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| --- | --- | --- |
| Version | Date | Description of Revisions |
| 1 | September 08, 2006 | Approved final document. |
| 2 | February 19, 2010 | Modified ‘Related Sections’ and approved suppliers |
| 3 | March 21, 2011 | Minor edits |
| 4 | June 3, 2013 | Final Draft – Consolidated Comments Spec Update Project |
| 5 | June 18, 2013 | Incorporation of new Commissioning and Computerized Maintenance Management System Data Requirements Specification cross references. |
| 6 | July 29, 2014 | Changes to reflect renaming of commissioning specification and final review (AV) |
| **7** | **February 9, 2015** | **Updated, Finalized Specification – Reference eDOCS #5630523 v7 (AV)** |
| 8 | February 10, 2017 | Revised all products with listed manufacturers (CPD PMO, OMM) (AV) |

NOTE:

This is a CONTROLLED Document. Any documents appearing in paper form are not controlled and should be checked against the on-line file version prior to use.

**Notice:** This Document hardcopy must be used for reference purpose only.

**The on-line copy is the current version of the document.**

# GEneral

## Related Sections

### [Under "Related Sections", identify other Sections that are related to, and/or dependent on, the work results or information specified elsewhere. The list should be limited to Sections with specific information that the reader might expect to find in this Section, but is specified elsewhere. For example, if hardware for aluminum entrances is specified in the aluminum entrance Section, a cross-reference would be appropriate in the finish hardware Section. The purpose of this cross-referencing is for information only, to aid in finding those other requirements—not to define the scope of the Section.

### Cross-referencing here may also be used to coordinate assemblies or systems whose components may span multiple Sections and which must meet certain performance requirements as an assembly or system.

### Contractor is responsible for coordination of the Work. Contractor is responsible for being familiar with and incorporating all required elements of cross-referenced Specifications cited.

### This Section is to be completed/updated during the design development by the Consultant. If it is not applicable to the section for the specific project it may be deleted.]

### [List Sections specifying installation of products supplied but not installed under this Section and indicate specific items.]

### Section [\_\_\_\_\_\_ – \_\_\_\_\_\_\_\_\_\_\_\_]: Execution requirements for ...[item]... specified under this Section.

### [List Sections specifying products installed but not supplied under this Section and indicate specific items.]

### Section [\_\_\_\_\_\_ – \_\_\_\_\_\_\_\_\_\_\_\_]: Product requirements for ...[item]... for installation under this Section.

### [List Sections specifying related requirements.]

### Section

#### Section 01810 – Equipment Testing and Facility Commissioning

#### Section 12050 – Substitutions

#### [Division 13 – SCADA and Instrumentation -insert applicable specifications]

#### Product requirements for [item]... for installation under this Section.

## References

### Canadian Electrical Code (23rd edition, 2015), Ontario edition (CEC)

### Canadian Standards Association (CSA)

#### CSA C22.2.239:2009 (R2014), Control and Instrumentation Cables.

#### CSA C22.2 No. 131-14, Type TECK 90 Cable.

#### CSA C22.2 No. 174-M1984 (R2012), Cables and Cable Glands for use in Hazardous Locations.

#### CSA C22.2 No. 38-14, Thermoset-Insulated Wires and Cables (Tri-national standard, with UL 44 and ANCE NMX-J-451-2014).

#### CAN/CSA C68.5-13, Shielded and Concentric Neutral Power Cable for Distribution Utilities.

### American National Standards Institute (ANSI)

#### ANSI/NEMA WC 70-2009/ICEA S-95-658-2009, Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.

### American Society for Testing & Materials (ASTM)

#### ASTM E230/E230M-12, Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

### Restriction of Hazardous Substances (RoHS)

### Underwriters' Laboratories (global) (UL)

## Measurement and Payment

*[Choose one of the following payment language provisions that best suits the individual project.*

*If this Section is not specifically referenced by an item in the Bid Form, please use the following language:*

### The work of this Section will not be measured separately for payment. All costs associated with the work of this Section shall be included in the Contract Price.

*OR If this Section is specifically referenced in the Bid Form, use the following language and identify the relevant item in the Bid Form:*

### All costs associated with the work of this Section shall be included in the price(s) for Item No(s). \_\_\_ in the Bid Form.

*If the work of this Section is to be measured and paid for by several different methods, please amend the standard wording given above to reflect the different methods of measurement and payment.*]

## Design Requirements

### The number and sizes of wires (and associated raceways) indicated in the Contract Documents are a guide only and are not necessarily the exact number and sizes required. Wire or cable sizes smaller than the sizes indicated in the Contract Documents are not acceptable.

### Unless otherwise indicated in the Contract Documents, combine motor or electric heater branch power wiring (below 1000 V systems) and associated local operator control or field control device wiring into a common conduit between the motor or heater and its starter or motor control centre, provided that all of the following conditions are met:

#### Motor circuit voltage does not exceed 600 V.

#### Conductors and termination fittings for power and control circuits are rated 600 V minimum.

#### Control circuits are designed to operate at 120 V AC or higher. Install wiring for control circuits operating below 100 V AC or with DC in a separate conduit system.

#### Power conductors do not exceed #2 AWG in size.

#### Control circuit wiring is solely associated with respective motor or heater. Install wiring for control circuits of other equipment and systems, or wiring common to two or more pieces of equipment in separate conduits.

### Supply spare conductors in control, communication and instrumentation cable circuits as follows:

#### Refer to Division 13 – SCADA and Instrumentation.

#### Up to four utilized conductors in one conduit or cable: one spare conductor.

#### Five to eight utilized conductors in one conduit or cable: two spare conductors.

#### Nine or more utilized conductors: 20% or three spare conductors, whichever is greater.

## Storage

### Cap cable ends to prevent water penetration into cable. Reseal after cutting length of cable.

### Cables stored with ends unsealed shall be immediately removed from the Site at the Contractor’s own expense. At no extra cost to the Region, the Contractor shall also replace cables to the satisfaction of the Consultant.

# PRODUCTS

## Manufactured Products

### Comply with the standards listed above in subsection 1.2- References.

### Insulated Cables Above 750 Volts

#### Rating: For operation in a [\_\_] kV, 3 phase, 60 Hz, [grounded] [ungrounded] system having a maximum symmetrical fault level of [\_\_] MVA phase-to-phase ([\_\_] seconds) and [\_\_] MVA phase-to-ground ([\_\_] seconds).

#### Conductors: Stranded, annealed copper, class B stranding, size as indicated on the Contract Drawings. [*Consultant to ensure required details are added to this subsection]*

#### Insulation: extruded cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) compound, Type RW90, suitable for installation in wet areas and suitable for handling at minus 40°C ambient, 90°C maximum conductor temperature.

#### Insulation level: 100% [133%] over each conductor.

#### Insulation shield: Semi-conducting thermosetting XLPE material applied over the insulation.

#### Metallic shield: Lapped copper tape or served copper wire.

#### Grounding conductor: Un-insulated, Class B stranded, soft bare copper conductor in multi-conductor cable, concentric copper wires over insulation shield in single conductor cable.

#### Armour: where indicated on the Drawings, interlocking galvanized steel or aluminum armour over jacketed cable assembly (only aluminum on single conductor cables).

#### Inner and outer jacket: PVC, moisture and oil resistant, flame retardant composition, [*Consultant to confirm if test method FT4 – Vertical Flame Test in accordance with CSA C22.2 No. 0.3-96 (R2000) is to be applied here and amend the subsection accordingly]*, extruded, suitable for -40°C applications and of low acid gas evolution. Outer jacket colour, [red] [orange] [black].

#### Multi-conductor cables: Suitable fillers and binders.

#### Where cables are subject to prolonged or continuous submersion in water, furnish a seamless sheath over inner PVC jacket. The use of lead is not permitted.

### Low Voltage Unarmoured Wire and Cable (750 V and Below).

#### Construction: Stranded, annealed copper conductors, 600 V minimum rating for #14, #12 and #10 AWG and 1000 V rating for Conductors larger than #10 AWG, shall have RW90 cross-linked polyethylene (XLPE) insulation[T90 Nylon], and shall be suitable for handling at minus 40°C ambient, 90°C maximum conductor temperature, limited flame spread [FT4], [jacketed].

#### Direct buried installations or installation in direct buried polyethylene pipe: Cross-linked polyethylene (XLPE), RWU90 insulation, 750 V minimum rating, [jacketed].

#### Standard: CSA C22.2 No. 38-14.

#### Minimum conductor sizes: Unless otherwise indicated in the Contract Documents, #12 AWG for power and current transformer circuits; #14 AWG for control circuits and fire alarm circuits; #16 AWG for PA circuits; [telephone wiring to comply with telephone utility standards as detailed by Consultant.]

#### Multi-conductor cables: PVC flame retardant [black] jacket overall, suitable for handling at minus 40°C, flame test rated [FT4].

#### Lighting wiring: GTF wire, 600 volt, 125°C, flexible copper conductor for connections between luminaire and outlet boxes.

#### Colour coding: For insulated conductors, conform to the following:

##### 1-conductor power - Black (Phase Conductors) - White (Neutral)

##### 1-conductor control - Red

##### 2-conductor power - Black, White

##### 3-conductor power - Red, Black, White (Neutral) - Red, Black, Blue

##### 4-conductor power - Red, Black, Blue, White

##### Multi-conductor cables - Manufacturer's standard

### Insulated ground conductors forming part of a multi-conductor cable assembly: ESA colour coding.

### Low Voltage Armoured Wire and Cable (750 V and Below)

#### Construction: Stranded, annealed copper conductors, 750 V rating, RW90 cross-linked polyethylene (XLPE) insulation, suitable for handling at minus 40°C ambient, 90°C maximum conductor temperature, flame test rated [FT4].

#### Power cabling: [TECK] construction.

#### Control cabling: [TECK] construction.

#### Lighting and receptacle branch wiring in office areas: [BX] construction.

#### Minimum conductor size: Unless otherwise indicated in the Contract Documents, #12 AWG for power and current transformer circuits and #14 AWG for control and fire alarm circuits.

#### Grounding conductor: Stranded, soft, bare copper conductor in multi-conductor cables, concentric copper wires over insulation in single conductor cable.

#### Multi-conductor cables: With inner jacket of suitable PVC (minus 40°C).

#### Interlocking armour: Flexible, galvanized steel or aluminum for multi-conductor cables and aluminum for single conductors, spirally wound over inner jacket.

#### Outer jacket: PVC (minus 40°C), flame-retardant, FT4 flame test rated, low acid gas evolution, [black] outer jacket extruded over the armour.

#### Colour coding: [Design Guideline 39 - SCADA and Instrumentation and Division 40 renamed from Division 13 – SCADA and Instrumentation, Section 13305 (subsection 2.4 - Multi-Conductor Cable Control Cabling)]. In the event of conflicts with cited references these conflicts to be resolved by the Consultant. For insulated conductors, conform to the following:

##### 1-conductor power - Black

##### 1-conductor control - Red

##### 2-conductor cable - Black, White

##### 3-conductor cable - Red, Black, White (Neutral) - Red, Black, Blue

##### 4-conductor cable - Red, Black, Blue, White

##### Multi-conductor cables - Manufacturer's standard

#### .12 Hazardous area installations: Where indicated on the Contract Drawings, TECK cables and fittings accepted for the application. Stamp outer jacket, "HL".

### Low Voltage Armoured Wire and Cable for VFD Application (750 V and Below)

#### Designed to reduce high frequency noise interference with data and control signals

#### Three bonding conductors - soft bare copper.

#### Cross-linked polyethylene RW90 insulation on main conductors.

#### Continuously corrugated, corrosion resistant aluminum sheath with matching connectors.

#### With overall PVC jacket rated FT4.

#### Cable type to be DriveRx® cable with “D” or “W” connectors.

### Thermocouple Wiring

#### Thermocouple extension wires: Unless otherwise noted, shielded, 90 deg. C rated PVC (-40°C) extension wires, jacket, matching associated thermocouple. Meets or exceeds ASTM E230/E230M-12.

### Wiring Accessories

#### Wire markers: Plastic slip-on, black letters on white background.

#### Cable markers: For cables or conductors, strap-on type, semi rigid PVC carrier strip.

#### Terminal blocks: 600 V, 25 A minimum rating, modular, 35 mm DIN rail mounted, provision for circuit number labeling, individually removable, sized to accommodate conductor size and circuit current.

#### Field wiring terminations: Where screw-type terminal blocks are provided, supply insulated fork tongue terminals, UL listed and CSA Certified, flame retardant shell, approved for circuits up to 300 V, temperature rating up to 645˚C.

#### Splice connectors for equipment pig-tail, lighting and receptacle circuits: For wire sizes #12 and #10 AWG inclusive, twist-on compression spring type, shell rated to 105˚C, UL listed and CSA Certified.

#### High voltage (above 750 V) cable terminations: Engineered termination kits, rated for conductor number, size and voltage class of cable, heat shrinkable type, stress relieving, with heat activated sealant. Supply outdoor skirts for outdoor terminations.[Consultant to provide additional details as required]

#### 5 kV motor terminations: Heat shrinkable connection kits, including compression lug connectors, sealant, cover caps and tubes. [Consultant to provide additional details as required]

#### Low voltage (750 V and lower) motor terminations: Heat shrinkable connection kit, including sleeves, caps and sealant.

#### Cable ties: Nylon, one-piece, self-locking type, RoHS compliant.

#### TECK cable connectors in hazardous locations: Approved for application.

#### TECK cable connectors in wet or outdoor areas: Watertight type. Provide “O” ring with connection.

#### Electrical insulating tape: able to splice and insulate wires up to 600V, can be applied in temperatures as low as 0°C, handles temperatures from -18ºC to 105ºC (0°F to 220°F), resists UV rays, abrasion, moisture, copper corrosion, alkalies and acids, flame retardant, black polyvinyl chloride backing with rubber based adhesive.

#### Cable grips: To accommodate the type and geometry of cable supported, single weave, variable mesh design.

#### Cable pulling lubricant: Compatible with cable covering and shall not cause damage or corrosion to conduits or ducts, environmentally safe - non-toxic, non-flammable, non-corrosive.

# EXECUTION

## Coordination

### Prior to installation of wiring, compare the Contract Drawings with latest issue of shop drawings.

### Report any discrepancies promptly to the Consultant.

## Installation

### Provide wires of the number and size (including corresponding raceways) required, with spare conductors as indicated on the Drawings. Provide adequate wiring for actual equipment installed.

### Provide wire and cable according to the Drawings and electrical system requirements.

### Pull cable into ducts, conduits and cable trays in accordance with the cable manufacturer's recommendations. Use patented cable grips suitable for the cable type, or pulling eyes fastened directly onto cable conductors.

### Limit pulling tension and minimum bending radii to those recommended by the manufacturer.

### Prevent damage to cable jackets by utilizing adequate lubricant when pulling cables through ducts and conduits.

### Support cables in manholes and utility tunnels on cable trays or cable racks.

### Arrange cables in parallel rows on cable trays. Maintain cable spacing by fastening cables, with cable ties, every 2000 mm minimum on straight horizontal runs and to each rung at bends, including two rungs of adjoining straight sections. Fasten cables on vertical tray runs every 1000 mm maximum.

### Connect cables to electrical boxes and equipment enclosures located in wet or sprinkled areas with watertight cable connectors.

### Provide cable grips for vertical and catenary cable suspension installations to reduce cable tension at connectors and at cable bends.

### Install through wiring in junction and pull boxes having no connection within the box. Leave a minimum of 150 mm of slack inside box.

### Facilitate the making of joints and connections by leaving sufficient slack in each conductor at panel boards, outlet boxes and other devices.

### Do not connect more than three lighting circuits for three phase panels and two lighting circuits for single phase panels to a common neutral.

### Use #10 AWG minimum for home runs to lighting panels exceeding 25 m. Canadian Electrical Code, Ontario Edition requirements for voltage drop to be applied as it pertains to wiring specifications.

### Install instrumentation signal and thermocouple extension wires in separate raceways from power and control wiring.

### Provide mechanical protection for cables within 1500 mm of the floor in buildings and within 2000 mm above grade outdoors.

### Identify each cable by attaching a cable marker at each end, in all intermediate manholes, junction boxes and pull boxes.

### Provide cable grips on vertical and horizontal catenary cable suspensions.

## Underground Installation

### Install direct buried cables in 75 mm layers of sifted sand, free of rock, stone and other sharp objects, above and below.

### Where indicated on the Drawings, protect direct buried cables with 50 mm thick concrete protection tiles. Extend protection a minimum of 50 mm on either side of cabling.

### Install direct buried cable at a minimum depth of 600 mm. Where rock is encountered and the minimum depth cannot be attained, install cables in concrete encased ducts.

### Install in suitably sized concrete encased ducts where cables pass under roadway or an area subject to vehicular traffic or heavy loads.

## Wiring Terminations

### Insulate equipment pig-tail power circuit connections with wire sizes #8 AWG and larger, with heat shrink sleeving termination kits.

### Terminate armoured cables with accepted connectors suitable for application, size and type of cable.

### Except where pulling tensions exceed allowable cable limits or where tap connections are required, only install splices in power, control and instrumentation cable runs with prior written permission of the Consultant. Where unavoidable, install splices in junction boxes only.

### Make power (1000 V and below), control and instrumentation wiring taps, splices and terminations in junction boxes with labelled terminal blocks, securely fastened to avoid loosening under vibration or normal strain. Terminate lighting circuits and 120 V convenience receptacle circuits with twist on type connectors and insulating tape. Do not use split bolt connectors for 120 V circuits.

### Terminate control, signal and instrumentation circuit conductors, including spares, on terminal blocks. Label terminal blocks with unique alphanumeric designation or as shown on the Drawings.

### Identify each conductor, including spares, by wire markers at each termination. Indicate circuit designation or unique wire number. Identify spare conductors as 'SP1', 'SP2', etc.

## High Voltage Terminations (Above 750 V)

### Prepare high voltage cable ends [for type of termination indicated]. Assemble and install heat shrinkable, stress relieving cable terminations in accordance with termination and cable manufacturers' recommendations. Utilize only personnel trained, experienced and qualified in this type of installation.

### For motor terminations, provide compression lugs with bolt type connections on the motor leads and incoming conductors. Install cable stress relief termination kits and motor termination kits in accordance with manufacturer's recommendations. Prevent conductors and splices from coming into contact with enclosure walls.

## Testing

### High Voltage Cable (Above 750 Volts). Refer to Section 16031 - Inspection and Testing.

#### Install the cable without making final connections so equipment (motors, switchgear, transformers, capacitors, and similar items) will not be subjected to test voltages.

#### Test complete with cable termination fittings.

#### The Contractor shall engage the services of a competent independent testing agency, approved by the Consultant, specializing in this work that is required to test cable and terminations, including high potential tests, in accordance with the ANSI/NEMA WC 70-2009/ICEA S-95-658-2009 and CSA standards.

#### Connect the cable upon successful conclusion of tests. Submit two copies of certified test results to the Consultant.

#### Replace defective or substandard cable runs.

### Cable and Wire - 750 Volt and Below

#### Conduct insulation resistance measurements using a "Megger" (500 V instrument for circuit up to 350 V systems, 1000 V instrument for 351-600 V systems). *[Consultant to clarify need to conduct insulation resistance tests on cables other than feeder cables and amend this subsection accordingly.]*

#### Record test results in a log book and submit to the Consultant for reference. Replace or repair circuits which do not meet ESA requirements. With equipment disconnected, measure insulation resistance of the following circuits:

##### Power, lighting, heater and motor feeders: Phase-to-phase, phase-to-ground.

##### Control circuits: To ground only.

#### Do not perform "Megger" tests on equipment containing solid-state components.

#### Disconnect power factor correction capacitors from the system prior to testing.

### Instrumentation and Thermocouple Extension Wiring

#### Check the continuity of each conductor using an ohmmeter or a DC buzzer. Megger or 120 volt filament lamp testing is not acceptable.

#### Test thermocouple wiring for continuity and polarity in accordance with the manufacturer's recommendations.

## Wiring Identification

### Identify wiring, including fibre optic cabling, with wire markers.

### Colour code power, feeder and branch conductors at both ends with coloured plastic tapes. Tapes are not required where conductors are identified by jacket colour. Maintain the phase and colour sequence throughout.

### Identify each conductor, including spares, with a unique [alphanumeric] [numeric] designation [to be defined by Consultant and approved by Region] in order to facilitate troubleshooting and maintenance.

### Identify PLC wiring at terminal blocks and connection points with PLC terminal (I/O) address numbers. Refer to Division 13 – SCADA and Instrumentation.

## Wiring Signal Level Separation

### To control or eliminate electrical noise in plant wiring systems, group wires of compatible signal or power levels together and run separately or electromagnetically isolated from wires of incompatible signal or power level. These groups are defined as levels.

### In general, install low level analog signals, 50 V DC maximum or 4-20 mA, and digital signal operating at 50 V AC or DC maximum, in raceway electromagnetically isolated from higher power or signal wiring. Comply with wiring separation and isolation guidelines recommended by the instrument and computer/PLC equipment manufacturers.

### Levels

#### The following are representative of each of the Levels:

##### Level 1 - Low Level (most sensitive to noise)

###### General

Analog Signals: Less than 50 V DC, 4-20 mA

Digital Signals: 0-12 V DC

###### Typical Examples

All wiring connected to components associated with sensitive analog hardware less than 50 mV (for example. strain gauges, thermocouples).

±12 V or +5 V DC buses feeding sensitive digital hardware.

All signal wires associated with 12 V or 5 V digital hardware.

Digital tachometers.

4-20 mA and 0-10 V PLC input/output circuits.

CCTV circuits.

##### Level 2 - Medium Level

###### General

Analog signals 50 V DC or greater with less than 24 V AC ripple.

24 V DC lamp and low speed logic circuits.

###### Typical Examples

24 V DC bus feeding digital relays, lights, and input buffers.

All wiring connected to 24 V input buffers, 24 V lights and 24 V relays.

Telephone circuits.

Analog tachos and pilots.

Public address system.

Fire alarm circuits.

##### Level 3 - High Level Signals and Small Power

###### General

AC feeders 20 A or less. DC switching signals greater than 24 V, analog signals greater than 50 V DC with more than 24 V AC ripple. Regulating signals greater than 50 V with current less 20 A. 110 V AC control circuits.

###### Typical Examples

Fused 250 V control bus.

Indicating lights other than 24 V DC or 6 V, AC.

Circuit breaker coils (less than 20 A).

Ground detector circuits.

All AC feeders less than 20 A.

Lighting and convenience outlets.

Recording meter chart drives.

Small motor drives (10 kW or less).

110 V digital logic control circuits.

##### Level 4 - Utilization Power (not generally sensitive to noise)

###### General

AC and DC circuits O-800 V with currents 20-800 A.

###### Typical Examples

Motor and feeder circuits.

Primaries and secondaries of transformers above 5 kVA.

Large contactor coil circuits.

##### Level 5 - Bulk Power (noise insensitive)

###### Power greater than 600 V and/or 800 A.

### Field Wiring

#### General

##### Field wiring is used to interconnect various pieces of equipment and is generally external to equipment enclosures. Group wiring conductors according to their signal levels, particularly since more noise sensitive control wires may run in parallel with other power wiring.

#### Basic Installation Requirements

##### Except as noted on the Contract Drawings, run each level of wire in a separate tray or conduit; intermixing of levels is not acceptable.

##### Comply with the recommended spacing between trays of dissimilar levels in accordance with Table 1 below.

##### Level 3 may be run in a common tray with Level 4, but separated by a grounded steel barrier. Space other levels equivalent to Level 4.

##### When the provision of separate trays is impractical, install Level 1 and 2 cabling in a common tray, separated by a grounded steel barrier. Where Level 1 and 2 cables are run side by side in separate trays, maintain a minimum of 25 mm of spacing between trays.

##### Install Level 5 cables in separate conduits and trays. Do not mix cables of different voltages in the same tray.

##### When cables of unlike signal levels must cross either in trays or conduits, install them to cross at 90 degree angles to each other at a maximum spacing. Where it is not possible to maintain a minimum spacing (in accordance with the tables below), provide a grounded steel barrier between the raceways at the crossover point.

##### Provide trays containing Level 1 and Level 2 wiring of galvanized steel construction with ventilated trays (not solid bottoms). Where cables are armoured, ventilation slots or louvres may be used on trays, provided that perforation does not exceed 20% of total surface for Level 1 and 2. Install steel tray covers on Level 1 and 2 trays to provide complete shielding. Cover contact to side-rails must be positive and continuous to avoid air gaps which impair shielding.

##### Do not route trays and conduits containing Levels 1 and 2 parallel to enclosures of high power equipment rated above 100 kVA at a spacing of less than 1500 mm for trays and 750 mm metres for steel conduit.

##### Where practical, for Level 4 and 5 wiring, route the complete power circuit between equipment in a continuous raceway system (no gaps with exposed conductors).

##### When the spacing previously listed are difficult to maintain (e.g. at entry to the equipment), maintain parallel runs to a minimum; do not exceed 1500 mm cumulative over the entire cable run.

##### All spacing given in Table 2 assumes that the Level 1 and 2 trays will be covered. Otherwise, utilize Table 1 spacing.

##### Where O is indicated as a tray or conduit spacing, the levels may be installed together but spacing with respect to other levels must be based on the most stringent criteria.

##### Do not run Level 3 in the same conduit as Level 4 or 5. Locate Level 1 and 2 trays and conduits closest to the control panels, Levels 3, 4 and 5 furthest.

### Specific Routing of Levels

#### Comply with the following specified practices to attain a noise free installation:

##### Pull boxes and Junction Boxes

###### Within the confines of pull boxes and junction boxes, keep levels separate and provide grounded barriers where necessary.

###### Tray to conduit transition spacing and separations are a potential source of noise. Cross wires of dissimilar levels at right angles and maintain required separation. Protect transition areas in accordance with the level recommendations.

##### Conduits Around and Through Equipment Housings

###### Maintain level spacing on both embedded and exposed conduit systems in and around the equipment. Minimize runs containing mixed levels to 1500 mm or less in the overall run.

###### For conduits running through and attached to equipment housings, follow Level spacing recommendations. Coordinate the work with the equipment supplier early in the project.

###### Where cables of different levels are running together for short distances, connect each group of cables according to level by cord ties, barriers or some other method so that intermixing is avoided.

##### Transition Areas

###### For cables entering or leaving conduits or trays, ensure that cables of dissimilar levels do not become intermixed.

###### Provide grounded metal barriers for level separation when parallel runs over 1500 mm in overall length become necessary.

**TABLE 1**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | TRAY-TO-TRAY SPACING (mm)  *[All cross references to be verified by the Consultant]* | | | | |
| **Level** | **1** | **2** | **3** | **4** | **5** |
| **1** | 0 | See 3.9.4.2.8 | 150 | 650 | 1500 |
| **2** | See 3.9.4.2.4 | 0 | 150 | 450 | 1500 |
| **3** | 150 | 150 | 0 | See 3.9.4.2.3 | 300 |
| **4** | 650 | 450 | See 3.9.4.2.3 | 0 | 0 |
| **5** | 1500 | 1500 | 300 | 0 | 0 |

Figures indicate the minimum distance between the side rail top of one tray and the underside the tray above, or between the outside walls of adjacent trays. This also applies to the separation distance between trays and power equipment rated less than 100 kVA.

**TABLE 2**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| CONDUIT SPACING (mm) | | | | | |
| **Level** | **1** | **2** | **3** | **4** | **5** |
| **1** | 0 | 25 | 100 | 450 | 750 |
| **2** | 25 | 0 | 100 | 300 | 750 |
| **3** | 100 | 100 | 0 | 0 | 200 |
| **4** | 450 | 300 | 0 | 0 | 0 |
| **5** | 750 | 750 | 200 | 0 | 0 |

Table 2 indicates the minimum distance between trays and conduits. This also applies to the distance between trays or conduits and power equipment of less than 100 kVA.

**TABLE 3**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | CONDUIT-CONDUIT SPACING (mm)  *[All cross references to be verified by Consultant]* | | | | |
| **Level** | **1** | | **2** | **3** | **4** | **5** |
| **1** | 0 | | 25 | 75 | 300 | 300 |
| **2** | 25 | | 0 | 75 | 220 | 300 |
| **3** | 75 | | 75 | 0 | See 3.9.4.2.13 | 150 |
| **4** | 300 | | 220 | See 3.9.4.2.13 | 0 | 0 |
| **5** | 300 | | 300 | 150 | 0 | 0 |

Table 3 indicates minimum distance between outside surfaces of conduits run in banks. This also applies to the distance between conduits and power equipment of less than 100 kVA.

## Commissioning

### For all commissioning activities on systems where components of this Specification are integral to functionality, refer to Section 01810 – Equipment Testing and Facility Commissioning. All inspection and testing activities are to be completed with documentation provided to the Consultant prior to start of commissioning such activities.

**END OF SECTION**