acceptable.
4) Longitudinally cut pipe. One pipe shall be longitudinally sawcut in half using equipment which will not damage the concrete or reinforcing steel. The exposed surface shall be inspected for voids adjacent to the circumferential steel. Voids shall be considered continuous if a 1/16 inch (1.5 mm) diameter pin can be inserted 1/4 inch (6 mm) deep.

   This test will be acceptable if no more than 10 percent of the circumferential bars exposed have continuous voids.

Plant inspection shall include cage manufacturing, curing process, batching equipment and process, aggregate and cement storage, concrete mix designs, and product handling.

The interior surface of the pipe shall be smooth and well-finished. Joints shall be of such type and design and so constructed as to be adequate for the purpose intended so that, when laid, the pipe will form a continuous conduit with a smooth and uniform interior surface.

Sockets and spigots shall be free from any deleterious substance or condition which might prevent a satisfactory mortar bond at the joints.

If the Engineer determines that the forms, end rings, or form gaskets used in the manufacture of the pipe are inadequate, the Contractor shall replace or repair said equipment to the satisfaction of the Engineer.

Pipe of greater strength than that specified or cover greater than required in 207-2.4.2 may be furnished at the Contractor's option, and its expense, provided such pipe conforms in all other aspects to the applicable provisions of these specifications.

The Contractor shall furnish, install, and maintain stulls or other devices in the pipe as may be necessary to meet the limitations on cracks specified herein.

207-2.2 Materials. Unless otherwise approved by the Engineer, no materials shall be used in manufacturing the pipe other than water, water reducing admixture, cement, mineral aggregates, and steel conforming to ASTM C76/ASTM, C76M with the following requirements:

a) Cement shall conform to 201-1.2.1.

b) Aggregate shall conform to the reactivity requirements in 201-1.2.2.

c) Fly ash shall conform to the quality requirements in 201-1.2.5.

Aggregate shall be so graded, proportioned, and thoroughly mixed in a batch mixer so as to produce a homogeneous concrete mixture of such quality that pipe will conform to the test and design requirements of these Specifications. The proportion of cementitious material (Portland cement and fly ash) shall not be less than 560 pounds per cubic yard (330 kg/m^3) of concrete.

207-2.3 Dimensions.

207-2.3.1 Length. The nominal length shall be not less than 8 feet (2.4 m) except as otherwise specified or required for bends or special joints.

Variations in laying lengths of 2 opposite sides of pipe shall not be more than 1/8 inch per foot (10 mm/m) of diameter with a maximum of 5/8 inch (16 mm) in any length of pipe.

207-2.3.2 Cast Pipe Wall Thickness. Cast pipe wall thickness shall conform to the following:

TABLE 207-2.3.2

Nominal Internal Diameter inches (mm)	Minimum Barrel Thickness inches (mm)
12 (300)	2 (50)
15 (375)	2-1/4 (57)
18 (450)	2-1/4 (57)
21 (525)	2-1/4 (57)
24 (600)	3 (76)
27 (675)	3 (76)
30 (750)	3 (76)
33 (825)	3 (76)

For pipe larger than 33 inches (825 mm) in diameter, the minimum wall thickness permitted will depend upon the strength of the concrete used. If the concrete has a strength of 4,500 pounds per square inch (31.0 MPa) in 28 Days, any wall thickness not less than 1/12 the internal diameter is permitted. If the concrete has a strength less than 4,500 pounds per square inch (31.0 MPa) but more than 4,000 pounds per square inch (27.6 MPa) at 28 Days, a wall thickness 1 inch (25 mm) greater than 1/12 the internal diameter will be required. The concrete strength shall be determined in accordance with ASTM C31 and C39.

207-2.3.3 Spun Pipe Wall Thickness. Spun pipe wall thickness shall conform to the following:

TABLE 207-2.3.3

Nominal Diameter inches (mm)	Minimum Wall Thickness inches (mm)
12 (300)	2 (50)
15 (375)	2 (50)
18 (450)	2 (50)
21 (525)	2 (50)
24 (600)	2-1/2 (63)
27 (675)	2-5/8 (66)
30 (750)	2-3/4 (69)
33 (825)	2-7/8 (73)
36 (900)	3 (75)
39 (975)	3-1/8 (78)
42 (1050)	3-3/4 (94)
45 (1125)	3-7/8 (98)
48 (1200)	4 (100)

The thickness of the barrel of pipe larger than 48 inches (1200 mm) in diameter shall not be less than 1/12 the internal diameter of the pipe.

207-2.3.4 Machine-Made Pipe Wall Thickness. The minimum wall thickness for all pipe sizes shall be as specified in ASTM C76/C76M Wall B (1/12 the internal diameter plus 1 inch (25 mm)) using 4,000 pounds per square inch (27.6 MPa) minimum strength concrete.

207-2.4 Reinforcement.

207-2.4.1 General. The reinforcement shall be a cage fabricated of bars or wire. Circumferential reinforcement shall be in the amount and type shown on Plans, or that required to sustain the specified test loads. Longitudinal reinforcement shall be sufficient to make the cage rigid and to support the circumferential reinforcement firmly in place in the forms during placing and consolidation of the concrete.

Pipe which is to be jacked shall have a circular cage reinforcement.

In pipe larger than 96 inches (2400 mm) diameter, the minimum size of circumferential reinforcement for the inside circular cage shall be 7/16 inch (11 mm) diameter.

Fastenings (supports) and/or retractable mechanical devices, approved by the Engineer, shall be used for holding the cage rigidly in place in the form in its elliptical or circular shape. In wet-cast and machine-made pipe these fastenings shall be spaced not closer than 2 feet (0.6 m) center-to-center along the longitudinal reinforcement except for pipe having a nominal length of 4 feet (1.2 m) or less.

All reinforcing steel shall be clean and free from loose rust, scale, paint, grease, form oil, or other foreign matter.

Splices shall be butt-welded or lap-welded a minimum of 6 diameters. Nonwelded splices shall be lapped a minimum of 20 diameters for deformed bars and 40 diameters for plain bars or cold-drawn wire. Nonwelded lapped splices shall be wired tightly. Welds shall develop not less than 75 percent of the minimum specified ultimate strength of the bars or wires being welded.

Elliptical cages may be specifically fabricated or deformed from a circular cage to the required elliptical dimensions.

Cages for machine-made pipe shall be circular.

Upon request, the Contractor shall furnish data to the Engineer indicating lot number, wall thickness, and the size, spacing, and positioning of reinforcement for any pipe manufactured.

207-2.4.2 Location of Reinforcement. Measurements of position, except for concrete cover, shall apply to the center of the bar or wire.

For pipe with wall thickness greater than 2-1/4 inches (57 mm), the required minimum cover measured between reinforcement surface and pipe surface, and the permitted cover tolerances are given in the following table:

TABLE 207-2.4.2

Reinforcement	Storm Drain Pipe Nominal Diameter			Sewer Pipe Nominal Diameter	
	24 to 36 inches (600 to 900 mm)	39 to 96 inches (975 to 2400 mm)	Greater than 6 inches (2400 mm)	96 inches (2400 mm) or less	Greater than 96 inches (2400 mm)
Circumferential, inches (mm)	3/4 ± 1/4 (19 ± 6)	3/4 ± 1/4 (19 ± 6)	1-1/4 ± 1/4 (32 ± 6)	1 ± 1/4 (25 ± 6)	1-1/4 ± 1/4 (32 ± 6)
Longitudinal, inches (mm)	3/8 (9.5) minimum	1/2 (12.5) minimum	1/2 (12.5) minimum	1 (25) minimum	1 (25) minimum

In lined sewer pipe, the tabulated cover shall be increased as necessary to ensure that the distance from any reinforcement to embedded lugs or locking extensions of the liner is at least 1/4 inch (6 mm).

The required covers shown in the table are minimums. Certain conditions such as high velocities or corrosive environments, may require greater covers as indicated on the Plans or in the Special Provisions.

The tabulated tolerances shall not apply where the Plans show cover over circumferential steel which differs from the values shown above.

For pipe with a wall thickness of 2-1/4 inches (57 mm) or less, the circumferential reinforcement shall be located at the center of the wall. The cover over longitudinal reinforcement shall be at least 3/8 inch (9.5 mm).

207-2.4.3 Placement of Reinforcement. The location of the minor axis of elliptically reinforced pipe shall be marked so that an imprint will be left in the interior of the concrete.

The circumferential reinforcement shall be placed in the body of pipe in such a manner that the longitudinal reinforcement of the cage will hold the last hoop or coil 3/4 inch (19 mm) minimum from the end plates or rings. Both ends of the circumferential reinforcement shall be finished off with a complete hoop of reinforcement.

For storm drain pipe, the longitudinal reinforcement may extend to the base plate or ring to act as a cage support. For sanitary sewer pipe, the longitudinal reinforcement shall have a minimum cover of 3/4 inch (19 mm) from the end faces of the pipe.

Circumferential reinforcement may be included in the joint projections at the option of manufacturer, and shall be included when required by Plans or Special Provisions.

Where the wall reinforcement does not extend into the joint projection, the longitudinal distance to the last circumferential reinforcement from the inside shoulder of the bell or shoulder of the spigot shall be a maximum of 1-3/4 inches (44 mm), but not less than 3/4 inch (19 mm) from any face.

207-2.5 Joints. Joints shall be designed to be self-centering. Unless otherwise specified, joints in concrete pipe shall be of the tongue-and-groove mortar type of joint.

When pipe joints of the reinforced concrete collar type or of rubber-gasketed type are specified or indicated on the Plans, joint details shall be submitted to the Engineer for approval before commencing pipe manufacture.

Pipe with beveled ends for use around curves, the radii of which are shown on the Plans, shall be provided where necessary. Either one or both ends shall be beveled a maximum of 5 degrees as may be required to provide well-fitting joints.

If required by the Engineer, the pipe shall be "match-marked" to meet specified laying tolerances at the place of manufacture and laying diagrams shall be furnished to the Contractor.

207-2.6 General Manufacturing Requirements.

207-2.6.1 Wet-Cast Pipe. Wet-cast RCP shall be manufactured by placing the concrete into stationary, vertical, cylindrical metal forms. During placing of each batch the concrete shall be vibrated continuously with internal or external mechanical vibrators operating at a minimum rate of 6,500 vibrations per minute.

207-2.6.2 Spun Pipe. Spun RCP shall be manufactured by introducing the concrete into a rotating horizontal cylindrical metal form. After the concrete materials have been mixed, they shall be promptly placed in the forms and spun on a horizontal axis. If, for any reason, the work of filling the forms is interrupted long enough for the concrete to take its initial set, any partly filled form shall be emptied and the concrete rejected. While the concrete is being placed in the forms, they shall be revolved on a horizontal axis at a speed that will ensure uniformity of aggregates. After all the concrete has been placed in the forms, they shall be revolved at proper speed and duration to secure a dense concrete with smooth interior surface. Water and laitance collecting on the surface of the concrete shall be removed, and the interior surface of the pipe shall be troweled and finished to the form of a true cylinder.

207-2.6.3 Machine-Made Pipe. Machine-made RCP shall be manufactured by placing the concrete between vertical cylindrical forms or by placing the concrete into a vertical form and the interior surface formed with one or more roller packing heads and a long bottom-trowel rotating in opposite directions. The concrete shall be mixed to a uniform consistency and the reinforcing cage shall be held by fastening (supports) and/or retractable mechanical devices to ensure correct cage position.

Concrete placed between inner and outer forms shall be continuously vibrated throughout the manufacturing cycle and after all concrete has been placed in the forms, axial pressure shall be applied simultaneously with vibration to further densify the concrete, or the concrete shall be placed against the outer jacket and densified by continuous vibration during the manufacturing cycle. On completion of densification, the pipe may be removed immediately from the forms.

207-2.7 Curing.

207-2.7.1 Steam Curing Facilities. The manufacturer shall provide adequate enclosures, steam plant, piping, and other facilities for curing pipe. The enclosures shall be such that the temperature and humidity can be controlled to keep the pipe surfaces moist at all times and temperature maintained continuously between 80°F and 170°F (27°C and 77°C). Bulkhead curing is permissible, but will only be given credit for a maximum of 12 hours of the steam cycle.

207-2.7.2 Curing Procedures.

General. Wet-cast, machine-made, and spun pipe shall be cured by steam or water, or a combination of both, as described in the following paragraphs:

a) **Steam Curing.** Steam may be applied as soon as the pipe is enclosed, but not later than 10 hours after completion of concrete placement. The temperature within the enclosure shall not be raised above 100°F (38°C) by the use of steam for the first hour; thereafter the temperature shall not be

increased at a rate greater than 40°F (22°C) per hour. The temperature shall be maintained continuously between 80°F and 170°F (27°C and 77°C) for 28 hours.

For wet-cast and spun pipe, 6 hours of steam (at least 5 hours at 80°F (27°C) or higher) is required before forms may be removed. The period necessary to remove the forms may be included in the 28 hours, as long as it does not exceed 4 hours. Any time more than 4 hours shall be added to the total steam cycle. The time lapse during form removal shall not exceed 1 working day.

b) **Combination Curing.** At any time after 6 hours of the steam cycle, the steam may be stopped and the cure continued using water applied in such a manner that the outside surfaces of the pipe is kept moist. Water may be substituted for steam on a basis of 4 hours of water being equal to 1 hour of steam. The manufacturer shall notify the Engineer prior to using water in lieu of steam.

c) **Water Curing.** Pipe may be water cured by any method that will keep the outside surface moist for 4 consecutive days. Pipe to be given a total water cure may not be stripped from the forms until 20 hours after concrete placement or until the concrete has reached a compressive strength of 1,500 pounds per square inch (10.3 MPa), whichever occurs first.

d) **Alternate Curing Based On Compressive Strength.** Pipe cured by any of the above methods may have the water or steam stopped when the concrete strength reaches 3,000 psi (20.7 MPa). The strength shall be determined in accordance with ASTM C31 and C39.

e) **Alternate Curing Procedures.** The manufacturer may request approval of alternate methods of curing that differ from the procedures specified above. The alternative method shall be specified in writing to the Engineer and fully substantiated by test data.

207-2.8 Causes for Rejection. Inspection of pipe as may be deemed necessary by the Agency will be made at the place of manufacture, and unless it can be repaired as provided in 207-3.3, or as approved by the Engineer, pipe may be rejected for any of the following reasons:

a) A piece of any size broken out of the pipe.

b) Defects that indicate imperfect mixing or molding.

c) Any crack extending entirely through the wall of the pipe and having a longitudinal or transverse length greater than the wall thickness of the pipe.

d) Any shattering or flaking of concrete at a crack.

e) A deficiency greater than 1/4 inch (6 mm) from the specified wall thickness of pipe 30 inches (750 mm) or smaller in diameter, or a deficiency greater than 5 percent (6 percent) from the specified wall thickness of pipe larger than 30 inches (750 mm) in internal diameter, except that the deficiency may be 8 percent (7 percent) adjacent to the longitudinal joint, provided that additional deficiency does not lie closer than 20 percent of the internal diameter to the vertical axis of the pipe and does not extend along the circumference for a distance greater than 20 percent of the internal diameter.

The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces in gasketed joint pipe. Dimensions and tolerances of such contact surfaces shall be submitted for approval.

f) Internal diameter of the pipe varying from the true circle of the specified diameter by more than 1 percent for U.S. Standard Measures units (for SI units, pipe having less than the specified diameter, or exceeding it by more than 2.6 percent).

g) The roundness of the pipe varies from a true circle of the actual internal diameter by more than one percent at any location along the barrel.

h) Rock pockets and water pockets in any pipe.

i) Exposure of any reinforcement arising from misplacement thereof.

j) Evidence of cage twist or misplacement of reinforcement.

k) Delamination of the concrete.

l) Surface defects indicating honeycomb or open-texture.

m) Separations or "blisters."

n) Slumped or sagged concrete.

o) For sewer pipe, any crack showing two visible lines or separation for a continuous length of 2 feet (0.6 m) or more, or an interrupted length of 3 feet (0.9 m) or more anywhere in evidence, both inside and outside, except where such cracks occur during the external loading test specified herein.

p) Any continuous crack or concrete separation having a surface width of 0.010 inch (0.255 mm) or more and extending for a length of 12 inches (300 mm) or more, regardless of depth or position in the wall of the pipe.

q) The pipe fails the D-load bearing strength test.

The imperfections and variations as causes for rejection in sewer and storm drain pipe, as specified herein, shall apply to pipe for which design details are indicated on the Plans as well as for pipe which is specified by D-load. The procedure of the Engineer for marking the pipe with the Agency's stamp at the place of manufacture shall not be considered a final acceptance of the pipe.

Pipe shall be considered ready for transporting to the Work site when it conforms to the specified requirements for curing, testing, and inspection.

207-2.9 Basis for Acceptance.

207-2.9.1 General. The basis for acceptance shall be by one of the following, as designated in the Special Provisions:

a) The D-load bearing strength test, compliance with these Specifications, inspection of the pipe manufacture and inspection of the completed pipe.

b) The structural design details, materials, tests, inspection of the pipe manufacture and inspection of the completed pipe.

c) Acceptance of a Certificate of Compliance.

207-2.9.2 D-load Bearing Strength Test. Pipe to be D-load tested shall be selected at random by the Engineer at the point of manufacture. One pipe will be selected for each lot, or fraction thereof, of the pipe to be furnished for the Work.

For the purpose of these specifications, a lot is defined as 400 feet (122 m) but no more than 50 sections of pipe, or fraction thereof, of one size and class manufactured on consecutive working days. If the 400 feet (122 m), but no more than 50 sections, of pipe are not made on consecutive working days, then only those made on consecutive working days shall be considered a lot. If an interruption in manufacturing occurs, the Engineer may permit the pipe made after the interruption to be included in the lot, provided that the interruption lasts less than 7 Days. A new lot number will be assigned if any change occurs in size or spacing of reinforcing steel, in the concrete mix, or in the curing method.

The Contractor shall furnish the test pipe without charge and shall provide adequate equipment and facilities for conducting tests and shall bear all expense in connection therewith, all tests being under the supervision of the Engineer. All testing equipment shall be calibrated at intervals not to exceed 6 months, by an agency approved by the Engineer.

Test pipe shall conform in all other respects to the applicable requirements specified herein. Pipe shall be tested by the 3-edge bearing test as prescribed in ASTM C497/C497M.

TABLE 207-2.9.2:
ALLOWABLE CRACK WIDTH

Pipe Wall Thickness inches (mm)	Allowable Crack Width in inches (mm) Pipe Diameters up to 96 inches (2400 mm)					
	Concrete Cover on Transverse Reinforcement in inches (mm)					
	0.75" (19 mm)	1.25" (32 mm)	1.75" (44 mm)	2.25" (57 mm)	2.75" (70 mm)	
2.5 (63)	0.010 (0.255)	0.015 (0.380)				
3.0 (76)	0.010 (0.255)	0.014 (0.355)				
3.5 (89)	0.010 (0.255)	0.013 (0.330)	0.018 (0.455)			
4.0 (101)	0.010 (0.255)	0.013 (0.330)	0.017 (0.430)			
4.5 (114)	0.010 (0.255)	0.012 (0.305)	0.015 (0.380)	0.020 (0.510)		
5.0 (127)	0.010 (0.255)	0.012 (0.305)	0.015 (0.380)	0.018 (0.455)		
5.5 (140)	0.010 (0.255)	0.012 (0.305)	0.014 (0.355)	0.017 (0.430)	0.021 (0.535)	
6.0 (152)	0.010 (0.255)	0.012 (0.305)	0.013 (0.330)	0.016 (0.405)	0.019 (0.485)	
6.5 (165)	0.010 (0.255)	0.012 (0.305)	0.013 (0.330)	0.015 (0.380)	0.018 (0.455)	
7.0 (178)	0.010 (0.255)	0.011 (0.280)	0.013 (0.330)	0.015 (0.380)	0.017 (0.430)	
7.5 (191)	0.010 (0.255)	0.011 (0.280)	0.013 (0.330)	0.014 (0.355)	0.017 (0.430)	
8.0 (203)	0.010 (0.255)	0.011 (0.280)	0.013 (0.330)	0.014 (0.355)	0.016 (0.405)	
8.5 (216)	0.010 (0.255)	0.011 (0.280)	0.013 (0.330)	0.014 (0.355)	0.015 (0.380)	
9.0 (229)	0.010 (0.255)	0.011 (0.280)	0.013 (0.330)	0.013 (0.330)	0.015 (0.380)	
9.5 to 10.5 (241 to 267)	0.010 (0.255)	0.011 (0.280)	0.013 (0.330)	0.013 (0.330)	0.014 (0.355)	

Pipe Wall Thickness inches (mm)	Allowable Crack Width in inches (mm) Pipe Diameters Greater than 96 inches (2400 mm)					
	Concrete Cover on Transverse Reinforcement in inches (mm)					
		1.25" (32 mm)	1.75" (44 mm)	2.25" (57 mm)	2.75" (70 mm)	3.25" (83 mm)
8.0 (203)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.014 (0.355)	0.016 (0.405)
8.5 (216)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.014 (0.355)	0.015 (0.380)
9.0 (229)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.013 (0.330)	0.015 (0.380)
9.5 (241)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.013 (0.330)	0.015 (0.380)
10.0 (254)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.013 (0.330)	0.014 (0.355)
10.5 (267)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.013 (0.330)	0.014 (0.355)
11.0 (279)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.013 (0.330)	0.014 (0.355)
11.5 (292)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.012 (0.305)	0.013 (0.330)
12.0 (305)		0.010 (0.255)	0.011 (0.280)	0.012 (0.305)	0.012 (0.305)	0.013 (0.330)
12.5 (318)		0.010 (0.255)	0.011 (0.280)	0.011 (0.280)	0.012 (0.305)	0.013 (0.330)
13.0 (330)		0.010 (0.255)	0.011 (0.280)	0.011 (0.280)	0.012 (0.305)	0.013 (0.330)
13.5 (343)		0.010 (0.255)	0.011 (0.280)	0.011 (0.280)	0.012 (0.305)	0.013 (0.330)

1. Concrete cover is measured between reinforcement surface and concrete surface.
2. The tabulated crack width dimensions are measured in inches (mm).
3. Sewer pipe shall have an allowable crack width of 0.01 inch (0.25 mm) regardless of concrete cover.

The required strength of the pipe specimens undergoing the bearing test will be designated in terms of D-load. Such designation indicates the actual load in pounds per linear foot (N/m) of pipe, divided by the inside diameter of the pipe in feet (mm). The pipe shall withstand the required test load before a crack having a width as indicated in the following table, measured at close intervals, occurs throughout a

length of 1 foot (300 mm) or more. The crack shall be considered to be at the indicated width when the point of the measuring gauge will, without forcing, penetrate it 1/16 inch (1.5 mm) at close intervals throughout the specified distance of 1 foot (300 mm).

The load shall be applied at a uniform rate not to exceed 2,000 pounds per minute per foot-length (29.2 kN per minute per meter of length) of pipe for the first 80 percent of the required load and then at a uniform rate not to exceed 500 pounds per minute per foot-length (7.3 kN per minute per meter of length) of pipe for the remainder of the test.

The test specimens shall be surface dry when tested.

The length on which the test load is computed shall be determined by measuring the inside length of the barrel of the pipe from the bottom of the socket to the end of the spigot. The length of a beveled pipe shall be the average length of the inside of the barrel of the pipe, measured from the bottom of the socket to the end of the spigot.

If the tested specimen of a designated lot passes the test, all of the pipe of that lot shall be considered as complying with the requirements.

If the tested specimen of a designated lot fails to pass the test, then 5 additional specimens from that same lot shall be selected for testing.

If the 5 additional specimens pass, the total number of that lot to be furnished shall be considered as complying, except the one previous failing specimen.

If any of the five additional specimens fail, the entire lot shall be rejected; or may be downgraded except those specimens which passed the first time.

The Contractor may test specimens of a rejected lot individually to determine whether they may comply with the requirements for acceptance.

207-2.9.3 Structural Design Basis. Where structural details of the pipe are shown on the Plans, the manufacture of pipe shall be checked by making the appropriate tests on the concrete placed in the pipe forms, by inspection of the steel reinforcing cages that are to be used in the pipe, and by inspection of the fabrication of the pipe.

Concrete in pipe shall attain a minimum compressive strength of 4,500 pounds per square inch (31.0 MPa) at 28 Days.

207-2.9.4 Downgrading of Pipe. For the purpose of these specifications, "downgraded" pipe shall be defined as pipes which are to be used under loads less than those for which they were designed.

Pipes manufactured in accordance with these specifications which have not met their designed test loads may be downgraded by the Engineer and used provided that:

a) Enough load tests are made to establish the load under which they may be used. The number of tests to be made shall be as determined by the Engineer and may require the testing of each section.

b) They comply with the testing and inspection requirements of these specifications.

Individual specimens of pipe which will require major repair, or which have numerous hairline cracks extending the full length of the section on the inside of the pipe at the minor axis or on the outside of the pipe at the major axis, may be tested for downgrading purposes only at the discretion on the Engineer.

207-2.9.5 Acceptance of Stockpiled Pipe. Pipe may be used from stockpiles only when approved in advance by the Engineer, and provided the pipe meets all other requirements for pipe with the exception of inspection of manufacture.

For the purpose of these specifications, "stockpiled" pipe shall be defined as pipe manufactured in quantity which will meet requirements of this section, but was not manufactured for use in specific

projects. However, pipe which has been rejected by another agency will not be considered as "stockpiled" pipe, nor will such pipe be accepted.

207-2.10 Marking. The date of manufacture, size and D-load, lot number, manufacturer's identification mark, and where elliptical reinforcement is used, a 4-inch (100 mm) high "T" marking the location of the minor axis of the reinforcement shall be legibly painted or stamped on the inside of each pipe. If the Plans or Specifications require a minimum interior clearance for the reinforcing steel, the minimum clearance shall also be painted or stamped on the inside of the pipe.

Sections of pipe to be inspected shall be so situated at the manufacturer's plant as to provide the Engineer with free accessibility for inspection and marking. In no case shall the pipe be stacked to a height that would require the Engineer to climb or use or a ladder to properly inspect the pipe.

At the place of manufacture, the Engineer will indicate acceptance of the pipe for delivery to the Worksite by marking the pipe with the Agency's stamp. Such acceptance, however, shall be considered a tentative acceptance. Final acceptance will be made only when the Work has been completed.

If pipe is rejected subsequent to its manufacture, the mark placed thereon by the Engineer shall be defaced.

207-2.11 Inspection Platform. For machine-made pipe, a permanently installed inspection platform shall be provided. The platform shall be located such that the inspector can observe the cage and concrete during placement and manufacturing.

207-3 LINED REINFORCED CONCRETE PIPE.

207-3.1 General. These specifications apply to pipe manufactured with a plastic lining. The plastic lining material shall be tested in accordance with 211-2 and conform to 210-2. Pipe not installed within 180 days from the date of pipe manufacture shall have both ends of the pipe covered with an opaque material to prevent ultra-violet degradation of the plastic liner. The Contractor shall not install any lined RCP that is more than 2 years old from the date of manufacture.

Such pipe shall conform to the applicable provisions in 207-2, except that the causes for rejection shall be as listed herein, and repair of pipe will be permitted only within limits set forth in this subsection.

All such pipe shall be manufactured with Type II cement unless otherwise specified in the Special Provisions. All cement shall contain not more than 0.6 percent by weight of alkalis calculated as Na_2O plus 0.658 K_2O.

Chairs or spacers between the reinforcement and forms or base rings shall be stainless steel or a nonferrous material approved by the Engineer. Spacers may only come in contact with the liner plate if they are made of plastic and have a flat base plate of sufficient size to prevent puncture of the liner plate.

207-3.2 Causes for Rejection. Lined pipe may be rejected for any of the following reasons:

a) Exposure of any wires, positioning spacers, or chairs used to hold the reinforcement cage in position, or steel reinforcement in any surface of the pipe, except for holding rods in end projections.

b) Transverse reinforcing steel found to be in excess of 1/4 inch (6 mm) out of specified position after the pipe is molded.

c) Any shattering or flaking of concrete at a crack.

d) Air bubble voids (bugholes) on the interior and exterior surfaces of the pipe exceeding 1/4 inch (6 mm) in depth unless pointed with mortar or other approved material.

e) Unauthorized application of any wash coat of cement or grout.

f) A deficiency greater than 1/4 inch (6 mm) from the specified wall thickness of pipe 30 inches (750 mm) or smaller in internal diameter.

g) A deficiency greater than 6 percent (5 percent) from the specified wall thickness of pipe larger than 30 inches (750 mm) in internal diameter, except that the deficiency may be 8 percent (7 percent) adjacent to the longitudinal form joint, provided that the additional deficiency does not lie closer than 20 percent of the internal diameter to the vertical axis of the pipe and does not extend along the circumference for a distance greater than 20 percent of the internal diameter of the pipe.

The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces in gasketed joint pipe. Dimensions and tolerances of such contact surfaces shall be submitted for approval.

h) Internal diameter of the pipe varying from the true circle of the specified diameter by more than 1 percent (for metric units, pipe having less than the specified diameter, or exceeding it by more than 2.6 percent) or interior surfaces reworked after placing of the concrete. The variation in internal diameter permitted herein does not apply to gasket contact surface in gasketed joint pipe. Tolerances at such contact surfaces shall be submitted for approval.

i) A water pocket (identified by tapping the internal surface of the pipe) which is greater than 30 inches (750 mm) in length or wider than three times the specified wall thickness. Repair of such defective areas not exceeding these limits shall be made as described in 207-3.3.

j) A piece broken from the end projections of the pipe which has circumferential length exceeding 60 degrees of the circle, or extends into the body of the pipe, or extends into the gasket contact surfaces of gasketed joint pipe for a circumferential length in excess of 6 inches (150 mm) measured at the midpoint of the gasket contact surface on the bell end, and at the inner shoulder of the gasket groove at the spigot end. If 2 or more pieces are broken from an end projection, the total length of such broken pieces on any end shall not exceed 90 degrees of the circle; and there shall be a distance of at least 9 inches (225 mm) of sound concrete between breaks. The total length of broken pieces that extends into the gasket contact surfaces of gasketed joint pipe shall not exceed a circumferential length of 6 inches (150 mm).

If less than 9 inches (225 mm) of sound concrete exists between two individual breaks, the 2 breaks shall be considered as one continuous break. Repair of such defects not exceeding above limits shall be made by Method III as described in 207-3.3.3. Unsound portions of end projections shall be removed, and if pieces removed do not exceed the above limits, the pipe may be similarly repaired.

k) Defects that indicate imperfect molding of concrete; or any surface defect indicating honeycomb or open-texture (rock pockets) greater in size than an area equal to a square with a side dimension of 2-1/2 times the wall thickness or deeper than 2 times the maximum graded aggregate size; or a local deficiency of cement resulting in loosely bonded concrete, the area of which exceeds in size the limits of area described in i) and j) above when the defective concrete is removed. Repair of such defects not exceeding these limits shall be made as provided in i) and j) above. Sand rings occurring at the ends of the pipe shall be repaired for the full circumference.

l) Any of the following cracks:

1) A crack having a width of 0.01 inch (0.255 mm) or more throughout a continuous length of 12 inches (300 mm) or more.

2) Any crack extending through the wall of the pipe and having a length in excess of the wall thickness.

3) Any crack showing two visible lines of separation for a continuous length of 2 feet (0.6 m) or more, or an interrupted length of 3 feet (0.9 m) or more anywhere in evidence, both inside and outside, except where such cracks occur during the external loading test specified in 207-2.9.

When required by the Engineer, any crack which is 0.01 inch (0.255 mm) wide or wider and is not a cause for rejection, shall be filled with neat cement grout composed of cement mixed with water to a fluid consistency.

207-3.3 Repair of Imperfections.

207-3.3.1 Method I - Repair by Hand-Placed Mortar.

a) **Preparation of Surfaces to be Repaired.** Unsound or imperfect concrete shall be removed by chipping. Edges where concrete has been chipped out shall be sharp and squared with the surface, leaving no feathered edges. The chipped area shall be washed with water to remove all loose material and concrete dust.

Surfaces within the trimmed areas shall be kept wet for several hours, preferably overnight, before the repair replacement is made. All surfaces in areas to be repaired shall be damp, but not wet, when the material is applied.

b) **Placement of the Mortar.** The mortar used for the repair shall contain the same proportions of cement and sand as the mix from which the pipe was made.

This mortar shall be pre-shrunk by mixing it to a plastic consistency as far in advance of its use as possible. Trial mixes shall be made and aged to determine the longest period the mortar's use can be delayed while retaining sufficient plasticity to permit good workmanship.

Immediately prior to the application of the mortar, the damp surface of the area to be repaired shall be scrubbed thoroughly with a small quantity of neat cement grout, using a wire brush. Remaining loose sand particles shall be swept away before application of the mortar.

In applying the mortar, it shall be compacted into the space to be filled, care being taken to eliminate air pockets and to secure bond at the edges. The surfaces shall be shaped and finished to correspond with the adjacent surface of the pipe.

c) **Curing.** The newly repaired surfaces shall be kept damp for 24 hours after the repair is completed. A membrane coating of an approved white-pigmented sealing compound shall then be applied.

207-3.3.2 Method II - Repair by Pneumatically Applied Mortar (PAM).

a) **General.** PAM shall not be used when the repair extends to a depth greater than the embedment of the reinforcing steel. Such repairs shall be made with pre-shrunk mortar.

b) **Preparation of Surface to be Repaired.** Surfaces to which PAM is to be applied shall be prepared in the same manner as described in 207-3.3.1 a) except that the edges of the area from which unsound or imperfect concrete is removed shall be beveled so as not to entrap rebound.

c) **Placement of Mortar.** No rebound shall be included in the repair. The pipe shall be turned so that the area being repaired is at the side of the pipe in a near vertical position to permit rebound to fall clear.

The mortar used for the repair shall contain the same properties of cement and sand as the mix from which the pipe was made.

Before repairing grooved concrete spigots, the snap ring shall be replaced and retained in position until the repair has attained sufficient strength to assure no damage to the gasket groove by its removal.

Areas repaired with PAM shall be filled in excess of the dimension required and then carefully trimmed to correspond with adjacent surfaces.

d) **Curing.** Surfaces to which PAM has been applied shall be cured in the same manner as described in 207-3.3.1 c).

207-3.3.3 Method III - Bonding Mortar Repairs With Epoxy Resin Adhesives. Unsound or imperfect concrete shall be removed by chipping. If hand placed mortar is to be used, the edges shall be left sharp and square with the surface. If PAM is to be used, the edges shall be beveled.

The area to be repaired shall be kept dry. Loose material and concrete dust remaining after the chipping operation shall be removed by means of an air jet.

Epoxy resins previously approved for such use by the Engineer shall be used in the manner prescribed by the Engineer. The prepared area shall be primed with the epoxy resin compound, care being taken to ensure intimate contact with the base material. Mortar shall be applied before the epoxy resin compound sets. Mortar shall be applied by either Method I or II as described in 207-3.3.1 and 207-3.3.2.

207-4 Not Used.

207-5 Not Used.

207-6 Not Used.

207-7 Not Used.

207-8 VITRIFIED CLAY PIPE (VCP).

207-8.1 General. Except as modified in this subsection, vitrified clay pipe and fittings including perforated pipe shall be extra strength or high strength manufactured in accordance with ASTM C700.

207-8.2 Manufacturing Requirements.

207-8.2.1 General. All pipe and fittings shall be clearly marked with the name or trademark of the manufacturer, the location of the plant, and the strength designation. All standard length straight pipe as defined in 207-8.2.2 shall, in addition to the above, be marked with a manufacturer's date code. All fabricated bends and/or bevels shall be manufactured from pipe meeting all requirements of the pipe specifications for the Work.

207-8.2.2 Dimensions and Tolerances. The pipe diameter shall not vary from a true circle by more than 3 percent of nominal diameter. Except for special purposes, the minimum standard length of straight pipe, exclusive of socket depth, shall be 40 inches (1000 mm). Pipe shall not deviate from straight by more than 1/16 inch per foot (5 mm/m) of length.

207-8.2.3 Imperfections. Imperfections in pipe and fittings containing blisters, cracks, and chips in excess of the limits herein will be rejected; however, certain cracks and chips meeting the requirements of 207-8.2.4 may be repaired in accordance with 207-8.6.

a) **Blisters.** For pipe of nominal sizes 3 to 18 inches (75 to 450 mm), blisters shall not exceed 3 inches (75 mm) in any direction, and no blister or pimple shall project more than 1/8 inch (3 mm) above the surface of the pipe.

   For pipe of nominal sizes over 18 inches (450 mm), no blister shall exceed in any direction, 2 inches per foot (170 mm/m) of internal diameter, and no blister or pimple shall project above the surface of the pipe more than 1/8 inch per foot (10 mm/m) of internal diameter.

   Pipe shall have no broken blisters.

b) **Cracks.** There shall be no cracks passing through the barrel or socket except that a single crack at the spigot end of the pipe not exceeding 75 percent of the depth of the socket, or a single circumferential crack in the socket not exceeding 3 inches (75 mm) in length or a single crack not exceeding 2 inches (50 mm) in the axial direction is permitted.

c) **Chips.** Chips on the interior surface shall not exceed 2 inches (50 mm) in length, 1 inch (25 mm) in width, and a depth of 1/4 of the barrel thickness, but not to exceed 1/4 inch (6 mm). A single pipe shall contain no more than 2 such defects.

207-8.2.4 Repairable Imperfections.

a) General. Structurally sound clay pipe larger than 15 inches (375 mm) in size may be repaired as provided in 207-8.6.

Repairs of any type at the spigot or socket, shall be limited to one for each 60 degrees of circumference, and a maximum of four at either end. Repaired pipe shall not be used for fabricated fittings unless the repaired pipe is tested. Molded fittings may be repaired within the scope of the Specifications.

b) Cracks. The following longitudinal cracks parallel to the axis caused by shrinkage or drying and not more than 1/32 inch (0.8 mm) wide may be repaired:

1) A crack on the exterior of the spigot that does not penetrate the entire barrel thickness and does not exceed 50 percent of the depth of the socket in length.
2) A crack in the socket of the pipe that does not penetrate the entire thickness and does not exceed 75 percent of the depth of the socket in length.
3) A crack that penetrates the entire thickness of the socket and does not exceed 50 percent of the depth of the socket in length.
4) A crack on the interior of the socket and in the shoulder on the exterior of the socket which does not exceed 3 inches (75 mm) in length and does not penetrate more than 20 percent of the wall thickness.

c) Surface Chips. Surface chips located on the exterior of the spigot, the interior or exterior of the socket, or on the shoulder of the socket may be repaired, provided:

1) The length of the circumference of the chip does not exceed twice the barrel thickness.
2) The width is not greater than 50 percent of the socket depth measured parallel to the axis.
3) The depth is not greater than 25 percent of the wall thickness measured perpendicularly to the axis.

d) Full-Depth Chips. Full-depth chips located on the socket may be repaired provided the length of the chip does not exceed twice the barrel thickness or the width does not exceed 25 percent of the socket depth.

207-8.3 Fittings and Stoppers. Fittings shall be made to such dimensions as will accommodate the joint system specified. Y- and T-branch fittings shall be furnished with spurs securely fastened by the manufacturer to the barrel of the pipe. There shall be no projection on the inner surface of the barrel.

T-branch fittings shall have their axis perpendicular to the longitudinal axis of the pipe. The axis of the spur on Y-branch fittings shall be 45-degrees from the longitudinal axis of the pipe. The barrel of each spur shall be of sufficient length to permit the proper jointing of the connecting pipe.

Stoppers furnished for installation in branch fittings and ends of pipe left unconnected shall be strong enough to sustain all applied construction and in-place loads, including field pressure tests. Stoppers for pipe shall be one of the following: polyethylene (PE), polyurethane, polypropylene, acrylonitrilebutadiene-styrene (ABS), polyvinyl chloride (PVC), ozone-resistant synthetic rubber, clay discs, or other material approved by the Engineer. The Contractor shall retest within 60 Days prior to installation any stopper that is more than 180 days old from the date of manufacture to ensure compliance with the requirements of the Specifications. The Contractor shall not install any stopper that is more than 2 years old from the date of manufacture.

207-8.4 Joints. Joints for vitrified clay pipe shall conform to 208-2. The maximum bevel of the ends of pipe to be laid on a curve shall be 4 degrees. Plain-end pipe shall not be beveled.

Each joint within vertical and horizontal curves shall be constructed using factory fabricated mitered or beveled pipe or by deflecting joints. In no case shall joints be deflected more than allowed in 306-1.2.3. Shop and layout drawings for mitered or beveled pipe shall be submitted to the Engineer for review and approval.

207-8.5 Testing Requirements.

207-8.5.1 General. Before a lot of pipe is acceptable for use, test pipes selected from the lot shall meet the requirements of the hydrostatic pressure and bearing tests described herein. The tests shall be made at the point of manufacture, in the presence of the Engineer, and at no cost to the Agency. Fittings will be subject to the requirements of the hydrostatic pressure test only.

When less than 50 pipes are to be furnished to the Work, the Engineer may waive the sampling, testing and acceptance requirements of this subsection and accept the manufacturer's written Certificate of Compliance that the pipe meets the quality and strength specified. All pipe will be subject to visual inspection and acceptance by the Engineer after delivery to the Work site.

All testing equipment shall be calibrated by a testing agency acceptable to the Engineer at intervals not to exceed 12 months or following repair of the hydraulic system or modification or relocation of the equipment.

Each lot of vitrified clay pipe is defined as not more than 500 sections of pipe for one size and class. The Engineer shall select for testing the following number of samples:

TABLE 207-8.5.1

No. of Sections in Lot	No. of Sections for Testing
Less than 41	2
41 - 60	3
61 - 80	4
81 - 250	5
251 - 300	6
301 - 350	7
351 - 400	8
401 - 450	9
451 - 500	10

The pipe selected for testing shall be sound and shall meet the dimensions and tolerances of the specifications.

207-8.5.2 Hydrostatic Pressure Test. Shall be carried out in accordance with the applicable requirements of ASTM C301 and shall precede the bearing test by not more than 3 hours.

207-8.5.3 Bearing Tests. Shall be carried out in accordance with the 3-edge bearing method requirements of ASTM C301. The pipe shall withstand the minimum 3-edge bearing test loads indicated in the following table:

TABLE 207-8.5.3

Nominal Diameter inches (mm)	Extra Strength Pipe lbs/ft (kN/m)	High Strength Pipe lbs/ft (kN/m)
3 (75)	2000 (29.2)	2200 (32.1)
4 (100)	2000 (29.2)	2200 (32.1)
6 (150)	2000 (29.2)	2200 (32.1)
8 (200)	2200 (32.1)	2400 (35.0)
10 (250)	2400 (35.0)	2600 (37.9)
12 (300)	2600 (37.9)	2900 (42.3)
15 (375)	3100 (45.2)	3400 (49.6)
18 (450)	3600 (52.5)	4000 (58.4)
21 (525)	4200 (61.3)	4600 (67.1)
24 (600)	4800 (70.1)	5300 (77.3)
27 (675)	5200 (75.9)	5700 (83.2)
30 (750)	5500 (80.3)	6100 (89.0)
33 (825)	5800 (84.6)	6400 (93.4)
36 (900)	6300 (91.9)	6900 (100.7)
39 (975)	6600 (96.3)	7300 (106.5)
42 (1050)	7000 (102.2)	7700 (112.4)

207-8.5.4 Acceptance. When all test pipes meet the hydrostatic pressure and bearing tests, the entire lot of pipe is acceptable. When 2 test pipes fail, the entire lot will be rejected. When one pipe fails, a second group of 2 pipes must pass the tests, otherwise the entire lot will be rejected.

207-8.6 Clay Pipe Repair.

207-8.6.1 Repair Methods and Materials.

a) General. All surfaces to be repaired shall be clean and dry. All unsound material at lumps or blisters shall be ground smooth and flush with adjacent surfaces. Cracks shall be grooved 1/8 to 1/4 inch (3 mm to 6 mm) wide and 1/8 to 1/4 inch (3 mm to 6 mm) deep for the full length of the crack. All unsound material at chips, flakes, pits, and spalls shall be removed and edges shall be 1/16 inch (1.5 mm) minimum below adjacent surfaces. There shall be no feather edges.

Prepared areas shall be cleaned of dust and other loose particles and then filled with repair material compounded to provide properties most desirable for sewerage service. Repair material shall resist bacterial attack and attack by chemicals or combinations of chemicals normally present in domestic and industrial sewage.

Repair material shall be mixed, applied, and cured as recommended by the manufacturer and approved by the Engineer, and shall have a color contrasting with the color of pipe to be repaired. If necessary to produce a contrast in color, carbon black in a small quantity may be added to the repair material. The repair material shall be subject to adhesion and chemical testing as required by the Engineer to determine its suitability for use.

b) Adhesion Test. Vitrified clay bars 1 inch (25 mm) square in cross section and approximately 8 inches (200 mm) in length, compounded of the same materials as the vitrified clay pipe and fired to clay pipe manufacturing temperature shall be used in preparing test specimens. The bars shall have a modulus of rupture of not less than 1,600 psi (11.0 MPa) when tested in flexure with third-point loading.

The bars shall be cut through at the midpoint and then bonded with the repair material. Following a 7-Day maximum cure period at ambient room temperature, the bonded bars shall be tested in flexure with third-point loading.

The average modulus of rupture of 5 test bars bonded with the repair material shall not be less than 1,600 psi (11.0 MPa).

Five additional test bars bonded with the repair material and immersed for 60 Days in water at ambient room temperature shall have an average modulus of rupture not less than 1,500 psi (10.3 MPa).

c) **Chemical Tests.** Each specimen of repair material shall lose not more than 2 percent of its weight after being immersed in the solutions listed in Table 208-2.3.2 (Note 3) for a period of 30 Days and being reconditioned as indicated.

207-8.6.2 Inspection of Repairs. All pipe to be repaired shall be inspected by the Engineer after preparation for repair, again after repair has been made. Repairs made without prior inspection will be rejected. The Engineer may require retesting of any repaired pipe to demonstrate its soundness. The Agency shall be reimbursed for all costs incurred for inspection and testing of repaired pipe.

207-9 CAST IRON SOIL PIPE. Cast iron soil pipe and fittings shall conform to ASTM A74. Cast iron soil pipe shall not be used for mainline gravity sewers or for any pressure piping used to convey sewage.

207-10 Not Used.

207-11 CORRUGATED STEEL PIPE AND PIPE ARCHES.

207-11.1 General. Corrugated steel pipe, pipe arches, nestable pipe, slotted pipe, spiral rib pipe, spiral rib pipe arches, and coupling bands shall be manufactured and inspected in conformance with AASHTO M36/ASTM A760/A760M or AASHTO M245/ASTM A762/A762M and as specified herein. The size, type, and metal thickness of the pipe to be furnished shall be as shown as on the Plans or specified in the Special Provisions.

Corrugated steel pipe arches and spiral rib pipe arches shall consist of round pipe which has been re-formed to multi-centered pipe having an arch shaped top with a slightly curved integral bottom. Nominal diameter shall be the minimum inside dimensions of the round pipe. Pipe arch dimensions shall be in accordance with AASHTO M36/ASTM A760/A760M or AASHTO M245/ASTM A762/A762M.

207-11.2 Materials.

207-11.2.1 General. The material for corrugated steel pipe, pipe arches, spiral rib pipe, and spiral rib pipe arches shall be zinc coated (galvanized) or aluminum coated (AL-T-2) or polymer precoated steel sheet conforming to AASHTO M218/ASTM A444/A444M or AASHTO M274/ASTM A819 or AASHTO M246/ASTM A742/A742M. Material Safety Data Sheets (MSDS) are available from the pipe manufacturers.

The manufacturer of corrugated steel pipe, pipe arches, spiral rib pipe, and spiral rib pipe arches shall furnish to the Engineer a Certificate of Compliance. Additional testing, as required by the Engineer, shall be done at the Contractor's expense.

207-11.2.2 Coupling Bands. The coupling bands shall be of either one-, two-, or three-piece construction and shall be of the same material as the pipe. The coupling bands for the pipe larger than 42 inches (1050 mm) shall be of 2- or 3-piece construction. Coupling bands shall be formed metal not more than three standard culvert sheet thicknesses lighter than that of the pipe to be connected, but shall be not less than 0.052 inch (1.32 mm) or more than 0.109 inch (2.77 mm) thick. The minimum width of the coupling bands for pipe ends other than flanged shall be 10-1/2 inches (265 mm) for annular corrugations and rerolled ends and 12 inches (300 mm) for helical corrugations except for hugger bands for pipes 42

inches (1050 mm) or less in diameter installed in a buried condition without watertight joints, which may be 4 inches (100 mm). Dimpled coupling bands shall not be used without prior written approval of the Engineer. All coupling band connection hardware shall be galvanized in accordance with 210-3 or electroplated in accordance with ASTM A164, Type RS, or ASTM B633, Class Fe/Zn 5. Bolts and nuts for all types of coupling bands shall conform to the requirements of ASTM A307.

The installed distance between corrugated pipe ends shall be no greater than 1-1/2 inches (38 mm) and the maximum difference in diameter between pipe ends to be joined shall be 1/2 inch (12.5 mm) for pipe sizes 48 inches (1200 mm) and under and 1 percent of the diameter for larger pipe sizes.

When required by the Plans or the Special Provisions, watertight joints shall be provided by the use of approved sealant or gasket materials. Gasket material shall conform to 208-1.2. These materials shall be neoprene expanded rubber or sheet rubber gaskets, "O" ring rubber gaskets, butyl rubber base joint sealant, or other approved materials. Sheet rubber gaskets shall be at least 7 inches (175 mm) wide and 3/8 inch (9.5 mm) thick and shall conform to the requirements of ASTM D1056 with Grades 41 to 43 inclusive, unless otherwise specified. "O" rings shall conform to ASTM C443 and shall not be used on helical corrugations. Test for watertight joints shall conform to 306-1.4.6.

207-11.3 Fabrication.

207-11.3.1 General. Unless otherwise specified, corrugated steel pipe, pipe arches, spiral rib pipe and spiral rib pipe arches, shall be furnished with pipe ends cut perpendicularly to the longitudinal axis of the pipe. Pipe ends shall be cut uniformly and shall be fabricated so that the pipe can be effectively joined with coupling bands conforming to 207-11.2.2.

Corrugated steel pipe may be fabricated either by riveting, resistance spot welding or using a helically corrugated steel pipe with a continuous helical lock seam or a continuous helical welded seam paralleling the corrugation.

Spiral rib pipe shall be fabricated with helical ribs projecting outwardly with a continuous lock seam or welded seam paralleling the rib.

207-11.3.2 Fabrication by Spot Welding. Pipe fabrication by spot welding shall conform to the requirements of AASHTO M36/ASTM A760/A760M. Pipes fabricated by resistance spot welding shall be the full circle type with lap joint construction. The center of each spot weld shall be at least its radius plus 1/4 inch (6.5 mm) from the edge of the steel sheets.

Spot welding shall be performed in such a manner that the exterior surfaces of 90 percent or more of the spot welds on a length of pipe show no evidence of melting or burning of the base metal; and the base metal is not exposed when the area adjacent to the electrode contact surface area is wire brushed. Discoloration of the spot weld surfaces will not be cause for rejection.

207-11.3.3 Fabrication by Continuous Helical Seam.

a) **Helical Corrugations and Pitches.** Helically corrugated steel pipe and spiral rib pipe shall be fabricated using corrugated profiles and continuous helical pitches as shown in Table 207-11.3.3 (A).

TABLE 207-11.3.3 (A)

Diameters inches (mm)	Nominal Pitch[1] inches (mm)	Max. Pitch[1] inches (mm)	Rib Width inches (mm)	Min. Depth inches (mm)	Seam Pitch[1] inches (mm)
6 thru 12 (150 thru 300)	1-1/2 (38)	1-7/8 (48)	—	1/4 (6.5)	12 (305)
12 thru 96 (300 thru 2400)	2-2/3 (68)	2-7/8 (73)	—	1/2 (13)	24 (610)
42 thru 120 (1050 thru 3000)	3 (75)	3-1/4 (83)	—	1 (25)	21 (533)
42 thru 120 (1050 thru 3000)	5 (125)	5-1/4 (133)	—	1 (25)	29-1/2 (749)
18 thru 72 (450 thru 1800)	11-1/2 (292)	11-3/4 (298)	3/4 (19)	1 (25)	—

1. Pitch shall be measured at right angles to the direction of the corrugation.

For spiral rib pipe and spiral rib pipe arches, the corrugations shall be essentially rectangular ribs projecting outwardly from the pipe wall. The width of the ribs shall be 3/4 inch (19 mm) plus 2 times the wall thickness ± 1/8 inch (3 mm). The height of the ribs shall be a minimum of 0.90 inch (23 mm). The radius bend of the metal at the corners of the ribs shall be not less than 0.10 inch (2.55 mm) or greater than 0.17 inch (4.30 mm). All rib measurements will be made outside to outside except for the inside radius bend. The rib spacing shall be 11-1/2 inches (292 mm) ± 1/2 inch (12.5 mm) center to center.

b) Continuous Lock Seam Pipe. Pipe shall be fabricated with the lock seam parallel to the corrugation, and may be used for full circle and equivalent pipe-arch sizes. The lock seam shall be formed in the tangent element of the corrugation profile with its center near the neutral axis, and shall meet the following requirements:

1) The edges of the sheets within the cross-section of the lock seam shall lap at least 5/32 inch (4 mm) for the pipe 10 inches (250 mm) or less in diameter and at least 5/16 inch (8 mm) for pipe greater than 10 inches (250 mm) in diameter, with an occasional tolerance of minus 10 percent of lap width allowable.
2) The lapped surface shall be in tight contact.
3) There shall be no excessive angularity on the interior of the 180-degree fold of metal at the lock seam which will cause any visual cracks in the sheet. Roller indentations shall not cause any cracks in the sheet or a loss of metal-to-metal contact within the seam.
4) Tensile specimens cut from production pipe normal to and across the lock seam shall develop the strength as tabulated in Table 207-11.3.3 (B).
5) Continuous lock seam pipe shall be sampled and tested in accordance with AASHTO T 249.

TABLE 207-11.3.3 (B)

Pipe Sheet Thickness inches (mm)	Gage No. (U.S. Std.)	Minimum Lock Strength lb/in (kN/m) of width
0.064 (1.63)	16	425 (74)
0.079 (2.01)	14	650 (114)
0.109 (2.77)	12	875 (153)
0.138 (3.51)	10	1,100 (193)
0.168 (4.21)	8	1,500 (263)

c) **Continuous Welded Seam Pipe.** Pipes fabricated with a continuous helical weld seam parallel to the corrugations may be used for full circle and equivalent pipe arch sizes. The welding process shall be so controlled that the combined width of the weld and adjacent spelter coating burned by the welding does not exceed 3 times the thickness of the metal. If the spelter is burned outside of these limits, the weld and burned spelter shall be treated as specified in 207-11.4. When pipe is fabricated with aluminum coated sheets, the weld seam shall be metalized during the fabrication of the pipe with an aluminum alloy wire to completely cover and protect the damaged coated area. Testing for welded seam quality control shall conform to AASHTO T241. This test may be waived for pipe manufactured with factory reformed ends.

207-11.4 Repair of Damaged Galvanizing or Aluminizing. When the metallic coated surface has been burned by gas or arc welding, all surfaces of the welded connections shall be thoroughly cleaned by wire brushing and all traces of the welding flux and loose or cracked zinc or aluminum removed, after which the areas shall be repaired as specified in 210-3.5. In addition, damaged aluminized surfaces shall be given an asphalt mastic coating per 207-11.5.2.

207-11.5 Coatings, Linings, and Pavings.

207-11.5.1 General. When required by the Special Provisions, corrugated steel pipe, coupling bands, and fittings shall be coated, lined, or paved. Each section of pipe and fittings shall have the nominal metal thickness painted on the inner surface so that the metal thickness can readily be identified. Coupling bands need not be coated on the interior surface.

207-11.5.2 Coatings.

a) **General.** Coatings shall be applied to one or both pipe surfaces to a minimum thickness as specified herein. Any appearance of pinholes, blisters, cracks, excessive whiskering (stalactites), or lack of bond shall be cause for rejection.

b) **Bituminous Coatings.** Hot-applied bituminous coating shall be applied to both surfaces and shall conform to AASHTO M190, Type A/ASTM A849, Class B. Minimum coating thickness shall be 0.050 inch (1.3 mm). Where concrete lining or paving is to be placed on aluminum coated steel, that portion of the conduit in contact with the concrete shall be coated with asphalt mastic coating per 207-11.5.2 prior to placement of the concrete. With the approval of the Engineer, the Contractor or manufacturer may add (anti-corrosion) additives to the concrete mix in lieu of asphalt coating.

c) **Asphalt Mastic Coating.** Cold-applied asphalt mastic coating shall conform to the requirements of AASHTO M243, except that asbestos fiber shall not be used. The asphalt mastic material shall be applied to the surface specified to a minimum thickness of 0.050 inch (1.3 mm).

d) **Polymeric Coating.** The polymeric coating shall comply with the requirements of ASTM A849 Class P, and may be plant applied after pipe fabrication. Polymeric coatings shall be applied to the surfaces specified to a minimum thickness of 0.010 inch (0.25 mm).

207-11.5.3 Linings.

a) **General.** Linings shall be applied to the interior of the pipe to produce a smooth surface.

b) **Bituminous Linings.** Hot-applied bituminous linings shall conform to the requirements of AASHTO M190, Type D/ASTM A849, Class M. Minimum lining thickness shall be 1/8 inch (3.2 mm) over the tops of the crests of the inside corrugations.

c) **Concrete Lining.** The concrete lining shall be plant applied to produce a homogeneous, non-segregated, smooth lining with a minimum thickness of 1/8 inch (3 mm) over the crest of the inside corrugations, in accordance with ASTM A849, Class C.

The concrete shall comply with 201-5, except that sand gradation requirements will be waived. Fly ash in accordance with 201-1.2.5 is permitted. The 28-Day strength of the concrete shall be a minimum of 5,000 pounds per square inch (34.5 MPa). Cracks in the lining greater than 1/16 inch (1.5 mm) shall be repaired in accordance with 207-3.3. Interior joints shall be mortared in accordance with 306-1.2.4.

207-11.5.4 Pavings.

a) **General.** Paving material shall cover at least 25 percent of the circumference of round pipe and 40 percent of the circumference of pipe arches and shall be placed symmetrically, left and right of the bottom centerline of the pipe.

b) **Bituminous Paving.** Hot-applied bituminous paving shall conform to the requirements of AASHTO M190, Type C/ASTM A849, Class M.

c) **Concrete Paving.** Concrete shall be Class 600-E-3250 (360-E-23). Steel reinforcing, when specified, shall conform to 201-2. The concrete shall be placed to the thickness specified, after the pipe has been backfilled.

207-11.6 Nestable Pipe. Nestable pipe shall be fabricated in 2 separate half-circle sections and the sections shall be firmly joined together, all in accordance with Federal Specification MIL-P-236E. The longitudinal joint of the nestable pipe sections may be either Type I, flanged, or Type II, notched, as specified in MIL-P-236E.

207-11.7 Slotted Pipe. The corrugated steel pipe used in the slotted drain shall meet the requirements of AASHTO M36/ASTM A760/A760M and shall be galvanized or aluminized coated (AL-T-2) steel. The diameter and gage shall be as shown on the Plans.

The grates shall be manufactured from ASTM A570/A570M, Grade 36 steel. The spacers and bearing bars (sides) shall be 3/16 inch (4.763 mm) material ± 0.0075 inch (0.190 mm).

The spacers shall be on 6-inch (150 mm) centers and welded on both sides to each bearing bar (sides) with 4, 1-1/4 inch (32 mm) long, 3/16 inch (5 mm) fillet welds on each side of the bearing bars.

The Engineer may require tensile strength tests on the grate if the grate is not in compliance with the above. If tensile strength tests are required, minimum results for an in-place spacer pulled perpendicular to the bearing bar shall be:

T = 12,000 pounds (53.4 kN) for 2-1/2 inch (63 mm) grate

15,000 pounds (T = 66.7 kN) for 6-inch (150 mm) grate

The grates shall be trapezoidal with a 1-3/4-inch (44 mm) opening in the top and 30-degree slanted spacers unless shown otherwise on the Plans. If vertical grates are shown on the Plans, the grates shall be vertical (straight sides) with a 1-3/4-inch (44 mm) opening in the top and 30-degree slanted spacers. The grate shall be 2-1/2 inches (63 mm) or 6 inches (150 mm) high as shown on the Plans.

The grate shall be galvanized in accordance with ASTM A123 except with a 2-ounce per square foot (605 g/m^2) galvanized coating.

The grate shall be fillet welded with a minimum 1 inch (25 mm) long weld to the corrugated steel pipe on each side of the grate at every other corrugation.

The corrugated steel pipe shall have a minimum of 2 re-rolled annular ends. The slotted drain bands shall be a modified Hugger band to secure the pipe and prevent infiltration of the backfill. When the slotted drain is banded together, the adjacent grates shall have a maximum 3-inch (75 mm) gap.

207-11.8 Underdrains. The pipe for underdrains shall be of the full-circle type and perforations in the pipe may be drilled or punched. The perforations may be located either in the inside crests or in the flat tangent portion of the corrugations, but not in both locations in the same length of pipe.

Steel band couplers shall be as specified in 207-11.2.2. Sleeve type couplings may be substituted for the band couplers. The couplings may be either plastic or galvanized steel, suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets. The couplings shall not distort under normal conditions of use.

207-11.9 Siphons. Pipe and couplings shall be watertight and shall conform to 207-11.2.

The pipe for siphons shall be of such lengths that the number of field connections will be held to a minimum. The outside seams of riveted, spot welded or continuous helical lock seam pipe shall be continuously soldered. Rivets and spot welds on circumferential seams shall be spaced at approximately 2-1/2 inches (64 mm) on center with maximum of 3 inches (75 mm) on center.

Prior to backfilling, the pipe for siphons shall be subject to the hydrostatic test as specified in 306-1.4.6.

207-11.10 Pipe Downdrains. Pipe and couplings for downdrains shall be watertight in accordance with 207-11.2. When required by the Plans or the Special Provisions, the Engineer may require testing in accordance with 306-1.4.6.

Joints for downdrains shall comply with the following joint property requirements:

TABLE 207-11.10:

TENSILE STRENGTH (PULL APART STRENGTH)

0 thru 42 inches (0 thru 1050 mm) pipe diameter	5,000 lbs (22.3 kN)
42 thru 84 inches (1050 thru 2200 mm) pipe diameter	10,000 lbs (44.5 kN)

207-12 STRUCTURAL STEEL PLATE PIPE AND ARCHES.

207-12.1 General. The sizes, thicknesses, and dimensions of structural steel plate pipe, arches, and pipe arches shall be as designated on the Plans or in the Special Provisions.

207-12.2 Materials.

207-12.2.1 General. Steel sheets, plates, bolts, and nuts shall conform to AASHTO M 167. In accordance with the requirements of Section 4, the fabricator of the structural steel products shall furnish to the Engineer a Certificate of Compliance stating that the materials furnished comply with these requirements. Galvanized surfaces which are damaged shall be repaired in accordance with 210-3.5.

207-12.2.2 Identification. When plates of 2 dissimilar thicknesses are involved in one cross-section of an installation, the thickness of structural steel plates will be identified on the Plans, or in the proposal in accordance with the following:

Each installation will be designated by size and symbol indicating the number and thickness of plates required. Thus, "(4 x 0.109-1 x 0.168)" [(4 x 2.77-1 x 4.27)]) will be used to designate an installation for one plate length composed of 4, 0.109 inch (2.77 mm) thick plates and one 0.168 inch (4.27 mm) thick plate, with the heaviest thickness to be placed in the invert. This designation does not prevent the Contractor from using fewer or more plates, provided the minimum thickness requirements are met.

207-12.3 Distorting. When required by the Plans or the Special Provisions, circular structural steel plate pipe shall be distorted, either at the fabricating shop or in the field.

Plates distorted in the fabricating shop shall provide an increase in the vertical diameter of the pipe, after assembly, of approximately 5 percent for the full length. Plates shall be marked to assure that they will be placed in proper position.

The method for distorting plates in the field shall conform to details shown on the Plans and to 304-4.

207-12.4 Coatings. When required by the Plans or the Special Provisions, a protective coating shall be applied to structural steel plate pipe and arches, including all appurtenant fasteners and fittings. Bituminous coating shall conform to 207-11.5.2. Asphalt mastic coating shall conform to 207-11.5.4. Asphalt mastic coating may be field applied after assembly of the structure.

When bituminous coatings are shop applied, each plate shall have the plate thickness on the inner surface so that the plate thickness can be readily identified.

207-13 CORRUGATED ALUMINUM PIPE AND PIPE ARCHES.

207-13.1 General. Corrugated aluminum pipe, pipe arches, and connectors shall be manufactured and inspected in conformance with the requirements of AASHTO M 196, M 197, and as specified herein. The size, type, and gage of the pipe to be furnished shall be as shown on the Plans or in the Special Provisions.

Corrugated aluminum pipe arches shall consist of corrugated aluminum pipe which has been re-formed to multicentered pipe having an arch-shaped top with a slightly curved integral bottom. The minimum radius of any part of the pipe section shall be not less than 3 inches (75 mm).

The specifications contained herein for pipe shall also apply to pipe arches.

Nominal diameter, as referred to in AASHTO M 196 and M 197, shall be defined as meaning the minimum inside dimension of the pipe.

207-13.2 Materials.

207-13.2.1 General. Corrugated aluminum sheets covered by this section shall be fabricated from Alloy Alclad 3004 with Temper H-34 and shall conform to ASTM B209/B209M and the following mechanical properties:

TABLE 207-13.2.1 (A)

Thickness inches (mm) Property	0.051 to 0.113 (1.30 to 2.87)	0.114 to 0.249 (2.88 to 6.32)
Tensile Strength (minimum)	31,000 psi (215 MPa)	31,000 psi (215 MPa)
Yield Strength (2% offset) (minimum)	24,000 psi (165 MPa)	24,000 psi (165 MPa)
Elongation in 2 inches (50 mm)	4% min.	5% min.

The gages and thickness referred to in this specification are as follows:

TABLE 207-13.2.1 (B)

Thickness inches (mm)	Gage Number (U.S. Standard)
0.060 (1.52)	16
0.075 (1.91)	14
0.105 (2.67)	12
0.135 (3.43)	10
0.165 (4.19)	8

The cladding thickness shall be 5 percent of the total composite thickness.

Rivets shall conform to ASTM B316M/B316 for Alloy 6053 with Temper T-4 and the following physical properties:

TABLE 207-13.2.1 (C)

Tensile Strength (minimum)	25,000 psi (170 MPa)
Yield Strength (2% Offset) (minimum)	14,000 psi (95 MPa)
Shear Strength (minimum)	15,000 psi (105 MPa)
Elongation in 2 inches (50 mm) (minimum)	16%

The corrugations for all pipe, measured at right angles to the direction of the corrugation, shall conform to the dimensions in the following table:

TABLE 207-13.2.1 (D)

Diameter[1] inches (mm)	Width[2] inches (mm)	Depth (Min.)[2] inches (mm)	Type of Corrugation
8 and larger (200 and larger)	2-2/3 (68)	1/2 (13)	Annular
36 and larger (900 and larger)	3 (76)	1 (25)	Annular
6 through 10 (150 through 250)	1-1/2 (38)	1/4 (6)	Helical
12 and larger (300 and larger)	2-2/3 (68)	1/2 (13)	Helical
36 and larger (900 and larger)	3 (76)	1 (25)	Helical

1. Inside diameter of pipe shall not vary more than the following:
   6 inch through 18 inch (150 mm through 450 mm) in diameter, 1/4 inch (6 mm) maximum
   21 inch through 24 inch (525 mm through 600 mm) in diameter, 3/8 inch (9.5 mm) maximum
   24 inch (600 mm) and over in diameter, 1/2 inch (12.5 mm) maximum.
2. Minimum and maximum width and depth of corrugation shall conform to AASHTO M196 and M197.

The lengths and thickness of sheet, width of laps, and computed weight per lineal foot of finished corrugated aluminum pipe and arches shall be as specified in Table 4 of AASHTO M196. The dimensions of the corrugated aluminum pipe arch shall be as shown in Table 7 of AASHTO M196.

207-13.2.2 Connecting Bands. The connecting bands shall conform to the requirements of AASHTO M196, except the minimum width of band for 12-inch (300 mm) and larger pipe shall be 12 inches (300 mm). Minimum width of band for pipe less than 12 inches (300 mm) shall be 7 inches (175 mm) and minimum width of band for 1 inch x 3-inch (25 mm x 75 mm) corrugations shall be 14 inches (355 mm). The base metal of connecting bands shall be the same base metal as that of the pipe. The gage of the connecting bands for corrugated pipe and pipe arches may be 2 standard-use thicknesses lighter than that used for the pipe, but not less than 0.060 inch (1.52 mm) thick.

The band couplers shall be connected with galvanized steel bolts of not less than 1/2 inch (12.5 mm) diameter.

207-13.2.3 End Finish. The ends of 0.060 inch (1.52 mm) and 0.075 inch (1.91 mm) thickness installations shall be reinforced where shown on the Plans. The reinforcement shall consist of an aluminum band of at least 0.135 inch (3.43 mm) material at least 6 inches (150 mm) wide, on at least the outer 12 inches (300 mm) of 0.060 inch (1.52 mm) and 0.075 inch (1.91 mm) pipe shall be at least 0.075 inch (3.43 mm) material.

207-13.3 Fabrication.

207-13.3.1 General. At the option of the Contractor, corrugated aluminum pipe may be fabricated by riveting or by using a helically corrugated metal pipe with a continuous helical lock seam paralleling the corrugation.

207-13.3.2 By Riveting. Pipe fabricated by riveting shall conform to AASHTO M 196.

207-13.3.3 By Continuous Lock Seam. Pipe fabricated with a continuous helical lock seam parallel to the corrugations shall conform to the requirements of AASHTO M 196 and as specified herein.

207-13.4 Underdrains. Pipe for underdrains shall be of the full circle type and perforations in the pipe may be drilled or punched in accordance with AASHTO M 196. The perforations may be either in the inside crests or in the flat tangent portion of the corrugations but not in both locations in the same length of pipe.

Sleeve-type couplings may be substituted for the band couplers. The couplings may be either plastic or aluminum, suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets. The couplings shall not distort under normal conditions of use. Minimum thickness for underdrains shall be 0.060 inch (1.52 mm).

207-13.5 Pipe Downdrains. Joints for downdrains shall be watertight in accordance with 207-11.2.2. When required by the Special Provisions, the Engineer may require testing in accordance with 306-1.4.6.

Joints for downdrains shall comply with the following joint property requirements:

TABLE 207-13.5:

TENSILE STRENGTH (PULL APART STRENGTH)

0 to 42 inches (0 to 1050 mm) pipe diameter	5,000 pounds (22.3 kN)
45 to 84 inches (1125 to 2100 mm) pipe diameter	10,000 pounds (44.5 kN)

207-13.6 Bituminous Coating. When required by the Plans or Special Provisions, pipe and connecting bands shall be protected, both inside and outside, with a bituminous coating. The bituminous coating shall conform to the requirements of AASHTO M190 and as hereinafter specified.

The minimum thickness of bituminous material for all coated pipe measured on the crest of the corrugations shall be 0.05 inch (1.3 mm).

In paving the invert of aluminum pipes, the bituminous material shall cover the crests to a minimum depth of 1/8 inch (3 mm) and the width of paving shall at least cover one third of the periphery of pipe arches and one quarter of the periphery of circular pipes.

The bituminous material shall conform to Paragraph 4 of AASHTO M190, except that it shall be at least 90 percent soluble in cold carbon disulfide.

When corrugated aluminum pipes are to have a bituminous coating, the fabrication requirements specified in AASHTO M196 shall be altered so that the rivet heads inside the pipe will be in the valley of the corrugations.

Damaged bituminous coatings shall be repaired by the Contractor at its expense by applying bituminous material conforming to the provisions of this subsection.

207-13.7 Repair of Damaged Alclad Coating. Alclad coatings which have been damaged shall be repaired. The damaged area shall be thoroughly cleaned by wire brushing. The cleaned area shall be painted with 2 coats of zinc oxide-zinc dust paint conforming to the requirements of Military Specification MIL-P-15145. The paint shall be properly mixed with a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight.

207-14 STRUCTURAL ALUMINUM PLATE PIPE AND ARCHES.

207-14.1 General. The sizes, thicknesses, and dimensions of structural aluminum plate pipe, arches, and pipe arches shall be as designated on the Plans or in the Special Provisions.

207-14.2 Materials.

207-14.2.1 General. Aluminum sheets, plates, bolts, and nuts shall conform to AASHTO M 219. The fabricator of the structural aluminum products shall furnish to the Engineer a Certificate of Compliance stating that the materials furnished comply with these requirements. Each plate shall be marked on the inner surface so that the plate thickness can be readily identified after installation.

207-14.2.2 Identification. When plates of 2 dissimilar thicknesses are involved in one cross-section of an installation, the thickness of structural aluminum plates will be identified in accordance with 207-12.2.2.

207-14.2.3 Distorting. When required by the Plans or the Special Provisions, circular structural aluminum plate pipe shall be distorted, either at the fabricating shop or in the field.

Plates distorted in the fabricating shop shall provide an increase in the vertical diameter of the pipe, after assembly, of approximately 5 percent for the full length. Plates shall be marked to ensure that they will be placed in proper position.

Distorting of plates in the field shall conform to 304-4.3.

207-14.2.4 Coatings. When required by the Plans or the Special Provisions, a protective coating shall be applied to structural aluminum plate pipe and arches, including all appurtenant fasteners and fittings. Bituminous coating shall conform to 207-11.5.2 b). Asphalt mastic coating shall conform to 207-11.5.2 c). Asphalt mastic coating may be field applied after assembly of the structure.

207-15 ABS SOLID WALL PIPE.

207-15.1 General. This subsection applies to ABS plastic solid wall pipe for use as sanitary sewers, storm drains, and house connection sewers. Pipe, fittings, and joints shall comply with ASTM D2751 except as modified herein. Minimum wall thickness shall correspond with SDR 35. Joints for sanitary sewers, except for house connection sewers, shall be gasketed joints.

Joint solvent cement shall be an ABS cement conforming to ASTM D2235. Gaskets shall conform to the requirements of 208-4.

207-15.2 Material Composition and Testing. The pipe and fittings shall be made of ABS plastic which shall meet the minimum cell classification of 1-3-3, 3-2-2, or 2-2-3 as defined in ASTM D1788 and having the chemical composition as follows:

Acrylonitrile-butadiene-styrene (ABS) pipe - plastics containing polymers or blends of polymers, or both, in which the minimum butadiene content is 6 percent, the minimum acrylonitrile content is 15

percent, the minimum styrelene or substituted styrene content or both, is 15 percent and the maximum content of all other monomers is not more than five parts by weight per 100 parts of ABS resin. Additives and fibers, including but not limited to stabilizers, antioxidants, colorants, etc., shall not exceed 10 parts by weight per 100 parts of ABS resin.

Material shall meet or exceed the values and properties below:

TABLE 207-15.2

Property	ASTM Test Method	Minimum Value Based on Cell Classification		
		1-3-3	3-3-2	2-2-3
Izod impact @ 23° ± 2°C foot-lb/inch (J/m) of notch	D256	1 (53)	3 (160)	2 (107)
Deflection Temperature under load 264 psi (1820 kPa)	D648			
°F		190	180	190
°C		87	82	87
Tensile stress at yield , psi (MPa)	D638	5000 (34.5)	4000 (27.6)	5000 (34.5)
Specific Gravity:	D792			
Minimum		1.0	1.0	1.0
Maximum		1.2	1.2	1.2

207-15.3 Chemical Resistance (Pickle Jar Test). The Engineer may at any time direct the manufacturer to obtain samples of the compound and to prepare test specimens in accordance with ASTM D1987. These specimens shall comply with the minimum property values shown below and also with the applicable ASTM requirements.

Tensile, impact and weight change exposure specimens shall be immersed in the solutions specified in Table 211-2 (A) for a period of 112 Days. At 28-Day intervals, selected specimens shall be removed, washed, surface dried, and tested.

The weight change specimens shall be 2 inches (50 mm) in diameter and may be molded discs or discs cut from the pipe wall. They shall be conditioned in a mechanical convection oven for 7 Days at 110° ± 4°F (43° ± 2°C), then cooled in a desiccator for 3 hours at 73°± 4°F (23° ± 2°C), weighed, and then immersed in the solutions in Table 211-2 (A). At 28-Day intervals, selected specimens shall be removed, washed, surface dried, and weighed. These same specimens shall be reconditioned in a mechanical convection oven for 7 Days at 110° ± 4°F (43° ± 2°C), then cooled in a desiccator for 3 hours at 73°± 4°F (23° ± 2°C) and weighed again. If any specimen fails to meet these requirements at any time, the material will be rejected.

TABLE 207-15.3

Property	ASTM Test Method	Initial Values	Values After 112-Day Exposure
Tensile stress at yield, psi (MPa), minimum	D638	5,000 (34.5)	5,000 (34.5)
Impact Strength foot-lbs/inch (J/m) of notch, minimum	D256 Method A Size 1/2 x 1/8 x 2-1/2" (Size 12.7 x 3.17 x 63.5 mm)	2 (107)	2 (107)
Weight Change	D543		
Unconditioned			± 1.5% maximum
Conditioned			± 1.0% maximum

207-15.4 Pipe Acceptance. At the time of manufacture each lot of pipe and fittings shall be inspected for defects, and tested for impact, stiffness, and flattening in accordance with ASTM D2751.

When testing subsequent to manufacture, the impact requirement shall be excluded. For the flattening requirement, the percentage reduction in pipe diameter shall be not less than 15 percent for pipe marked SDR 23.5 or lower, and not less than 25 percent for pipe marked with higher SDR numbers. The stiffness requirement is unchanged.

A pipe lot shall consist of all pipe having the same marking number. The lot test specimen shall have a minimum length of 4 feet (1.2 m).

207-15.5 Marking. Pipe shall have a home mark to indicate full penetration of the spigot when the joint is made. Pipe shall be marked at 5-foot (1.5 m) intervals or less with a marking number which identifies the manufacturer, SDR, size, machine, date, and shift on which the pipe was produced.

207-15.6 Installation Time Limit. The Contractor shall retest within 60 Days prior to the installation of all pipe and fittings that are more than 180 Days old from the date of manufacture to ensure compliance with the requirements of the Specifications. The Contractor shall not install any pipe that is more than 2 years old from the date of manufacture.

207-16 ABS OR PVC COMPOSITE PIPE.

207-16.1 General. This subsection applies to ABS or PVC composite pipe for use as sanitary sewers, storm drains, and house connection sewers. Pipe, fittings, and joints shall comply with ASTM D2680, except as modified herein.

The pipe shall consist of two concentric extruded thermoplastic tubes integrally connected by webs to form a circular truss. The longitudinal void spaces shall be filled with inert material. The maximum average ID of the pipe, as determined by ASTM D2122, shall be:

TABLE 207-16.1

Nominal Size inches (mm)	Max. Average ID inches (mm)
6 (150)	5.81 (148)
8 (200)	7.90 (201)
10 (250)	9.88 (251)
12 (300)	11.83 (301)
15 (375)	14.80 (376)

Joint solvent cement shall be in accordance with 207-15.1 for ABS and 207-17.3.3 for PVC.

207-16.2 Material Composition and Testing. The ABS resin compound used in the manufacture of ABS composite pipe shall conform to the requirements of 207-15.2. The PVC resin shall conform to the requirements of 207-17.2.2.

207-16.3 Chemical and Physical Testing. ABS resins shall conform to 207-15.3. PVC resins shall conform to 207-17.5.

207-16.4 Pipe Acceptance. Each lot of pipe and fittings shall be inspected for defects and tested for stiffness and deflection in accordance with ASTM D2680. Installation time shall conform to 207-15.7.

A pipe lot shall consist of all pipe having the same marking number. The lot test specimen shall be a minimum length of 4 feet (1.2 m).

207-16.5 Marking. Pipe shall have a home mark to indicate full penetration of the spigot when a joint is made. Pipe shall be marked at 5-foot (1.5 m) intervals or less with a marking number which identifies the manufacturer, size and machine, date, and shift on which the pipe was made.

207-16.6 Repair. There shall be no discontinuity of the pipe inner wall. Ruptures in the pipe outer wall may be repaired if the damage is limited to an area that can be encompassed by a 3-inch (75 mm) diameter circle superimposed over the damage. Cell filler repair is unnecessary. A solvent welded repair patch of the same material as the pipe, at least equal to the thickness of the pipe outer wall, shall extend at least 1 inch (25 mm) beyond the damage. When damage exceeds these limits, the damaged section shall be cleanly removed.

207-17 PVC GRAVITY PIPE.

207-17.1 General. This subsection applies to the requirements for unplasticized PVC plastic pipe for sanitary sewers, storm drains, and house connection sewers. Pipe, fittings, couplings, and joints for solid wall pipe shall conform to the requirements shown in Table 207-17.1. Pipe, fittings, couplings, and joints for large diameter ((21 inch to 54-inch) (525 mm to 1350 mm)) closed profile wall pipe shall conform to ASTM F1803.

TABLE 207-17.1

Nominal Size inches (mm)	ASTM	Wall Thickness Min.
4 - 15 (100 - 375)	D3034	SDR 35
18 - 30 (450 - 750)	F679	"T-1" only

Joints for sanitary sewers, except house connection sewers, shall be gasketed joints.

207-17.2 Manufacturing Requirements.

207-17.2.1 Identification Marks. All pipe, fittings, and couplings shall be clearly marked at intervals not to exceed 5 feet as follows:

a) Nominal pipe diameter.

b) PVC cell classification.

c) Company, plant, shift, ASTM, SDR, and date designation.

d) Service designation or legend.

For fittings and couplings, the SDR designation is not required.

207-17.2.2 Cell Classification. Pipe shall be made of PVC plastic having a cell classification of 12454 or 13364, as defined in ASTM D1784. The fittings shall be made of PVC plastic having a cell classification of 12454, or 13343. PVC compounds of other cell classifications shall be in conformance with 207-17.5. Additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, colorants, etc., shall not exceed 10 parts by weight per 100 of PVC resin in the compound.

207-17.3 Joining Systems.

207-17.3.1 General. All pipe shall have a home mark on the spigot end to indicate proper penetration when the joint is made.

The socket and spigot configurations for the fittings and couplings shall be compatible to those used for the pipe.

207-17.3.2 Elastomeric Gasket Joints. Pipe with gasketed joints shall be manufactured with a socket configuration which will prevent improper installation of the gasket and will ensure that the gasket remains in place during the joint operation. The gasket shall be manufactured from a synthetic elastomer and shall conform to the requirements of 208-1.2 and 208-4.

207-17.3.3 Solvent Cement Joints. Pipe with solvent cement joints shall be joined with PVC cement conforming to ASTM D2564.

207-17.3.4 Injection Sealed Joints. Pipe with injection sealed joints shall be sealed with a PVC adhesive compound. The compound shall conform to the requirements of ASTM D2564 and shall have a minimum viscosity of 50,000 centipoises (50 Pa·S). The internal diameter of the socket shall be uniform with a locking taper at the base and an outer seal ring attached to the end. The socket shall have an injection port to inject the adhesive and an exhaust port on the opposite side to allow air to escape from the annular space.

207-17.4 Test Requirements.

207-17.4.1 General. Pipe, fittings, and couplings shall meet the requirements of the section titled "Requirements" of ASTM D3033, D3034, or F679 ("T-1" wall only). During production of the pipe, the manufacturer shall perform the specified tests for each pipe marking. A Certificate of Compliance by the manufacturer indicating compliance with specification requirements shall be delivered with the pipe. The Certificate of Compliance shall include the test result data. The PVC compound shall also meet the chemical resistance requirements of 207-17.5.

207-17.4.2 Acceptance. The basis for acceptance will be the inspection of pipe, fittings, and couplings; the tests specified in 207-17.4.1; and compliance with the Specifications. When the pipe is delivered to the Work site, the Engineer may require additional testing to determine conformance with the requirements of pipe flattening, impact resistance, pipe stiffness, and extrusion quality. Installation time shall conform to 207-15.7.

207-17.4.3 Selection of Test Pipe. When testing is required by the Engineer, one test pipe shall be selected at random by the Engineer from each 1,200 feet (370 m) or fraction thereof of one test pipe per lot. A lot shall be defined as pipe having the same identification marking. The length of specimen for each selected pipe shall be a minimum of 8 feet (2.4 m).

207-17.5 Chemical Resistance and Physical Testing. PVC shall be tested in accordance with 211-2 and conform to Table 207-17.5.

TABLE 207-17.5

Property	ASTM Test Method	Values (Initial and After 112-Day Exposure)		
		Cell Classification		
		12454	13343	13364
Tensile stress at yield, psi (MPa), min.	D638	7000 (48.3)	6000 (41.4)	6000 (41.4)
Impact Strength ft-lbs/inch (J/m) of notch, min.	D256 Method A Size 1/2 x 1/8 x 2-1/2" (12.7 x 3.17 x 63.5 mm)	0.65 (35)	1.5 (80)	1.5 (80)
Weight Change	D543			
Unconditioned		± 1.5% max	± 1.5% max	± 1.5% max
Conditioned		± 1.0% max	± 1.0% max	± 1.0% max

207-18 ANNULAR HIGH-DENSITY POLYETHYLENE PIPE WITH SMOOTH INTERIOR, CORRUGATED EXTERIOR, WITH BELL AND SPIGOT JOINTS (TYPE S).

207-18.1 General. These specifications apply to high density polyethylene, annular corrugated pipe and applicable fittings and coupling systems intended for use in the construction of gravity flow storm drains, culverts, and subsurface drains. The size, type, and material properties of the pipe to be furnished shall be as shown on the Plans or as specified in the Special Provisions.

207-18.2 Materials.

207-18.2.1 Extruded Pipe and Fittings and Blow Molded Fittings. Pipe and fittings shall be made of virgin HDPE that conforms to the requirements of AASHTO M294. The residue from ignition shall not exceed 30 percent as determined by ASTM D2584 except that the furnace temperature shall be 840° ± 45° F (450° ± 25° C).

207-18.2.2 Reworked Plastics. In lieu of virgin HDPE, the manufacturer may use clean reworked plastics, provided that it meets the cell class requirements specified in AASHTO M294. Reworked plastics shall be from a processor's own production that has been reground, palletized, or solvated after having been previously processed by molding, extrusion, etc.

207-18.3 Nominal Diameter, Wall Thickness, and Pipe Stiffness. The inside diameter, minimum wall thickness and minimum pipe stiffness shall be as specified in Table 207-18.3. The nominal diameter for each pipe shall be determined in accordance with ASTM D2122. The diameter shall not vary from a true circle by more than 2 percent of the nominal diameter. The wall thickness and inside diameter for each production pipe shall be determined in accordance with AASHTO M294. Wall thickness of Type S corrugated polyethylene pipe shall be the thickness of the inner liner measured between corrugated valleys. Pipe stiffness values shall be determined in accordance with 207-18.5.2.

TABLE 207-18.3

Diameter, inches (mm)	Minimum Wall Thickness, inches (mm)	Minimum Pipe Stiffness, psi (kPa)
12 (300)	0.035 (0.89)	50 (345)
15 (375)	0.039 (1.00)	42 (290)
18 (450)	0.050 (1.27)	40 (275)
24 (600)	0.059 (1.50)	34 (235)
30 (750)	0.059 (1.50)	28 (195)
36 (900)	0.069 (1.70)	22 (150)
42 (1050)	0.070 (1.80)	20 (140)
48 (1200)	0.070 (1.80)	18 (125)

Tolerance on the above specified inside diameter shall be 4.5 percent oversize and 1.5 percent undersize, but not more than 1-1/2 inch (38 mm) oversize.

207-18.4 Joints, Fittings, and Connections.

207-18.4.1 Water-Tight Joints. Pipe shall be joined with bell and spigot joints and unless otherwise shown on the Plans or specified in the Special Provisions, be water-tight. Pipe shall incorporate a gasket conforming to 208-4. Water-tight joints shall be tested at a pressure of at least 11 psi (74 kPa) in conformance with ASTM D3212. The manufacturer shall clearly identify watertight joints on the pipe delivered to the Work site.

207-18.4.2 Silt-Tight Joints. Pipe shall be joined with bell and spigot joints and shall at a minimum be silt-tight and leak resistant. The pipe shall incorporate a gasket conforming to 208-4. Silt-tight joints shall conform to ASTM D3212, modified to a test pressure of at least 2 pounds per square inch (14 kPa).

207-18.4.3 Fittings. Corrugated fittings include in-line joint fittings, such as couplings and reducers, and branch or complimentary assembly fittings such as tees, wyes, and end caps. Fittings shall be installed in accordance with the Plans and Special Provisions.

a) Fittings shall not reduce or impair the overall integrity or function of the pipe.

b) Fittings shall not reduce the inside diameter of the pipe being joined by more than 1/2 inch (12.5 mm). Reducer fittings shall not reduce the cross-sectional area of the smaller size.

c) Fabricated fittings shall be welded on the interior and exterior of all junctions.

d) Fittings shall conform to 207-18.4.2 unless otherwise specified in the Special Provisions.

207-18.5 Testing.

207-18.5.1 General. For testing purposes a production lot size shall consist of all pipe having the same lot marking number, but shall not exceed a total of 50 lengths per Day.

207-18.5.2 Pipe Stiffness. A minimum of 3 pipe specimens per production run shall be tested for pipe stiffness (PS) in accordance with ASTM D2412 modified as follows:

a) The test specimens shall be a minimum of one diameter length.

b) Position the first specimen in the loading machine with an imaginary line connecting the two seams formed by the corrugation mold (end view) parallel to the loading planes, when applicable. The specimen shall lie flat on the plate within 1/8 inch (3 mm). The specimen may be straightened by hand bending at room temperature to accomplish this. The first location shall be used as a reference point for rotation and testing of the two other specimens. Rotate the other specimens 45 and 90 degrees, respectively, from the reference point. Each specimen shall be tested in one position only.

c) The deflection indicator shall be readable and accurate to $\pm 7.9 \times 10^{-4}$ inches ($\pm$ 0.2 mm).

d) The beginning point for deflection measurement shall be at a load of 4.5 $\pm$ 1.1 pounds (20 $\pm$ 5 N). This point shall be considered as the origin of the load deflection curve.

207-18.5.3 Pipe Flattening. The specimens specified in 207-18.5.2 shall be flattened until the vertical inside diameter is reduced by 20 percent. The rate of loading shall conform to 207-18.5.2. The specimens shall not exhibit any cracking, splitting, or delamination. Wall buckling is indicated by reverse curvature in the pipe wall accompanied by a decrease in load carrying ability of the pipe. Any decrease or downward deviation in the pipe stiffness test curve shall be considered a wall buckling point.

207-18.5.4 Brittleness. Test pipe specimens shall be tested in accordance with ASTM D2444, except 6 specimens shall be tested, or 6 impacts shall be made on one specimen. In the latter case, successive impacts shall be separated by 120 $\pm$ 10 degrees for impacts made on one circle, or at least 12 inches (300 mm) longitudinally for impacts made on one element. Impact points shall be at least 6 inches (150 mm) from the end of the specimen. A tup (type B) shall be used, with a mass of 10 pounds (4.5 kg). The height of drop shall be 10 feet (3.0 m). A flat plate specimen holder shall be used. Specimens shall be conditioned for 24 hours at a temperature of 24.8 $\pm$ 1.8° F (–4 $\pm$ 2° C), and all tests shall be conducted within 60 seconds of removal from this atmosphere. The center of the falling tup shall strike on a corrugation crown for all impacts.

207-18.5.5. Environmental Stress Cracking of Finished Pipe. Pipe shall be tested for environmental stress cracking in accordance with ASTM D1693 modified as follows:

a) Three specimens shall be tested.

b) Each specimen shall consist of a 90-degree arc length of pipe.

c) Bend the specimens to shorten the inside chord length 20 ± 1 percent and retain in this position using a suitable holding device. Determine the arc chord measurement (B) of the specimen under test as follows:

Place the bent specimen in a container of suitable size and cover completely with a preheated wetting agent at 122 ± 1.8° F (50 ± 2° C). Maintain this temperature for 24 hours, and then remove the sample and inspect immediately. The wetting agent used in this test shall be 100 percent nonylphenoxy poly (ethyleneoxy) ethanol.

207-18.5.6 Slow Crack Growth Resistance. Basic resin compounds shall be tested for stress crack resistance in accordance with ASTM F2136 modified as follows:

a) The applied stress for the NCLS test shall be 600 pounds per square inch (4100 kPa).

b) The notched depth shall be 20 percent of the nominal thickness of the specimen.

c) The average failure time of the 5 test specimens shall not exceed 24 hours with no single test specimen's failure time less than 17 hours.

207-18.5.7 Joint Integrity. Joint integrity shall be tested in accordance with the following:

a) Each fitting or coupling shall be assembled in accordance with the manufacturer's recommendations. Use pipe samples at least 12 inches (300 mm) in length. Assemble a specimen at least 21 inches (600 mm) in length with the connection at the center.

b) Load the connected pipe and fitting between parallel plates at the rate of 1/2 inch (12.5 mm) per minute until the vertical inside diameter is reduced by at least 20 percent of the nominal diameter of the pipe.

c) Inspect for damage while at the specified deflection and after removal of the load.

d) Measure the maximum radial distance between pipe and fittings or between bell and spigot, during test and after the load is removed.

Pipe connections shall not separate to create a gap exceeding 3/16 inch (5 mm) when measured in the radial direction between pipe and coupling or between bell and spigot portions of the pipe. The gap measurement shall be taken at the gasket or hinge point. The test shall be conducted on a fully assembled joint, including the gasket. Fittings shall not crack or delaminate.

207-18.5.8 Cell Classification. Cell classification of pipe and fittings shall conform to 207-18.2.1.

207-18.6 Marking. Pipe and fittings shall be clearly marked at intervals of 11.5 feet (3.5 m) or less. Markings shall display the manufacturer's name and/or trademark, nominal size, plant designation code, and date of manufacture.

207-18.7 Pipe Acceptance or Rejection. Pipe shall be free of cracks, holes, delaminations, foreign inclusions, blisters, or other defects that would, due to their nature, degree or extent, have a deleterious effect on pipe performance as determined by the Engineer. Prior to installation, damaged pipe shall either be repaired or field cut to remove the damaged portion as approved by the Engineer and in accordance with the manufacturer's recommendations.

207-19 POLYETHYLENE (PE) SOLID WALL GRAVITY PIPE.

207-19.1 General. Polyethylene (PE) plastic solid wall pipe and liner for use in gravity flow sanitary sewers, storm drains, and house connection sewers shall comply with ASTM D3350 or ASTM F714. Unless otherwise specified, pipe shall conform to SDR 21. Fittings shall comply with ASTM D2683 or D3261.

207-19.2 Material Composition. Pipe and fittings shall be made from PE resins complying with ASTM D1248, Type III, Class C, Category 5, Grade P34, and ASTM D3350, and which shall further meet the requirements as listed in the following table:

TABLE 207-19.2

Property	Value	ASTM Test
Density (g/cm^3)	0.941-0.959	D1505
Melt Index (g/10 minutes)	0.15 max.	D1238 cond. E.
Flexural Modulus psi (MPa)	120,000 (827) minimum	D790
Tensile strength at yield psi (MPa)	3,200 (22.1) minimum	D638
Elongation at break	800%	D638
Brittleness temperature °F (°C)	-180° (-118°) max.	D746
Environmental Stress Crack Resistance F_0 (hrs.)[1] Test Condition "C"	192 min.	D1693
Hydrostatic Design Basic, psi (MPa) @ 73°F (23°C)	1600 (11.0)	D2837
Color	2% Carbon Black min.	

1. F_0 indicates no failures.

Additives and fillers including, but not limited to, stabilizers, antioxidants, lubricants, colorants, etc., shall not exceed 5 parts by weight per 100 of PE resin in the compound. The Engineer may require a Certificate of Compliance by the manufacturer that the test results conform to the requirements of the Specifications.

207-19.3 Pipe Acceptance. At the time of manufacture, each lot of pipe, liner, and fittings shall be inspected for defects and tested for Elevated Temperature Sustain Pressure in accordance with ASTM F714. Installation time limit shall conform to 207-15.7.

At the time of delivery, the pipe shall be homogeneous throughout, uniform in color, free of cracks, holes, foreign materials, blisters, or deleterious faults.

For testing purposes, a production lot shall consist of all pipe having the same marking number. It shall include any and all items produced during any given work shift and must be so identified as opposed to previous or ensuing production.

207-19.4 Marking. Pipe shall be marked at 5-foot (1.5 m) intervals or less with a coded number which identifies the manufacturer, SDR, size, material, machine, date, and shift on which the pipe was extruded.

At the end of the production shift, during which a production lot has been extruded, the marking code on the pipe shall be changed to indicate that said time intervals have elapsed and that a new production shift has begun.

Fittings shall be marked with the name of the manufacturer or its logo, the size, and the material from which they were molded or fabricated.

207-19.5 Chemical Resistance and Physical Testing. PE resins shall be tested in accordance with 211-2 and conform to Table 207-19.5.

TABLE 207-19.5

Property	ASTM Test Method	Initial Value	Value After 112 Days Exposure
Tensile stress at yield, psi (MPa) min.	D638	3,200 (22.1)	3,200 (22.1)
Impact Strength, ft-lb/inch (J/m) min.	D256 Method A Size 1/2 x 1/8 x 2-1/2" (12.7 x 3.17 x 63.5 mm)	3.5 (187)	3.5 (187)
Weight Change	D543		
Unconditioned			± 1.5% max.
Conditioned			± 1.0% max.

The Engineer may, at any time, direct the manufacturer and/or Contractor to obtain compound samples and to obtain compression molded test specimens in accordance with ASTM D1928. These specimens shall comply with the minimum property values in Table 207-19.5.

207-20 FIBERGLASS REINFORCED POLYMER MORTAR (FRPM) PIPE.

207-20.1 General. These specifications apply to FRPM pipe to be used for the construction of direct bury gravity sanitary sewers. storm drains, and related structures. Pipes. joints, and fittings shall conform to ASTM D3262. Unless otherwise specified, the minimum pipe stiffness shall be 46 pounds per square inch (318 kPa) when tested in accordance with ASTM D2412. The size, type, and stiffness of the pipe to be furnished shall be as shown on the Plans or in the Special Provisions.

207-20.2 Materials. The amount, location, and orientation of the chopped glass-fiber reinforcement shall be specifically designed for each application. The glass shall be a commercial grade of E-type glass fibers with a finish compatible with the resin used. The sand shall be a minimum 98 percent silica kiln-dried and graded. The polyester wall resin shall be an isophthalic, orthophthalic, or other approved resin with a minimum tensile elongation of 2 percent. A vinyl ester liner resin shall be used to meet the chemical requirements of 207-20.5. Designation per ASTM D3262 shall be Type 1, Liner 2, Grade 3, and a minimum pipe stiffness of 46 pounds per square inch (318 kPa) or greater, unless a higher value is indicated in the Plans or in the Special Provisions. Elastomeric sealing gaskets shall conform to the requirements of ASTM F477.

207-20.3 Dimensions.

207-20.3.1 Length. The nominal length shall be 20 feet (6 m) except as otherwise specified or required for bends or special joints, with a minimum length of 5 feet (1.5 m). At least 90 percent of the total footage of each size and class of pipe, excluding special order lengths, shall be furnished in nominal length sections.

207-20.3.2 Minimum Wall Thickness and Weight for Class SN 46 (Minimum Pipe Stiffness of 46 psi (318 kPa)). The outside diameter, minimum wall thickness, and weight are shown in Table 207-20.3.2.

TABLE 207-20.3.2

Nominal Inside Diameter inches (mm)	Maximum Outside Diameter inches (mm)	Minimum Wall Thickness inches (mm)	Average Weight lbs/ft (kg/m)
12 (300)	13.4 (340)	0.30 (7.7)	11 (16)
18 (450)	19.5 (495)	0.42 (10.7)	21 (31)
20 (500)	21.6 (549)	0.46 (11.7)	25 (37)
24 (600)	25.8 (655)	0.54 (13.8)	35 (52)
30 (750)	32.0 (813)	0.66 (16.8)	54 (80)
36 (900)	38.3 (973)	0.78 (19.9)	77 (115)
42 (1050)	44.5 (1130)	0.90 (22.9)	104 (155)
48 (1200)	50.8 (1290)	1.02 (26.0)	134 (199)
54 (1350)	57.1 (1450)	1.14 (29.0)	169 (251)
60 (1500)	62.9 (1598)	1.26 (32.0)	209 (311)
66 (1650)	69.2 (1758)	1.38 (35.1)	249 (371)
72 (1800)	75.4 (1915)	1.50 (38.1)	298 (443)
78 (1950)	81.6 (2073)	1.62 (41.2)	352 (524)
84 (2100)	88.7 (2253)	1.76 (44.7)	414 (616)
90 (2250)	94.3 (2395)	1.86 (47.3)	468 (696)
96 (2400)	100.6 (2555)	1.98 (50.3)	532 (792)
102 (2550)	108.0 (2743)	2.13 (54.1)	611 (909)

207-20.4 Joints. Pipes and fittings shall be field connected with a coupling or bell-and-spigot joint containing a compressed elastomeric gasket. Elastomeric gasket material shall conform to 208-1.2. Joints shall meet the performance requirements of ASTM D4161. Maximum allowable joint angular deflections for curves are shown in Table 207-20.4.

TABLE 207-20.4

Nominal Diameter, inches (mm)	Maximum Joint Deflection Angle (Degrees)
12 to 14 (300 to 350)	4
16 to 20 (400 to 500)	3
24 to 36 (600 to 900)	2
42 to 48 (1050 to 1200)	1.5
54 to 60 (1350 to 1500)	1
66 to 78 (1650 to 1950)	0.75
84 to 102 (2100 to 2550)	0.50

207-20.5 Chemical Resistance and Physical Testing. All pipe furnished under this subsection shall be tested in accordance with 211-2 and conform to Table 207-20.5 (A). In addition, the pipe shall be tested as follows:

a) **Properties.** In accordance with ASTM D3262.

b) **Accelerated Aging of Pipe Using A Deflected Condition.** Pipe rings shall be tested for retention of properties after exposure for 112 Days in a strained deflected condition to solutions specified in Table 207-20.5 (B).

Tests for initial properties to comply with Table 207-20.5 (A) shall be conducted on pipe rings and specimens cut from pipe rings all prior to their exposure.

Initial properties to be used in evaluation of physical property retention for each exposed pipe ring shall be determined from specimens cut from each ring after exposure. Initial property test specimens shall be taken from ring locations that were 45 degrees either side of the top position in the exposure test.

The deflection of pipe rings during the exposure shall be based on achieving a specific strain as shown in Table 207-20.5 (C).

c) **Test Procedures.** The following procedures shall be used for performing the accelerated aging test on pipe specimens:

1) Select 2 pipe diameters for testing.
2) Obtain 16 pipe rings each 12 inches (300 mm) long from both diameters.
3) One ring of each diameter shall be tested for initial properties in accordance with 211-2 and meet or exceed the values in Table 207-20.5 (A).
4) Weigh the remaining pipe rings and test for pipe stiffness per ASTM D2412.
5) Determine the appropriate test deflection of each pipe ring in accordance with Table 207-20.5 (C).
6) Deflect each pipe ring in accordance with ASTM D3681 procedures to the determined test deflection, dam the ends, and immediately begin the test exposure. Depth of test solution shall be 1/3 of pipe diameter.
7) Three pipe rings of each diameter and pipe joint section shall be exposed for 112 Days to each test solutions specified in Table 207-20.5 (B).
8) After exposure, immediately remove rings from deflections restraints, clean, and visually inspect (note any changes).
9) Weigh each ring and test for pipe stiffness.
10) Determine initial strength and elongation properties for each pipe ring in accordance with Table 207-20.5 (A).
11) Determine exposed properties of each pipe ring in accordance with Table 207-20.5 (A).
12) Compute changes in pipe stiffness, weight, and properties for each ring.
13) Compute average retentions for each test solution and evaluate for conformance to the requirements of Table 207-20.5 (A).

TABLE 207-20.5 (A)

Property	Initial and After Exposure[1]	After Exposure in strained deflected condition
Minimum Axial Tensile Strength	100% of initial	90% of initial
Minimum Axial Tensile Modulus	350,000 psi (2413 MPa) (secant tangent method)	90% of initial
Minimum Axial Elongation at break	0.5%	90% of initial
Weight change	+ 1.5%	+ 1.5%
Minimum Pipe Stiffness	46 psi (0.32 MPa)	90% of initial

1. After 112 Days in chemical solutions listed in 211-2.

TABLE 207-20.5 (B)

Chemical Solutions	Concentration
Sulfuric Acid	20%
Sodium Hydroxide	5%
Nitric Acid	1%
Sodium Hypochlorite	1%
Bacteriological	BOD not less than 700 PPM

1. Volumetric percentages: Actual concentration of reagent must be corrected to 100%.
2. After 112 Days in chemical solutions listed on Table 207-20.5 (B) in the stressed condition given in Table 207-20.5 (C).
3. May be 85% of initial if after exposure value exceeds 46 psi (0.32 MPa).

TABLE 207-20.5 (C)

Pipe Stiffness psi (MPa)	Minimum Strain (%)	Test Deflection
46 (0.32)	$0.39t/D^1$	9.1%
72 (0.50)	$0.34t/D^2$	7.9%

1. Linearly interpolate minimum strain values and test deflections for other values of pipe surface.
2. t and D are the nominal local wall thickness and the inside diameter.

207-20.6 Marking. Each pipe section shall be marked at both ends inside and every 5 feet (1.5 m) on the outside to identify the manufacturer, manufacturer number (identifies factory location, date of manufacture, shift, and sequence), nominal diameter, pipe stiffness, ASTM D3262 and designation, and lot number.

207-20.7 Pipe Acceptance or Rejection. The pipe shall be free of cracks, holes, delaminations, foreign inclusions, blisters, or other defects that would, due to their nature, degree, or extent, have a deleterious effect on the pipe performance as determined by the Engineer. Prior to installation, damaged pipe shall be either repaired or field cut to remove the damaged portion as approved by the Engineer. For testing purposes, a production lot shall consist of all pipe having the same lot marking number, but shall not exceed a total of 50 pipes. Pipe length, wall thickness, joint dimensions, pipe stiffness, and deflection characteristics shall be verified by inspection and testing in accordance with 4-1.3, 4-1.4, and ASTM D3262 requirements for each lot. Installation time limit shall conform to 207-15.6.

207-21 VITRIFIED CLAY MICROTUNNELING PIPE.

207-21.1 General. This specification is for vitrified clay microtunneling pipe to be used for sanitary sewers, storm drains, and related structures. Vitrified clay microtunneling pipe shall be manufactured in accordance with 207-8 and ASTM C1208, except as modified herein.

207-21.2 Dimensions and Tolerances. For typical tolerances, see Table 207-21.2. Since the physical properties of clay pipe vary at different manufacturing locations, the minimum wall thickness of the pipe shall be included with the submittals.

a) **Length.** Typical lengths shall be 4, 6, or 8 feet (1.5, 2, or 2.5 m).

b) **Straightness.** Pipe shall not deviate from straight by more than 0.05 inch per linear foot (4 mm/m) when the maximum offset is measured from the concave side of the pipe. Measurements shall be taken by placing a straightedge along the concave side of the full length of the pipe barrel, excluding the joint, and measuring the maximum distance between the straightedge and concave side of the pipe.

c) **Roundness.** The diameter shall not vary from a true circle by more than 2 percent of the nominal diameter. The out-of-round dimension is the difference between the maximum and minimum diameters measured at any one location along the barrel.

d) End Squareness. The ends of the pipe shall be perpendicular to the theoretical longitudinal axis within 0.004 inch per inch (4 mm/m) of outside diameter.

TABLE 207-21.2: DIMENSIONS AND TOLERANCES

Nominal Diameter inches (mm)[1]	Maximum Out-of-Round inches (mm)	Maximum Out-of-Square inches (mm)[2]	Minus Tolerance from Lying Length, inch/foot (mm/m)	Minimum Allowable Diameter inches (mm)[3]
8 (200)	0.16 (4)	0.04 (1.2)	0.25 (21)	7.6 (192)
10 (250)	0.20 (5)	0.06 (1.4)	0.25 (21)	9.5 (240)
12 (300)	0.24 (6)	0.06 (1.6)	0.25 (21)	11.4 (289)
16 (400)	0.30 (8)	0.09 (2.2)	0.25 (21)	15.2 (385)
18 (450)	0.36 (9)	0.09 (2.3)	0.25 (21)	17.2 (437)
20 (500)	0.38 (10)	0.10 (2.5)	0.25 (21)	18.9 (480)
21 (525)	0.42 (11)	0.10 (2.7)	0.25 (21)	20.0 (509)
24 (600)	0.43 (12)	0.12 (3.0)	0.38 (32)	23.1 (586)
27 (675)	0.54 (14)	0.13 (3.4)	0.38 (32)	25.9 (658)
30 (750)	0.60 (15)	0.14 (3.6)	0.38 (32)	28.7 (730)
33 (825)	0.70 (16)	0.16 (4.2)	0.38 (32)	31.5 (801)
36 (900)	0.72 (18)	0.18 (4.5)	0.38 (32)	34.6 (878)
39 (975)	0.80 (20)	0.19 (4.9)	0.38 (32)	37.5 (953)
42 (1050)	0.84 (21)	0.21 (5.2)	0.38 (32)	40.5 (1028)

1. The outside diameter of the delivered pipe shall not vary by more than 2.5% for outside diameters up to and including 24 inches (600 mm), and 2.0% for outside diameters greater than 24 inches (600 mm).
2. These are based on the outside diameter and are approximate. Consult with the pipe manufacturer for the specific dimensions.
3. No fixed "+" tolerance limit.

207-21.3 Imperfections.

a) Fractures or Cracks. There shall be no fractures or cracks passing through the barrel which are visible to the unaided eye.

b) Chips, Fractures, or Blisters. Chips, fractures, or blisters on the pipe shall not exceed 2 inches (50 mm) laterally in any surface dimension and shall not exceed a depth of 1/8 the minimum thickness of the barrel.

207-21.4 Repair Methods and Materials. Repairs, if any, shall be made in accordance with 207-8.6.

207-21.5 Fittings and Stoppers. 207-8.3 is not applicable to microtunnel-installed vitrified clay pipe.

207-21.6 Joints. Joints for vitrified clay pipe shall consist of a seat, an elastomeric sealing element, a sleeve, and a compression disc.

a) Seat. The seat is either formed or recess-ground on the pipe ends.

b) Elastomeric Sealing Element(s). The elastomeric sealing element is an elastomeric gasket configuration and location may vary by pipe manufacturer. The sealing element(s) shall conform to 208-2.

c) Sleeve. The sleeve is an element which bridges between the pipe sections and shall be made of non-corrosive materials which, in conjunction with the sealing element(s), forms a joint which meets the test requirements of 207-21.7. Stainless steel sleeves shall be AISI Type 316.

d) **Compression Disc.** The compression disc is a flat disk that forms a continuous ring of contact with the ends of the pipe and which functions to distribute the jacking forces which develop during pipeline installation. The width of the compression disc shall not exceed the maximum wall thickness of the pipe, not extend into the flow, nor inhibit the installation of the sleeve onto the joint of the pipe.

207-21.7 Testing Requirements.

207-21.7.1 General. Testing shall be in accordance with 207-8.5 and ASTM C1208.

207-21.7.2 Joint Test. Testing shall be in accordance with ASTM C1208.

207-21.7.3 Hydrostatic Pressure Test. Testing shall be in accordance with ASTM C1208.

207-21.7.4 Bearing Strength Test. Testing shall be in accordance with ASTM C1208. Pipe shall meet Table 207-8.5.3 for Extra Strength pipe.

207-21.7.5 Compressive Strength Test. Testing shall be in accordance with ASTM C1208. Pipe material shall have a minimum compressive strength of 7,000 pounds per square inch (48 MPa).

207-21.7.6 Acid Resistance Test. Testing shall be in accordance with ASTM C301.

207-21.7.7 Acceptance. Pipe acceptance shall be in accordance with 207-8.5.4.

207-22 FIBERGLASS REINFORCED POLYMER MORTAR (FRPM) MICROTUNNELING PIPE.

207-22.1 General. This specification applies to FRPM microtunneling pipe to be used for sanitary sewers, storm drains, and related structures. Such pipe shall conform to 207-20 except as modified herein. The minimum pipe stiffness shall be 120 pounds per square inch (830 kPa) when tested in accordance with ASTM D2412.

207-22.2 Materials. Materials shall conform to 207-20.2, except that the minimum pipe stiffness shall be 120 psi (830 kPa). Pipe material shall have a minimum compressive strength of 10,000 pounds per square inch (69 MPa).

207-22.3 Dimensions. Dimensions and sizes of pipe shall conform to the requirements of Table 207-22.3.

207-22.3.1 Length. The nominal lengths shall be 6, 10, or 20 feet (2, 3, or 6 m). At least 90 percent of the total footage of each size and class of pipe, excluding special order lengths and pipes sampled for quality control testing, shall be furnished in nominal length sections.

207-22.3.2 Minimum Wall Thickness. The outside diameter and minimum wall thickness are shown in Table 207-22.3. The allowable jacking load for microtunnel pipe shall be determined from the pipe wall thickness where the cross-section is reduced (the bottom of the spigot gasket groove).

TABLE 207-22.3

Nominal Diameter inches (mm)	Outside Diameter inches (mm)[1]	Nominal Inside inches (mm)[2]	Minimum Pipe Wall inches (mm)[2]
18 (450)	19.5 (495)	17.0 (432)	1.12 (28.4)
20 (500)	21.6 (549)	19.0 (483)	1.15 (29.2)
24 (600)	25.8 (655)	23.1 (587)	1.22 (31.0)
28 (700)	30.0 (762)	27.1 (688)	1.30 (33.0)
30 (750)	32.0 (813)	28.7 (729)	1.52 (38.6)
33 (825)	34.0 (864)	30.6 (777)	1.54 (39.1)
36 (900)	38.3 (973)	34.8 (884)	1.59 (40.4)
42 (1050)	44.5 (1130)	40.8 (1036)	1.67 (42.4)
48 (1200)	50.8 (1290)	46.7 (1186)	1.88 (47.8)
51 (1275)	53.9 (1369)	49.7 (1262)	1.94 (49.3)
54 (1350)	57.1 (1450)	52.8 (1341)	2.00 (50.8)
57 (1425)	60.0 (1524)	55.5 (1410)	2.06 (52.3)
60 (1500)	62.9 (1598)	58.3 (1481)	2.11 (53.6)
63 (1575)	66.0 (1676)	61.3 (1557)	2.15 (54.6)
66 (1650)	69.2 (1758)	63.9 (1623)	2.44 (62.0)
69 (1725)	72.5 (1842)	67.1 (1704)	2.50 (63.5)
72 (1800)	75.4 (1915)	69.9 (1775)	2.56 (65.0)
78 (1950)	81.6 (2073)	75.8 (1925)	2.94 (68.8)
82 (2050)	87.0 (2210)	80.7 (2050)	2.94 (74.7)
84 (2100)	88.7 (2253)	82.3 (2090)	3.00 (76.2)
90 (2250)	94.3 (2395)	87.6 (2225)	3.13 (79.5)
96 (2400)	99.5 (2527)	92.6 (2352)	3.23 (82.0)
102 (2550)	108.0 (2743)	100.7 (2558)	3.42 (86.9)

1. The outside diameter of the pipe delivered to the Work site shall not vary by more than ± 0.1% for each pipe size.
2. For standard tonnage ratings.

207-22.3.3 Tolerances.

a) Length. Laying length tolerance shall be ± 1/2 inch per foot (± 42 mm/m).

b) Straightness. Pipes shall not deviate from straight by more than 0.006 inch per linear foot (0.5 mm/m). Measurements shall be taken by measuring gaps between the pipe wall and a straightedge placed along any longitudinal line on the exterior surface of the pipe.

c) Roundness. The diameter shall not very from a true circle by more than ± 0.5 percent of its nominal diameter. The out-of-round dimension is the difference between the maximum and minimum diameters measured at any one location along the barrel.

d) End Squareness. All points around each end of the pipe shall fall within 1/16 inch (1.5 mm) to a plane perpendicular to the longitudinal axis of the pipe.

207-22.4 Joints. Joints shall conform to 207-20.4, except that bell and spigot joints shall have a flush exterior. Joints at tie-ins, when needed, may utilize fiberglass gasket-sealed closure couplings which have an outside diameter larger than the pipe. The maximum allowable joint angular deflections for curves shown in Table 207-20.4 shall not apply.

207-22.5 Accelerated Aging and Physical Testing. Testing shall conform to 207-20.5, and values used shall reflect actual pipe stiffness.

207-22.6 Marking. Marking shall conform to 207-20.6. The maximum allowable jacking load shall also be indicated.

207-22.7 Pipe Acceptance or Rejection. Pipe shall conform to 207-20.7.

207-23 REINFORCED CONCRETE MICROTUNNELING PIPE.

207-23.1 General. This specification applies to reinforced concrete microtunneling pipe manufactured for the construction of storm drains, sewers, water pipelines, and related structures. Such pipe shall comply with 207-2 for reinforced concrete pipe; 207-3 for lined reinforced concrete pipe; or 209-3 for AWWA C300 Reinforced Pressure Pipe, Steel Cylinder Type, or AWWA C302 Reinforced Pressure Pipe, Noncylinder Type, except as modified herein. A minimum concrete compressive strength of 5,000 pounds per square inch (34.5 MPa) is required.

207-23.2 Materials. All materials used shall conform to the requirements of 201 and 207-2.2, except that the Contractor shall submit written certification from the pipe manufacturer that no calcium chloride has been used in the manufacturer of the pipe.

207-23.3 Dimensions and Tolerances.

a) **Length.** Pipe shall have a nominal laying length of 8 to 24 feet (2.4 to 7.3 m) unless otherwise specified. Variations in laying lengths of 2 opposite sides of pipe shall not be more than 1/16 inch per foot (5 mm/m) with a maximum of 3/8 inch (9.5 mm) in any length of pipe for diameters up to and including 72-inch (1800 mm), or 1/2 inch (12.5 mm) for larger diameters. The underrun in length of a section of pipe shall not be more than 1/8 inch per foot (10 mm/m) with a maximum of 1/2 inch (12.5 mm) in any length of pipe.

b) **Wall Thickness.** The minimum wall thickness for all pipe sizes shall be as specified in ASTM C76, Wall B.

c) **Inside Diameter.** The inside diameter of 12-inch to 24-inch (300 mm to 600 mm) pipe shall not vary more than 1/4 inch (6 mm). The internal diameter of 27-inch (675 mm) and larger pipe shall not vary more than 1 percent or 5/8 inch (16 mm), whichever is less.

d) **Outside Diameter.** The outside diameter of 12-inch to 24-inch (300 mm to 600 mm) pipe shall not vary more than 1/4 inch (6 mm). The outside diameter of 27-inch (675 mm) and larger pipe shall not vary more than 1 percent or 5/8 inch (16 mm), whichever is less.

e) **Straightness.** Pipes shall not deviate from straight by more than 1/16 inch per linear foot (5 mm/m). Measurements shall be taken by measuring gaps between the pipe wall ends and a straightedge placed along any longitudinal line on the exterior surface of the pipe.

f) **Roundness.** The outside diameter of the pipe shall not vary from a true circle by more than 1 percent.

g) **End Squareness.** The ends of the pipe in contact with the jacking pads shall be perpendicular to the longitudinal axis of the pipe with a maximum of 1/2 inch (12.5 mm), measured with a square and a straight edge across the end of the pipe. The bearing surfaces shall be smooth and free of projections.

207-23.4 Reinforcement. Pipe shall have concentric circular cage reinforcement conforming to the requirements of 207-2.4 for reinforced concrete pipe or 207-5 for reinforced concrete pressure pipe. The total area of reinforcement provided shall be at least 1/8 square inch per foot (265 mm^2/m) in each direction. When 2 reinforcement cages are used, the longitudinal reinforcement shall be divided approximately equal between the 2 cages, and only the longitudinal reinforcement on the outer cage need extend into the bell. Supports between the reinforcement and the forms that are to be exposed in the finished pipe shall be made of stainless steel, plastic or plastic coated steel.

207-23.5 Joints. Pipe shall have rubber-gasket type, concrete or steel joints. Tongue and groove joints are not acceptable. Joint details shall be submitted to the Engineer for approval before commencing pipe manufacturing. For flush bell and spigot joints, the slope of the longitudinal gasket contact surfaces of the joint with respect to the longitudinal axis of the pipe shall not exceed 2 degrees. The ends of the pipe shall be so formed that, when the pipes are joined, they shall make a continuous and uniform line of pipe with a smooth and regular surface. The rubber gasket shall conform to 208-3.

207-23.6 Repair. Unsound or imperfect concrete shall be repaired per the applicable sections of 207-2, 207-3, 207-4 or other methods approved by the Engineer.

207-23.7 Pipe Acceptance or Rejection. Pipe shall conform to 207-2.9 and 207-3.2.

207-24 STEEL MICROTUNNELING PIPE.

207-24.1 General. This specification applies to steel microtunneling pipe manufactured for the construction of storm drains, sewers, water pipelines, and related structures. Such pipe shall comply with 209-2 except as modified herein.

207-24.2 Materials. All materials used shall conform to the requirements of 209-2.2.

207-24.3 Dimension and Tolerances.

a) **Length.** The nominal length shall conform to the requirements of Table 209-2.2.1. Pipe shall have a nominal laying length of 8 to 40 feet (2.4 m to 12 m) unless otherwise specified. Variations in laying lengths of 2 opposite sides of pipe shall not be more than with a maximum of 3/8 inch (9.5 mm) in any length of pipe for diameters up to and including 72 inches (1800 mm), or 1/2 inch (12.5 mm) for larger diameters. The underrun in length of a section of pipe shall not be more than 3/8 inch per foot (30 mm/m) with a maximum of 1/2 inch (12.5 mm) in any length of pipe.

b) **Wall Thickness.** Plate and sheet thickness shall conform to 307-1.3. For plate, the maximum allowable thickness variation shall be 0.010 inch (0.254 mm) under the ordered thickness. For sheet, the maximum allowable thickness variation shall be as tabulated in ASTM A568, ASTM A635, or 0.010 inch (0.254 mm) under the ordered thickness,

c) **Diameter.** Internal diameter shall conform to 207-10.2.3. The outside circumference of the pipe shall not vary by more than 1 percent but not to exceed 3/4 inch (19 mm) from the nominal outside circumference. The circumference of the pipe ends shall not vary by more than 0.196 inch (5 mm) under, or 0.393 inch (10 mm) over the required outside circumference.

d) **Straightness.** Finished cylinder shall not deviate by more than 1/8 inch (3 mm) from a 10-foot (3 m) long straight edge held against the cylinder.

e) **Roundness.** The outside diameter of the pipe shall not vary from a true circle by more than 1 percent. The out-of-round of the pipe ends shall be determined by measuring the ring diameter at a minimum three locations equally spaced on the contact surface. The out-of-round shall be the difference between the high and low readings. The maximum out-of-round shall not exceed 0.5 percent of the average of the low and high readings or 1/4 inch (6 mm), whichever is less.

f) **End Squareness.** For pipe that is to be butt welded in the field, the end of the pipe shall be perpendicular to the longitudinal axis of the pipe with a maximum deviation of no more than 1/8 inch (3 mm) measured with a square and a straight edge across the end of the pipe.

207-24.4 Joints. Joints shall conform to the requirements of 307-1.3. Connecting adjacent pieces of steel pipe shall be achieved by field butt welding. For casing application, integral press fit connectors may be used as approved by the Engineer.

207-24.5 Protective Lining and Coating. Exterior coatings, if required, shall be the type that minimize skin friction between the exterior of the pipe and the soil. Such an exterior coating shall be

epoxy-based polymer concrete, fusion-bond epoxy, or other product that provides a hard, smooth surface. Strict adherence to the coating manufacturer's recommendations for surface preparation and application procedure shall be required with holiday detection and repair. If the steel pipe is field welded, the Contractor shall submit a procedure for approval to the Engineer to field repair the coating which maintains the coating integrity and minimizes the repair and curing time.

Exterior coating of steel pipe, used as encasement, is not required if a wall thickness increase of at least 0.063 inch (1.5 mm) is specified.

Interior lining of steel pipe should be shop-applied coating such as liquid epoxy, polyurethane, cement mortar, or appropriate material for the desired service. Consideration should also be given to line-in-place procedures.

207-24.6 Inspection and Acceptance. Pipe shall be inspected and accepted in accordance with AWWA C 200.

SECTION 208 - PIPE JOINT TYPES AND MATERIALS

208-1 GENERAL.

208-1.1 Material Designation. The type of pipe joint shall be designated on the Plans. The Engineer may require testing of the joint materials for compliance with these requirements prior to delivery to the Work site.

208-1.2 Installation Time Limit. The Contractor shall retest within 60 Days prior to installation any pipe gasket that is more than 180 Days old from the date of manufacture to ensure compliance with the requirements of the Specifications. The Contractor shall not install any pipe gasket that is more than 2 years old from the date of manufacture.

208-2 JOINTS FOR CLAY PIPE.

208-2.1 General. Joints other than those specified below, made of approved materials and meeting the chemical and bacteriological resistance requirements contained herein, may be submitted to the Engineer for approval.

208-2.2 Type "D" Joints (Synthetic Rubber Coupling with Corrosion-Resistant Shear Ring for Plain-End Clay Pipe, 12-Inch (300 mm) Maximum). The joint shall consist of 3 parts: a circular synthetic rubber sleeve of 2 stainless steel compression bands with stainless steel nut and bolt type tightening devices and an injection molded acrylonitrile-butadiene-styrene (ABS), polyethylene (PE), or polyvinylchloride (PVC) shear ring.

208-2.2.1 Sealing Components. The compression bands shall be fabricated from AISI Type 316 stainless steel with stainless steel nut and bolt (any AISI series 300) type tightening devices and meeting the requirements of ASTM A240. The sleeve shall be fabricated in a configuration approved by the Engineer. It shall be made of a synthetic rubber molded to form a smooth surface, free of pits, cracks, air marks, porosity, and air pockets.

208-2.2.2 Testing of the Synthetic Rubber Sealing Component. Test specimens that are exposed to various chemical and bacteriological environments shall be conditioned in the same manner, both before and after exposure, prior to testing.

a) **Initial Physical Requirements.** The initial physical requirements shall conform to Table 208-2.2.2 (A):

TABLE 208-2.2.2 (A)

Property	Value	ASTM Test Method No.
Tensile strength, at 73.4° ± 3.6°F (23° ± 2°C), psi (kPa), min.	1000 (6900)	D412 (Die C)
Elongation at break, 73.4° ± 3.6°F (23° ± 2°C), %, min.	200	D412 (Die C)
Shore Durometer, Type A (1 sec. reading, min.)	60	D2240
Compression set (after exposure to 158° ± 3.6°F [70° ± 2°C], for 22 hours), % max.	20	D395 (Method B)
Water absorption (after immersion at 73.4° ± 1.8°F [23° ± 1°C] for 28 days), %, max.	4	D570

b) Physical Requirements after Accelerated Aging. The physical requirements after accelerated aging shall conform to Table 208-2.2.2 (B).

TABLE 208-2.2.2 (B)

Property	Value	ASTM Test Method No.
Tensile strength (after exposure to 300 psi (2100 kPa) oxygen at 158° ± 1.8°F [70° ± 1°C] for 96 hours), % of initial, min.	70	D572
Elongation at break (after exposure to 300 psi (2100 kPa) oxygen at 158° ± 1.8°F [70° ± 1° C] for 96 hours), % of initial, min.	70	D572
Ozone resistance (after exposure to 100 pphm ozone for 50 hours at 104° ± 2°F [40° ± 1°C])	No cracks or crazing	D518 (Procedure C) and D1149

c) Chemical Resistance and Physical Testing. After exposure to the chemical solutions specified in Table 211-2 (A), test specimens shall be tested in accordance with 211-2 and meet the physical requirements specified in Table 208-2.2.2 (C).

TABLE 208-2.2.2 (C)

Property	Value	ASTM Test Method No.
Tensile strength at 73.4° ± 3.6°F (23° ± 2°C), psi (kPa), min.	800 (5500)	D412 (Die C)
Elongation at break at 73.4° ± 3.6°F (23° ± 2°C), % min.	150	
Shore Durometer, Type A at 75° ± 5°F (23° ± 2°C) (1 second reading) point change, max.	15	D2240
Compression set (after exposure to 158° ± 1.8°F [70° ± 1°C] for 22 hours), % max.		D395 (Method B)
a. Chemical exposures	25	
b. Bacteriological exposure (unconditioned surface dry)	30	
Weight change, % max. (approx. specimen size 1.0 x 3.0 x 0.1 inch) (25 x 75 x 2.5 mm)	–1.0, +5.0	

208-2.2.3 Circular Plastic Shear Ring Component and Testing Requirements. The plastic shear ring shall be injection molded from an ABS, PE, or PVC resin meeting the requirements specified below. The ABS shear ring material shall conform to 207-15.2. The PE shear ring shall conform to 207-19.2 except that the hydrostatic design and color requirements need not be satisfied and crack resistance failure maximum percentage be zero.

The PVC shear ring shall conform to 207-17.2.2 and 207-17.4.1.

The shear rings shall be homogeneous throughout, uniform in color and free of cracks, holes, foreign materials, blisters, or deleterious faults.

Markings on all shear rings shall indicate the name of the manufacturer and Type "D" joint.

208-2.2.4 Laboratory Test of Joint. An assembled joint shall provide sufficient resistance to shear loading to allow a load of 150 pounds-force per inch (26.3 N/mm) of nominal diameter to be uniformly applied over an arc of not less than 120 degrees and a longitudinal distance of 12 inches (300 mm) immediately adjacent to one edge of the sleeve coupling. The assembled pipe shall rest on three supports. A support shall be located at each extreme end of the assembly. The third support shall be placed immediately adjacent to the coupling. The shear load shall be placed on the unsupported end of the pipe, immediately adjacent to the coupling. There shall be no visible leakage when tested with an internal hydrostatic pressure of 10 pounds per square inch (70 kPa) for 10 minutes. The joint including the plastic shear ring for the 6-inch to 12-inch (150 mm to 300 mm) diameter pipe, inclusive, shall exhibit sufficient flexibility when joined to allow a maximum deflection of 3 degrees in any direction. The deflected joint shall show no visible leakage when subjected to the same shear load as indicated in the previous paragraph and when tested under an internal hydrostatic pressure of 10 pounds per square inch (70 kPa) for 10 minutes.

During these tests, the ends of the tested pipe shall be restrained only in the amount necessary to prevent longitudinal movement. Upon completion of the above tests, the joint shall be disassembled and if any component has failed, that joint will be rejected. Failures shall include, but not be limited to the following: breaks, flange cracks, gouges, tears, and deformation beyond reuse.

208-2.2.5 Joint Acceptance. When all components of this joint meet the requirements as set forth in these specifications and when one percent of the joints are successfully laboratory tested, then the joints will be accepted.

208-2.3 Type "G" Joints (Polyurethane).

208-2.3.1 General. The Type "G" joint shall consist of polyurethane elastomer sealing components, one bonded to the outside of the spigot and the other bonded to the inside of the socket. The sealing components shall be shaped, sized, bonded, and cured to uniform hardness to form a tight seal of the joint when it is assembled. The sealing components shall resist attack by bacteria and chemicals or combinations of chemicals normally present in domestic or industrial waste sewage.

208-2.3.2 Polyurethane Sealing Components. The polyurethane sealing component material shall be tested in accordance with 211-2. The number of samples to be tested shall be designated in the Special Provisions.

TABLE 208-2.3.2 (A)

Property	Values[1]		Test Method and Conditions
Tensile strength, psi (kPa) min.	4125 (600)	2425 (350)	ASTM D412 (Die C) 73.4 ± 3.6°F (23° ± 2°C)
Elongation, % min.	70	70	ASTM D412 (Die C) 73.4° ± 3.6°F (23° ± 2°C)
Compression set, % max.	3	3	ASTM D395, Method B, 24 hours 73.4° ± 3.6°F (23° ± 2°C)
Shore durometer	Not less than value designated for the joint design by the manufacturer		ASTM D2240, Type A, 5-second reading, 32° to 80°F (0° to 27°C)
Water absorption, % max. (Weight gain)	3.5	3.5	ASTM D570, after immersion for 28 Days at 73.4° ± 1.8°F (23° ± 1°C)
Volatile loss, % max. (Weight loss)	1	1	After 28 Days in mechanical convection oven at 150° ± 3°F (66° ± 2°C)
Adhesive strength, psi (kPa) min			Before immersion in accordance with Note 2. After immersion in water at 73.4° ± 3.6°F (23° ± 2°C) in accordance with Note 2
Original	2425 (350)	2425 (350)	
Final	1725 (250)	1725 (250)	
Chemical resistance (See Note 3)			After exposure to each of the chemical environments for 112 Days as described in Note 3
Weight change, % max.	1.5	1.5	
Tensile strength, psi (kPa)	2975 (430)	1800 (260)	
Shore durometer, change max.	± 15	± 15	
Compression set, % max.	5	5	
Bacteriological resistance (See Note 3)			After exposure to bacteriological environment for 112 Days as described in Note 3.
Weight change, % max.	2	2	
Tensile strength, psi (kPa) min.	3450 (500)	2000 (290)	
Shore Durometer			
Before reconditioning, loss max.	15	15	
After reconditioning, change max.	5	5	
Compression set			
Before reconditioning, % max.	3	3	
After reconditioning, % max.	3	3	

1. The configuration of the jointing system determines the necessary physical properties of the polyurethane joint material. The columns of values in this table represent properties of polyurethane that, in conjunction with specific joint configurations, will provide functionally equal acceptable jointing systems. The values for a single product shall be all from one of the columns.
2. Adhesion test specimens shall be clay blocks 1/2 inch (12.5 mm) thick and 1 inch square (25 mm x 25 mm), of the same composition of materials and fired at the same vitrifying temperatures as sewer pipe.
   The clay block shall be placed flat in the center of a mold 7 inches (175 mm) long, 1 inch (25 mm) wide, and 1/2 inch (12.5 mm) deep. The edges of the clay block at right angles to the longitudinal axis of the form shall be coated with the adhesive and the form on each side of the block shall be filled to a depth of approximately 1/4 inch (6 mm) with the sealing component compound. Curing of this last specimen shall simulate the curing process at the pipe manufacturing plant.
   At the end of the immersion period, samples shall be removed, surface dried, and immediately pulled in tension at the rate of 20 inches (500 mm) per minute to determine the final tensile strength of the bonded interfaces. The specimens retained for controls shall be pulled at the same time to determine the original strength of the bonded interfaces.
3. Exposure environments for bacteriological and chemical resistance tests per Table 211-2 (A). At the end of the exposure period, specimens shall be washed and reconditioned before testing.

208-2.3.3 Type "G" Joint Acceptance Tests. Joint tests shall be performed in accordance with ASTM C425. The Engineer may perform additional acceptance tests on one joint for each 100 pipes in a lot (or fraction of a lot) for each size. For this additional testing the pipe joints shall not leak when subjected to the shear load test described in ASTM C425, except that the internal hydrostatic pressure shall be 10 pounds per square inch (70 kPa) for pipe sizes up to 18 inches (450 mm) and 5 pounds per square inch (35 kPa) for pipe sizes 21 inches (525 mm) and larger before and after being deflected the following distances at the sealing components of the joint for a period of 10 minutes.

TABLE 208-2.3.3

Nominal Pipe Size inches (mm)	Deflection inches (mm)
4 - 10 (100 - 250)	5/8 (16)
12 - 21 (300 - 525)	3/4 (19)
24 - 30 (600 - 750)	7/8 (22)
33 - 42 (825 - 1050)	1 (25)

If one of the selected joints fails the test, the lot shall be rejected unless 2 additional joints selected from the lot pass the test.

208-3 GASKETS FOR CONCRETE PIPE. Unless otherwise specified, gaskets shall be manufactured from a synthetic elastomer. The compound shall contain not less than 50 percent by volume of first-grade synthetic rubber. The remainder of the compound shall consist of pulverized fillers free of rubber substitutes, reclaimed rubber, and deleterious substances. The installation of gaskets shall conform to 208-1.2.

Gaskets shall be extruded or molded and cured in such a manner as to be dense, homogeneous and of smooth surface, free of pitting, blisters, porosity and other imperfections. The tolerance for any diameter or profile dimension measured at any cross section shall be ± 1/32 inch (0.8 mm).

When required by the Engineer, the Contractor shall furnish test samples of gaskets from each batch used in the work. Gasket material shall meet the following:

TABLE 208-3

Property	Value	ASTM Test Method
Tensile strength, psi (MPa) min.	1500 (10.3)	D412
Elongation at break (% min.)	350	D412
Shore durometer, Type A (Pipe manufacturer shall select value suitable for type of joint).	40 to 65[1]	D2240
Compression set (constant deflection) max. % of original deflection.	16	D395 Method B
Tensile strength after oven aging (96 hours, 158°F [70°C]) % of tensile strength before aging.	80	D573
Increase in Shore durometer hardness after oven aging. Maximum increase over original Shore durometer.	10	D2240
Physical Requirements after exposure to ozone concentration (50 pphm. 72 hours, 104°F [40°C], 20% extension).	No Cracks	D1149

1. This applies only to the sealing component of the gasket.

No more than one splice will be permitted in a gasket. A splice shall be made by applying a suitable cement to the ends and vulcanizing the splice in a full mold. The splice shall show no separation when subjected to the following tests:

a) Elongation Test. The part of the gasket which includes the splice shall withstand 100 percent elongation with no visible separation of the splice. While in the stretched position, the gasket shall be rotated in the spliced area a minimum of 180 degrees in each direction in order to inspect for separation.

b) Bend Test. The portion of the unstretched gasket containing the splice shall be wrapped a minimum of 180 degrees and a maximum of 270 degrees around a rod of a diameter equal to the cross section diameter of the gasket.

208-4 GASKETS FOR THERMOPLASTIC PIPE. Gaskets shall be manufactured from a synthetic elastomer conforming to the requirements of 208-3. The installation of gaskets shall conform to 208-1.2.

208-5 TYPE "Z" JOINT.

208-5.1 General. Except as modified herein, Type "Z" Joints shall conform to Type "D" Joints per 208-2.2. This joint shall be used as a field closure coupling, repair coupling, or outside diameter transition coupling for identical or dissimilar pipe materials for gravity sewers and drains. The joint shall be applied to 4-inch through 12-inch (100 mm through 300 mm) diameter pipe sizes only.

208-5.2 Components. The joint shall consist of three components as follows:

a) A circular synthetic rubber sleeve meeting the physical, chemical and bacteriological requirements of the Type "D" Joint per 208-2.2.2. The sleeve shall conform to 208-1.2.

b) Two stainless steel compression bands (AISI 316) with stainless steel nut and bolt (any AISI Series 300) type tightening devices and meeting the requirements of ASTM A240.

c) A stainless steel shear band shall wrap around the joint a minimum of 380 degrees. Welded to the shear band shall be two stainless steel nut and bolt tightening devices or worm drive tightening devices fabricated from any 300 Series stainless steel and meeting the requirements of the compression bands above. The minimum shear band thickness shall be 0.012 inches (0.30 mm). Minimum shear band width shall be 2.120 inches (54.0 mm) for 4-inch and 6-inch (100 mm and 150 mm) diameter pipe sizes and 2.437 inches (62.0 mm) for 8-inch through 12-inch (200 mm through 300 mm) diameter pipe sizes.

208-5.3 OD Transitions. Pipe joints where the pipe outside diameters have a differential of 3/8 inch (9 mm) or greater shall require an outside diameter transition coupling. Outside diameter transition coupling shall be comprised of the components per 208-5.2 plus a synthetic rubber bushing meeting the requirements of 208-2.2.2. The bushing shall compensate for the differential in pipe Outside Diameters.

208-5.4 Testing Requirements. The Type "Z" Joint, with or without bushing, shall meet the test requirements for Type "D" Joints per 208-2.2.4.

208-6 PIPE TO MANHOLE FLEXIBLE COUPLINGS.

208-6.1 General. The joint shall consist of a flexible connector designed to produce a positive watertight connection for pipes entering precast manholes and other concrete structures.

208-6.1.1 Seal. The connector shall be in accordance with ASTM C923/C923M so that a positive seal is made between the connector and the manhole wall and between the connector and the pipe. The seal between the connector and the manhole wall may be made by either mechanical means or by casting the connector integrally with the manhole wall. The seal between the connector and the pipe may be made by mechanical means or by compression of the resilient material against the outside of the pipe.

208-6.1.2 Parameters. The connector shall withstand 23 feet (10 psi) (7.1 m (70 kPa)) of hydrostatic pressure and be capable of sustaining an axial deflection of at least 7 degrees in any direction. The test methods and requirements shall be in accordance with ASTM C923/C923M, Section 7.

208-6.2 Materials. The gaskets shall be manufactured from a synthetic elastomer and shall contain not less than 50 percent by volume of first-grade synthetic rubber. All rubber gaskets shall be either molded or extruded and cured in such a manner that any cross-section shall be dense, homogeneous, and free of porosity blisters, pitting, and other imperfections. The gaskets shall comply with the physical requirements prescribed by ASTM C923/C923M Table 1 when tested in accordance with the referenced ASTM. However, the chemical resistance shall be tested in accordance with 211-2 and meet the weight change per Table 210-2.4.1. Metal components shall be fabricated from AISI Type 316 stainless steel

for all bands, and the nut and bolt shall be AISI Type 305 stainless steel. Gaskets shall conform with the installation time requirements in 208-1.2.

208-6.3 Performance Test Requirements. A performance test of the connector to be used shall be made at least once when the manhole producer begins using a pipe to manhole connector system. The test methods and requirements shall be made in accordance with ASTM C923/C923M, Section 7. The connector shall be marked clearly by the manufacturer with his trade name and size designation or part number. This shall be visible on the gasket when installed in the manhole.

208-6.4 Plant Fabrication Method. The flexible connector shall be installed in accordance with the specific instructions of the manufacturer.

208-6.5 Installation Instructions. The manhole manufacturer shall provide installation instructions to the Contractor. The connector shall have all foreign matter removed and shall be inspected to ensure that there are no defects in the rubber or splice.

SECTION 209 – PRESSURE PIPE

209-1 IRON PIPE AND FITTINGS.

209-1.1 Ductile Iron Pipe (DIP).

209-1.1.1 General. This subsection specifies ductile iron pipe used for pressure piping applications for water and recycled water pressure pipes and for sewage force mains.

209-1.1.2 Materials. Unless otherwise specified, ductile iron pipe shall conform to the following:

TABLE 209-1.1.2

Item	Material	Reference Specification/Requirements	
Pipe	Manufacturing Standards	Conform to AWWA C151/ANSI 21.50 for 3"-64" (75 mm - 1600 mm) pipe.	
	Design Standards	Conform to AWWA C150/ANSI A21.50 and AWWA M41.	
	NSF Certification	NSF 61 certification required for potable water pipe.	
	Material	Ductile iron.	
	Size	As shown on the Plans.	
	Minimum Wall Thickness	3"-12" (75 mm - 300 mm) pipe	Pressure Class 350.
		14"-36" (350 mm - 900 mm) pipe	Pressure Class 250.
		42"-64" (1050 mm -1600 mm) pipe	Pressure Class 200.
		Pipe with grooved couplings	Thickness Class 53.
	Markings	Conform to AWWA C151 Section 4.6.	
	Lengths	18' or 20' (5.5 m or 6.1 m) lengths per AWWA C151/ANSI A21.51. Shorter lengths may be used to facilitate curves or fit horizontal or vertical alignment.	
Interior Lining and Exterior Coating	Buried Exterior Coatings	Shop coat with one prime coat of asphaltic coating approximately 1 mil (25 µm) thick per AWWA C151.	
	Exterior Coatings on Pipe Above Ground and in Vaults	Conform to 212-12.	
	Cement-Mortar Interior Lining (AWWA C104 "Double Thickness")	**Pipe Size**	**Lining Thickness**
		3"-12" (75 mm - 300 mm) pipe	1/8" (3 mm)
		14"-24" (350 mm -0600 mm) pipe	3/16" (5 mm)
		30"-64" (900 mm - 1600 mm) pipe	1/4" (6 mm)
		Conform to AWWA C104 using Type II cement.	
	Fusion-Bonded Epoxy Interior Lining where shown on the Plans	Conform to 212-12.	
	Ceramic Epoxy Interior Lining, where shown on the Plans	Amine cured novalac epoxy lining.	
		Permeability rating of 0.00.	
		Abrasion resistance < 4 mils (100 µm) loss after 1,000,000 cycles on ± 22.5° sliding aggregate slurry abrasion tester using a sharp natural siliceous gravel with particle size between 2 mm and 10 mm.	
Joints	Standard Push-on Style	AWWA C111/ANSI 21.11.	
	Mechanical Joint	AWWA C111/ANSI 21.11.	
	Restrained Style	Special push-on type joint providing longitudinal restraint to full test pressure without relying on thrust block.	
		Boltless, restrained push-on joint design with positive axial locking restrained system capable of deflection after assembly.	
		Use one type of restrained joint exclusively for all Work.	
	Flanged Joint	Conform to AWWA C110/ANSI A21.10.	
	Flanged Joint Threaded Flanges	Conform to AWWA C115/ANSI A21.15.	
Bell Joint Gaskets	Material	Conform to AWWA C111/ANSI A21.11. Vulcanized styrene butadiene rubber (SBR).	
	Material for Hydrocarbon Applications and Contaminated Soils	NBR (Nitrile) (acrylonitrile butadiene), FLUOREL, or FKM (Viton) (fluorocarbon).	
	Gasket Age	< 180 Days old or < 2 years old but retested < 60 Days prior to installation.	
Flange Gaskets	Material	212-2.7.	
Fittings	Material	Ductile iron.	
	Standards	Conform to AWWA C110/ANSI 21.10 or AWWA C153/ANSI A21.53.	
	Style	Push-on (standard) or restrained joint (as shown).	
	Marking	Cast letters "DI" or "DUCTILE" into fittings, unless otherwise specified. Cast "AWWA C110" or "AWWA C153" depending on thickness.	
	Exterior Coatings	Use same coating as adjacent pipe, as specified above.	
	Interior Linings	Use same lining as adjacent pipe, as specified above.	
Ductile Iron Pipe Joint Restraints	Material	Ductile iron.	
	Style	Gripping wedge	
	Design Pressure Rating	3"-16" (75 mm - 400 mm)	350 psi (2.4 MPa)
		18"-64" (450 mm -1600 mm)	250 psi (1.7 MPa)
Pipe Shop Coat	Prime Coat	12 mils (300 µm) MDFT.	
Polyethylene PE Encasement	Polyethylene Film and Tape	Conform to 212-12.1.1. Color per 212-12.2.	
Alternate to Polyethylene Encasement	Pipe Finish Coat	15 mils (375 µm) MDFT field-applied bitumastic coating.	

209-2 STEEL PIPE AND FITTINGS.

209-2.1 General. This subsection specifies steel pipe and fittings up to 64-inch (1600 mm) diameter for the transmission and distribution of raw, potable, or recycled water under pressure. Steel pipe shall be of the size, type, and cylinder wall thickness or pressure class shown on the Plans or specified in the Special Provisions.

209-2.2 Fabricated Steel Pipe and Fittings.

209-2.2.1 Materials. Unless otherwise specified, fabricated steel pipe shall conform to the following:

TABLE 209-2.2.1

Item	Material	Reference Specification/Requirements
Pipe	Manufacturing Standards	Butt or offset-butt electrically welded straight or spiral-seam steel cylinders, shop fabricated from coil or plates and conforming to AWWA C200 for pipe 6" (150 mm) and larger.
		4" (100 mm) pipe when required shall conform to the requirements of AWWA C200.
	Design Standards	Conform to AWWA M11.
	NSF Certification	NSF 61 certification required for potable water pipe.
	Material	Steel plates or sheets used to manufacture fabricated steel pipe shall conform to the physical and chemical requirements for sheet steel listed in AWWA C200 Table 1.
	Size	As shown on the Plans. Net inside diameter after interior lining shall equal or exceed nominal pipe diameter with tolerance of minus 1/4" (6 mm).
	Minimum Wall Thickness	Where the Plans do not show thickness, submit design and supporting calculations prepared by the manufacturer in accordance with AWWA M11 using a maximum design working stress of 1/2 the yield stress for the grade of steel used in pipe fabrication. Compute wall thickness using pressure equal to 150 psi (1.0 MPa) or the design pressure shown on the Plans, whichever is greater.
		No pipe 4" (100 mm) and larger outside buildings or vaults shall have a wall thickness less than 14-gauge (1.9 mm).
		No pipe 4" (100 mm) and larger inside buildings or vaults shall have a wall thickness less than 3/8" (9.5 mm).
	Markings	Mark each special and each length of straight pipe at bell end to identify: • Manufacturer's name or mark • Type of steel • Design pressure • Diameter and weight of pipe or special • Proper location of pipe or special by reference to layout schedule
	Lengths	Maximum pipe length of 42' (13 m). Shorter lengths may be used to facilitate curves or fit horizontal or vertical alignment.
Lining and Exterior Coating (Required on exposed steel surfaces and ring joints)	Cement-Mortar Interior Lining and Exterior Coating	Conform to AWWA C205 and AWWA C602 using Type II/V cement.
		Trim lining as necessary to allow full operation of butterfly or check valves at connections to steel pipe.
		Line exposed portions of pipe interior with hand-applied epoxy conforming to 212-12.
		3/4" (19 mm) minimum coating thickness unless otherwise shown or soil is identified as corrosive.
		Trim coating 6" to 12" (150 mm to 300 mm) above grade on spools penetrating to daylight or vault interiors.
	Cold-Applied Tape Exterior Coatings	Conform to AWWA C209 for exterior of specials, connections, and fittings. Conform to AWWA C214 for steel pipeline exteriors.
	Liquid Epoxy Interior Lining and Exterior Coating of Above-Ground Pipe	Conform to AWWA C210 and 212-12.
	Fusion-Bonded Epoxy Interior Lining and Exterior Coating of Above-Ground Pipe	Conform to AWWA C213 and 212-12.
	Extruded Polyolefin Exterior Coatings	Conform to AWWA C215 for extruded coatings. Conform to AWWA C216 for heat-shrinkable cross-linked coatings.

TABLE 209-2.2.1 *(Continued)*

Item	Material	Reference Specification/Requirements
Joints	Bell-and-Spigot Ends with Rubber Gaskets	Conform to AWWA C200 Section 4.13. Design for maximum interior pipe lining gap joint of 1/2" (12.5 mm) after joint assembly, measured from ends of lining of pipe sections being joined.
	Ends Prepared for Mechanical-Coupled Field Joints	Conform to AWWA C200 Section 4.13. Square cut or beveled with no burrs. Outside surfaces where coupling seats shall be free of indentations, projections, or roll marks to ensure watertight seal. Pipe ends shall have tolerances within limits required by mechanical coupling manufacturer.
	Lap Joints for Field Welding	Conform to AWWA C200 Section 4.13. Design for maximum interior pipe lining gap joint of 1/2" (12.5 mm) after joint assembly, measured from ends of interior lining of pipe sections being joined.
	Plain Ends with Butt Straps for Field Welding	Conform to AWWA C200 Section 4.13. Design for maximum interior pipe lining gap joint of 1/2" (12.5 mm) after joint assembly, measured from ends of interior lining of pipe sections being joined. For pipe less than 24" (600 mm) nominal diameter, furnish butt straps with a 4" (100 mm) diameter hand hole, complete with screwed cap or plug, suitable for use in "pointing" the interior joint lining after field installation of the joint.
	Flanged Joint	Conform to AWWA C207. Faced and dimensioned in accordance with ASME/ANSI B16.5 for the pressure class shown on the Plans or specified in the Special Provisions.
Bell Joint Gaskets	Material	Conform to AWWA C300 Section 4.4.11 and 4.5.4. Vulcanized styrene butadiene rubber (SBR).
	Material for Hydrocarbon Applications and Contaminated Soils	NBR (Nitrile) (acrylonitrile butadiene), FLUOREL or FKM (Viton) (fluorocarbon).
	Gasket Age	< 180 Days old or < 2 years old but retested < 60 Days prior to installation
Flange Gaskets	Material	212-2.7.
Fittings	Material	Same steel as pipe.
	Standards	Conform to AWWA C208.
	Exterior Coatings	Use same coating as adjacent pipe, as specified above.
	Interior Linings	Use same lining as adjacent pipe, as specified above.

209-2.2.2 Submittals. Prior to fabricating pipe, the Contractor shall submit, in accordance with 2-5.3, Shop Drawings for the fabrication of pipe, pipe specials, and joint details. The Contractor shall also submit a schedule of pipe marks accompanied by a plan showing the field location of each mark. Pipe shall be marked using the coordinate system or stationing shown on the Plans.

The Contractor shall also submit a certified laboratory report stating the type of steel, and the physical and chemical properties for each heat number of the steel used in fabricating the pipe.

The Contractor shall submit documentation showing all field welders are certified to perform the required work in accordance with AWS D1.1.

209-2.2.3 Factory Testing. After fabrication, but prior to the application of the specified interior lining and exterior coating, straight pipe cylinders of all sizes shall be successfully hydrostatically tested to 75 percent of the specified minimum yield point of the steel sheets or plates used to manufacture the pipe in accordance with Section 5.25 of AWWA C200.

All special pipe sections not fabricated from tested pipe shall be hydrostatically tested after specification as specified above for straight pipe. Sections that cannot be tested in a testing machine may be prepared for testing by welding a head on the open ends, or as may otherwise be approved by the Engineer. After testing, the ends shall be reconditioned.

209-2.2.4 Joints. Laying of bell-and-spigot, rubber-gasket-joint pipe on curved alignment using unsymmetrical closure of spigot into bell will be permitted only if a joint qualification test is successfully conducted with the joint aligned in this condition. The amount of "pull" and the method of

achieving the "pull" shall conform to the manufacturer's recommendation, but the deviation from the normal interior lining gap at the joint shall not exceed 3/4 inch (19 mm) "pull" on the outside of the curve and a 1/4 inch (6 mm) "push" on the inside of the curve with no "push" to be permitted until the full 3/4 inch (19 mm) "pull" has been used.

Where the allowable pipe deflection using unsymmetrical joint closure is insufficient to fit the curved alignment of the pipe, as shown on the Plans, special beveled-end pipe sections or multiple-piece bends shall be fabricated. In no case shall the pipe bell or spigot composing the joint between sections of pipe be field-cut or altered in any manner.

209-2.2.5 Special Sections. Special sections, including curves, tees, branches, manifolds, reducers, and enlargers, shall be fabricated as shown from sections of previously lined and coated straight pipe of the kind being furnished under the Contract, or of specially rolled, lined, and coated pipe for fittings to conform to the Work site conditions shown on the Plans.

Bends shall be required on curves having a shorter radius than can be accommodated by beveled pipe ends or by pushing and pulling joints.

The courses of special sections shall be joined by butt welding after which the pipe protective interior lining and exterior coating shall be repaired to a like condition as existed on the previously lined and coated straight sections from which the special was fabricated.

209-2.2.6 Welding. Factory welding of fabricated steel pipe shall conform to AWWA C200 Section 4.11. Field welding shall conform to AWWA C206.

Patching of pipe where test specimens have been taken will not be permitted.

If specified in the Special Provisions, the Contractor shall submit certified laboratory reports stating the results of the required welding tests.

209-2.3 Mill-Type Steel Pipe.

209-2.3.1 Materials. Unless otherwise specified, mill-type steel pipe shall conform to the following:

TABLE 209-2.3.1

Item	Material	Reference Specification/Requirements
Pipe	Manufacturing Standards	Furnace-welded, electrically welded or seamless pipe conforming to AWWA C200 for pipe 6" (150 mm) and larger or ANSI B36.10 for pipe smaller than 6" (150 mm) or for pipe with wall thickness specified by strength or schedule on the Plans.
	Design Standards	Conform to AWWA M11.
	NSF Certification	NSF 61 certification required for potable water pipe.
	Material	ASTM A53 Grade A or B, ASTM A134 (steel plate per ASTM A283 Grades C or D or A36), ASTM A135, or ASTM A139.
	Size	As shown on the Plans.
		Conform to dimensional tolerances of AWWA C200 for pipe ≥ 6" (150 mm) identified on the Plans by class, gauge or decimal wall thickness.
		Conform to ANSI B36.10 for pipe < 6" (150 mm) or for pipe specified on the Plans by strength or wall-thickness schedule.
	Minimum Wall Thickness	Where the Plans do not show thickness, submit design and supporting calculations prepared by the manufacturer in accordance with AWWA M11 using a maximum design working stress of 1/2 the yield stress for the grade of steel used in pipe fabrication. Compute wall thickness using pressure equal to 150 psi (1.0 MPa) or the design pressure shown on the Plans, whichever is greater.
		No pipe 4" (100 mm) and larger outside buildings or vaults shall have a wall thickness less than 14-gauge (1.9 mm).
		No pipe 4" (100 mm) and larger inside buildings or vaults shall have a wall thickness less than 3/8" (9.5 mm).
	Markings	Mark each special and each length of straight pipe at bell end to identify: • Manufacturer's name or mark • Type of steel • Design pressure • Diameter and weight of pipe or special • Proper location of pipe or special by reference to layout schedule
	Lengths	Furnish in single random lengths, double random lengths, or in specified cut lengths.
		For single random lengths, average length shall not be less than 17.5' (5.3 m) and no piece shall be shorter than 9' (2.7 m).
		For double random lengths average length shall not be less than 35' (10.7 m), not less than 10% of pieces shall be shorter than 26.25' (8.0 m) and no piece shall be shorter than 14' (2.7 m).
		For specified cut lengths, the actual pipe length shall not vary from the specified length by more than 1/8" (3 mm).
Interior Lining and Exterior Coating (Required on exposed steel surfaces and ring joints)	Cement-Mortar Interior Lining and Exterior Coating	Conform to AWWA C205 and AWWA C602 using Type II/V cement.
		Trim lining as necessary to allow full operation of butterfly or check valves at connections to steel pipe.
		Line exposed portions of pipe interior with hand-applied epoxy conforming to 212-12.
		3/4" (19 mm) min coating thickness unless otherwise shown or soil is identified as corrosive.
		Trim coating 6" to 12" (150 mm to 300 mm) above grade on spools penetrating to daylight or vault interiors.
	Cold-Applied Tape Exterior Coatings	Conform to AWWA C209 for the exterior of specials, connections, and fittings. Conform to AWWA C214 for steel pipeline coatings.
	Liquid Epoxy Interior Lining and Exterior Coating of Above-Ground Pipe	Conform to AWWA C210 and 212-12.
	Fusion-Bonded Epoxy Interior Lining and Exterior Coating of Above-Ground Pipe	Conform to AWWA C213 and 212-12.
	Extruded Polyolefin Exterior Coatings	Conform to AWWA C215 for extruded coatings. Conform to AWWA C216 for heat-shrinkable cross-linked coatings.

TABLE 209-2.3.1 ***(Continued)***

Item	Material	Reference Specification/Requirements
Joints	Ends Prepared for Mechanical-Coupled Field Joints	Conform to AWWA C200 Section 4.13. Square cut or beveled with no burrs. Outside surfaces where coupling seats shall be free of indentations, projections, or roll marks to ensure watertight seal. Pipe ends shall have tolerances within limits required by the mechanical coupling manufacturer.
	Field-Butt-Welded Joints	Pipe with wall thickness 15/64" (6.0 mm) or greater, intended for field butt welding. Bevel pipe on outside, inside or both sides as shown or specified. Bevel angle shall be 30 to 35 degrees measured from plane perpendicular to pipe axis. Width of root face at pipe end shall be 1/32" to 3/32" (0.8 mm-2.3 mm)
	Flanged Joint	Forged steel conforming to ASTM A181 Faced and dimensioned in accordance with ASME/ANSI B16.5 for the pressure class shown on the Plans or specified in the Special Provisions. Threads for screwed flanges and companion pipe ends shall conform to ASME/ANSI B1.20.1. Pipe ends for welding neck flanges shall be beveled.
Bell Joint Gaskets	Material	Conform to AWWA C300 Section 4.4.11 and 4.5.4. Vulcanized styrene butadiene rubber (SBR).
	Material for Hydrocarbon Applications and Contaminated Soils	NBR (Nitrile) (acrylonitrile butadiene), FLUOREL, or FKM (Viton) (fluorocarbon).
	Gasket Age	< 180 Days old or < 2 years old but retested < 60 Days prior to installation
Flange Gaskets	Material	212-2.7.
Fittings	Material	Same steel as pipe.
	Standards	Manufacture from mill-type steel pipe in accordance with ASME/ANSI B16.9.
	Exterior Coatings	Use same coating as adjacent pipe, as specified above.
	Interior Linings	Use same lining as adjacent pipe, as specified above.

209-2.3.2 Submittals. If specified in the Special Provisions, prior to fabricating pipe, the Contractor shall submit, in accordance with 2-5.3, a certified laboratory report stating the type of steel, and the physical and chemical properties for each heat number of the steel used in fabricating the pipe.

209-2.3.3 Factory Testing. After fabrication, but prior to the application of the specified interior lining and exterior coating, straight pipe cylinders of all sizes shall be successfully hydrostatically tested to 1.5 times the test pressure shown on the Plans or specified in the Special Provisions.

209-2.3.4 Welding. Factory welding of mill steel pipe shall conform to AWWA C200 Section 4.11. Field welding shall conform to AWWA C206.

Patching of pipe where test specimens have been taken will not be permitted.

If specified in the Special Provisions, the Contractor shall submit certified laboratory reports stating the results of the required welding tests.

209-2.4 Stainless Steel Water Pipe.

209-2.4.1 Materials. Unless otherwise specified, stainless steel pipe shall conform to the following:

TABLE 209-2.4.1

Item	Material	Reference Specification/Requirements
Pipe	Manufacturing Standards	Furnace-welded, electrically welded or seamless pipe conforming to AWWA 220 or ASTM A312 (pipe ≤ 10" (250 mm)), or ASTM A409 or ASTM A778 (pipe ≥ 12" (300 mm)).
	Design Standards	Conform to AWWA M11.
	NSF Certification	NSF 61 certification required for potable water pipe.
	Material	Stainless Steel SAE Type 316L unless otherwise specified.
	Size	As shown on the Plans.
		Conform to dimensional tolerances of AWWA C200 for pipe ≥ 6" (150 mm) specified on the Plans by class, gauge or decimal wall thickness.
		Conform to ANSI B36.10 for pipe < 6" (150 mm) or for pipe specified on the Plans by strength or wall thickness schedule.
	Minimum Wall Thickness	Where the Plans do not show thickness, submit design and supporting calculations prepared by the manufacturer in accordance with AWWA M11 using a maximum design working stress of 1/2 the yield stress for the grade of steel used in pipe fabrication. Compute wall thickness using pressure equal to 150 psi (1.0 MPa) or the design pressure shown on the Plans, whichever is greater.
		No pipe 4" (100 mm) and larger outside buildings or vaults shall have a wall thickness less than 14-gauge (1.9 mm).
		No pipe 4" (100 mm) and larger inside buildings or vaults shall have a wall thickness less than 3/8" (9.5 mm).
	Markings	Mark each special and each length of straight pipe at bell end to identify: • Manufacturer's name or mark • Type of steel • Design pressure • Diameter and weight of pipe or special • Proper location of pipe or special by reference to layout schedule
	Lengths	Furnish in single random lengths, double random lengths, or in specified cut lengths.
		For single random lengths, average length shall not be less than 17.5' (5.3 m) and no piece shall be shorter than 9' (2.7 m).
		For double random lengths average length shall not be less than 35' (10.7 m), not less than 10% of pieces shall be shorter than 26.25' (8.0 m) and no piece shall be shorter than 14' (2.7 m).
		For specified cut lengths, the actual pipe length shall not vary from the specified length by more than 1/8" (3 mm).
Joints	Ends Prepared for Mechanical-Coupled Field Joints	Conform to AWWA C220 Section 4.13. Square cut or beveled with no burrs. Outside surfaces where coupling seats shall be free of indentations, projections, or roll marks to ensure watertight seal. Pipe ends shall have tolerances within limits required by the mechanical coupling manufacturer.
	Field-Butt-Welded Joints	Pipe with wall thickness 15/64" (6.0 mm) or greater, intended for field butt welding. Bevel pipe on outside, inside or both sides as shown or specified. Bevel angle shall be 30 to 35 degrees measured from plane perpendicular to pipe axis. Width of root face at pipe end shall be 1/32" to 3/32" (0.8 mm-2.3 mm).
	Flanged Joint	Forged steel conforming to ASTM A181 faced and dimensioned in accordance with ASME/ANSI B16.5 for the pressure class shown on the Plans or specified in the Special Provisions. Threads for screwed flanges and companion pipe ends shall conform to ASME/ANSI B1.20.1. Pipe ends for welding neck flanges shall be beveled.
Bell Joint Gaskets	Material	Conform to AWWA C300 Section 4.4.11 and 4.5.4. Vulcanized styrene butadiene rubber (SBR).
	Material for Hydrocarbon Applications and Contaminated Soils	NBR (Nitrile) (acrylonitrile butadiene), FLUOREL or FKM (Viton) (fluorocarbon).
	Gasket Age	< 180 Days old or < 2 years old but retested < 60 Days prior to installation
Flange Gaskets	Material	212-2.7.
Fittings	Material	Same steel as pipe.
	Standards	Manufacture from mill-type steel pipe in accordance with ASME/ANSI B16.9.

209-2.4.2 Submittals. If specified in the Special Provisions, prior to fabricating pipe, the Contractor shall, in accordance with 2-5.3, submit a certified laboratory report stating the type of steel, and the physical and chemical properties for each heat number of the stainless steel used in fabricating the pipe.

209-2.4.3 Factory Testing. After fabrication, straight pipe cylinders of all sizes shall be successfully hydrostatically tested to 1.5 times the test pressure shown on the Plans or specified in the Special Provisions.

Special sections manufactured from previously tested pipe need not be hydrostatically tested but any welds not previously hydrostatically tested shall be tested by the air-soap or dye-check method,

209-2.4.4 Welding. Factory welding of mill-type steel pipe shall conform to AWWA C220 Section 4.4. Field welding shall conform to applicable AWS/ANSI standards.

Patching of pipe where test specimens have been taken will not be permitted.

If specified in the Special Provisions, the Contractor shall submit certified laboratory reports stating the results of the required welding tests.

209-2.5 Pipe End Preparation for Lined and Coated Pipe. Pipe interior linings and exterior coatings shall be held back from the socket and spigot ends in accordance with the manufacturer's standard practices.

Exterior coatings shall be held back from the ends of all butt-strap, mechanical coupling, and flanged joint pipe a sufficient distance to permit field assembly of joints.

Interior linings shall terminate at pipe ends, unless otherwise specified or where necessary to accommodate free motion of butterfly or check valve discs.

Non-coated or unlined surfaces shall be cleaned and covered with a brush coat of suitable NSF-61 certified rust preventative material compatible with field-applied finish interior lining and exterior coating materials.

209-3 CONCRETE PRESSURE PIPE.

209-3.1 General. This subsection specifies concrete cylinder pipe and reinforced concrete pipe up to 64-inch (1600 mm) diameter for the transmission and distribution of raw, potable, or recycled water, or sewage under pressure. Concrete pipe shall be of the size, type, and cylinder wall thickness or pressure class shown on the Plans or specified in the Special Provisions.

209-3.2 Materials. Unless otherwise specified, concrete pressure pipe shall conform to the following:

TABLE 209-3.2

Item	Material	Reference Specification/Requirements
Pipe	Standards	Butt or offset-butt electrically welded straight or spiral-seam steel cylinders, shop fabricated from plates and conforming to AWWA C300 for pipe ≥ 30" (750 mm) or AWWA C301 for pipe ≥ 16" (400 mm) or AWWA C303 for pipe ≥ 10" (250 mm).
		Reinforced concrete non-cylinder type pipe shall conform to AWWA C302 for pipe ≥ 12" (300 mm).
	Design Standards	Conform to AWWA C304 and AWWA M9
	NSF Certification	NSF 61 certification required for potable water pipe
	Material	Cement – ASTM C150 Type II/V Steel plates, sheets, and reinforcement used to manufacture concrete pressure pipe shall conform to requirements for steel shown in applicable AWWA standard.
	Size	As shown on the Plans. Net inside diameter after interior lining shall equal or exceed nominal pipe diameter with tolerance of minus 1/4" (6 mm).
	Minimum Wall Thickness	Where the Plans do not show thickness, or reinforcing, submit design and supporting calculations prepared by the manufacturer in accordance with AWWA M9 and AWWA C304. Compute wall thickness and reinforcing requirements using maximum design working stress of 1/2 the yield stress for the grades of steel used in pipe fabrication. Compute wall thickness and reinforcement requirements using the design pressure shown on the Plans.
		No pipe 4" (100 mm) and larger outside buildings or vaults shall have a wall thickness less than 14-gauge (1.9 mm).
		No pipe 4" (100 mm) and larger inside buildings or vaults shall have a wall thickness less than 3/8" (9.5 mm).
	Markings	Mark each special and each length of straight pipe at bell end to identify: • Manufacturer's name or mark • Type of steel and concrete • Design pressure • Diameter and weight of pipe or special • Proper location of pipe or special by reference to layout schedule
	Lengths	Maximum pipe length of 42' (13 m). Shorter lengths may be used to facilitate curves or fit horizontal or vertical alignment.
Interior Lining and Exterior Coating (Required on all exposed steel surfaces and ring joints)	Liquid Epoxy Interior Lining and Exterior Coating of Exposed Steel on Pipe	Conform to AWWA C210 and 212-12.
	Fusion-Bonded Epoxy Interior Lining and Exterior Coating of Exposed Steel on Pipe	Conform to AWWA C213 and 212-12.
Joints	Bell-and-Spigot Ends with Rubber Gaskets	Conform to AWWA C300, C301, C302, or C303 as applicable. Design for maximum interior pipe interior lining gap joint of 1/2" (12.5 mm) after joint assembly, measured from ends of interior lining of pipe sections being joined.
	Ends Prepared for Mechanical-Coupled Field Joints	Conform to AWWA C300, C301, or C303 as applicable. Cylinders shall be square cut or beveled with no burrs. Outside surfaces where coupling seats shall be free of indentations, projections, or roll marks to ensure watertight seal. Pipe ends shall have tolerances within limits required by the mechanical coupling manufacturer.
	Lap Joints for Field Welding	Conform to AWWA C300, C301, or C303 as applicable. Design for maximum interior pipe lining gap joint of 1/2" (12.5 mm) after joint assembly, measured from ends of interior lining of pipe sections being joined.
	Plain Ends with Butt Straps for Field Welding	Conform to AWWA C300, C301, or C303 as applicable. Design for maximum interior pipe lining gap joint of 1/2" (12.5 mm) after joint assembly, measured from ends of interior lining of pipe sections being joined. For pipe less than 24" (600 mm) nominal diameter, furnish butt straps with a 4" (100 mm) diameter hand hole, complete with screwed cap or plug, suitable for use in "pointing" the interior joint lining after field installation of the joint.
	Flanged Joint	Conform to AWWA C207. Faced and dimensioned in accordance with ASME/ANSI B16.5 for the pressure class shown on the Plans or specified in the Special Provisions.
Bell Joint Gaskets	Material	Conform to AWWA C300 Section 4.4.11 and 4.5.4. Vulcanized styrene butadiene rubber (SBR).
	Material for Hydrocarbon Applications and Contaminated Soils	NBR (Nitrile) (acrylonitrile butadiene), FLUOREL or FKM (Viton) (fluorocarbon).
	Gasket Age	< 180 Days old or < 2 years old but retested < 60 Days prior to installation.
Flange Gaskets	Material	212-2.7.
Fittings	Material	Same steel as pipe.
	Standards	Conform to AWWA C208 .
	Exterior Coatings	Use same coating as adjacent pipe, as specified above.
	Interior Linings	Use same lining as adjacent pipe, as specified above.

209-4 PVC PRESSURE PIPE.

209-4.1 General. This subsection specifies PVC pipe used for pressure piping applications for water and recycled water pressure pipes and for sewage force mains.

209-4.2 Materials. Unless otherwise specified, PVC pressure pipe shall conform to the following:

TABLE 209-4.2

Item	Material	Reference Specification/Requirements	
Pipe	Manufacturing Standards	Conform to AWWA C900 for pipe 4"-12" (100 mm-300 mm). Conform to AWWA C905 for pipe 14" (350 mm) and larger.	
	Design Standards	Conform to AWWA M23 using hydraulic design basis below.	
	NSF Certification	NSF 61 certification required for potable water pipe.	
	Material	Virgin rigid poly-vinyl-chloride. Conform to ASTM D1784 Cell Class 12454B or better. Conform to NSF 14. Conform to AWWA C900 Section 4.2 or AWWA C905 Section 4.2 as appropriate.	
	Hydrostatic Design Basis (HDB)	≥ 4,000 psi (27.5 MPa) for water at 73.4°F (23°C). Apply 2.5 Safety Factor and use 1,600 psi (11.0 MPa) maximum design stress.	
	Markings (each pipe)	Conform to AWWA C900 or C905 Section 6.1.	
		Mark applicable AWWA standard.	
		Show nominal pipe diameter.	
		Show AWWA pressure class or DR.	
		Show NSF 61 stamp (for potable water service).	
		Show manufacturer and manufacturing date code.	
	Size	As shown on the Plans. Conform to outside diameter of ductile iron pipe unless otherwise shown.	
	Minimum Wall Thickness (Dimension Ratio)	**Design Pressure and Diameter Shown on the Plans**	**Minimum Dimension Ratio**
		0-100 psi (.7 MPa) 4"-48" (100 mm-1200 mm)	DR 18 (Class 235)
		150 psi (1.0 MPa) 4"-12" (100 mm-300 mm)	DR 14 (Class 305)
		150 psi (1.0 MPa) 14"-48" (350 mm-1200 mm)	DR 18 (Class 235)
		200 psi (1.4 MPa) 4"-12" (100 mm-300 mm)	DR 14 (Class 235)
		200 psi (1.4 MPa) 14"-48" (350 mm-1200 mm)	Use DIP or Steel Pipe
		Greater than 200 psi (1.4 MPa)	Use DIP or Steel Pipe
		Pipe with Grooved Couplings	Use DIP or Steel Pipe4"
	Lengths	Laying lengths shall be 20' with option to supply up to 15% random (minimum length 10') sections.	
Joints	Standard Push-on Style	Conform to ASTM D3139.	
Bell Joint Gaskets	Material	Elastomeric membrane per AWWA C900 Section 4.2.4 (Gaskets and Lubricants) and ASTM F477. Butadiene styrene (SBR or BR) for potable water. Ethylene propylene (EPM or EPDM) for recycled water.	
	Material for Hydrocarbon Applications and Contaminated Soils	Elastomeric membrane per AWWA C900 Section 4.2.4 (Gaskets and Lubricants) and ASTM F477. NBR (Nitrile) (acrylonitrile butadiene), FLUOREL or FKM (Viton) (fluorocarbon).	
	Gasket Age	< 180 Days old or < 2 years old but retested < 60 Days prior to installation	
Fittings	Material	Ductile iron.	
	Standards	Conform to AWWA C110/ANSI 21.10 or AWWA C153/ANSI A21.53.	
	Style	Push-on (standard) or restrained joint (as shown).	
	Marking	Cast letters "DI" or "DUCTILE" into fittings, unless otherwise specified.	
	Exterior Coatings	1 mil (25 µm) petroleum asphaltic coating.	
	Interior Linings	Cement mortar (double thickness).	
	Plastic Film Wrap for Corrosion Protection	Conform to 212-12.1.1. Color per 212-12.2.	

209-5 HIGH-DENSITY POLYETHYLENE (HDPE) SOLID WALL PRESSURE PIPE.

209-5.1 General. This subsection specifies HDPE solid wall pipe to be used for pressure piping applications for water and recycled water pressure pipes and for sewage force mains.

209-5.2 Materials. Unless otherwise specified, HDPE pressure pipe shall conform to the following.

TABLE 209-5.2

Item	Material	Reference Specification/Requirements	
Pipe	Manufacturing Standards (Potable Water Pipe)	Conform to AWWA C901 for pipe 1/2"-3" (12.5 mm -75 mm). Conform to AWWA C906 for pipe 4"-63" (100 mm -1575 mm).	
	Manufacturing Standards (Non-Potable Water Pipe)	Conform to ASTM F714.	
	Design Standards	Conform to AWWA M55.	
	NSF Certification	NSF 61 certification required for potable water pipe.	
	Material	ASTM D3350 PE 4710 Cell classification 4454 or higher. Conform to AWWA C901 Section 4.2 or AWWA C906 Section 4.2 as appropriate.	
	Hydrostatic Design Basis (HDB)	≥ 1600 psi (11.0 MPa) for water at 73.4°F (23°C). Apply 2.0 Safety Factor (0.5 Design Factor) and use 800 psi (5.5 MPa) maximum design stress.	
	Markings (each pipe)	Conform to AWWA C901 or C906 Section 6.1.	
		Mark applicable AWWA standard.	
		Show nominal pipe diameter.	
		Show standard material code designation.	
		Show AWWA pressure class or DR.	
		Show NSF 61 stamp (for potable water service).	
		Show manufacturer and manufacturing date code.	
	Size	1-1/4"-63" (32 mm-1575 mm) diameter as shown on the Plans. Ductile iron pipe size (DIPS) outside diameter for pipe 4"-48" (100 mm -1200 mm) unless otherwise shown. Iron pipe size (IPS) outside diameter for pipe < 4" (100 mm) or > 48" (1200 mm).	
	Minimum Wall Thickness (Dimension Ratio)	**Design Pressure Shown on the Plans**	**Minimum Dimension Ratio**
		0-80 psi (0.6 MPa)	DR 21
		100 psi (0.7 MPa)	DR 17
		150 psi (1.0 MPa)	DR 11
		200 psi (1.4 MPa)	DR 9
		250 psi (1.7 MPa)	DR 7.3
		Not shown	DR 11
Joints	Style	Thermal butt fusion for joining pipe in accordance with the manufacturer's recommendations.	
		Flanged for connections to appurtenances and other pipe materials in accordance with manufacturer's recommendations.	
	Flange Back-up Ring	Provide flange back-up ring of Type 316 SS or fusion bonded epoxy coated ductile iron.	
	Design Pressure	Match design pressure rating of pipe shown on the Plans.	
Fusion Fittings	Standards	ASTM D2683 socket-type, ASTM D3261 butt-type, or ASTM F1055 electrofusion (fittings shall be marked as complying).	
	Material	HDPE conforming to pipe specifications.	
	Design Pressure	Match design pressure rating of pipe shown on the Plans.	
	Safety Factor	2:1 minimum.	
	Quick Burst Strength	Not less than pipe connected to fitting.	
Adaptor Fittings (For Connections to Flanged Fittings)	Internal Stiffener Ring	Required.	
	Backup Ring	Stainless steel.	
	Thrust Restraint	Per anchoring kit per manufacturer's requirements.	

209-6 FIBERGLASS PRESSURE PIPE.

209-6.1 General. This subsection specifies fiberglass pressure pipe up to 64-inch (1600 mm) diameter to be used for pressure piping applications for water and recycled water pressure pipes and for sewage force mains.

209-6.2 Materials. Unless otherwise specified, fiberglass pressure pipe shall conform to the following:

TABLE 209-6.2

Item	Material	Reference Specification/Requirements
Pipe	Manufacturing Standards	Conform to AWWA C950.
	Design Standards	Conform to AWWA M45.
	NSF Certification	NSF 61 certification required for potable water pipe.
	Material	Type I Centrifugally-Cast Fiberglass-Reinforced Polymer Mortar Pipe or Type II Filament-Wound Fiberglass Reinforced Polymer Mortar as specified in the Special Provisions.
	Grade	As specified in the Special Provisions.
	Liner	As specified in the Special Provisions.
	Markings (each pipe)	Mark each length of pipe or fitting to identify: • Applicable ASTM or AWWA standard • Manufacturer's name or mark • Type and grade of pipe and liner if applicable • Design pressure • Stiffness class Proper location of pipe or special by reference to layout schedule
	Size	As shown on the Plans, Conform to outside diameter of ductile iron pipe unless otherwise shown.
	Pressure Class	As shown on the Plans or specified in the Special Provisions.
	Stiffness Class	As shown on the Plans or specified in the Special Provisions.
	Maximum Long-Term Deflection	5%.
	Wall Thickness	As required to conform to minimum pressure class or minimum stiffness class shown on the Plans.
	Lengths	Laying lengths shall be from 10' to 40' (3 m to 12 m) with option to supply up to 15% of sections in random lengths.
	Pipe Ends	Square to pipe axis with maximum tolerance of ± 1/4" (6 mm) or 0.5% of the nominal diameter, whichever is greater.
Joints	Unrestrained Coupling or Bell-and-Spigot Joints	Conform to performance requirements of ASTM D4161 Section 7.
	Mechanical Coupling Joints	Conform to manufacturer's recommendation and performance requirements of ASTM D4161 Section 7.
	Butt Joint with Laminated Overlay	Use only for specials or when approved by the Engineer. Conform to manufacturer's recommendation and performance requirements of ASTM D4161 Section 7.
	Flanged	Conform to manufacturer's recommendation and performance requirements of ASTM D4161 Section 7. Bolt pattern to match adjacent pipe.
Joint Gaskets	Material	Conform to ASTM F477. Butadiene Styrene (SBR or BR) for potable water. Ethylene Propylene (EPM or EPDM) for recycled water; EPM, EPDM, or NBR (Nitrile) for wastewater. NBR (Nitrile) for wastewater sludge.
	Material for Hydrocarbon Applications and Contaminated Soils	Elastomeric Membrane per AWWA C900 Section 4.2.4 (Gaskets and Lubricants) and ASTM F477. NBR (Nitrile) (acrylonitrile butadiene), FLUOREL or FKM (Viton) (fluorocarbon).
	Gasket Age	< 180 Days old or < 2 years old but retested < 60 Days prior to installation.
Fittings	Standards	Conform to AWWA C950 or ASTM D3517.

209-7 PIPELINE IDENTIFICATION.

209-7.1 General. This subsection specifies pipe warning and locating materials and methods for use with buried pressure pipe.

209-7.2 Requirements: Pipeline identification shall conform to the following:

TABLE 209-7.2

Function	Type	Materials/Method
Pipe Contents Identification	Pipe Color (Plastic Pipe or Polywrap)	Blue for Potable Water. Purple for Recycled Water. Green for Sewage.
	AND	
	Stenciling	Stenciling marked on pipe in contrasting color to background color of pipe stating: "POTABLE WATER", "CAUTION RECYCLED WATER - DO NOT DRINK" or "CAUTION SEWER" as appropriate.
		5/8" (16 mm) high letters.
		Repeated at 1 foot (300 mm) intervals.
	OR	
	Identification Tape	Polyethylene tape 6" (150 mm) wide and 4 mils (100 µm) minimum thickness with 2" (50 mm) high letters stating: "POTABLE WATER", "CAUTION RECYCLED WATER - DO NOT DRINK" or "CAUTION SEWER" as appropriate. For pipe > 12" (300 mm) diameter, use 12" (300 mm) wide tape.
		Color - Blue with white letters for potable water, Purple with white letters for recycled water, Green with white letters for sewage.
		Attached to top of pipe with adhesive tape.
Pipe Warning and Locating	Warning and Locating Tape	Polyethylene tape 6" (150 mm) wide and 4 mils (100 µm) minimum thickness with 2"(50 mm) high letters stating: "CAUTION: WATERLINE BURIED BELOW", "CAUTION: RECLAIMED WATERLINE BURIED BELOW – DO NOT DRINK", or "CAUTION: SEWER BURIED BELOW" as appropriate. For pipe > 12" (300 mm) diameter, use 12" (300 mm) wide tape.
		Color - blue with black or white letters for potable water, Purple with black or white letters for recycled water, Green with black or white letters for sewage.
		Place in pipe trench 18" (450 mm) above pipe.
		Tape shall contain metallic strip that can be registered by magnetic field locating device.
	OR	
	Locating Wire	In lieu of installing metallic warning tape; non-metallic warning tape 18" (450 mm) above pipe and 10-gauge copper wire attached to top of pipe and accessibly terminated may be used.

SECTION 210 - PAINT AND PROTECTIVE COATINGS

210-1 PAINT.

210-1.1 General Requirements. Paint shall be homogeneous, free of contaminants, and of a consistency suitable for the use for which it is specified. The pigment shall be finely ground and properly dispersed in the vehicle according to the requirements of the paint; and this dispersion shall be of such nature that the pigment does not settle appreciably, does not cake or thicken in the container, or become granular or curdled. Paint and paint materials shall be delivered to the Work site in new, unopened, airtight containers, appropriately identified with the manufacturer's name, date of manufacture, type of paint or paint material, State Specification number, and lot or batch number.

No paint shall be used until at least 7 Days have elapsed from the date of manufacture.

210-1.2 Testing. All paint and paint materials shall be sampled and tested prior to use. All tests will be conducted in accordance with the methods specified in ASTM or methods set forth in Federal Standard 141. In the absence of any such methods, other suitable methods may be designed and utilized by the Engineer.

Lots or batches of paint of proprietary brand, which have been previously sampled and tested by the Agency and approved as conforming with these specifications, may be used without further testing, if permitted by the Engineer. For the purpose of these specifications, proprietary brands of paint and paint materials are construed to mean those conforming to the requirements of these specifications which are produced for distribution through regular wholesale and retail outlets.

210-1.3 Paint Coats. Paint coats shall consist of pre-treatment when specified, primer, and finish coats in that order, in accordance with 210-1.5.

210-1.4 Paint Materials. Paint materials shall conform in all respects to the requirements of the reference specifications indicated for such material in the table of paint systems shown below.

210-1.5 Paint Systems. Unless otherwise specified, the paint systems to be used shall conform to the requirements shown in the following table and the State of California Department of Transportation Standard Specifications.

TABLE 210-1.5

Surface to be Painted	Pre-Treatment/Surface Preparation[1]	Primer[1]	Finish Coats[1]
Galvanized Metal	Vinyl Wash	Zinc Dust – Zinc Oxide Fed. Spec. TT-P- 641 Type II	Aluminum White Enamel White Tint Base[2] Aluminum Green Tan Burnt Sienna
Structural Steel – General Use	Commercial Blast Per SSPWC 310-2.5	Per Manufacturer's Recommendations	
Wood Structures, Wood Primer and Surfaces		Wood Primer	Exterior White[2]
Signal Standards	Vinyl Wash	Yellow	Yellow
Signal Heads and Mounting	Vinyl Wash		Olive Green[2]
Backplates, Visors, Louvers	Vinyl Wash		Black[2]

1. Refer to Section 91, State of California Department of Transportation (CalTrans) Standard Specifications unless otherwise specified.
2. Finish color shall be in accordance with Specifications or as determined by the Engineer.

210-2 PLASTIC LINER.

210-2.1 General. Plastic liner sheet, joint, corner, and weld strips shall be manufactured from a polyvinyl chloride compound that meets the properties specified herein and is approved by the Engineer. The material shall be suitable for use as protective liner and joint systems in pipe or other structures. Copolymer resin will not be permitted.

At any time during the manufacture or prior to the final acceptance of the Work, utilizing material qualified under 210-2.3, the Engineer may sample specimens taken from any part of the assembled or unassembled product for testing of physical properties per 211-2.

Changes in the compound formulation may be permitted only after 12 months if prior notice is given to the Engineer, and the Contractor proves that the new formulation meets or exceeds all requirements specified herein and is approved by the Engineer. The Engineer shall be notified 7 Days prior to any approval testing as to the type of material to be tested.

All plastic liner sheets including locking extensions, joint, corner, connecting, and welding strips shall be free of cracks, cleavages, or other defects adversely affecting the protective characteristics of the material. The Engineer may authorize the repair of such defects by approved methods.

Plastic liner older than 180 Days from the date of manufacture shall not be used in lined reinforced concrete pipe as specified in 207-3.

210-2.1.1 Adhesive Products. The Engineer shall approve adhesive products and application procedures to be used in the installation of the plastic prior to their use. Adhesive products intended for use inside joined plastic-lined pipe or cast-in-place structures shall be nonflammable.

210-2.1.2 Cleaners. The Engineer shall approve cleaners used in the installation of the liner prior to their use. Cleaners shall be nonflammable, shall be water soluble or water dispersible, and shall not be detrimental to the plastic liner.

210-2.2 Details and Dimensions.

210-2.2.1 Approval of Details. Liner sheet, strip, and other accessory pieces shall conform to the requirements shown on the Plans and specified in the Specifications.

210-2.2.2 Thickness of Material. The minimum thickness of sheet and strip shall be as shown in Table 210-2.2.2.

TABLE 210-2.2.2

Material	Thickness mils (mm)
Sheet, integral locking extensions	65 (1.65)
Sheet, plain	94 (2.39)
Joint strip	75 (1.91)
Weld strip	94 (2.39)

210-2.2.3 Material Sizes. Sheets of liner used for pipe shall be sized to provide the coverage required by the Plans. Joint strips shall be 4 ± 0.25 inches (100 ± 6 mm) in width and shall have each edge beveled prior to application. Welding strips shall be 1 ± 0.125 inch (25 ± 3 mm) in width. All welding and outside corner strips shall have edges beveled at time of manufacture.

210-2.2.4 Locking Extensions. All liner to be embedded in concrete shall have integral locking extensions.

Locking extensions shall be of the same material as the liner; shall be integrally bonded, molded, or extruded with the sheets; and shall have an approved cross section with a minimum height of 0.375 inch

(9.5 mm) and a minimum web thickness of 0.085 inch (2.2 mm). Locking extensions shall be 2-1/2 ± 0.250 inches (63 ± 6 mm) apart for pipe and structure applications. The locking extensions shall be such that when they are embedded in concrete, the liner will be held permanently in place and meet the pull-out requirements of 210-2.3.4. There shall be a minimum of one locking extension embedded in each continuous surface, except any continuous surface of 4 inches (100 mm) or more shall have a minimum of two locking extensions, or the material shall be bonded in place. Locking extensions shall be parallel and continuous except where interrupted for joint flaps, weep channels, strap channels, and for other purposes shown on the Plans or where permitted by the Engineer.

A flexible liner sheet edge which will be the lower terminal edge in the structure or pipe shall not extend beyond the base of the final locking extension more than 3/8 inch (9.5 mm).

Liner shall be bonded to concrete surfaces with an adhesive if shown on the Plans or specified in the Specifications.

210-2.2.5 Provisions for Strap Channels. If required, strap channels shall be wide maximum and formed by removing the locking extensions so that a maximum of 3/16 inch (5 mm) remains.

210-2.2.6 Flaps. When transverse flaps are specified or required, they shall be fabricated by removing locking extensions so that a maximum of 0.032 inch (0.80 mm) of the base of the locking extensions remains on the sheet.

210-2.3 Tests.

210-2.3.1 General. Liner materials shall be tested for physical and chemical properties prior to approval by the Engineer. Samples taken from sheets, joints, or weld strips of material representative of those to be furnished shall be tested to determine material properties. Determination of physical properties shall be in accordance with the tests specified in 210-2.4 or 210-2.5. Properties specified in 210-2.4 or 210-2.5 shall be submitted to the Engineer per 2-5.3.4.

210-2.3.2 Not Used.

210-2.3.3 Chemical Resistance Test (Pickle Jar Test). Test specimens shall be tested in accordance with 211-2.

210-2.3.4 Pull Test for Locking Extensions. Liner locking extensions embedded in concrete shall withstand a test pull of at least 100 pounds per linear inch (18 N/m), applied perpendicularly to the concrete surface for a period of 1 minute, without rupture of the locking extensions or withdrawal from embedment. This test shall be made at a temperature between 70°F to 80°F (21°C to 27°C) inclusive.

210-2.3.5 Shop Welded Joints. Shop-welded joints, used to fuse individual sections of liner together, shall be at least equal to the minimum requirements of the liner for thickness, corrosion resistance, and impermeability. Welds shall show no cracks or separations and shall be tested for tensile strength. Tensile strength measured across the welded joint in accordance with ASTM D412 using Die B shall be at least 2,000 pounds per square inch (13.8 MPa). Test temperatures shall be 77°F ± 5°F (25°C ± 3°C) and the measured minimum width and thickness of the reduced section shall be used.

210-2.3.6 Spark Test. All liner shall be shop tested for holes with a spark tester set to provide from 15,000 to 20,000 volts. Sheets having holes shall be satisfactorily repaired in the shop prior to shipment from the manufacturer's plant. Welders qualified in accordance with 311-1.2.2 shall make all repairs.

210-2.4 Flexible PVC Liner.

210-2.4.1 Flexible PVC Liners for Structures, Manholes, and Pipes. Flexible PVC plastic liner sheets, joint assembly components, corner and weld strips shall be tested in accordance with 211-2 and shall conform to the requirements in Table 210-2.4.1.

TABLE 210-2.4.1

Property	Initial[1]	Exposure[1]
Tensile Strength ASTM D412	2,200 psi (15 MPa)	2,100 psi (14.4 MPa)
Elongation at break ASTM D412	200%	200%
Hardness, Shore durometer, Type D ASTM D2240	Within 1 sec. 50-60	± 5[3]
	Within 10 sec. 35-50	± 5[3]
Weight change	—	± 1.5%[3]

1. For 112 Days in chemical solutions listed in 211-2. All above values are minimum required except for hardness and weight, which is the maximum permissible gain or loss in weight.
2. Except that a single thickness of material shall be used.
3. With respect to initial test result.

210-2.4.2 Shop-Welded Joints. Tensile strength measured across the welded joint in accordance with ASTM D412 using Die B shall be at least 2,200 pounds per square inch (15 MPa) minimum.

210-2.5 Rigid PVC Liners.

210-2.5.1 Rigid PVC Liners for Structures, Manholes, and Pipes. Rigid PVC plastic liner sheets, joint assembly components corner and connecting strips for pipe, manhole, and linings for structures shall be tested in accordance with 211-2 and shall conform to the requirements in Table 210-2.5.1.

TABLE 210-2.5.1

Property	Initial[1]	After Exposure[1]
Tensile Strength ASTM D638	6,500 psi (44 MPa)	80% of initial
Tensile Modulus ASTM D638	408,000 psi (2810 MPa)	N/A
Elongation at break ASTM D638	25%	N/A
Hardness, Shore Durometer, Type D ASTM D2240[2]	Instantaneous 70	N/A
Flexural Strength ASTM D790	13,000 psi (90 MPa)	N/A
Flexural Modulus ASTM D790	455,000 psi (3140 MPa)	N/A
Heat Deflection ASTM D648	160°F at 264 psi (71°C at 1.8 MPa)	N/A
Izod Impact ASTM D256	1.2 ft-lbs/inch (1.63 J/25 mm) of notch	N/A
Variable Height Impact Test ASTM D4226		
W/.25 Hemispherical Dart		
Procedure A[2]	1.6 inch-lbs/mil (7.2 J/mm) thickness	N/A
Procedure B[3]	2.8 inch-lbs/mil (12.8 J/mm) thickness	N/A
W/.125 Conical Dart		
Procedure A[2]	1.7 inch-lbs/mil (7.7 J/mm) thickness	80% of initial
Procedure B[3]	2.9 inch-lbs/mil (13.1 J/mm) thickness	80% of initial
Weight Change		± 1.5%

1. All above values are minimum required except for hardness and weight, which is the maximum permissible gain or loss in weight.
2. Minimum Failure Energy.
3. Ductile/Brittle Transition.
4. With respect to initial test result.

210-3 GALVANIZING.

210-3.1 General. Zinc used for galvanizing shall be grade Prime Western conforming to ASTM B6. Except as otherwise specified, materials shall be galvanized by the hot-dip, mechanical, or electrode positing process.

210-3.2 Requirements of Coating. The minimum weight of coating and other requirements shall be as shown in the following table. If there is a conflict between the ASTM and minimum weight columns, the minimum weight column shall apply. The weight shown is ounces per square foot (grams per square meter) of surface area. The weight of coating shall be determined in accordance with ASTM A90, modified to determine the coating of each surface separately. All surfaces, when tested separately, shall meet the minimum requirements.

TABLE 210-3.2 (A)

Material	ASTM	Minimum Weight of Coating oz/ft^2 (g/m^2)
Steel products including structural shapes, tie rods, handrails, manhole steps, and miscellaneous items.	A123	2.00 (610)
	A153	2.00 (610)
	B633	2.00 (610)
	B695	2.00 (610)
Hardware including cast, rolled, pressed and forged articles.	A153	2.00 (610)
	B633	2.00 (610)
	B695	2.00 (610)
Bolts, screws, nuts and washers	A153	1.25 (381)
	B633	1.25 (381)
	B695	1.25 (381)
CSP culverts and underdrains	A444	1.00 (305)
Chain link fence fabric, tie wire only.	A392	1.20 (366)
Steel pipe (includes fence posts, braces, and rails)		
Class 1 (see Note 1)	F1083	1.80 (550)
Class 1A (pipe only, see Notes 2 and 3).		1.00 (305)
All other chain link fence articles	A123	1.80 (550)
Iron or steel wire fencing	A116	0.80 (244)
Steel or iron sheets	A525	1.20 (366)
Barbed wire	A121	0.80 (244)
Electrolier standards, 7-gage steel and over	A386	2.00 (610)
Electrolier standards, under 7-gage steel	A386	1.50 (458)

1. "C" and "H" section fence posts shall be hot-dipped galvanized after forming.
2. Class 1A pipe shall, in addition to the galvanized exterior coating indicated, have coatings of chromate conversion and acrylic urethane in accordance with Subsection 210-4.
3. The interior surface coating for Class 1A pipe shall have 1 ounce per square foot (305 g/m^2) of hot-dipped galvanized coating or a zinc-rich organic a minimum of 0.3 mils (8 µm) thick. The coating shall have a minimum zinc powder loading of 87 percent by weight. The interior coated surface shall have a demonstrated ability to resist 650 hours of exposure to salt fog with a maximum of 5 percent red rust when tested in accordance with ASTM B117.

210-3.3 Workmanship. The zinc coating shall adhere tenaciously to the surface of the base material. The finished product shall be free from blisters and excess zinc, and the coating shall be even, smooth, and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening, and other fabricating shall be done as far as is practicable before

the galvanizing. All members, nuts, bolts, washers, etc., shall be galvanized before a structural unit is assembled. All uncoated spots or damaged coatings shall be cause for rejection.

Products that are warped or distorted to the extent of impairment for the use intended shall be rejected.

210-3.4 Test Coupons. Test coupons for determining the quantity and quality of the galvanizing shall be of such size and shall be wired to the materials to be galvanized before immersion so as to represent the amount of coating deposited on the finished product.

Nondestructive tests for uniformity of coating may be made by the Engineer with a magnetic instrument in accordance with ASTM E 376.

210-3.5 Repair of Damaged Zinc Coatings. Zinc coating which has been field or shop cut, burned by welding, abraded, or otherwise damaged to such extent as to expose the base metal, shall be repaired and recoated by one of the following methods approved by the Engineer.

210-3.5.1 Hot-Dip Process. The damaged areas shall be thoroughly stripped and cleaned and a coating of zinc shall be applied by the hot-dip process per 210-3.1 and 210-3.2.

210-3.5.2 Metalizing Process. The damaged area shall be repaired per ASTM A780, Annex A3, and the following requirements:

a) The damaged areas shall be thoroughly cleaned by blasting with sharp sand or steel grit per 310-2.5.1b).

b) The blasted area shall lap the undamaged zinc coating at least 1/2 inch (12.5 mm).

c) Zinc wire containing not less than 99.98 percent zinc shall be used in the metalizing operation.

d) A zinc coating shall be applied to the damaged area with a metalizing gun to a thickness of not less than 5 mils (130 μm) on the damaged area, and shall taper to zero thickness at the edge of the blasted undamaged section.

210-3.5.3 Zinc Dust Paint. When zinc surfaces have small areas of abrasion which occur after shop application of zinc coating, zinc dust paint may be used to repair these areas when approved by the Engineer. The damaged area shall be thoroughly cleaned by wire brushing and traces of welding flux and loose or cracked zinc coating removed prior to painting. The cleaned area shall be painted with a minimum of two coats of an unthinned zinc paint to provide a total minimum film thickness of 8 mils (205 μm). The zinc dust paint shall conform to the requirements of ASTM A780, Annex A3, except that it shall have a 90 percent minimum dry film content of zinc dust by weight. The method of application shall be approved by the Engineer.

210-3.5.4 Zinc Based Solders. The damaged areas shall be repaired using zinc alloy solders per ASTM A780, Annex A3. Zinc solder shall be deposited until a minimum thickness of 5 mils (130 μm) is applied to the damaged area.

210-4 CHROMATE CONVERSION AND CLEAR ACRYLIC URETHANE COATINGS.

210-4.1 General. Class 1A Steel pipe for chain link fencing used for posts, braces, top rail, and gate frames shall have an exterior chromate conversion coating placed on the galvanized coating followed by a clear acrylic urethane coating.

210-4.2 Chromate Conversion Coating. The chromate conversion coating weight shall be a minimum of 23 g/m^2. The weight of chromate coating shall be determined by stripping the acrylic urethane coating with a neutral epoxy polyurethane stripper, determine the total weight of chromate and zinc coating in accordance with ASTM A90; then determine the percent of chromate and percent of zinc in the total metallic coating by atomic absorption spectrophotometer.

210-4.3 Clear Acrylic Urethane Coating. The coating shall be manufactured from high grade raw materials which produce a crosslinked acrylic polyurethane coating.

The acrylic urethane coating shall be a minimum of 0.3 mil (8 μm) thick. The thickness shall be determined in accordance with ASTM G12. The gage shall be calibrated on the bare metal substrate after chemically removing the urethane and underlying zinc coatings. The total thickness of the urethane and zinc coatings shall then be determined. Chemically strip the urethane and determine the thickness of the zinc coating only. The difference between the thickness of the zinc and the total thickness of the urethane coating and zinc is the thickness of the urethane coating.

Alternate test methods may be used when approved by the Engineer.

210-4.4 Test of Coating System. These tests shall be performed with the entire coating system in place.

The exterior clear-coated surface of the pipe shall have a demonstrated ability to resist 1,000 hours of exposure to salt fog with a maximum of 5 percent red rust when tested in accordance with ASTM B117.

There shall be no film cracking of the clear finish coat after 500 hours exposure in a weatherometer in accordance with ASTM G23, Type E, or EH carbon arc weatherometer, or G 26, Type B, or BH xenon arc weatherometer. There shall be no blistering or cracking of the clear finish coat after 500 hours of exposure to 100 percent relative humidity in accordance with ASTM D2247.

210-4.5 Repair of Coatings. Repairs of damaged areas for Class 1A steel pipe shall be done by first repairing the galvanized coating in accordance with 210-3.5. In addition, a clear acrylic lacquer such as acrylon, shall be used as a final coating on the repaired area.

210-5 POLYVINYL CHLORIDE (PVC) COATINGS.

210-5.1 General. This specification covers PVC coatings for posts, frames, gates, and fittings. PVC coating thickness shall be a minimum of 15 mils (380 μm).

210-5.2 Properties. The requirements for PVC coating shall be as shown in the following table:

TABLE 210-5.2

Property	ASTM Test No.	Requirements
Specific Gravity of Fused Resin	D792	1.30 ± 0.030
Hardness,		
Shore A	D2240	88 ± 2
Shore D	D2240	36 ± 2
Tensile Strength, psi (MPa)	D651	2500 ± 100 (17.2 ± 0.2)
Elongation, %	D638	250 ± 10
Tear Strength, lbs/inch (N/mm)	D1004	440 ± 20 (77 ± 3)
Brittleness Temperature	D746	0 ± 4°F (-18 ± 2°C)
Weathering Test Method, Langley Melting Range	E838	395°F to 415°F (202°C to 213°C)
Dielectric Strength Range V/mil (V/ μm)	D419	800 to 1000 (32 to 40)

210-5.3 Workmanship. All surfaces to be PVC coated shall be thoroughly cleaned, removing all foreign matter to ensure noncontaminated surfaces. The substrate shall be primed, preheated to a temperature of 450°F (232°C) and with 0.5 mil (13 μm) thickness primer. Primer shall be composed of a mixture of acrylic, phenolic, and epoxy. All pipe and fittings shall be immersed in a fluidized-bed system for PVC coating. Gate frames shall be fabricated and welded prior to the application of zinc substrate and PVC coatings.

210-5.4 Repair of Damaged PVC Coatings. Damaged PVC coatings, which have been field or shop cut, burned, abraded, or otherwise damaged, shall be repaired and recoated by the following method: the damaged area shall be thoroughly cleaned by wire brushing, then wiped clean with a non-oil-base solvent such as methyl ethyl ketone or acetone solvent. The cleaned area shall be painted with 5-mil (130 μm) thickness of acrylic enamel. Acrylic enamel shall be a PVC resin in solution, consisting of high level pigments, ultraviolet absorbers, and solvent blends applied by brush in a minimum of three coats.

SECTION 211- MATERIAL TESTS

211-1 COMPACTION TESTS.

211-1.1 Laboratory Maximum Density. The following method shall be used for compaction tests unless otherwise specified:

Laboratory maximum densities will be performed in accordance with ASTM D1557.

The Engineer may modify ASTM D1557 at his option to calculate relative compaction based on adjusted laboratory maximum wet density calculated as follows:

Da = (100 Dm) / (100 ± Wa)

Da = Adjusted laboratory maximum wet density.

Dm = Maximum wet density per ASTM D1557.

± Wa = Percent change in moisture content from field moisture to laboratory optimum moisture. Use minus when field moisture content is higher than laboratory optimum moisture content. Use plus when field moisture content is lower than laboratory optimum moisture content.

211-1.2 Field Density. Field density of soil shall be determined by ASTM D2922 or ASTM D1556.

211-1.3 Relative Compaction. The words Relative Compaction shall mean the ratio of the field dry or wet density to the laboratory maximum dry or adjusted wet density, respectively, expressed as a percentage.

211-2 CHEMICAL RESISTANCE (PICKLE JAR) TEST. This test is used to determine the physical properties and weight change of specimens of materials used in sewers after exposure to chemical solutions. Specimens of composite materials shall be seal coated on 2 adjacent edges of their 4 edges and not seal coated on the inner or outer surface. Specimens of non-composite materials shall not be seal coated. Test specimens shall be conditioned in a mechanical convection oven for 7 Days at a constant weight and at a temperature of 110° F ± 3° F (43° C ± 3° C) and subsequently cooled for 3 hours in a desiccator. This conditioning shall be performed before and after submersion of the test specimens in the solutions shown in Table 211-2 (A) for a period of 28, 56, 84 and 112 Days at 77° F ± 5° F (25° C ± 3° C). Test specimens shall be provided as follows, unless otherwise approved by the Engineer.

a) Specimens For Non-Composite Materials - Provide 55 each ASTM D638 specimens and 164 each ASTM D543 specimens measuring 1 inch x 3 inches x 0.125 inch thick (25 mm x 75 mm x 3 mm).

b) Specimens For Composite Materials - Provide 55 each ASTM D638 specimens and 164 each ASTM D543 specimens measuring 1 inch x 3 inches x 0.125 inch to 0.25 inch thick (25 mm x 75 mm x 3 mm to 6 mm).

The allowable percent weight gain or loss for these specimens shall be as specified for the respective type of material.

TABLE 211-2 (A)

Chemical Solution	Concentration[1]	Tolerance	Check Concentration	Replace Chemical Solution
Sulfuric Acid (H_2SO_4)	20%	± 0.1%	NA[2]	NA
Sodium Hydroxide (NaOH)	5%	± 0.2%	56 Days	When < 4.8%
Ammonium Hydroxide (NH_4OH)	5%	± 1.0%	28 Days	When < 4.0%
Nitric acid (HNO_3)	1%	± 0.1%	28 Days	When Turbid
Ferric Chloride ($FeCl_3$)	1%	± 0.2%	28 Days	When Turbid
Sodium Hypochlorite (NaOCl)	1%	± 0.1%	NA	28 Days
Soap	0.10%	NA	NA	28 Days
Detergent (Linear alkyl benzyl sulfonate or LAS)	0.10%	NA	NA	28 Days
Bacteriological (BOD)	≥ 700 ppm	NA	NA	7 Days

1. Volume percentages – Actual concentration of reagent must be corrected to 100%.
2. NA – Not Applicable.

If required by the type of material and the manufacturer, specimens thicker than 0.25 inch (6 mm) will be accepted and evaluated. The same number of ASTM D638 AND D543 specimens, as specified in 211-2a or 211-2b above, will be required. The allowable weight change value for the 112-Day test period for these thicker specimens shall conform to the values shown in Table 211-2 (B).

At 28-Day intervals, specimens shall be removed from each chemical solution and tested. If any specimen fails to meet the 112-Day requirement specified for the material being tested before completion of the 112-Day exposure, the material will be rejected.

TABLE 211-2 (B)

Thickness of Sample Inches (mm)	Weight Change[1,2]
0.375 (9.5)	± 0.75 %
0.50 (12.7)	± 0.63 %
0.75 (19.1)	± 0.50 %
1.0 (25.4)	± 0.44 %
1.5 (38.1)	± 0.38 %

1. With respect to initial test results.
2. Allowable percent weight gain or loss for the thickness between the designated values can be a straight line interpretation.

If required by the type of material being evaluated, additional size and quantity specimens may be required in order to meet the testing and ASTM requirements in the section for the material.

Five of the ASTM D638 specimens and 16 of the ASTM D543 specimens for the type of material being tested shall be submersed in each of the 9 solutions listed in Table 211-2 (A). At 28-Day intervals, 4 specimens shall be removed from each chemical solution, tested for weight change and the percent weight gain or loss shall be recorded. Required physical property testing shall be obtained at 0 and 112 Days. The chemical strength of each solution shall be tested and replaced if not in compliance with the required values shown in Table 211-2 (A). If any specimen fails to meet the 112-Day requirement specified for the material being tested before completion of the 112-Day exposure, the material will be rejected.

The Contractor shall furnish a Certificate of Compliance, signed by an authorized representative of the testing laboratory, identifying the product, the test results for each of the 9 solutions and confirming conformance with the Specifications. Supporting test data shall be furnished upon request by the Engineer.

The chemical resistance test is a qualification test only. Requalification is required only when the compound formulation changes.

211-3 INFILTRATION CAPACITY TEST.

211-3.1 Test Apparatus. Test apparatus shall consist of a:

a) One gallon (4 L), minimum size, water container with a spout. The spout shall be able to produce a stream with a circular cross section, the diameter of that which is large enough to discharge the entire contents of the container in 20 seconds or less;

b) Stopwatch capable of indicating elapsed time to the nearest second;

c) Tape measure of at least 36 inches (900 mm) that is graduated in 1/4 inch (6 mm) increments or smaller.

211-3.2 Water. Water shall be free of suspended solids. The volume of water shall be determined to 2 significant figures.

211-3.3 Test Procedure. The testing procedure shall be as follows:

a) Place a pre-measured amount of water into the container.

b) Pour the water onto the surface in one spot. Control the discharge rate by manually adjusting the angle of the spout so that the diameter of the pool of water is between 10 to 30 inches (250 mm to 750 mm). Empty the container holding the spout over the spot until the pool of water vanishes.

c) Start the stopwatch when the water initially touches the concrete surface and stop it when the pool disappears from the surface.

d) Measure the longest dimension (d_1) of the dampened area. Measure the width (d_2) of the pool perpendicular to d_1.

e) Repeat this procedure at a minimum of 4 separate locations.

211-3.4 Infiltration Capacity. Infiltration Capacity shall be calculated as follows:

a) The formula for U.S. Standard Measures shall be: $IC=(V)(3{,}326{,}400)/(\pi)(d_1)(d_2)(t)$ inches per hour.

b) The formula for SI Units shall be: $IC=(V)(14.4X10^6)/(\pi)(d_1)(d_2)(t)$ cm per hour.

Where:

IC is Infiltration Capacity

V is the volume of water in gallons or liters

d_1 and d_2 are the dimensions that were determined in part 211-3.3

π is approximately 3.14159

211-3.5 Test Report. The test report shall include:

a) The time and date of testing.

b) The name and affiliation of the person performing the test.

c) The location of the Work site.

d) The location of each test site tested within the Work site.

e) The volume of water used at each test site.

f) The length of the two measurements taken at each test site.

g) The discharge time for the water at each test site.

h) The Infiltration Capacity at each test site.

i) The average Infiltration Capacity for the Work site.

211-4 HAND HELD VISCOMETER TEST.

211-4.1 Test Apparatus. Test apparatus shall consist of the following:

a) Viscometer: Haake Model VT – 02 rotational viscometer or equivalent.

b) Spindle: Rotor No. 1, diameter 24 mm ± 0.1 mm, height 53 mm ± 0.1 mm or equivalent.

c) Thermometer: Digital with metal-jacketed probe, 1°F (1°C) precision.

d) Sample Container: 1 gallon metal can with wire bale.

e) Standard Fluids: per fluid manufacturer's recommendations, calibrate viscometer in absolute viscosity (centipoises).

211-4.2 Calibration. The viscometer shall be calibrated in accordance with the manufacturer's recommendations. The accuracy of the viscometer shall be verified by comparing the viscosity results obtained with the hand held viscometer to 3 separate calibration fluids of known viscosity ranging from 1000 to 5000 centipoises. The viscometer will be considered accurate if the values obtained are within 300 centipoises of the known viscosity. The known viscosity value shall be based on the fluid manufacturer's standard test temperature or the test temperature versus viscosity correlation table provided by the fluid manufacturer. The viscometer calibration may be performed at an offsite laboratory and a Certificate of Compliance conforming to 4-1.5 verifying the calibration shall be submitted to the Engineer.

211-4.3 Test Procedure. The test procedure shall be in accordance with the following:

a) Obtain a representative sample of asphalt rubber binder from an appropriate sample valve during production. Prior to sampling, run a 1 gallon (4 L) sample of binder through the sampling valve and discard the sample. Place a clean 1 gallon (4 L) sample can under the sampling valve and fill the container to approximately 85 percent full.

b) Transport the sample immediately to the testing location. The testing location shall be close to the sampling location to avoid undue temperature loss. The temperature of the binder prior to sampling shall be a minimum of 375°F (190°C). The sample container shall then be placed on a smooth, level support for testing.

c) The binder shall be continuously stirred using an appropriate metal stirring rod. Use of the temperature probe is permitted. Insert the temperature probe into the binder and check the temperature. Stirring shall continue until the binder reaches a temperature of 375°F ± 5°F (190°C ± 3°C).

d) The viscometer spindle shall be cleaned in a suitable solvent and free of any binder material prior to the test. While holding the viscometer over the sample container insert the spindle of the viscometer into the sample container near the side of the container and turn the viscometer on. While the spindle is rotating, move the spindle in and out of the binder 3 times to bring the spindle up to the temperature of the binder. Continue stirring the binder.

e) Determine the viscosity of the binder at 375°F ± 5°F (190°C ± 3°C) as follows:

   1) In one continuous operation, remove the spindle vertically from the binder, turn off the spindle rotation after the binder stops dripping from the spindle (after heating), and immediately insert the spindle back into the center of the binder sample until fully immersed.

2) Wait 5 seconds to fill the spindle. While holding the viscometer level, turn the spindle on, watch the needle on the viscometer dial and record the maximum value obtained on the dial.
3) Record the test temperature and maximum viscosity. (The viscometer shall be maintained and operated in accordance with the manufacturer's instructions. However, this test method shall apply if there are any differences in the instructions for the determination of the viscosity.)

f) Report the following information for the viscosity test:
1) Name of the technician performing the viscometer test,
2) date and location of the plant,
3) asphalt rubber binder supplier,
4) binder test temperature and viscosity,
5) spindle size and rotational speed in revolutions per minute, and viscometer model and serial number.

211-5 MOVING AVERAGE COMPUTATIONS.

The moving average shall be computed as follows:

The moving average shall be rounded to the same number of significant figures as are reported for individual test results. When the figure to be dropped is less than 5, round down, if greater than 5, round up, and if it is 5, round up or down to the even number.

The moving average shall be continuous for the individual material processing or batch plant. In determining a moving average for a material property, all of the individual test results that represent material actually used in the Work shall be used in the calculation. The test results shall be entered into the calculation sequence in the chronological order that the Work is performed. The first individual test result shall start the moving average and shall meet the moving average requirements. Until more than 4 test results are available, the moving average shall be the numerical average of the individual test results. When more than 4 test results are available the moving average shall be determined by multiplying the last moving average by 4, adding the new result to this product and then dividing this sum by 5.

In computing the moving average, whenever an upper calculation limit value for an individual test is stated in the Specifications, the upper calculation limit value shall be used in the calculation in lieu of any actual individual test results which exceed said upper calculation limit value.

211-6 RAP CORRECTION FACTOR.

211-6.1 General. A RAP correction factor must be determined for asphalt concrete mixtures containing greater than 25 percent reclaimed asphalt pavement (RAP). The RAP correction factor shall be determined in accordance with Caltrans Lab Procedure LP-9 dated May 22, 2006. This factor shall be used in determining the combined gradation of the virgin aggregates and RAP.

SECTION 212 – WATER AND SEWER SYSTEM VALVES AND APPURTENANCES

212-1 GENERAL.

212-1.1 Submittal Package. Before ordering or shipping materials, the Contractor shall submit the following in accordance with 2-5.3:

TABLE 212-1.1

Submittal	Description
Shop Drawings	Required for valves larger than 16" (400 mm) diameter.
Supporting Information	Required for all water and sewer system valves and appurtenances furnished. a) Catalog data (with items, options, sizes and pressure ratings to be furnished clearly highlighted or otherwise indicated on the submittal.) b) Interior lining and exterior coating data and thicknesses. c) NSF 61 Certificate of Compliance for potable water applications. d) California AB 1953 Certificate of Compliance for potable water applications. e) Certificate of Compliance with referenced AWWA standards. f) Certified test results for tests required by AWWA standards – proof of design and hydrostatic tests in both directions. g) Installation instructions h) Manufacturer's operation, maintenance, and warranty instructions.
Cavitation Calculations	a) Required for valves intended for throttling or pressure regulating service where normal pressure drop across valve exceeds 40 psi (0.275 MPa). b) If calculations indicate valves specified in the Contract Documents are improperly sized or specified, or if internal cavitation trim is not specified but believed to be required, submit a letter to the Engineer requesting the appropriate variance.

212-1.2 Products Conveying Potable Water. Products conveying potable water shall:

a) bear a marking showing compliance with NSF 61,
b) have an interior lining listed as complying with NSF 61,
c) bear a marking showing compliance with NSF 372 if constructed of bronze or brass, and
d) contain no more than 0.25 percent lead by average weight in compliance with Section 116875 of the California Health and Safety Code.

Solder shall be tin-silver solder conforming to ASTM B32, Grade Sb5. Cored solder shall not be used. Solder and flux used in joints of potable waterlines shall contain no more than 0.2 percent lead.

Water service-lateral and on-site piping products shall conform to the requirements of Chapter 6 of the California Plumbing Code."

Stainless steel products may be substituted for bronze or brass products provided dielectric protection is provided between stainless steel and bronze or copper alloys.

212-1.3 Products Conveying Fluids Other than Potable Water. Products conveying fluids other than potable water shall conform to the following requirements:

a) Pipeline, valve, and pipeline appurtenance materials shall be chemically compatible with chemicals and solutions handled. If any portion of a specified valve is chemically incompatible with chemicals or solutions handled, the Contractor shall submit a valve with appropriate materials stating the reason for the exception request.
b) NSF International marking is not required for piping not intended for potable water service.
c) Brass products carrying sewage shall be lead-free.

212-2 FLANGED AND THREADED CONNECTIONS.

212-2.1 Threaded Ends. Threaded ends of pipe and appurtenances shall conform to ASME/ANSI B1.20.1 NPT National Pipe Thread Taper and ASME/ANSI B2.1.

212-2.2 Flanges. Flanges shall be cast iron, ductile iron, PVC, fiberglass, steel or stainless steel as shown, raised or plain-faced as shown. For design pressures in excess of 150 pounds per square inch (1.0 MPa), only ductile iron, steel, or stainless steel flanges and cast ferrous valve components shall be used.

212-2.3 Flange Drilling. Flange drilling shall conform to the following:

TABLE 212-2.3

Design Pressure	Material	Required Drilling Pattern
0 -150 psi (0 -1.0 MPa)	Cast Iron Flanges	ASME/ANSI B16.1 Class 125.
	Ductile Iron Flanges	ASME/ANSI B16.42 Class 150.
	Carbon Steel Flanges	AWWA C207 Class D or E.
150 - 250 psi (1.0 -1.7 MPa)	Ductile Iron Flanges	ASME/ANSI B16.42 Class 150.
	Carbon Steel Flanges	AWWA C207 Class E.
250 - 300 psi (1.7 – 2.1 MPa)	Ductile Iron Flanges	ASME/ANSI B16.42 Class 300.
	Carbon Steel Flanges	AWWA C207 Class F.
> 300 psi (> 2.1 MPa)	Carbon Steel Flanges	Provide drilling pattern and gasket appropriate for temperature and class of service.

212-2.4 Flange Drilling Alignment. Bolt holes of flanged valves shall straddle horizontal and vertical centerlines of pipe run.

212-2.5 Flange, Coupling, and Harness Bolts, Nuts, and Washers.

212-2.5.1 Buried Ferrous or Plastic Piping Applications. Unless otherwise specified, flange, coupling, and harness bolts, nuts and washers for buried ferrous or plastic piping or ferrous or plastic piping in underground structures shall conform to the following:

TABLE 212-2.5.1

Item	Material	Reference Specification/Requirements
Bolts for Underground Ferrous Installations	SAE Type 316 Stainless Steel	ASTM A193 B8M T-316. Heavy hexagon series. ANSI B1.1 Class 2A fit. 1/4" to 1/2" (6 mm -12.5 mm) shall project through tightened nut. Threading per ANSI/ASME B18.2.1 Bolt-Head Identification Mark – "B8M"
Nuts for Underground Ferrous Installations	SAE Type 316 Stainless Steel	ASTM A194 8M T-316. Heavy hexagon series. ANSI B1.1 Class 2B fit. Threading per ANSI/ASME B18.2.2 1/4" to 1/2" (6 mm -12.5 mm) shall project through tightened nut.
Coating for New Bolts and Nuts	Nickel-Phosphate undercoating PTFE (Teflon), Fluorokote #1, Xylan 1424, or Equal Fluoropolymer Coating	
Coating for Existing Bolts and Nuts	Antiseize Lubricant	
Washers	Same material as bolt.	Provide one washer for each nut.

212-2.5.2 Above-Ground Ferrous or Plastic Piping Applications. Unless otherwise specified, flange, coupling, and harness bolts, nuts and washers for above-ground ferrous or plastic piping shall conform to the following:

TABLE 212-2.5.2

Item	Material	Reference Specification/Requirements
Bolts for Above-Ground Ferrous Installations	SAE Type 316 Stainless Steel or	ASTM A193 B8M-316. Heavy hexagon series. ANSI B1.1 Class 2A fit. Class 3A fit may be used for holes tapped for studs. 1/4" to 1/2" (6 mm -12.5 mm) shall project through tightened nut. Threads may be either cut or cold-formed. Threading per ANSI/ASME B18.2.1. Bolt-Head Identification Mark – "B8M"
	Zinc-Plated Carbon Steel	ASTM A307 Grade B. Heavy hexagon series. ANSI B1.1 Class 2A fit. Class 3A fit may be used for holes tapped for studs. 1/4" to 1/2" (6 mm-12.5 mm) shall project through tightened nut. Threads may be either cut or cold-formed. Threading per ANSI/ASME B18.2.1. Bolt-Head Identification Mark – "A307B"
Nuts for Above-Ground Ferrous Installations	Zinc-Plated Carbon Steel or	ASTM A563. Heavy hexagon series. ANSI B1.1 Class 2B fit. Threading per ANSI/ASME B18.2.2.
	SAE Type 316 Stainless Steel	ASTM A194 8M T-316. ASTM Heavy hexagon series. ANSI B1.1 Class 2B fit. Threading per ANSI/ASME B18.2.2.
Coating for New Bolts and Nuts	Nickel-Phosphate undercoating PTFE (Teflon), Fluorokote #1, Xylan 1424 or Equal Fluoropolymer Coating	
Coating for Existing Bolts and Nuts	Anti-Seize Lubricant	Use on SAE Type 316 hardware.
	Non-Oxide Grease	Use on zinc-plated carbon steel hardware.
Washers	Same material as bolt.	Provide one washer for each nut.

212-2.5.3 Applications in Corrosive, High-Chloride, or Saltwater Environments. Unless otherwise specified, flange, coupling, and harness bolts, nuts and washers for above-ground or buried ferrous or plastic piping in corrosive environments shall conform to the following:

TABLE 212-2.5.3

Item	Material	Reference Specification/Requirements
Bolts for Above-Ground Ferrous Installations	SAE Type 316 Stainless Steel	ASTM A193 B8M T-316. Heavy hexagon series. ANSI B1.1 Class 2A fit. Class 3A fit may be used for holes tapped for studs. 1/4" to 1/2" (6 mm -12.5 mm) shall project through tightened nut. Threads may be either cut or cold-formed. Threading per ANSI/ASME B18.2.1. Bolt-Head Identification Mark – "B8M"
Nuts for Above-Ground Ferrous Installations	SAE Type 316 Stainless Steel	ASTM A194 8M316, Grade 1 or 2. ASTM Heavy hexagon series ANSI B1.1 Class 2B fit. Threading per ANSI/ASME B18.2.2.
Lubrication for Above-ground or Vault-enclosed Steel Bolt Threads	Oil and Graphite, Blue Fluoropolymer Coating or Accepted Valve Manufacturer's Anti-seize Coating	
Coating for Buried Nuts and Bolts	Commercially Available Coating Expressly Manufactured for Buried Applications or	2 coats, minimum 15 mils (400 µm) per coat.
	AWWA C217 Petrolatum Wax and Wax-Tape System	Primer, wax, and 40-mil (1 mm) tape per AWWA C217. 1" (25 mm) minimum tape overlap with 1.5-mil (40 µm) clear metallocene resin tape outer wrap.
Washers	Same material and coating as bolt.	Provide one washer for each nut. Nickel-phosphate undercoating.

212-2.5.4 Applications where Heavy Hexagon Heads will Not Fit Valves. Where heavy hexagon series bolts and nuts will not fit cast flanges, finished SAE type 316 stainless steel finished hex bolts and nuts conforming to ASTM F593 Grade G or H and ASTM F594 Grade G or H shall be substituted.

212-2.5.5 Above-Ground Bronze Piping Applications. Unless otherwise specified, flange, coupling, and harness bolts, nuts and washers for above-ground bronze piping shall conform to the following:

TABLE 212-2.5.5

Item	Material	Reference Specification/Requirements
Bolts for Above-Ground Bronze Installations	Low-Silicon Bronze Grade C65100 or Grade C63000	ASTM B98 or ASTM F468. Finished hexagon series. ANSI B1.1 Class 2A fit. 1/4" to 1/2" (6 mm-12.5 mm) shall project through tightened nut. Threads may be either cut or cold-formed. Threading per ANSI/ASME B18.2.1. Bolt-Head Identification Mark – "651," "SB," or unmarked.
Nuts for Above-Ground Bronze Installations	Low-Silicon Bronze Grade C65100 or Grade C63000 to match bolt material	ASTM B98 or ASTM F467. Finished hexagon series. ANSI B1.1 Class 2B fit. 1/4" to 1/2" (6 mm-12.5 mm) shall project through tightened nut. Threads may be either cut or cold-formed. Threading per ANSI/ASME B18.2.1.
Washers	Same material as bolt.	Provide one washer for each nut.

212-2.6 Bonnet Bolts, Cover Bolts, and Cap Screws. Bonnet bolts, cover bolts, and cap screws shall be constructed of the same materials specified for flange bolts.

212-2.7 Flange Gaskets.

212-2.7.1 General. Flange gaskets on metallic flanges shall conform to ANSI B16.21.

The thickness shall be 1/8 inch (3 mm) minimum, except PTFE (Teflon) gaskets may be 1/16 inch (1.5 mm) thick.

Gaskets for design pressures up to 300 pounds per square inch (2.1 MPa) shall have design pressure rating of 350 pounds per square inch (2.4 MPa) at 180°F (82°C).

Gaskets shall be the full-face type with pre-punched bolt holes where both flanges are flat-face. Ring flange gaskets extending to the inner edge of the bolt circle may be used where a raised-face flange is present.

212-2.7.2 Materials. Flange gasket material shall be asbestos-free and conform to the following:

TABLE 212-2.7.2

Application	Allowable Flange Gasket Materials
Water or Wastewater Piping in Normal Soils	SBR (styrene butadiene rubber) with cloth insert EPDM (ethylene propylene diene monomer) CR (neoprene polychloroprene) NBR (Nitrile) (acrylonitrile butadiene) PTFE (Teflon) GoreTex (GR) SBR-Fiber Non-Asbestos Composite
Water or Wastewater Piping in Contaminated Soils or Hydrocarbon Piping in Normal Soils	NBR (Nitrile) (acrylonitrile butadiene) FLUOREL or FKM (Viton) (fluorocarbon)

212-2.8 Dissimilar Metals.

212-2.8.1 General. Dissimilar metals, when used in conjunction with each other shall have insulation provided between adjoining surfaces that eliminate direct contact and electrical current flow

Dissimilar metal pipe connections shall conform to the following where insulation is required:

TABLE 212-2.8.1

		Pipe Material				
		Existing Steel	**New Steel**	**Cast Iron or Ductile Iron**	**Stainless Steel**	**Copper, Brass or Bronze**
Contacting Pipe Material	Existing Steel	(NR)	Insulation is required	Insulation is required	Insulation is required	Insulation is required
	New Steel	Insulation is required	(NR)	Insulation is required	Insulation is required	Insulation is required
	Cast Iron or Ductile Iron	Insulation is required	Insulation is required	(NR)	Insulation is required	Insulation is required
	Stainless Steel	Insulation is required	Insulation is required	Insulation is required	(NR)	Insulation is required
	Copper, Brass or Bronze	Insulation is required	Insulation is required	Insulation is required	Insulation is required	(NR)

1. (NR) = Not required
2. Insulating kits or bushings are not required in the following cases:
   a) Where indicated as not required (NR) in the table above or in the Special Provisions.
   b) Where connecting any pipe material to plastic, fiberglass, clay or concrete pipe with no exposed reinforcing steel.
   c) Where new steel pipe is welded to existing steel pipe.

212-2.8.2 Insulation of Threaded Connections. Threaded insulating bushings shall be furnished and installed where dissimilar threaded piping materials come into contact.

212-2.8.3 Flange Insulating Kits.

212-2.8.3.1 General. Flange insulating kits shall be furnished and installed where flanges of dissimilar metals mate,

212-2.8.3.2 Materials. Flange insulating kits shall be constructed of the following:

TABLE 212-2.8.3.2

Item	Material	Reference Specification/Requirements
Insulating Gaskets	Dielectric Phenolic	500 V/mil dielectric strength. 25 ksi compressive strength.
Gasket Seal Element	NBR (Nitrile)	
Insulating Sleeves	Mylar	4000 V/mil dielectric strength. < 0.8% water absorption.
Insulating Washers for Bolts	Phenolic	500 V/mil dielectric strength. 33 ksi compressive strength. < 1.6% water absorption.
Steel Washers over Insulating Washers	Stainless Steel	SAE Type 316.

212-2.8.3.3 Design Options. The following design options are required:

TABLE 212-2.8.3.3

Item	Option	Reference Specification/Requirements
Insulating Gaskets	Gaskets	Full faced with bolt holes.
	Thickness	1/8" (3 mm) minimum.
	Drilling	Match adjacent flanges.
Flange Isolation Kits	Type	Double-insulating (2 steel washers + 2 insulating washers + 1 full-length insulating sleeve per bolt).
Insulating Washers	Dimensions	1/8" (3 mm) minimum thickness. ID of washer shall fit over isolating sleeve.
Steel Washers over Insulating Washers	Dimensions	1/8" (3 mm) minimum thickness. Steel and isolating washer shall have same ID and OD.

212-2.9 Mastic and Tape-Wrap Systems.

212-2.9.1 General. When specified, a 3-stage mastic tape-wrap system shall be applied in addition to required polyethylene encasement. Mastic and tape wrap systems shall cover appurtenant flanges, bolts, nuts, tie-rods, turnbuckles, restraint devices, couplings and appurtenances.

212-2.9.2 Materials. Mastic and tape-wrap systems shall be constructed of the following:

TABLE 212-2.9.2

Item	Material	Reference Specification/Requirements
AWWA C217 Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines	Surface Preparation	SSPC SP1 solvent cleaning. Remove weld spatter, sharp points and edges. On pipe with rust, paint or foreign matter, surface prep per SSPC SP2 hand-tool cleaning, or SSPC SP3 power-tool cleaning requirements. High pressure wash of 3,000-7,000 psi (2-5 MPa) is also acceptable.
	Petrolatum Primer	AWWA C217 primer containing moisture displacing, corrosion-inhibiting compounds.
	Mastic	After priming, use product of manufacturer supplying petrolatum primer and wax tape to mold mastic into a rounded configuration to completely fill irregular shapes and reduce sharp-edge surfaces.
	Petrolatum Tape	AWWA C217 Petrolatum and Petroleum Wax Tape Exterior Coating.
	Tape Width – 4" (100- mm) Pipe and under	4" (100 mm)
	Tape Width – 6"-12" (150-mm- 300- mm) Pipe	9" (225 mm)
	Tape Width – 14" (350 mm) Pipe and larger	12" (300 mm)
	Thickness	40 mils (1 mm) minimum
	Minimum Tape Overlap	1" (25 mm)
	Outer Wrap	1.5-mil (40 µm) (150-gauge) clear metallocene resin tape.

Mastic/coating shall be applied in a manner ensuring no voids exist under the coating system.

212-3 PIPE HANGERS AND SUPPORTS, CASING SPACERS, AND WALL PENETRATIONS.

212-3.1 Pipe Hangers and Supports.

212-3.1.1 General. Pipe hangers and supports shall be provided as required by Section 314 of the California Plumbing Code. Hanger rod sizes shall be as shown in Table 3-1. Support spacing and frequency shall be as shown in Table 3-2.

212-3.1.2 Materials. Pipe hangers and supports shall be constructed of the following:

TABLE 212-3.1.2

Item	Option	Reference Specification/Requirements
Bolts (Connection Bolts and Anchor Bolts) –Steel	High-Strength Carbon steel – Galvanized	ASTM A325 or ASTM A490. With self-locking nuts or lock-washers and plain nuts.
	Zinc Coating	ASTM A153 - 2.1-mil (53 µm) thickness - 1.30 oz./ft^2 (400 g/m^2)
Bolts (Connection Bolts and Anchor Bolts) – Stainless Steel	Stainless Steel	ASTM A193 Grade B8M bolts with ASTM A194 Grade 8M nuts. Alternate ASTM F593 Type 316 bolts with ASTM F594 SAE Type 316 nuts. Washers – same material as nuts.
Bolts – Embedded Eyebolts	Stainless Steel	SAE Type 316. Welded eye type.
Concrete Anchors – Epoxy Adhesive Anchor Systems	Stainless Steel	SAE Type 316.
Concrete Anchors – Expansion Bolt Systems	Stainless Steel	SAE Type 316.
Fiberglass Channel Framing System	Fiber-Reinforced Plastic	Flame-spread rating of 25 or less per ASTM D84. Dimensional tolerance per ASTM D3917 and D4385 with ultraviolet stabilizer.
Powder Actuated Fastening Systems	Steel	AISI 1061. Hardness: 52-58 Rockwell C.
	Galvanized Coating	ASTM B633 - 2.1-mil (53 µm) thickness - 1.30 oz./ft^2 (400 g/m^2).
Pipe and Conduit Hangers (Above Ground)	Steel	
	Galvanized Coating	ASTM A153 - 2.1-mil (53 µm) thickness - 1.30 oz./ft^2 (400 g/m^2).
Pipe and Conduit Hangers (Below Ground or Exposed to Water)	Stainless Steel	SAE Type 316.
	Fiberglass	
Washers	Carbon steel – Galvanized	Square or rectangular smooth beveled washers, tapered in thickness.
	Galvanized Coating	ASTM A153 - 2.1-mil (53 µm) thickness - 1.30 oz./ft.^{2}
Welding Electrode – Steel	Steel Electrodes	AWS D1.1 E70xx except E7024 rods or electrodes shall not be used.
Welding Electrode – Stainless Steel	Steel Electrodes	Type 347.

Zinc coatings shall be applied by the hot-dipped or electro-depositing process. Zinc shall conform to ASTM B6.

After fabrication, all steel not shown or specified to be galvanized or stainless shall receive one coat of a pigmented primer recommended by the manufacturer of the final paint system. Parts inaccessible after assembly shall receive a second coat of the same primer. Final painting shall be as specified in the Special Provisions.

212-3.2 Casing Spacers.

212-3.2.1 Metallic Casing Spacers. Metallic casing spacers (casing insulators or pipe skids) shall be constructed of the following:

TABLE 212-3.2.1

Item	Material	Reference Specification/Requirements
Casing Spacer Band	Stainless Steel	SAE Type 304. 14-gauge (1.98 mm) minimum. 8" (200 mm) minimum width with 2 runners on top and 2 on bottom for carrier pipe < 14" (350 mm) diameter. 12" (300 mm) minimum width with 2 runners on top and 4 on bottom for carrier pipe 14" (350 mm) diameter and greater. Center-restrained, position type.
Liner	PVC	0.090" thick.
Risers	Stainless Steel	SAE Type 304. 10-gauge (3.57 mm) minimum. Welded to band.
Anti-Friction Runners	Polyethylene, Polypropylene or Glass-Reinforced Polymer	Heavy-duty, 2" (50 mm) minimum width at ends.
Studs, Nuts and Washers	Stainless Steel	5/16" (8 mm) AISI Type 304.

212-3.2.2 Non-Metallic Casing Spacers. Non-metallic casing spacers (casing insulators or pipe skids) shall be constructed of the following:

TABLE 212-3.2.2

Item	Material	Reference Specification/Requirements
Casing Spacer Band and Risers	Polypropylene	Center-restrained, position type.

212.3.2.3 Casing End Seals. Casing end seals shall be constructed of the following:

TABLE 212-3.2.3

Item	Material	Reference Specification/Requirements
Casing End Seal	Butadiene Rubber Sheet	1/4" (6 mm) thick.
	Heat-shrinkable sleeve	Minimum 2500 psi (17 MPa) tensile strength. Use thixotropic adhesive sealant.
Bands and Hardware	Stainless Steel	SAE Type 316.

212-3.2.4 Casing Spacer Dimensions. Casing insulators shall be of such dimensions to center the carrier pipe within the casing and prevent it from floating. There shall be at least 1 inch (25 mm) but no more than 2 inches (50 mm) of clearance between the top runner and the soffit of the casing.

212-3.3 Wall Pipes, Seep Rings, and Penetrations.

212-3.3.1 General. Wall pipes or sleeves, and seep rings (collars) shall be furnished and installed at all pipe and conduit penetrations of new concrete walls, floors. slabs, and ceilings.

212-3.3.2 Materials. Wall pipes and seep rings shall be constructed of the following:

TABLE 212-3.3.2

Item	Material	Reference Specification/Requirements
Fabricated Wall Sleeves Containing Pipe	Steel Pipe	ASTM A53 Type E or S Grade B or ASTM A135 Grade B or ASTM A139 Grade B or API 5L or 5LX. Standard Weight Thickness per ANSI B36.10.
	PVC	Schedule 40 minimum.
Fabricated Steel Wall Sleeves Connecting to Steel Pipe	Steel Pipe	Material and thickness to match connecting pipe. Provide with ends as shown for connection to adjacent steel pipes.
Wall Collar on Steel Wall Sleeve	Steel	ASTM A105, A181 or A182.
Polyethylene Foam Filler for Pipe Penetrations	Extruded closed-cell polyethylene foam rod or disc	Rod or disc shall be 1/2" (12.5 mm) larger in diameter than annular space.

212-3.4 Rubber Annular Hydrostatic Sealing Devices.

212-3.4.1 General. Rubber annular hydrostatic sealing devices shall be modular mechanical type using interlocking synthetic rubber links shaped to continuously fill the annular space between a wall sleeve and passing pipe or conduit. Assembled links shall form a continuous rubber belt around the pipe or conduit, with pressure a plate under each bolt head and nut. The minimum sealing width shall be 4 inches (100 mm).

212-3.4.2 Materials. Rubber annular hydrostatic sealing devices shall be constructed of the following:

TABLE 212-3.4.2

Item	Material	Reference Specification/Requirements
Pressure Plate	Carbon Steel or Glass Reinforced Plastic Composite	
Bolts and Nuts for Links	Stainless Steel	ASTM F593. Type 316. Rod shall be 1/2" (12.5 mm) larger in diameter than annular space.
Sealing Element	EPDM Rubber (for Water, Wastewater or Treatment Chemical Applications)	Black.
	NBR (Nitrile Rubber) (for Oil and Fuel Applications)	Green.
	Silicone Rubber for Fire Wall Applications	Gray.

212-4 VALVE ACTUATORS, EXTENSIONS, AND VALVE BOXES.

212-4.1 Direction of Operation. Valves and hydrants shall open by turning the nut, lever actuator, or handwheel counterclockwise.

212-4.2 Valve Operators for Buried or Submerged Valves.

212-4.2.1 General. Buried valves and valves within manholes or pipe trenches shall have standard 2-inch (50 mm) AWWA actuator nuts. Shaft seals, valves, and actuator cover gaskets shall be watertight, totally enclosed, and designed for buried service.

212-4.2.2 Valve Extension Stems. Extension stems on valves shall be furnished and installed wherever the valve centerline is more than 4 feet (1.2 m) below the finish grade or water surface. The

extension stem shall bring the nut to within 6 inches (150 mm) below the finished grade or water surface. Stem extensions shall be pinned to the valve operating nut.

Extension stem diameters shall conform to the following:

TABLE 212-4.2.2

Valve Size	Minimum Extension Stem Diameter
3", 4" (75 mm, 100 mm)	⅞" (22 mm)
6" (150 mm)	1" (25 mm)
8" (200 mm)	1-⅛" (29 mm)
10" – 12" (250 mm - 300 mm)	1-¼" (32 mm)
14" (350 mm)	1-⅜" (35 mm)
16" – 18" (400 mm - 450 mm)	1-½" (38 mm)
20" – 36" (600 mm - 900 mm)	1-¾" (45 mm)
42"- 54" (1050 mm - 1350 mm)	2" (50 mm)

212-4.2.3 Valve Cans and Covers for Buried Valves.

212-4.2.3.1 General. Valve cans and covers shall be constructed over all buried valve operators, but not in manholes, vaults, tunnels, or pipe trenches.

212-4.2.3.2 Materials. Unless otherwise specified, valve boxes shall be H-20 traffic rated and constructed of the following:

TABLE 212-4.2.3.2

Item	Material	Reference Specification/Requirements
Valve Boxes	Cast Iron or	ASTM A126 Class B. Two-piece.
	PVC	AWWA C900 DR 14, color as appropriate for conveyed fluid.
Valve Box Covers	Cast Iron	ASTM A126 Class B. Solid skirt. 20-lb minimum weight.
Extension Pipes	Cast Iron	ASTM A126 Class B.

212-4.2.3.3 Valve Position Indicators for Buried Valves. Valve position indicators shall be designed to fit standard 5-1/4-inch (133 mm) valve boxes. Indicators shall show the valve position and direction, and the number of turns required to fully open or close the valve.

212-4.3 Valve Operators for Above-Ground Valves.

212-4.3.1 General. Above-ground valves 6 inches (150 mm) in diameter and smaller shall have hand or lever operators or handwheels with position indicators. Above-ground valves 8 inches (200 mm) in diameter and larger shall have handwheels with position indicators.

212-4.3.2 Stem Position for Valve Operators for Above-Ground Valves. Unless otherwise shown or directed by Engineer, valve stems shall be furnished and installed in the following positions:

TABLE 212-4.3.2

Valve Location	Stem Position
Horizontal pipe runs with centerline elevations no higher than 4'-6" (1.38 m) above floor.	Install stems vertical.
Horizontal pipe runs with centerline elevations higher than 4'-6" (1.38 m) but less than 6' 9" (2 m) above floor.	Install stems horizontal.
Manually operated valves 6'-9" (2 m) or more above floor or finish surface.	Provide chain-wheel and guide actuators with position indicator.
Vertical pipe runs next to walls.	Install stems horizontal and facing away from wall.

212-4.4 Gear Actuators. Gear actuators shall be enclosed and grease-lubricated, with seals on the shafts to prevent entry of dirt and water. Buried service gears shall be 90 percent-minimum grease-packed. Stop limiting devices shall be furnished and installed in actuators in open and closed positions. Actuators shall be self-locking to prevent disc or plug from creeping unless otherwise approved. Actuator gearing shall be as follows:

TABLE 212-4.4

Application	Gearing
Actuators on Manual Butterfly, Ball and Plug Valves 4"-30" (100 mm – 750 mm)	Enclosed worm and gear or enclosed traveling- nut-type gear actuators with position indicator.
Actuators on Manual Butterfly, Ball and Plug Valves 36" (900 mm) and Larger	Enclosed worm and gear type gear actuators with position indicator.
Actuators on All Motorized Butterfly, Ball and Plug Valves	Enclosed worm and gear type gear actuators with position indicator.

212-4.5 Floor Stands and Extension Stems. Floor stands shall be the cast or ductile iron base, non-rising, stem indicating type with SAE Type 316 stainless steel extension stems, couplings and stem guide brackets spaced such that L/R does not exceed 150. Anchor bolts shall be constructed of SAE Type 316 stainless steel.

212-4.6 Chain-Wheels and Guides. Chain-wheels and guides shall be galvanized or zinc-plated, or aluminum, extending to within 4 feet (1.2 m) of the operating floor elevation. Chains shall be galvanized steel, SAE Type 316 stainless steel, or zinc-plated steel. Anchor bolts shall be constructed of SAE Type 316 stainless steel.

212-4.7 Valve Operator Torque. Where operating torque requirements for valve operators are not stipulated by AWWA standards, valves shall open with a maximum pull of 80 pounds (355 N) on the hand-wheel, lever, chain-wheel or crank and a maximum torque input of 150 foot-pounds (203 J) when differential pressure across valve is equal to rated pressure class of valve. Actuator components shall be designed to withstand, without damage, a pull of 200 pounds (890 N) on the hand-wheel, lever, chain-wheel or crank and a maximum torque input of 300 foot-pounds (407 J) when operating against stops.

Actuators shall be sized to produce torque no less than 1.25 times the valve torque required to operate the valve at full rated pressure and a velocity of 16 feet per second (5 m/s).

212-4.8 Minimum Turns to Open Valve. For gate valves, the minimum number of turns to open shall be as shown in AWWA C515, Table 7. For other valves with traveling nut or worm gear operators, the minimum number of turns to open the valve shall be 1.5 times the valve diameter in inches, (38 times the valve diameter in mm) but no fewer than 30 turns.

212-5 VALVES.

212-5.1 Resilient Wedge Gate Valves.

212-5.1.1 General. Gate valves shall be the reduced-wall resilient-wedge type, conforming to AWWA C515.

212-5.1.2 Materials. Gate valves shall be constructed of the following:

TABLE 212-5.1.2

Item	Material	Reference Specification/Requirements
Body	Ductile Iron	ASTM A536 Grade 65-45-12.
Trim	Stainless Steel	SAE Type 316.
Stem and Stem Nut	Low-Zinc Bronze	Maximum 7% zinc, 2% aluminum . Minimum tensile strength = 70,000 psi (480 MPa). Minimum yield strength = 40,000 psi (275 MPa). Elongation >15% in 2" (50 mm). Visibly mark stem to show compliance with above.
Wedge – Potable Water Applications	Ductile Iron with Vulcanized Rubber Coating	Fully-encapsulated.
Wedge – Recycled Water Applications	Ductile Iron with Ethylene-Propylene Diene Monomer (EPDM) Coating	Fully-encapsulated. ASTM D429. Peroxide-cured.
O-Rings	Synthetic Rubber	ASTM D2000.

212-5.1.3 Design Options. The following design options are required:

TABLE 212-5.1.3

Item	Option	Reference Specification/Requirements
Resilient Wedge Gate Valves	Stem Seal	Double O-ring type.
	Stem	Non-rising stem unless otherwise shown.
	Actuator	2" (50 mm) AWWA stem nut required on buried operators
	Handwheel	Required on above-ground valves or valves in vaults unless otherwise shown.
	Resilient Wedge	Fully-encapsulated.
	Markings	Manufacturer's name or logo, size of valve, year of manufacture, and design pressure rating shall be cast in valve bonnet or body. Body shall have arrow cast in metal to show direction of opening.
	Ends	Flange x flange, flange x mechanical joint or mechanical joint x mechanical joint unless otherwise shown.
Polyethylene Encasement	Polyethylene Film	212-12.1.1. Color per 212-12.2.

212-5.1.4 Tapping Valves. Tapping valves shall be resilient wedge valves with a tapping valve flanged end. Tapping valves shall be sized to accept tapping machine shell cutters.

212-5.1.5 Tapping Sleeves. Tapping sleeves shall be ductile iron, steel, or stainless steel. Gaskets shall provide a full-circumferential seal on both sides of the tap capable of withstanding the specified test pressures or be a positive-seal-type gasket capable of withstanding the specified test pressures. Flanges shall match adjacent valves.

Size-on-size stainless-steel-type tapping sleeves will not be permitted.

Tapping sleeves may be used for design pressures up to 150 pounds per square inch (1.0 MPa). Unless otherwise specified, tapping valves shall not be used at higher pressures.

212-5.2 Butterfly Valves.

212-5.2.1 General. Butterfly valves shall be the short-body-type, conforming to AWWA C504.

212-5.2.2 Materials. Butterfly valves shall be constructed of the following:

TABLE 212-5.2.2

Item	Material	Reference Specification/Requirements
Body	Ductile Iron	ASTM A536 Grade 65-45-12.
Valve Shaft	SAE Type 316 Stainless Steel	ASTM A276.
Disc	Cast Iron or	ASTM A48, Class 40. or ASTM A136 Class B.
	Ductile Iron	ASTM A536 Grade 65-45-12 or 70-50-05.
Valve Disc Edge	SAE Type 316 Stainless Steel	ASTM A276.
Valve Seat	EPDM Rubber	ASTM D412. Peroxide-cured.
Exposed Body Cap Screws, Bolts, and Nuts including Squeeze Pins	SAE Type 316 Stainless Steel	ASTM A276 with anti-seize lubricant or blue fluoropolymer coating.

212-5.2.3 Design Options. The following design options are required:

TABLE 212-5.2.3

Item	Option	Reference Specification/Requirements
Butterfly Valves	Stem and Stem Nut	Non-rising stem.
	Seat Mounting	Secure resilient seat to valve body.
	Valve Shaft Sealing	Self-adjusting and wear-compensating. Do not use manually adjustable packing glands on buried valves.
	Ends	Flange x flange unless otherwise shown.
Polyethylene Encasement	Polyethylene Film	212-12.1.1. Color per 212-12.2.

212-5.3 Plug Valves.

212-5.3.1 General. Plug valves shall be the resilient-seated, cast iron, eccentric-type conforming to AWWA C517.

212-5.3.2 Materials. Plug valves shall be constructed of the following:

TABLE 212-5.3.2

Item	Material	Reference Specification/Requirements
Body	Ductile Iron or	ASTM A536 Grade 65-45-12.
	Cast Iron	ASTM A126 Grade B.
Body Seat	Nickel	
Plug	Ductile Iron	ASTM A536 Grade 65-45-12.
Bearings	SAE Type 316 Stainless Steel	SAE 841 Sintered.
Grit Seals	PTFE (Teflon)	
Thrust Washers – Top and Bottom	PTFE (Teflon)	

212-5.3.3 Design Options. The following design options are required:

TABLE 212-5.3.3

Item	Option	Reference Specification/Requirements
Plug Valve	Design	Eccentric-type.
	Port Size	80% minimum on valves 36" (900 mm) or less, 70% on valves 42" (1050 mm) and larger.
	Ends	Flange x flange unless otherwise shown.

212-5.4 Ball Valves.

212-5.4.1 General. Ball valves less than 6 inches (150 mm) shall be rated for minimum 250 pounds per square inch (1.7 MPa) water-oil-gas (WOG) pressure and shall be UL listed.

Ball valves 6 inches and larger shall conform to AWWA C507.

212-5.4.2 Materials. Ball valves shall be constructed of the following:

TABLE 212-5.4.2

Item	Material	Reference Specification/Requirements
Body	Ductile Iron	ASTM A536 Grade 65-45-12.
Valve Ball	Ductile Iron	ASTM A536 Grade 65-45-12.
Valve Shaft	SAE Type 316 Stainless Steel	ASTM A276.
Valve Seat	EPDM Rubber	Mount to body. ASTM D429. Peroxide cured.

212-5.4.3 Design Options. The following design options are required:

TABLE 212-5.4.3

Item	Option	Reference Specification/Requirements
Ball Valves	Design	AWWA C507
	Port Size	100%
	Ends	Flange x flange unless otherwise shown.

212-5.5 Check Valves.

212-5.5.1 Swing-Check Valves.

212-5.5.1.1 General. Swing check valves shall conform to AWWA C508.

212-5.5.1.2 Materials. Swing check valves shall be constructed of the following:

TABLE 212-5.5.1.2

Item	Option	Reference Specification/Requirements
Body and Cover	Ductile Iron or	ASTM A536 Grade 65-45-12.
	Cast Iron	ASTM A126 Grade B.
Body and Cover for Pressures over 250 psi (1.7 MPa)	Ductile Iron	ASTM A536 Grade 65-45-12.
Disc and Disc Arm	Ductile Iron	ASTM A536 Grade 65-45-12.
Seat	SAE Type 316 Stainless Steel	ASTM A276.
Pivot Shaft	SAE Type 316 Stainless Steel	ASTM A276.

212-5.5.1.3 Design Options. The following design options are required:

TABLE 212-5.5.1.3

Item	Option	Reference Specification/Requirements
Swing Check Valves	Design	AWWA C508 outside lever and weight.
	Ends	Flange x flange unless otherwise shown.

212-5.5.2 Dual-Disc Check Valves.

212-5.5.2.1 General. Dual-disc check valves shall conform to AWWA C518.

212-5.5.2.2 Materials. Dual-disc check valves shall be constructed of the following:

TABLE 212-5.5.2.2

Item	Option	Reference Specification/Requirements
Body and Door	Ductile Iron or	ASTM A536 Grade 65-45-12.
	Cast Iron	ASTM A126 Grade B.
Body and Door for Pressures over 250 psi (1.7 MPa)	Ductile Iron	ASTM A536 Grade 65-45-12.
Hinge and Stop Pins	SAE Type 316 Stainless Steel	ASTM A276.

212-5.5.2.3 Design Options. The following design options are required:

TABLE 212-5.5.2.3

Item	Option	Reference Specification/Requirements
Dual-Disc Check Valves	Design	AWWA C518. Equip valve with closure spring.
	Ends	Flange x flange unless otherwise shown.

212-5.5.3 Silent Check Valves.

212-5.5.3.1 Materials. Silent check valves shall be constructed of the following:

TABLE 212-5.5.3.1

Item	Option	Reference Specification/Requirements
Body	Ductile Iron or	ASTM A536 Grade 65-45-12.
	Cast Iron	ASTM A126 Grade B.
Body for Pressures over 250 psi (1.7 MPa)	Ductile Iron	ASTM A536 Grade 65-45-12.
Plug and Seat	Bronze	NSF 372-compliant for potable water.
Spring	SAE Type 316 Stainless Steel	ASTM A276.

212-5.5.3.2 Design Options. The following design options are required:

TABLE 212-5.5.3.2

Item	Option	Reference Specification/Requirements
Silent Check Valves	Design	Center-guided valve plug with integral through-shaft and spring-loaded silent shutoff.
	Ends	Flange x flange unless otherwise shown.

212-5.5.4 Slanting-Disc Check Valves.

212-5.5.4.1 Materials. Slanting-disc check valves shall be constructed of the following:

TABLE 212-5.5.4.1

Item	Option	Reference Specification/Requirements
Body	Ductile Iron or	ASTM A536 Grade 65-45-12.
	Cast Iron	ASTM A126 Grade B.
Body for Pressures over 250 psi (1.7 MPa)	Ductile Iron	ASTM A536 Grade 65-45-12.
Disc and Seat	Ductile Iron or	ASTM A536 Grade 65-45-12.
	Cast Iron or	ASTM A126 Grade B.
	Bronze	NSF 372-compliant for potable water.
Hinge Pin	SAE Type 316 Stainless Steel	ASTM A276.
Spring	SAE Type 316 Stainless Steel	ASTM A276.

212-5.5.4.2 Design Options. The following design options are required:

TABLE 212-5.5.4.2

Item	Option	Reference Specification/Requirements
Slanting Disc Check Valves	Design	Two-piece construction bolted at center to hold seat at approximate 55° angle.
	Position Indicator	Required on valves 6" (150 mm) and larger.
	Top-Mounted Dashpot	Valve shall be configurable to accept a top-mounted dashpot.
	Ends	Flange x flange unless otherwise shown.

212-5.5.5 Rubber Flapper Swing Check Valves.

212-5.5.5.1 Materials. Rubber flapper swing check valves shall be constructed of the following:

TABLE 212-5.5.5.1

Item	Option	Reference Specification/Requirements
Body	Ductile Iron or	ASTM A536 Grade 65-45-12.
	Cast Iron	ASTM A48 Class 30 or ASTM A126 Class B.
Flapper	Steel and Rubber	Steel Disc insert and steel bar hinge covered with Buna-N vulcanized to metal pieces.
Cover Bolts	Stainless Steel	SAE Type 316.

212-5.5.5.2 Design Options. The following design options are required:

TABLE 212-5.5.5.2

Item	Option	Reference Specification/Requirements
Rubber Flapper Swing Check Valves	Design	Valve shall consist of body, flapper and bolted cover.
	Valve Seat	Set at 45° angle to pipe centerline.
	Manual Backflow Actuator	Required (screw type with stainless steel t-handle).
	Position Indicator	Provide position indicator or pre-wired limit or proximity switch.
	Ends	Flange x flange unless otherwise shown.

212-5.5.6 Rubber Sleeve In-Line Full-Cross-Section Check Valves. Rubber sleeve inline full-cross-section check valves shall be constructed of the following:

TABLE 212-5.5.6

Item	Option	Reference Specification/Requirements
Body	Ductile Iron	ASTM A536 Grade 65-45-12.
Rubber Flapper	EPDM	

212-5.6 Air Release, Air/Vacuum, and Combination Air Valves.

212-5.6.1 General. Air release, air/vacuum and combination air valves shall be capable of passing all tests described in AWWA C512, Section 5.

212-5.6.2 Materials. Air release, air/vacuum, and combination air valves shall be constructed of the following:

TABLE 212-5.6.2

Item	Material	Reference Specification/Requirements
Body and Cover (Potable and Recycled Water)	Ductile Iron or	ASTM A536 Grade 65-45-12.
	Cast Iron	ASTM A126 Grade B.
Body and Cover for Pressures over 250 psi (1.7 MPa) (Potable and Recycled Water)	Ductile Iron	ASTM A536 Grade 65-45-12.
Body and Cover (Sewage)	Stainless Steel	SAE Type 316.
Float, Linkage and Internal Parts	Stainless Steel or	ASTM A240 SAE Type 316.
	Polycarbonate	NSF 61 Certified.
Seats	Buna N or FKM (Viton) for Potable Water or Sewage	
	EPDM for Recycled Water or Sewage	

212-5.7 Diaphragm-Actuated Pilot-Control Valves.

212-5.7.1 General. Diaphragm-actuated pilot-control valves shall conform to AWWA C530.

212-5.7.2 Materials. Diaphragm-actuated pilot-control valves shall be constructed of the following:

TABLE 212-5.7.2

Item	Material	Reference Specification/Requirements
Main Valve Body and Cover, Disc Retainer and Diaphragm Washer	Ductile Iron (for pressures 0-300 psi) (2.1 MPa)	ASTM A536.
Main Valve Trim:, Stem, Seat and Bonnet Spring	SAE Type 316 Stainless Steel	ASTM A276 or A351.
Stem Guide Bearings, Upper and Lower	Brass,	ASTM B16.
	Bronze, or	SAE 660.
	SAE Type 316 Stainless Steel	ASTM A276.
Disc	Buna-N Rubber or	
	EPDM	
Diaphragm	Nylon-Reinforced Buna-N Rubber or	
	EPDM	
Pilot Control System	Cast Bronze with	Lead-free for potable water applications
	SAE Type 316 Stainless Steel Trim	ASTM A276.
Piping and Tubing	Copper and brass	Lead free for potable water applications. ASTM B75, B88 (copper) and ASTM B43 (brass).

212-5.7.3 Design Options. The following design options are required:

TABLE 212-5.7.3

Item	Option	Reference Specification/Requirements
Diaphragm-Actuated Control Valves	Manufacturer's Standard Internal Cavitation Trim	Where pressure drop across valve exceeds 40 psi (0.275 MPa) submit cavitation calculations per 212-1.1 and a letter to the Engineer requesting a waiver if applicable.
	Isolation Valves on Pilot Lines	Required on both sides of pilot.
	Opening and Closing Speed Control	Required.
	In-Line Y Strainer on Pilot Line	Required.
	Stem	Self-cleaning.
	Ends	Flange x flange unless otherwise shown.

212-6 HYDRANTS

212-6.1 Fire Hydrants.

212-6.1.1 General. With the exception of service areas subject to freezing, fire hydrants shall be the "California" wet-barrel-type, UL-listed and FM-approved, conforming to AWWA C503.

The color scheme and finish shall be as specified in the Special Provisions.

Outlet threads shall conform to AWWA C503. Appendix A

212-6.1.2 Materials. Fire hydrants shall be constructed of the following:

TABLE 212-6.1.2

Item	Material	Reference Specification/Requirements
Body	Bronze	AWWA C503 and NSF 372 lead-free.
	Cast Iron	AWWA C503.
Outlet Nozzles	Bronze	AWWA C503 and NSF 372 lead-free.
	Cast Iron	AWWA C503.
Outlet Nozzle Caps	Bronze, Cast Iron or Plastic	AWWA C503 and NSF 372 lead-free.
Exposed Body Cap Screws, Bolts, and Nuts including Squeeze Pins	SAE Type 316 Stainless Steel	ASTM A276 with anti-seize lubricant or blue fluoropolymer coating.
Flanges	Cast Iron or Ductile Iron	Raised or plain-faced.

212-6.1.3 Design Options. The following design options are required:

TABLE 212-6.1.3

Item	Option	Reference Specification/Requirements
Design	"California" or Wet-Barrel Type	AWWA C503.
Body	6" (150 mm) inlet	AWWA C503 §4.6.
Hydrant Bury	Same Diameter as Hydrant	AWWA C503 §4.6.
Outlets – Residential Hydrants	One 4" (100 mm) Pumper Outlet plus One 2-1/2" (64 mm) Hose Outlet	AWWA C503.
Outlets – Commercial/Industrial Hydrants	One 4" (100 mm) Pumper Outlets plus Two 2-1/2" (64 mm) Hose Outlets	AWWA C503.
Outlets – Commercial/Industrial Double-Steamer Hydrants	Two 4" (100 mm) Pumper Outlets plus One 2-1/2" (64 mm) Hose Outlet	AWWA C503.
Outlet Nozzle Cap Chain and Cap Gasket	Required	AWWA C503 §4.6.10.
Threads	Conform to National Standard for Fire Hose Connections	ANSI B26 and NFPA Standard 1963.
Hydrant Flange	6" (150 mm) Flange with Standard 8-hole drilling	AWWA C503 §4.6.
Hydrant Bolts	Hollow Metal Bolts at Junction of Hydrant and Hydrant Spool	ASTM A307 Grade A. Heavy hexagon series. ANSI B1.1 Class 2A fit. 5/8"(16 mm) bolt with 11/32" (9 mm) hole drilled 2-3/8" (60 mm) deep into shank and 100% silicon-filled to prevent internal corrosion. 1/4" to 1/2" (6 mm-12.5 mm) shall project through tightened nut. Threading per ANSI/ASME B18.2.1. Bolt-Head Identification Mark – "A 307 A"

212-7 BACKFLOW PREVENTION DEVICES.

212-7.1 General. Backflow prevention devices shall conform to Title 17 of the California Code of Regulations and Title 24, Part 5 of the California Plumbing Code.

212-7.2 Double Check (DC) Valve Backflow Prevention Assemblies. DC valve backflow prevention assemblies shall conform to AWWA C510, and shall be IAPMO listed, FM approved, UL classified, and approved by the Foundation for Cross Connection Control and Hydraulic Research at the University of Southern California.

212-7.3 Reduced-Pressure (RP) Backflow Prevention Assemblies. RP backflow prevention assemblies shall conform to AWWA C511 and shall be IAPMO listed, FM approved, UL classified, and approved by the Foundation for Cross Connection Control and Hydraulic Research at the University of Southern California.

212-8 COUPLINGS.

212-8.1 Bolted-Sleeve-Type Couplings.

212-8.1.1 General. Bolted sleeve type couplings shall conform to AWWA C219.

212-8.1.2 Materials. Bolted-sleeve-type couplings shall be constructed of the following:

TABLE 212-8.1.2

Item	Material	Reference Specification/Requirements
Sleeve	Steel	ASTM A283 Grade C or carbon steel with 30 ksi minimum yield.
	Ductile Iron	ASTM A536 Grade 65-45-12.
Gasket		AWWA C111.
Coupling and Harness Bolts	Stainless Steel	212-2.5.
Polyethylene Encasement	Polyethylene Film	212-12.1.1. Color per 212-12.2.

212-8.2 Flanged Coupling Adaptors.

212-8.2.1 General. Flanged coupling adaptors shall conform to AWWA C219.

212-8.2.2 Materials. Flanged coupling adaptors shall be constructed of the following:

TABLE 212-8.2.2

Item	Material	Reference Specification/Requirements
Body	Ductile Iron or Steel to Match Adjacent Pipe	AWWA C219.
Gasket		AWWA C111.
Coupling and Harness Bolts	Stainless Steel	212-2.5.
Polyethylene Encasement	Polyethylene Film	212-12.1.1. Color per 212-12.2.

212-8.3 Coupling Restraint Systems. Coupling restraint systems for bolted-sleeve-type couplings or flanged coupling adaptors furnished and installed on ductile iron or PVC pipe shall be constructed of the following:

TABLE 212-8.3

Item	Material	Reference Specification/Requirements
Follower Gland	Ductile Iron	ASTM A536 65-45-12.
Wedges	Ductile Iron	Single tooth, heat-treated for ductile iron applications.
Actuating Bolts	Ductile Iron	ASTM A536 65-45-18.
Breakaway Nuts	Carbon Steel	
	Cast Iron	
Tie Rods - Steel	Carbon Steel	ASTM A193 Grade B7 threaded rods. Do not use all-thread.
	Galvanized Coating	ASTM A123 - 3.4 mil (90 µm) thickness - 2.00 oz./ft^2 (610 g/m^2)
Tie Rods – Stainless Steel	Stainless Steel	SAE Type 316.
Coating for New Bolts and Nuts	PTFE (Teflon), Fluorokote #1, Xylan 1424 or Equal Fluoropolymer	212-2.5.
Coating for Existing Bolts and Nuts	Antiseize Lubricant	212-2.5.
Lubrication for Above-Ground or Vault-Enclosed Steel Tie-Rod or Bolt Threads	Oil and Graphite, Blue Fluoropolymer Coating or Accepted Valve Manufacturer's Anti-seize Coating	212-2.5.
Gland Exterior Finish Coat	Fusion-Bonded Epoxy	212-12.1.
Coating on Buried Bolts and Nuts	Mastic	212-2.9.
Polyethylene Encasement	Polyethylene Film	212-12.1.1. Color per 212-12.2.

212-8.4 Grooved and Shouldered Couplings and Joints.

212-8.4.1 General. Grooved and shouldered couplings and joints shall conform to AWWA C606.

212-8.4.2 Materials. Grooved and shouldered couplings shall be constructed of the following:

TABLE 212-8.4.2

Item	Material	Reference Specification/Requirements
Body	Ductile Iron or Steel to Match Adjacent Pipe	AWWA C606.
Coupling Bolts	Stainless Steel	212-2.5.
Polyethylene Encasement	Polyethylene Film	212-12.1.1. Color per 212-12.2.

212-8.4.3 Design Options. The following design options are required:

TABLE 212-8.4.3

Item	Option	Reference Specification/Requirements
Grooved Couplings – Mating Ductile Iron Pipe 4"-24" (100 mm-600 mm) diameter	Radius Grooving	Minimum wall thickness of grooved DIP shall be Class 53. Groove dimensions per AWWA C606 Table 2 for flexible joints.
Grooved Couplings – Mating Steel Pipe 4"-24" (100 mm-600 mm) diameter	Roll Grooving	Minimum wall thickness of grooved steel pipe shall be as shown in AWWA C606 Table 5. Groove dimensions per AWWA C606 Table 5.
Grooved and Shouldered Couplings – Mating Steel Pipe 4"-64" (100 mm-1600 mm)diameter	Shouldered	AWWA C606 Type C or D. Dimensions per AWWA C606 Table 6.

212-8.5 Dismantling Joints.

212-8.5.1 Materials. Dismantling joints shall be constructed of the following:

TABLE 212-8.5.1

Item	Material	Reference Specification/Requirements
Body	Match Adjacent Pipe	
	Ductile Iron	ASTM A536 Grade 65-45-12.
	Steel	ASTM A283 Grade C or carbon steel with 30 ksi minimum yield.
Gasket		ASTM A536 Grade 65-45-12.
Tie Rods	Stainless Steel	SAE Type 316.
Polyethylene Encasement	Polyethylene Film	212-12.1.1. Color per 212-12.2.

212-9 EXPANSION JOINTS.

212-9.1 Double-Ball Expansion Joints.

212-9.1.1 General. Double-ball expansion joints shall be capable of accommodating the minimum design displacements for piping attachments to tanks and mechanical equipment shown in ASCE 7, Table 15.7-1, when unrestrained.

Unless otherwise specified in the Special Provisions, expansion joints shall be the force-balanced, self-restraining type. If expansion joints are not force-balanced, the Contractor shall make provisions for restraining joints from damaging adjacent tanks and piping during testing.

212-9.1.2 Materials. Double-ball expansion joints shall be constructed of the following:

TABLE 212-9.1.2

Item	Material	Reference Specification/Requirements
Expansion Joints – Double Ball Type	Ductile Iron	ASTM A536 Grade 65-45-12.
Polyethylene Encasement	Polyethylene Film	212-12.1.1. Color per 212-12.2.

212-9.1.3 Design Options. The following design options are required:

TABLE 212-9.1.3

Item	Option	Reference Specification/Requirements
Expansion Joints – Double Ball Type	Minimum Expansion	8" (200 mm).
	Expansion/Contraction Pre-setting	50% expansion-50% contraction on horizontal installations. 75% expansion-25% contraction on vertical installations.
	Minimum Deflection	15 degrees per ball.
	Self-Contained Restraint	Larger of 250 psi (1.7 MPa) or rating of mating flanges.

212-9.2 Bellows-Type Expansion Joints.

212-9.2.1 General. Bellows-type lateral-offset seismic expansion joints on tanks shall be capable of accommodating the minimum design displacements for piping attachments to tanks and mechanical equipment shown in ASCE 7, Table 15.7-1, when unrestrained.

Unless otherwise specified in the Special Provisions, expansion joints shall be the self-restraining-type with spring steel reinforcing rings embedded in each bellows arch.

Under the specified test pressures, bellows-type expansion joints shall limit expansion under thrust to 1/8" (3 mm) maximum displacement. Restraint under the test pressure shall be provided by any of the following:

a) The spring rate capability of the steel bellows reinforcement.

b) An external steel harness with bolts designed to break away at 100 pounds per square inch (0.7 MPa) over the test pressure.

c) An external force restraint system shown on the Plans.

212-9.2.2 Materials. Bellows-type expansion joints shall be constructed of the following:

TABLE 212-9.2.2

Item	Material	Reference Specification/Requirements
Bellows	EPDM Rubber	ANSI/NSF 61 certified for any use with potable water.
Tie Rods – Stainless Steel	Stainless Steel	SAE Type 316.
Backing Rings – Stainless Steel	Stainless Steel	SAE Type 316.
Washers	Stainless Steel	SAE Type 316. Spherical to accommodate lateral deflection.
Reinforcing Ring on Bellows	Spring Steel	Provide at outside of arch on each bellows.

212-9.3 Mechanical Slip-Type Expansion Joints. Mechanical slip-type expansion joints shall conform to AWWA C221.

212-10 SERVICE LATERALS, METERS, AND METER BOXES.

212-10.1 Copper Tubing. Copper tubing shall be seamless copper water tubing conforming to ASTM B88, Type K. Temper shall be annealed,

The size and form of furnished pipe shall be as follows:

TABLE 212-10.1

Size	Form	Length	Temper
1" (25 mm)	Coils Minimum 24" (600 mm) ID	60'-100' (18.3 m-30.3 m) coils,	O-60 annealed.
2" (50 mm)	Flexible or rigid straight lengths	20' (6.1 m) (rigid)	O-50 annealed.

212-10.2 High Density Polyethylene (HDPE) Tubing. HDPE tubing shall conform to AWWA C901 for coiled or straight pipe.

The pressure class shall be either Pressure Class 160 or the pressure class shown on the Plans for the adjacent pipe, whichever is greater.

212-10.3 Corporation Stops, Angle Meter Valves, Service Saddles and Other Service Materials. Service materials shall be constructed of NSF 372 brass complying with AWWA C800 and Standard Plans except service saddles may be constructed of nylon-encased iron with double-flattened stainless steel straps. Unless otherwise shown on the Plans or specified in the Special Provisions, service saddles and corporation stop inlets shall be AWWA "CC" threaded.

212-10.4 Meters. Acceptable types of meters shall be as shown on the Plans or Standard Plans.

Registers shall be the straight-reading-type, hermetically sealed, having a register test hand. Registration shall be in gallons or cubic feet as specified in the Special Provisions. Registration accuracy shall conform to the AWWA standard or requirement shown in Table 212-10.4.

Meters shall conform to the following:

TABLE 212-10.4

Type of Meter	Size Range	Case	Reference Specification
Displacement Meters (Nutating Disc or Piston-Type)	½" - 2" (12.5 mm - 50 mm)	Bronze	AWWA C700
Multi-Jet Meters	½" - 2" (12.5 mm-50 mm)	Bronze	AWWA C708
Single-Jet Meters	⅝" - 6" (16 mm - 150 mm)	Bronze	AWWA C712
Fluidic Oscillator Meters	½" - 2" (12.5 mm - 50 mm)	Bronze	AWWA C713
Compound Meters	2" - 8" (50 mm - 200 mm)	Epoxy-Lined and Coated Steel, Iron, or Bronze - Match Adjacent Piping	AWWA C702 Class II
Fire-Service Meters	3" - 10" (75 mm - 250 mm)	Steel, Iron, or Bronze - Match Adjacent Piping	AWWA C703
Propeller Meters	2" - 72" (50 mm - 1800 mm)	Epoxy-Lined and Coated Steel or Iron – Match Adjacent Piping	AWWA C704
Turbine Meters	1-½" - 20" (38 mm - 500 mm)	Epoxy-Lined and Coated Steel, Iron, or Bronze - Match Adjacent Piping	AWWA C701 Class II
Sonic or Ultrasonic (Transit-Time) Meters	4" (100 mm) and larger	Epoxy-Lined and Coated Steel	AWWA C750
Magnetic Meters	1-½" - 54" (38 mm - 1350 mm)	Epoxy-Lined and Coated Steel	Accuracy to 0.5% within flow range having 20:1 minimum turndown ratio.

212-10.5 Remote Registration Systems. Direct-reading remote-registration systems shall conform to AWWA C706. Encoder-type remote registration systems shall conform to AWWA C707.

212-10.6 Meter Boxes.

212-10.6.1 General. Meter boxes shall be constructed of concrete or polymer.

212-10.6.2 Dimensions. The minimum meter box dimensions shall conform to the following:

TABLE 212-10.6.2

Size of Meter	Interior Length (Below Lip)	Interior Width (Below Lip)	Depth
¾" (19 mm) or less	15-⅜" (400 mm)	10" (250 mm)	12" (300 mm)
1" (25 mm)	25" (635 mm)	15" (380 mm)	12" (300 mm)
1-½" (38 mm)	28" (710 mm)	16" (400 mm)	12" (300 mm)
2" (50 mm)	30" (750 mm)	17" (430 mm)	12" (300 mm)

212-11 PRESSURE GAUGES.

212-11.1 Stem-Mounted Pressure Gauges.

212-11.1.1 General. Stem-mounted pressure gauges may be used for water or recycled water applications and shall conform to ASME/ANSI B40.100.

212-11.1.2 Materials. Stem-mounted pressure gauges shall be constructed of the following:

TABLE 212-11.1.2

Item	Material	Reference Specification/Requirements
Case	ABS or	
	Stainless Steel	SAE Type 316.
Process-Wetted Materials	Stainless Steel	SAE Type 316.
Window	Acrylic	
Sleeve	Pure Gum Rubber	
Fill Fluid	Ethylene Glycol	

212-11.1.3 Design Options. The following design options are required:

TABLE 212-11.1.3

Item	Option	Reference Specification/Requirements
Dial	Calibrated Pressure Range	0-150 psi (0 – 1,000 KPa) unless otherwise shown on the Plans.
Accuracy within Pressure Range	± 0.25%	
Process Connection	1/4" (6 mm) NPT	

212-11.2 Flanged In-Line Sensor Sleeve Style Pressure Gauges.

212-11.2.1 General. Flanged in-line sensor sleeve style pressure gauges may be used for water or recycled water applications and shall be used in wastewater applications.

212-11.2.2 Materials. Stem-mounted pressure gauges shall be constructed of the following:

TABLE 212-11.2.2

Item	Material	Reference Specification/Requirements
Body	Stainless Steel	SAE Type 316.
Process-Wetted Materials	Stainless Steel	SAE Type 316.
Sleeve	Pure Gum Rubber	
Fill Fluid	Ethylene Glycol	

212-11.2.3 Design Options. The following design options are required:

TABLE 212-11.2.3

Item	Option	Reference Specification/Requirements
Dial	Calibrated Pressure Range	0-150 psi (0 -1,000 KPa) unless otherwise shown on the Plans.
Accuracy within Pressure Range	± 0.25%	

212-12 PAINTING, INTERIOR LINING, AND EXTERIOR COATING.

212-12.1 Interior Lining and Exterior Coating of Ferrous Valve, Hydrant, Valve Operator, Meter, Coupling, Expansion Joint, Spool, Fitting, and Backflow Preventer Surfaces.

212-12.1.1 General. All ferrous exposed non-lubricated parts of valves, hydrants, valve operators, meters, couplings, spools, fittings, and backflow preventers shall be epoxy-coated, as shown in Table 212-12.1.2, with the exception of stainless steel surfaces and bituminous or cement-mortar-lined or coated pipe or fitting surfaces. Non-stainless ferrous interior surfaces of all valves, hydrants, operators, meters, couplings, expansion joints, spools, fittings, and backflow preventers 3-inch (75 mm) nominal diameter and larger shall be lined with epoxy conforming to AWWA C550. Interior linings for surfaces contacting potable water shall be NSF 61-listed.

In addition to required painting, all buried ductile or cast iron pipe, fittings, couplings, tie rods, expansion joints, valves and hydrant runs shall be encapsulated in polyethylene encasement.

212-12.1.2 Materials. Interior lining and exterior coating materials shall conform to the following:

TABLE 212-12.1.2

Item	Material	Reference Specification/Requirements
Interior Lining	Fusion-Bonded Epoxy or High-Solids Two-Part Epoxy	AWWA C550. 12-mil (300 µm) thickness. Do not coat seating areas or bronze or stainless steel parts.
Exterior Finish Coat	Fusion-Bonded Epoxy or Epoxy Urethane	AWWA C550. 12-mil (300 µm) thickness. Do not coat bronze or stainless steel parts.
Lubrication for Above-ground or Vault-enclosed Steel Bolt Threads	See 212-2.5	
Coating for Buried Nuts and Bolts	See 212-2.5	
Polyethylene PE Encasement on Buried Ductile or Cast Iron Pipe, Fittings, Couplings, Tie rods, Expansion Joints, Valves and Hydrant Runs	Standards	AWWA C105/ANSI A21.50.
	Material	Polyethylene plastic tube.
	Thickness	8-mil (200 µm) double layer on pipe. 8-mil (200 µm) triple layer on fittings, valves and appurtenances. Color per 212-12.2.
	Adhesive Tape to Connect Polyethylene Film Tubes and Polyethylene Encasement at Fittings and Appurtenances	2" (50 mm) wide polyethylene adhesive tape.

212-12.2 Color Scheme. The color of valves, polyethylene encasement, and appurtenances shall be as follows:

TABLE 212-12.2

Item	Color	Items Included
Domestic Water	Blue	Valves, polyethylene encasement, appurtenances, and above-ground or vault-enclosed piping.
	Chrome Yellow with Tops and Nozzle Caps colored per AWWA C503 Appendix B	Fire hydrants.
Recycled Water	Purple	Valves, polyethylene encasement, appurtenances, and above-ground or vault-enclosed piping.
Wastewater	Green	Valves, polyethylene encasement, appurtenances, and above-ground or vault-enclosed piping.
Fire Water Systems	Red	Valves, polyethylene encasement, appurtenances, and above-ground or vault-enclosed piping.

SECTION 213 - ENGINEERING GEOSYNTHETICS

213-1 GENERAL. Engineering geosynthetics (geosynthetics) shall consist of paving fabrics, geotextiles, and geogrids. Geosynthetics shall conform to ASTM D4759.

A Certificate of Compliance conforming to 4-1.5 shall accompany each shipment and be submitted to the Engineer prior to installation. The certificate shall include the name of the manufacturer, chemical composition, product description, lot number, signature of the manufacturer's representative, and quality control test results.

213-2 IDENTIFICATION, STORAGE, AND HANDLING. Identification, storage and handling shall conform to ASTM D4873.

Geosynthetic material shall be shipped in rolls. Each roll in the shipment shall be marked or tagged to identify the manufacturer, type, length, width, date, place of manufacture, and production identification number. Geotextiles and paving fabrics shall be wrapped with protective covering.

Paving fabric material shall be stored on clean, dry surfaces, free of foreign substances that could have a deleterious effect on the material. When stored in outside areas, paving fabric material shall be kept 1 foot (300 mm) minimum above ground level and protected from exposure to ultraviolet light. Protective coverings provided by the manufacturer shall not be removed more than 8 hours prior to placement. Open rolls shall be covered by a waterproof covering when not in use and at the end of each Working Day. No hooks, tongs or other sharp tools or instruments shall be used in handling. Unloading of paving fabric material shall be performed:

a) by slings;

b) by use of a pole inserted through a hollow core, provided the pole extends 1 foot (300 mm) minimum beyond each end, and lifting and handling devices are attached to only that portion of the pole located outside the ends of the core; or

c) by hand.

213-3 SAMPLING AND TESTING. Sampling and testing shall conform to ASTM D4354.

213-4 PAVING FABRIC. This subsection applies to paving fabric material placed within or under an asphalt concrete layer or a chip seal. Paving fabric material shall be nonwoven, needle-punched polyester or polypropylene and conform to Table 213-4.1.

TABLE 213-4.1

Property	ASTM Test No.	Requirements
Weight, oz./yd^2 (g/m^2)	D5261	4.1 to 5.5 (139 to 187)
Grab Tensile Strength 1 inch (25 mm) Grip, lbf (N)	D4632	101 (449) min.
Elongation at Break, %	D4632	40 min., 100 max.
Fabric Thickness, Mils (µm)	D5199	30 to 50 (760 to 1270)
Asphalt Retention, oz./ft^2 (g/ m^2)	D6140	2.90 (886)min.
Grab Tensile Strength After Asphalt Saturation 1 inch (25 mm) Grip, lbf (N)	D4632	200 (890) min.
Elongation at Break, % After Asphalt Saturation	D4632	40 min., 70 max

1. Asphalt paving fabric interlayer is used for stress relief and to resist surface moisture penetration.

Paving fabric material shall be treated by heat or other processes causing the fibers on one side only to become bonded together, forming a glazed, delamination-free surface.

213-5 GEOTEXTILES AND GEOGRIDS. This subsection applies to geotextiles (nonwoven and woven) and geogrids (uniaxial, biaxial, and multi-axial) placed on or within fill material, subgrade soil, or untreated base material.

Nonwoven geotextiles shall be needle punched or needle entangled and shall consist of long chain polymeric filaments of polypropylene, polyester, or nylon. The fabric shall be a stable network of fibers which retain their positions relative to each other.

Woven geotextiles shall consist of long chain polymeric monofilaments, slit film tapes, or multifilaments of tape and nonwoven yarn of polypropylene, polyester or nylon. The fabric shall be woven into a stable network and the edges of the fabric shall be selvedged or surged in such a way that the fabric will not unravel or fray during installation or usage.

Uniaxial, biaxial, and multi-axial geogrids shall be manufactured using polyolefins (high density polyethylene (HDPE), polypropylene (PP) and/or polyester (PET). The geogrid reinforcement elements shall consist of a regular network of integrally connected polymer tensile elements with aperture geometry capable of providing mechanical interlock with the surrounding soil, aggregate or other material.

Nonwoven and woven geotextiles shall conform to Table 213-5.2 (A) or Table 213-5.2 (B) for the type shown on the Plans or specified in the Special Provisions. Geogrids shall conform to Table 213-5.2 (C), Table 213-5.2 (D), or Table 213-5.2 (E) for the type shown on the Plans or specified in the Special Provisions. Unless otherwise shown, all values represent minimum average roll values (MARV) as defined in ASTM D4439.

TABLE 213-5.2 (A): NONWOVEN

Property	Test Reference	Type[1,2]		
		90 N	180 N	250 N
Grab Strength[2] lbs (N), Min.	ASTM D4632	90 (400)	180 (800)	250 (1110)
Elongation, Minimum (at peak load) %, Max.	ASTM D4632	50	50	50
Puncture Strength, lbs (N), Min.	ASTM D3787	45 (200)	80 (355)	115 (510)
Permitivity, Sec.[1], Min.	ASTM D4491	0.7	0.7	0.7
Burst Strength psi (kPa), Min.	ASTM D3786	180 (1240)	320 (2205)	360 (2485)
Toughness, lbs (N), Min.	% Elongation x Grab Strength	5,500 (24,500)	10,000 (44,500)	14,000 (62,500)
Ultraviolet Resistance % Strength Retained @ 500 Weatherometer Hours	ASTM D4355	70	70	70

1. N – Nonwoven.
2. For application and placement, refer to 300-8 or 300-10.
3. Minimum roll average in the weakest principal direction.

TABLE 213-5.2 (B): WOVEN

Property	Test Reference	Type[1,2]			
		90WS	200WS	270WS	200WM
Grab Strength[2] lbs (N), Min.	ASTM D4632	90 (400)	200 (890)	270 (1200)	200 (890)
Elongation, Maximum, at peak load %, Max.	ASTM D4632	25	25	25	25
Puncture Strength, lbs (N), Min.	ASTM D3787	30 (135)	70 (310)	110 (490)	100 (445)
Permitivity, Sec.[1], Min.	ASTM D4491	0.02	0.02	0.02	0.04
Burst Strength, psi (kPa), Min.	ASTM D3786	200 (1380)	400 (2760)	500 (3450)	400 (2760)
Ultraviolet Resistance % Strength Retained @ 500 Weatherometer Hours	ASTM D4355	70	70	70	70

1. WS – Slit Film; WM – Monofiliment.
2. For application and placemen, refer to 300-8, 300-9, or 300-10.
3. Minimum average roll value in each direction.

TABLE 213-5.2 (C): UNIAXIAL

Property	Test Reference	Type[1]				
		P1	P2	P3	P4	P5
Tensile Strength lbs/ft (kN/m), Min.	ASTM D6637	2700 (39.4)	4400 (64.2)	6900 (100.7)	9000 (131.3)	10800 (157.6)
Tensile Strength @ 2% strain lbs/ft (kN/m), Min.	ASTM D6637	550 (8)	1000 (14.6)	1800 (26.3)	2330 (34)	2740 (40)
Tensile Strength @ 5% strain lbs/ft (kN/m), Min.	ASTM D6637	1165 (17)	2000 (29.2)	3700 (54)	4450 (65)	5400 (78.8)
Initial Modulus lbs/ft (kN/m)	ASTM D6637	27500 (400)	50000 (730)	90000 (1310)	116500 (1700)	137000 (2000)
Junction Strength, lbs/ft (kN/m), Min.	ASTM D7737	2430 (35)	3960 (58)	6210 (91)	8100 (118)	9720 (142)
Long-Term Allowable Strength, lbs/ft (kN/m)	GRI GG-4[2]	809 (11.8)	1602 (23.4)	2424 (35.4)	3203 (46.7)	4026 (58.7)
Ultraviolet Stability, @ 500 hrs (%)	ASTM D4355-05	70	70	70	70	70

1. Uniaxial geogrid contains two primary ribs at each junction which serve to provide linear (uni-directional) reinforcement in mechanically stabilized earth (MSE) retaining wall applications. Two secondary ribs are also located at each junction (in the perpendicular direction) to provide stability to the geogrid structure. All property values are listed for the machine direction.
2. Minimum reduction factors are as follows: installation damage reduction factor for HDPE of 1.05 and 1.1 for PET geogrids, durability reduction factor of 1.1 for HDPE and 1.3 for PET geogrids.

TABLE 213-5.2 (D): BIAXIAL

Property	Test Reference	Type[1]	
		S1	S2
Ultimate Tensile Strength lbs/ft (kN/m), Min.	ASTM D6637 [1]	1300 (19)	1975 (28.8)
Tensile Strength @ 2% strain lbs/ft (kN/m), Min.	ASTM D6637 [1]	450 (6.57)	600 (8.75)
Tensile Strength @ 5% strain lbs/ft (kN/m), Min.	ASTM D6637 [1]	920 (13.4)	1340 (19.5)
Flexural Stiffness mg-cm	ASTM D7748	250000	750000
Junction Strength, lbs/ft (kN/m), Min.	ASTM D7737 [1]	1170 (17.1)	1778 (26)
Torsional Stiffness, cm-kg/degree	GRI:GG9 [2]	3.2	6.5
Ultraviolet Stability, @ 500 hrs (%)	ASTM D4355-05	70	70

1. Biaxial geogrid contains four perpendicular intersecting ribs at each junction formed into a bi-directionally stable network of open rectangular apertures. Biaxial geogrid is used as secondary reinforcement in grade separation applications. Also used for subgrade stabilization, aggregate base reduction and/or life extension in pavement or railroad applications. All property values are listed for the cross machine direction with the exception of flexural stiffness, measured in the machine direction, and torsional stiffness which is measured at the junction.
2. Geosynthetic Research Institute, Test Method GG9, "Torsional Behavior of Bidirectional Geogrids When Subjected to In-Plane Rotation."

TABLE 213-5.2 (E): MULTI-AXIAL

Property	Test Reference	Type[1]		
		R1	R2	R3
Aperture Shape	Observation	Triangular	Triangular	Triangular
Radial Stiffness @ 0.5% strain lbs/ft (kN/m), Min.	ASTM D6637[2]	10,285 (150)	15,430 (225)	20,580 (300)
Radial Stiffness Ratio, dimensionless	ASTM D6637[3]	>0.60	>0.60	>0.60
Junction Strength Efficiency (%)	ASTM D7737 [4]	93	93	93
Ultraviolet Stability, @ 500 hrs (%)	ASTM D4355-05	70	70	70

1. Multi-axial geogrid contains six or more intersecting ribs at each junction formed into a radially stable network of open equilateral triangular apertures. Multi-axial geogrid is used for subgrade stabilization, aggregate base reduction, asphalt concrete reduction, and/or life extension in pavement or railroad applications.
2. Minimum measured radial stiffness at 0.5% strain. Radial stiffness is measured on both the rib directions and the mid-rib directions (directions that bisect the angles between ribs).
3. Ratio of the minimum to maximum MARV values of radial stiffness at 0.5% strain.
4. Load transfer capability determined in accordance with ASTM D7737 and ASTM D6637 and expressed as a percentage.

SECTION 214 - TRAFFIC STRIPING, CURB AND PAVEMENT MARKINGS, AND PAVEMENT MARKERS

214-1 GENERAL. The following material specifications set forth the requirements for glass beads, paint, thermoplastic material, and reflective and non-reflective pavement markers for use in traffic striping (striping) and curb and pavement markings (markings).

Manufacturer's warranties, guaranties, and instruction sheets for materials used in the Work shall be submitted to the Engineer in accordance with 2-5.3.4.

State Specifications referred to in these specifications are available from the Caltrans Division of Engineering Services, Materials Engineering and Testing Services, Office of Roadway Materials Testing, Chemical Testing Branch (Caltrans Transportation Laboratory).

214-2 TEST REPORTS AND CERTIFICATES OF COMPLIANCE. The Contractor shall submit to the Engineer certified copies of the manufacturer's test reports and MSDS in accordance with 2-5.3 and 7-10.4.3. Test reports shall indicate the name of the manufacturer, type of material, date of manufacture, quantity, State Specification number, manufacturer's lot or batch number, and results of the required tests. Test reports shall be signed by an authorized representative of the manufacturer.

In lieu of test reports the Contractor may provide the Engineer with a Certificate of Compliance in accordance with 2-5.3.4 and 4-1.5. The certificate shall certify that the paint or thermoplastic material conforms to the Specifications and that the paint was manufactured to the same formulation and process that has passed Caltrans testing.

214-3 GLASS BEADS. Glass beads shall conform to State Specification 8010-004 (Type II).

214-4 PAINT FOR STRIPING AND MARKINGS.

214-4.1 General. Paint for striping and markings shall conform to the requirements shown in Table 214-4.1.

TABLE 214-4.1

Paint Type	Color	State Specification No.[1]
Waterborne Traffic Line, Type I (Rapid Dry)	White, Yellow and Black	PTWB-01
Acetone-Based	White, Yellow and Black	PT-150VOC(A)
Waterborne Traffic Line	Blue, Red and Green	Federal Specification No. TT-P-1952D

1. Copies of the State Specifications may be obtained from the Caltrans Transportation Laboratory.

The Contractor may select waterborne or acetone-based paint, depending on the weather conditions and local air pollution control regulations, subject to approval by the Engineer. Thinning of paint will not be allowed.

Paint shall contain at least 12 percent titanium dioxide in white paint.

Glass beads conforming to 214-3 shall be mechanically applied at a rate of 5 pounds per gallon (2 kg/L) of paint to the surface of each coat of prior to setting. Application shall conform to 314-4.3.5.

214-4.2 White, Yellow, and Black Traffic Line Paint. White, yellow, and black traffic line paint shall dry to a "no traffic pickup" condition in 30 seconds. The "no traffic pickup" time shall be determined in accordance with ASTM D711. The paint shall be completely dry in not more than 3 minutes when preheated to the temperature recommended by the manufacturer before application.

214-5 THERMOPLASTIC MATERIAL FOR TRAFFIC STRIPING AND MARKINGS.

214-5.1 General. Thermoplastic material shall conform to State Specification PTH-025SPRAY, PTH-02HYDRO, or PTH-02ALKYD as specified in the Special Provisions.

Glass beads conforming to 214-3 shall be added directly to the combined pigment, filler, and resin. Thermoplastic material shall contain at least 20 percent by weight of glass beads in the white and yellow paints and at least 12 percent titanium dioxide in the white.

Thermoplastic material shall be applied in a molten state by mechanical means. Prior to setting, an additional application of glass shall be mechanically applied to the surface of the molten thermoplastic material in conformance with 314-4.4.4. Thermoplastic material, when applied at a temperature range of 400°F to 425°F (200°C to 220°C) and a thickness of 90 to 125 mils (2300 to 3200 µm) for traffic markings and 60 to 70 mils (1500 to 1800 µm) for traffic striping, shall set to bear traffic in 2 minutes or less when the atmospheric temperature is 50°F (10°C) or greater and not more than 10 minutes when the air atmospheric temperature is 90°F (32°C) or greater. Thermoplastic material shall dry to "no traffic pick-up" in accordance with ASTM D711.

214-6 PAVEMENT MARKERS.

214-6.1 Types of Markers. Pavement markers shall conform to one or more of the following types:

a) Type A - Non-Reflective White.
b) Type AY - Non-Reflective Yellow.
c) Type C - Red-Clear Retroreflective.
d) Type D - Two-Way Yellow Retroreflective.
e) Type G - One-Way Clear Retroreflective.
f) Type H - One-Way Yellow Retroreflective.
g) Type I - Two-Way Blue Retroreflective.

214-6.2 Sampling and Acceptance.

214-6.2.1 Sampling. A representative sample size for each lot shall be selected in accordance with the requirements shown in Table 214-6.2.1. For sampling purposes the lot size shall not exceed 25,000 markers.

Table 214-6.2.1

Lot Size	Sample Size
10000 or less	20
10,001-25,000	40

214-6.2.2 Test Specimens. Three test specimens shall be randomly selected from the sample for each test except as otherwise specified in 214-6.2.3, and tested for conformance with these Specifications. If any one of the 3 specimens fails to comply with the requirements of these Specifications, 6 additional specimens will be tested. The failure of any one of these 6 specimens shall be a basis for rejection of the entire lot or shipment represented by the sample.

214-6.2.3 Reflectance. The entire sample of retroreflective pavement markers shall be tested for reflectance. The failure of 10 percent or more of the original sampling shall be a basis for rejection.

214-6.2.4 Re-samples. At the discretion of the Engineer, a re-sample may be taken consisting of twice the number of samples originally taken. Tolerances for re-samples shall be in the same ratio as specified in 214-6.2.2.