TWEED SHIRE COUNCIL

ELECTRICAL DESIGN SPECIFICATION

EL04

INSTALLATION OF INSTRUMENTATION AND ELECTRICAL WORKS

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1 CITATION

This document is named "Tweed Shire Council, Electrical Design Specification EL04 – Installation of Electrical and Instrumentation Works"

2 ORIGIN OF DOCUMENT, COPYRIGHT

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3 VERSIONS

VERSION	AMENDMENT DETAILS	CLAUSES AMENDED	DATE ISSUED (The new version takes effect from this date)	Authorised by the Director of Engineering Services
1.1	Original version		1 November 2005	

4 COMPLIANCE WITH AUTHORITIES, STATUTES, REGULATIONS AND STANDARDS

4.1 Standards

All equipment and workmanship shall conform with the most recent requirements of the relevant statutory Local, State and Commonwealth Authorities and current applicable Australian Standards. Alternatively, where no Australian Standard exists, work shall conform to the most current and applicable British standard.

Where conflict exists between different Codes, Standards or Regulations, the higher requirement shall apply.

The Contractor shall not deviate from the provisions of the relevant standard without first obtaining agreement in writing from the Council.

Particular standards and regulations relevant to the work include but are not necessarily limited to the following:

AS 1000 International System of Units (S.I.) and its applications

AS 1023	Protection of electric motors - Current sensing protection devices for a.c. motors
AS 1029	Part 1, Low Voltage Contactors (up to and including 1000 V AC)
AS 1042	Direct Acting Electrical Measuring and Indicating Instruments and their Accessories
AS/NZS 1158.1	Road lighting - Vehicular traffic (Category V) lighting
AS/NZS 1158.3	Road lighting - Pedestrian area (Category P) lighting
AS 60947.4.1	Low-voltage switchgear and controlgear - Contactors and motor-starters - Electromechanical contactors and motor-starters
AS 60947.4.2	Low-voltage switchgear and controlgear - Contactors and motor-starters - A.C. semiconductor motor controllers and starters
AS 1243	Voltage Transformers for Measurement and Protection
AS 1284	Electricity metering - General purpose induction watthour meters
AS 1675	Current Transformers for Measurement and Protection
AS 1775	Air Break Switches, Isolators and Fuse Combination Units (up to and including 1000 V AC and 1200 V DC)
AS 1930	Circuit Breakers for Distribution Circuits
AS 1931	High Voltage Testing Techniques
AS 1939	Classification of Degrees of Protection Provided by Enclosures for Electrical Equipment
AS 60269.1	Low-voltage fuses - General requirements
AS/NZS 60265.1	High-voltage switches - Switches for rated voltages above 1 kV and less than 52 kV
AS 2067	Switchgear assemblies and ancillary equipment for alternating voltages above 1 kV
AS 62271.200	High-voltage switchgear and controlgear - A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV.
AS 2184	Moulded Case Circuit Breakers
AS 2374	Power Transformers
AS 2024	High voltage a.c. switchgear and controlgear - Switch-fuse combinations
AS 2650	High voltage ac switchgear and controlgear - common requirements
AS/NZS 3439.2	Low-voltage switchgear and controlgear assemblies - Particular requirements for busbar trunking systems (busways)
AS 3000	SAA Wiring Rules
AS 3111	Approval and Test Certification for Miniature overcurrent Circuit Breakers
AS/NZS 5000.1	Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV
AS 3439.1	Low Voltage Switchgear and Control Gear Assemblies Part 1 - Type Tested and Partially Type Tested Assemblies

AS/NZS 2293.1,	Emergency Evacuation Lighting for Buildings Part 1: System Design, Installation and Operation
AS/NZS 1429.1	Electric cables – polymeric insulated for working voltages from 1.9/3.3 kV up to and including 19/33kV.
AS/NZS 1660	Test methods for electric cables – Test requirements – Power cables with extruded insulation for rated voltages from 1.9/3.3 kV up to and including 19/33kV.
AS/NZS 2373	Electric cables – twisted pair for control and protection circuits
AS/NZS 4805	Accessories for electric cables – test requirements – Power cables with extruded insulation for rated voltages from 1.9/3.3 kV up to and including 19/33kV.
BCA	Building Code of Australia

The following standard specifications form part of the Contract:

STD-EL-001

STD-EL-002

STD-EL-003

STD-EL-004

STD-EL-005

4.2 Regulations

Electricity Supply Act (1995) NSW.

Supply Authority Conditions of Supply and Consumer Metering.

Occupational Health and Safety Act 1983

5 GENERAL REQUIREMENTS

5.1 Site Location

The contractor shall familiarise himself with site conditions, including any requirements for access to plant and equipment.

5.2 Site Visit

A compulsory site visit must be made to confirm the site conditions, limits of contract, etc. The site visit will be advised during the tender period.

5.3 Design Responsibility

The Contractor shall be responsible for all design aspects of the project regarding functionality, safety, ratings, dimensions and layout of the electrical systems based on the drawings. This includes MCC, LCSs and cubicle general arrangements, equipment selection for Type 2 co-ordination, cable sizing, and cableway sizing and routes.

Determine the final conduit and cable ladder routes with the Council, before any installation commences.

5.4 Drawings

5.4.1 Required Drawings

The Contractor shall produce the following drawings based on the tender drawings:

1. General Arrangements and equipment layouts for MCC, LCSs, instrumentation panels, marshalling panels and junction boxes;
2. Single line diagrams;
3. Schematics diagrams;
4. Termination diagrams,
5. Label Lists;
6. Equipment schedules;
7. Cable schedules;
8. Cable block diagram;
9. Cable and cableway layouts;
10. Equipment and instrument layouts;
11. PLC Rack/Slot Layout & Network Diagrams

5.4.2 Interpretation of the Tender Drawings

The tender drawings are indicative only and show the preferred layout, arrangement, style and format for the drawings that are required to be submitted by the Contractor. The drawings developed by the Contractor for this project shall be developed based on the tender drawings.

6 SWITCHBOARD INSTALLATION

6.1 General

Liaise with the Switchboard supplier to determine the lifting facilities required to off load the switchboards at site. Provide appropriate lifting facilities and take delivery of the main switchboard. Lift switchboards using lifting rods inserted through the lifting loops in the switchboard support frame or by specifically provided lifting lugs. Ensure that there is no damage to the switchboard.

Fix the switchboards in the nominated positions. After fixing the switchboard to the floor slab, seal the base to the floor slab with grout or silicone sealant.

Fix into concrete using 10 mm diameter grade 316 stainless steel chemical or expansive type masonry anchors. Set the anchors strictly in accordance with the manufacturer’s recommendations.

Place a fibre or insulating washer between any dissimilar metals i.e. between stainless steel, aluminium alloy and galvanised steel).

All switchboards must be manufactured in accordance with EL03 – Preferred Electrical Equipment, EL14 – General Switchboard Requirements and EL15 – Low Voltage Switchboards.

7 ELECTRICAL EQUIPMENT INSTALLATION

7.1 Scope

This section specification details the technical requirements for installation of electrical equipment as specified.

7.2 Local Control Stations

All drives, shall have a Local Control Station (LCS) complete with full load whole current isolators (up to 100A), local control pushbuttons and emergency stop.

LCS for bioreactors, flow splitters, FSTs, pump stations, and similar structures shall be mounted on the walkway stanchions using suitable “Unistrut” (or equivalent) 316 stainless steel brackets and mounting poles. LCSs shall be mounted so that the front face of the LCS does not intrude into the walkway area.

LCS for mixers shall be installed in locations on the nearby handrail that provide safe clearance to install and remove mixers.

7.2.1 LCSs for Indoor Locations

The enclosure shall be constructed from 2.0 mm minimum, zinc sealed mild sheet steel, painted orange in accordance with this specification and sealed to IP50 to AS 60529. Operating equipment may be mounted on the external door provided the IP50 rating is maintained.

These LCSs shall be fitted with an overall door with a minimum of two chrome plated lift-off pintle hinges, and with a lockable 'T' handle. The door shall be sealed to IP50 in the same manner as MCC module doors.

7.2.2 LCSs for Outdoor Locations

The enclosure shall be constructed from 1.6 mm minimum, 316 stainless sheet steel, No. 4 finish or equivalent finish, and sealed to minimum IP65 to AS 60529.

All operating equipment shall be mounted on hinged escutcheons held closed with fasteners detailed in this specification. Push-buttons and isolator handles (if applicable) shall be sealed to IP65, and the exposed parts shall be non-corrodible. The push-buttons shall be fitted with protective rubber boots.

All incoming and outgoing control cables shall be terminated on rail mounted tunnel terminals.

These LCSs shall be fitted with an overall door with a minimum of two 316 stainless steel lift-off pintle hinges, and with a non lockable 'T' handle. The door shall be sealed using closed-cell neoprene foam stripping glued to the door and held in place with gasket retaining angle.

Where LCSs contain emergency stopping devices, these shall be mounted on the side of the panel to allow for ready access.

Where LCSs are to be column mounted, the support column shall be manufactured from 75 x 75 mm RHS and have a 250 x 250 mm base plate with four mounting holes. The column shall be mild steel,

protected as per the requirements of TSC Standard Specification EL06 – Corrosion Protection for Mechanical and Electrical Equipment and Structures.

The height of the column shall be such that the base of the LCS is approximately 1200 mm from the base plate level. The column shall be raised by 50 mm of grout to prevent the collection of water around the base plate.

Where the inside of the RHS is used to protect cables for LCSs, all machining, forming and drilling for cable entries etc. shall be done prior to painting.

7.3 Equipment Location

The general arrangement and layout drawings are indicative layout of cableways and equipment locations. The Contractor shall make allowance for the equipment and instruments locations to change within their relevant areas.

The Contractor shall design, supply and install cableways of complying size in suitable locations to reach all equipment. Consideration shall be given to access to equipment for maintenance and free movement of personnel around the site.

7.4 External Plant Lighting

All lighting levels shall be in accordance with AS 1158.3 and AS 1158.1. External plant lighting shall be provided to illuminate the external area to allow for safe operation of the plant.

The Contractor shall be responsible for the design, supply, installation, termination of all external plant lighting including light fittings, mounting brackets, poles and control equipment, PE cell and light push buttons for roadway, car park, walkway and general area lighting.

Lights shall be supplied and installed generally as shown in locations on the lighting layout drawings. The Contractor shall make allowance in their offer for the lights locations to change within their relevant areas.

Roadway and car park lighting shall be controlled by PE cells on each circuit or group of circuits. Each PE cell shall have a maintenance bypass switch.

All general area lighting shall be controlled by two way switching. Switching shall be by momentary push buttons rated to IP56. One group of push buttons shall be located in the Control Room and the second group of push buttons shall be located on the access points of various bridges, walkways, and structures. The lighting circuits shall be controlled via the PLC and contactors. A bypass switch shall be fitted to the DB board to override the circuits independent of the PLC. PLC fail relays shall be incorporated to place the lighting circuits in the on state in the event of PLC failure.

Walkway lights shall be mounted on the handrail using suitable “Unistrut” (or equivalent) 316 stainless steel brackets and mounting poles.

Discharge floodlights shall be mounted on hot dipped galvanised lampposts of suitable height.

7.5 Buildings Light and Power

The Contractor shall supply, install, and terminate all buildings internal light and power. The Contractor shall be responsible for the supply and installation of a suitably sized light and power DB in each switchroom. The DB shall have the required spare capacity. The location of the DBs shall be determined in consultation with the Superintendent on site.

The final sub-circuit details for the building light and power are not shown on the cable schedules or on the drawings. The Contractor shall amend the cable schedule to include all buildings light and power circuits installed.

The Contractor shall design the buildings lighting to meet the lighting levels as specified in AS 1680.1 and AS 1680.2.

The lighting for each building shall be connected to multiple circuits within each area within the buildings. Switching shall be arranged to provide switching of the area lights at each entry/exit point of an area.

The Contractor shall supply and install emergency lighting to meet the requirements of the Building Code of Australia. Emergency Lighting shall comply with AS/NZS 2293.1 Emergency Evacuation Lighting for Buildings – Part 1

The Contractor shall supply and install cables for the building air conditioners.

The Contractor shall allow for the units to be located in the vicinity of the area being air conditioned with scope for minor change in the unit configuration and/or location.

7.6 Area Power Outlets

The Contractor shall install IP56 32 Amps 3 phase outlets and 10 Amps single phase socket outlets with RCD protection for external power.

7.7 Spare Capacity

The Contractor shall allow for the following spare capacity to be left on cable ladders, cable tray and in conduits, at the point of Practical Completion:

1.) Cable ladder and tray - 25 % of the width of any ladder or tray

2.) Conduits - 50 %, after the conduit occupancy conditions set out in E2 of Appendix E, AS 3000, have been met

8 VENDOR PACKAGES

8.1 General

In some cases equipment will be supplied to the Council by an equipment vendor as a complete package. In most cases these packages require power only to be connected to a local control panel. Where relevant, the council will free issue these packages to the Contractor. The Contractor shall install the vendor packages. The Contractor shall supply, install and terminate all cabling and above ground cableways to the vendor packages. Council will provide as much available detail about the vendor package but it is the contractor's responsibility to satisfy himself that the information provided, is comprehensive enough to completely install all electrical, instrumentation and

communication services. This may include control and instrumentation circuits, I/O, remote I/O modules.

9 CABLING

Cables shall be installed on the cable ladders. Cable routes from the ladders to the equipment shall be determined on site and approved by the Council before installation.

Cable routes to luminaries and GPO's shall be determined on site and approved before installation. Circuit cables shall not be looped at welding outlets.

The temperature rating of cables into light fittings shall be suitable for the temperature within the fitting. Sleeving and taping shall not be accepted as a substitute for correctly rated cables.

Top entry into light fittings, GPO's and welding receptacles is not permitted in outside or wet locations.

Cables installed shall be suitably located, taking into account the operation of mechanical plant.

Cables shall be protected from ultra violet light damage over their entire length.

Cables shall be handled with all due care. At no time shall a cable be handled such that it takes up a radius less than its permissible bending radius. When laying or snaking the cable, no twists or kinks shall be allowed to occur.

Unless approved, all cable being drawn into place shall be run on sufficient rollers to ensure that it is kept clear of the ground or other obstructions. Vertical rollers shall be used at all points of change in direction unless otherwise approved.

Any damage occurring to a cable (including the serving) shall be reported to the Council before work on the particular cable proceeds.

The bending radius of cables shall not be less than the minimum recommended by the Manufacturer or the following, whichever is the greater:

Cables up to 0.6/1kV	Unarmoured with PVC sheath:	9 times outside diameter
High voltage cables	Single & 3Core with HDPE sheath:	25 times outside diameter

All cables shall be routed and terminated in such a manner to allow extra length for a re-termination.

Any winch used to pull cables shall have automatic limitation of the tension exerted. The tension shall not exceed that specified by the manufacturer for the cable and conditions applying. If winch ropes are used, they shall be attached to the cable using steel mesh stocking grips.

Plastic cables shall not be permitted to come into contact with petroleum substances such as grease, oil or petrol which are injurious to plastic cables. Only lubricants which are not injurious to the cable sheathing may be used and then only when approved.

The ends of cables shall be sealed in an approved manner on completion of erection or laying. Cables shall be installed in continuous lengths without joints, except where approved. Where joints are approved, they shall be carried out using suitably sized two part epoxy termination kits which provide a weatherproof joint, or approved heat shrink termination kits.

Cable installation methods shall comply with the Supply Authority regulations and the AS/NZS 3000 Electrical installations and as follows:

Voltage drop and maximum demand calculations shall be submitted prior to installation.

Power and instrument cables are to be separated by a minimum of 300 mm

The Contractor shall supply and install final sub-circuit cables to the respective equipment

Cables shall be installed to minimise the effects of electromagnetc interference and harmonic interference

Outgoing cables shall be 0.6/1 kV grade PVC/PVC cables glanded through gland plates provided or through the base of the switchboard. All cables entering or leaving the motor control centre shall be firmly anchored to prevent cable movement. Where cable gland plates are not provided, cables are to be glanded and fixed to the panel as required

All power and control cables supplied under this Contract shall be circular, 0.6/1kV, copper conductor, PVC sheathed, PVC insulated, V75 type cables manufactured in accordance with the requirements of AS 3147 unless otherwise noted in cable schedule.

All 4-20 mA analogue field wiring shall be DEKORON twisted pair instrumentation cable with an overall screen. Each black and white core of the cable shall be numbered.

9.1 Cable in Cable Ladder

Cables installed on cable ladders shall comply with the following requirements:

1.) Cables shall be neatly laid in parallel runs with a minimum of cross-overs.

2.) Motor power and control cables shall be installed in accordance with the layout drawings. The routing of light, general purpose power and earthing cables can be determined on site with the approval of the Council

3.) Cables on cable ladder shall be fixed to all rungs of vertical ladder and to at least every second rung on horizontal runs. They shall be fastened with saddles, clamps, or nylon cable ties which are resistant to ultraviolet light.

4.) Cable clamps shall be installed every 20 metres on long vertical runs of ladder to avoid undue stress on cables. They shall be installed in such a manner that no magnetic circuit is maintained through any supporting steelwork forming part of the clamp. The cable ties shall be heavy duty black nylon or PVC UV resistant with a stainless steel fulcrum.

5.) Cables shall be secured and installed in accordance with the cable manufacturer's recommendation.

6.) Cable ties shall be secured so as not cut into the cable sheathing or insulation.

7.) The maximum number of cables tied together shall not exceed 4 or an overall diameter of 100mm. Cables greater than 50mm out diameter shall be fixed separately.

8.) Separation of electrical power (low voltage and above) cabling from Profibus fieldbus and instrumentation cabling shall be achieved through separate cableways. However, where this is not practical, a metal divider barrier shall be installed on the cable ladder to separate these cables.

9.) Power and 240V AC control cables shall be segregated by a 100mm space where run on the same cable ladder.

10.) Where cables leave the ladder routes, segregation shall be maintained by spacing power and 240 & 110 VAC control cables a minimum of 100mm apart, and maintaining mechanical separation between power and instrument cables.

11.) Single core power cables shall be fixed in close trefoil formation by metal trefoil or 4 way clamps, up to as close as practical to the cable glands. Parallel trefoil circuits shall be installed with symmetric phasing as per AS3008.1 Appendix A.

12.) Power cables and control cables installed on the same ladder shall be run on opposite side of the ladder.

13.) Power cables on cable ladder shall be spaced to achieve maximum rating. Where single core cables are installed, they shall be in trefoil formation and spaced one cable diameter apart from other cables or groups of trefoils.

Power cables and 240V control cables shall not be run in conduits with Profibus fieldbus and instrumentation cabling.

PLC bus and Ethernet cables shall be securely mechanically protected from damage when running through cable pits by using Anaconda metallic conduits.

Control cables, lighting, small power and earth cables may be installed with motor power cables where necessary.

All fixing holes for brackets, ladder, rack, etc. shall be drilled. Flame cut holes are not permitted. Debris from hole cutting in an enclosure shall not be allowed to fall within the enclosure.

9.2 Conduits and Pits

This contract includes the supply and installation of all conduits and pits. Conduits shall be sized to allow for the correct derating of cables. At no stage should the voltage drop as determined in Australian Standards be exceeded.

9.3 Cable in Conduits

Graphite or other similar cable pulling lubricants recommended by cable manufacturers shall be used to limit cable-pulling tension. Conduit space loading of cables shall not exceed 40% of the total conduit cross-section. After installation pull cords shall be left within the conduits for future cable installation. All pit lids shall be reinstated after installation and inspection by the Contractor.

10 CABLE LADDER, TRAY AND CONDUIT

The cable ladder installation shall be designed to eliminate the effects of galvanic corrosion by the use of spacers where aluminium ladder is in contact with galvanised steel or stainless steel.

All cable ladder, tray and accessories (fish plates, covers etc.) shall be marine grade (6061 - T6) aluminium while all conduit and saddles shall be stainless steel grade 316. All nuts and bolts shall be stainless steel grade 316.

Cable ladders and associated accessories (splices, covers etc) shall be to NEMA 20B standard with 300mm maximum rung spacing. Rungs shall be welded to the ladder sidewalls. Ladders shall be supported at intervals such that when fully loaded with a load of 112 kg/m2 of cable ladder surface area, plus a mid span point load of 114 kg, then the deflection shall not exceed 1/300 of the span length.

Fibre washers or some suitable insulating medium between dissimilar metals shall be used.

All cable ladder supports shall comply with the following requirements:-

1. Cable ladders shall be mounted on suitable brackets fixed to concrete or structural steel members. Fibre washers or some suitable insulating medium between dissimilar metals shall be used
2. Cable ladder hangers and brackets shall be sized so that the fully loaded ladder is rigidly supported.
3. Fixing of cable ladder supports to the side of concrete walls or beams shall not be less than 60mm from the concrete edge. Fixing to structural steel shall be by welding unless otherwise directed and approved.
4. Cable ladders shall not be supported directly under splice plates.

Each splice plate shall be connected to the individual ladder sections using at least two (2) bolts.

Ladder sections shall be bolted together, not welded, and bolts shall not protrude inside the ladder where they may damage cables during installation.

Cable ladder runs shall be bonded to the earth grid via 120mm, green/yellow PVC covered cable at one end of each run, at the nearest available substation or MCC earth bar.

Where a section of cable ladder run is not continuous (i.e. an air gap exists), a 120mm² Cu G/Y PVC earth shall be installed to bond across the break. All cable ladder joints shall be similarly bridged.

Covers shall be installed on cable ladder where cables are exposed to sunlight or where exposed to mechanical damage. Where ladder is run vertically, the cover shall be attached to both sides where cables are exposed to sunlight or damage.

External Cable ladders shall be fitted with sheet metal covers as follows:-

Ladder mounting	Cover type
Horizontal Ladder	30° peaked cover
Edgewise Horizontal Ladder	Solid flat cover
Vertical Ladder	Solid flat cover

Cable ladder shall be mounted to maintain 300 mm vertical clearance between ladders and at least 150 mm clearance under structural sections.

Cable ladder shall be installed to maintain a minimum head clearance of 2100 mm above floors and walkways.

Where the back of a ladder is exposed to direct sunlight or mechanical damage, the back of the ladder shall be covered or otherwise protected in a manner approved by the Council. Chairing brackets shall be provided on the bottom edge of horizontal edgewise cable ladders, to support the covers.

Prior to installation, all cable ladder runs shall be checked for interference with piping, equipment and structures. The relevant drawings of other disciplines shall be examined in the Contractor's office. Any changes to the cable ladder location shall only be made where directed and approved by the Council.

When changing cable ladder run direction the preference is to use manufactured bends, tees and risers. Where this is not possible due to space constraints, the ladder may become discontinuous but must be made electrically continuous with bonded earth straps.

Continuous runs of cable ladder exceeding 30 metres without 90 degree bends and exposed to direct sunlight, shall have provision for expansion using the manufacturer's standard expansion fittings. Ladder hold down clamps shall allow for lateral movement and support brackets shall be provided on both sides of the expansion fittings.

Cable ladders shall be clamped or bolted as appropriate; they shall not be welded into position.

Supports for cable ladders shall be arranged such that cables can be lifted onto the ladders rather than threaded through supports.

Cable ladders shall be installed to enter buildings with a rising gradient to prevent water ingress. The ladders shall enter the building at a level at least 50mm above the lowest point of the ladder.

10.1 Conduit Systems

Where cable is not installed on cable ladder or in underground conduit, it shall be installed in an open conduit system for cable support and protection. Conduits and ducts shall be installed as required and at any location where additional mechanical protection of cables is required.

Conduits exposed to direct sunlight and/or mechanical damage shall be manufactured from Grade 316 stainless steel complying with AS2052. Conduits in other locations not exposed to sunlight may be heavy duty orange rigid PVC complying with AS2053.

Ends and joints in steel conduits shall be properly made off, using the correct fittings and bushes for cable protection. The threads of screwed fittings shall be coated with anti-seize compound before assembly.

All conduit fittings and junction boxes shall be of a manufacture compatible with the conduit being used. All surface conduit fittings of the inspection type shall be provided with neoprene gaskets.

Unless otherwise shown on the Drawings, conduit elbows and tees shall not be used. Changes in directions shall be by bends, large radius sets in the conduits, or by using junction boxes, or pull in boxes.

Cut ends of all conduits shall be filed smooth prior to installation.

Damage to galvanised coatings shall be repaired with zinc rich protective paint.

All UPVC conduits and ducts shall be sealed with a permanent plastic waterproof compound, in particular spare conduits that are provided in a substation.

10.2 Conduit Systems for Unarmoured Cable

Where unarmoured cable is not installed on cable ladder or in underground conduits and is installed in locations less than 2100mm above walkway or access level, a conduit system shall be installed for cable protection. The conduit shall protect the cable to within 211mm of the termination and a standard weatherproof cable gland termination installed. A shroud shall then be installed over the conduit and cable gland and secured with cable ties. At motors and LCSs, flexible Grade 316 stainless steel conduits with proper fittings shall be installed to protect the cable between the motor gland plate and the point of cable exit from the cable ladder or conduit system.

Coaxial cables of ultrasonic instruments, load cell cables of weight instruments and similar un-armoured fragile cables shall be enclosed in a continuous run of steel or flexible armoured conduit

throughout their length. Flexible armoured conduit shall be used to make the final connection to the field device using proper conduit termination fittings.

10.3 Conduit Systems for Armoured Cable

Conduit may be used to support armoured cables only provided it has been cleared of internal projections and cut ends are filed round.

10.4 Fixing To Structural Steelwork

Structural steelwork shall not be drilled, welded or cut without the Council's written approval.

The Contractor shall ensure that any welding to structural members does not reduce the strength of that member.

10.5 Frameworks and Fixings

Unless otherwise specified all framework and fixing accessories for the support of cables, cable ladders, joint boxes, distribution boards and all other electrical apparatus and equipment shall be provided and fixed by the Contractor.

Where designed by the Contractor, details of all supports for equipment and cables shall be submitted for approval by the council before work is commenced.

The Contractor shall be responsible for "making good" any damage to civil works or steel, including paintwork, resulting from electrical installation works.

11 CABLE TERMINATIONS

11.1 General

All cable terminations shall be bottom entry unless approved by the Council.

All cores in every cable shall be terminated at spare terminals in switchboards and Manual Control Panels unless specifically indicated otherwise in the tender drawings

All cables shall be terminated using cable glands, lugs and fittings of the correct size and type supplied by the Contractor.

11.2 Cable Glands

Cable Glands for non-hazardous and intrinsically safe circuits shall be Alco type "WG" for armoured cables and Clipsal Class 12 type or Alco Type UA for unarmoured cables, or approved equivalent. Cable glands for flame proof installations shall be Alco type FLPW. Glands installed in outdoor locations shall be fitted with shrouds of the correct size attached to the gland with cable ties.

Threads of metal glands shall be coated with anti-seize compound before assembly.

11.3 Cable Lugs

11.3.1 General

Lugs shall be manufactured from tinned copper and sized to suit the cable.

The Contractor shall use compression tools approved by the manufacturer of the lugs.

Where hand operated compression tools are used they shall be of the type which will not release until full compression is applied. Hexagonal crimping dyes shall be used on all cables of 70 mm² cross section and above where compression tools are used.

Lugs shall be of the type most suited to the device terminal e.g. fork tongue for stud terminals, and wire pin type for tunnel type terminals. Only one wire shall be crimped in each terminal lug or pin.

All conductor strands shall be effectively crimped in the terminal lug. If strands are broken or separated during conductor preparation, the termination shall be re-made. Conductor insulation shall end well inside the lug insulation.

The Contractor shall apply a pull test to each core of each cable (including terminated spare cores) to verify that the core is properly crimped and is firmly held by the terminal.

11.3.2 Termination of Power Cables

All power cables shall be connected with a suitably sized lug unless the equipment (circuit breaker, contactor or thermal overload or field device) has tunnel type terminals and the conductor size is larger than 2.5mm2.

Lugged power circuit connections shall be made with high-tensile, electroplated steel or phosphor bronze bolts, with a large flat washer and spring locking washer under the bolt head.

It shall be possible to check the tightness of all connections, by removing covers if necessary, when the switchboard is completely assembled.

Provision shall be made in the termination area to allow circuits to be checked with clip-on type ammeters.

11.3.3 Termination of Control and Instrument Cables

Control and instrument cable cores connected to tunnel-type terminals shall be terminated using pin lugs and Grafoplast of the correct size for the conductor. The lug shall be crimped using a ratchet crimping tool (Grafoplast YAC-5 or approved equivalent) prior to insertion into the terminal. Crimping shall not be effected using the terminal screw alone.

For terminals requiring ring or fork lugs, Utilux or approved equivalent pre-insulated lugs and "TRASP" label carriers shall be used.

Not more than two wires shall be terminated on any one stud type terminal. Not more than one wire shall be terminated in any tunnel type terminal. Where multiple connections are required on tunnel terminals, multiple terminals linked with proprietary terminal link bars shall be used.

The Contractor shall terminate every core in every control and instrument cable at spare terminals in switchboards and Local Control Stations unless specifically indicated otherwise.

All cables which terminate to instruments shall have a single or double coil of cable approximately 150mm diameter before the cable gland.

11.4 Special Termination Requirements

In addition to the above general requirements for termination, the following specific requirements shall be noted.

11.4.1 High Voltage Terminations

High voltage terminations shall be carried out by a certified HV cable jointer using approved high voltage termination kits (Raychem, Remtek, Sigmaform or approved equivalent) and high voltage glands (Alco PLA or approved equivalent), installed strictly in accordance with the manufacturer's instructions for the particular cable.

High voltage terminations and joints once started shall be worked on continuously until completed unless otherwise approved by the Council.

Cable cores shall be neatly spread and crossovers avoided. Cable armour shall be earthed using armour clamps.

Bolted connections shall be fully insulated using right angle and in line sleeves such that bushings are fully covered up to the mounting steelwork.

The HV terminations to the transformer terminals shall be insulated with heat shrink boots where suitable or otherwise with tapes. Bolts shall be fitted with Belleville washers.

Final HV cable terminations shall not be made to equipment until HV cable tests have been completed; i.e. cables shall be tested separately from equipment.

The Contractor shall notify the Council so that all high voltage terminations may be inspected prior to covers being installed.

Approved hydraulic compression tools shall be used for lugging cables 50mm^2 and above; and the die shall be of the circumferential type.

HV cable connections at HV switchboards shall be by compression lugs and fully insulated heat shrink terminations.

11.4.2 Terminations at Switchboards and Enclosures

The Contractor shall ensure that when cables are terminated at switchboards and other enclosures, the arrangement of wiring in ducts within the switchboards complies with the segregation requirements of AS3000 i.e., extra low voltage wiring such as the conductors within 'Dekoron' cable shall not be in the same wiring enclosure with cables carrying a voltage higher than 110V. The Contractor shall supply the necessary barriers to provide segregation.

When cables are terminated at existing switchboards which have no facilities for glanding, the cable shall be securely fastened to limit movement and shall be lugged and ferruled in accordance with this specification.

The protection (IP) rating of the switchboard shall be achieved by the glanding of the cables, not the glanding of the conduits enclosing the cables entering the switchboard.

11.4.3 Termination of Earth Cables

All earth cables shall be terminated on a copper busbar, or an equipment earth terminal. Not more than one earth shall be terminated on any one terminal.

Where cable shields are present, they shall be earthed at the MCC end only.

11.4.4 Terminations at Motors

1. Terminal Boxes

The terminal boxes on all motors will be provided with gland plates by the motor manufacturer. Regardless of how motor terminal boxes arrive on site, the Contractor shall be responsible for making the required modifications and providing the required equipment to carry out a proper termination. This shall include drilling of gland plates, adapting terminal boxes and reorientation of terminal boxes as necessary.

Cables terminated to equipment such as motors etc. shall be run in non-metallic flexible conduits that shall offer excellent protection from abrasion, sunlight, mild acids, alkalies, and oils. Such flexible conduits shall be UV resistant and coloured grey. Flexible conduits shall be run from the mechanical support to the equipment junction box. Flexible conduits shall be terminated using stainless steel terminating adaptors. The correct sized cable glands shall be used to connect the cable to the terminal box or gland plate.

2. Connections

If the motor terminal box contains links to allow a star or delta winding connection, the Contractor shall make the appropriate connection for the supply voltage.

3. Rotation

The Contractor shall be responsible for reversing the phase connections of those motors found to be rotating in the wrong direction during testing. The phase connections shall be reversed at the motor terminal box to maintain consistent phase colouring for the entire motor circuit.

11.5 Terminations at Field Equipment using Flexible Cords

Solenoids, proximity switches, Flygt level switches and other items of equipment with DIN type plugs or similar connections not suitable for direct termination of ordinary circular cable shall be connected in the following manner: -

The supply cable shall be terminated at a junction box supplied by the Contractor, close to the device.

If the item is supplied with a plug, then flexible cord with 1.5mm² conductors shall be run from the junction box to the plug.

If the item is supplied with a flexible cord (e.g. Flygt level switch), the cord shall be connected to junction box.

The flexible cord shall be run in conduit for the whole of its length and shrouds fastened at each end with cable ties.

The Contractor shall supply this type of termination if required for solenoids or field instruments, regardless of whether it is called for on the Contract drawings.

For terminations in sewage wells, the flexible conduit shall be glanded as described in the termination of motors 11.4.4. – Ray, don't know which section this is supposed to relate to

12 CABLE IDENTIFICATION

12.1 Cable Number Tags

The Contractor shall provide and fix cable number tags clearly and indelibly indicating the cable number, which shall be permanently strapped to each end of every power, control and instrument cable, and at such other points as the Contractor may require. At switchboards and other places where both sides of a cable gland plate cannot be viewed from the one location, cable number tags shall be fitted to cables both above and below the gland plate.

Where a cable is external to the switchroom (i.e. exposed to the weather) the 316 stainless cable number tags shall be used. The Contractor shall attach the stainless tags to the cable with 316 stainless ties using the correct tool to prevent sharp exposed ends forming.

The Contractor shall use the specified suppliers of the internal and external cable number tags as specified in standard specification STD-EL-003 Preferred Electrical Equipment List

12.2 Ferruling of Cable Cores

The cores of every control and instrument cable, including those at switchboards, marshalling boxes and wherever such cables are connected, shall be ferruled with wire numbers which correspond with the relevant termination diagrams, equipment drawings and schedules.

"Grafoplast" SI2000 type ferrules as described above shall be fitted to each end of each core. Ferrules shall have black letters on a background of white insulating material. Circular type, clip-on ferrules, or saddle type clip-on numbers shall not be used.

The same ferrule number shall be used on wires forming connections directly in series or parallel in the same panel.

Where cables for different items of equipment are terminated at the one location (e.g. field marshalling box) and wire numbers are the same for the different items, then each wire number shall be prefixed with the item equipment number to distinguish between the cores. This shall be done whether or not it is shown on Contract drawings.

Ferrules shall be arranged to read from bottom to top and from left to right.

All ferrules shall be arranged so that they are completely visible without disturbance to the wiring.

12.3 Penetrations

The Contractor shall make all penetrations through walls and floors, other than those provided in structures by civil works, which are necessary for the installation of cables, cable ladder and conduit. Penetrations shall not be made without permission from the Contractor.

After completion of erection, the Contractor shall seal all holes in floors and walls and all cable pipes through which pass cables, conduits or earth bars.

Where a penetration is made through a weatherproof surface, adequate weatherproofing shall be carried out to seal the hole. All cable holes passing through watertight decks and bulkheads shall be thoroughly sealed against the passage of moisture or liquids. All Contractor installed conduits passing through weatherproof surfaces shall also be sealed after cable installation.

Cable ladder entries into sub-station buildings shall be sealed with "Zellemite" panel or equivalent, scribe fitted and sealed with "Henley" green compound after completion of cable installation. The Contractor shall test the seal to ensure its water-tightness.

13 EARTHING

The earth system installation and reticulation shall comply with the relevant requirements of AS3000 and the requirements of the Electrical Authority.

Copper joints required for testing purposes and joints between copper lugs and busbars shall have joint faces tinned and shall be arranged for bolting together.

Earthing points shall be provided on all electrical enclosures and the Contractor shall ensure that all enclosures and items of mechanical equipment are effectively earthed.

All metal gland plates shall be earthed. Glands fitted to plastic or painted steel gland plates shall be earthed using proprietary gland earthing lugs.

Radial connections to both the earth grid and equipotential bond systems shall be PVC yellow/green insulated, Cad-welded (exothermic) to the grid/bond conductor and lug bolted to equipment.

Conductor size shall be copper and sized in accordance with AS3000 but shall be at least a minimum of 6mm^2.

Connections to the earth electrodes shall be by means of cad welding which shall be housed in an earthenware or concrete pot or as approved by the Council and fitted with a lid at ground level.

Where the base of electrical equipment is not bolted to the general mass of structural steel, the equipment shall be bonded to the structure by an insulated earth cable unless otherwise approved by the Council.

Exposed connections between dissimilar metals such as copper and stainless steel shall be protected against corrosion by painting with zinc rich paint.

Multiple earth connections within equipment shall terminate at earth bars, with one conductor per screw, stud or tunnel type terminal. Tunnel type terminals shall have two screws.

An earth conductor shall be connected to all high voltage cable glands unless otherwise required by the protection system.

Cable armour and lead sheath shall be earthed at both ends via a suitable cable glands and earth connections.

14 INSTRUMENTATION INSTALLATION

14.1 General

The installation shall be carried out in an organised and workmanlike manner by competent tradesmen in accordance with the best current practice.

Instrument enclosures and fittings shall be suitable for the prevailing environment and hazardous area classification of the area. Instruments shall be treated with due care and installed in accordance with the manufacturers instructions.

Field mounted transmitters shall be mounted 1500mm above ground or walkway level.

The use of spring girder clips is not permitted.

The Contractor shall be responsible for estimating the lengths required for services, e.g. air galvanised pipe, stainless and copper tubing for air, and stainless steel impulse tube.

'Installation detail' drawings in the contract are diagrammatic and the exact routing, arrangement and supporting shall be approved by the Council prior to commencing work.

The Contractor shall ensure when making screwed connections that the male and female threads are of the same size and form before making the joint.

Transmitters shall be enclosed in their own weatherproof enclosure and in addition, those mounted outdoors shall be shaded by 316 stainless steel covers with sides, drip hood, back and door. The metal enclosure shall have 100mm clearance around the transmitter and the sides and top shall protrude 100mm in front of the transmitter.

All brackets and mounting bolts etc for sensors and transmitters shall be 316 stainless steel.

14.2 Instrumentation

The Contractor shall supply all instrumentation for the works, excluding:

1. vendor package instrumentation;
2. where otherwise notified by Council.

The Contractor shall carry out installation of all instrumentation.

The Contractor shall supply, install and terminate all cabling to the instrumentation as per the tender drawings, cable schedule and I/O list.

It is the Contractor's responsibility to ensure that any instrument offered is suitable for the application. The Contractor shall be able to choose a desired instrument make and model from any of the listed instrument suppliers. The Contractor shall then supply the nominated instrument.

For some instrumentation (eg magnetic flowmeters) the instrument primary element is installed as part of the civil works. In this case the Contractor shall install the instrument transmitter and connect to the primary element.

All instrumentation located external to a building, and not housed in an instrument panel, shall be supplied with a suitably sized stainless steel enclosure with a door

14.3 Instrument Mounting and Accessibility

Instruments shall be installed to facilitate ease of operation, inspection and maintenance and shall incorporate all safety measures necessary to protect operating and maintenance personnel.

Where equipment is mounted along or in access ways, it shall be positioned so that it does not present a hazard to vehicular traffic or personnel using the access way.

Instrumentation shall not be supported from handrails or from steel work or plant which may be subject to vibration, except as approved by the Council.

Instrumentation shall be installed in such a manner that it is serviceable or replaceable without the aid of a ladder or scaffolding, except as approved by the Council.

Field instruments shall be located as close to primary connection as consistent with instrument accessibility.

Dial thermometers, pressure gauges shall be plainly visible and accessible from grade or platform.

The mounting of equipment and/or accessories on, or saddling cables to building cladding shall not be permitted under any circumstances.

All brackets and supports shall be so constructed that vibration from wind, operation of surrounding equipment, etc. is negligible.

Drilling holes in and welding of brackets, etc. on pressure vessels is strictly forbidden.

Under no circumstances, shall metal structures be drilled or have any metal removed.

Mounting of instruments on process piping shall only be allowed for those circumstances where alternative off line mounting would render the instrument unserviceable.

14.4 Instrument Stands and Brackets

Brackets and instrument stands shall be made from 316 stainless steel.

Instrument stands shall be located as close as possible to the process tapping points within the following constraints:

1. Location and height of the instrument on the relevant 'Layout' drawings.
2. An optimum working height of 1500mm above grade.
3. Location and height of the instrument according to the typical 'Installation Detail' drawings.
4. Stands shall not be affixed to grating or hand rails unless indicated otherwise on drawings.
5. Where stands are not located on paved areas, a concrete plinth typically 300mm square by 400mm deep, shall be cast in the ground with no more than 100mm projecting above the grade level and the stand bolted to this.

Loxins or dynabolts may be used for securing stands to the concrete pavement.

Spacers shall be used to permit concrete grouting to take place after installation.

Column mounted stands shall be clamped. Welding may be allowed under certain situations but requires approval from the Council.

Customised stands may be needed in some applications. Approval from the Council is required before fabrication commences.

More than one instrument may be mounted on each instrument stand with approval from the Council.

A method of attaching a label to the stand is required. The labels shall not be mounted on the instrument, but as close to it as possible. Each instrument and piece of equipment shall have a Tag Number or Equipment Number.

14.5 Labels

All apparatus shall have fitted to non-detachable parts of equipment conspicuous labels conforming to the following requirements:

Equipment	Type of Label	Function
Pushbutton Identification	Engraved W-B-W laminated plastic	Circuit and equipment

Junction boxes, distribution boards, marshalling boxes and miscellaneous components	Engraved W-B-W laminated plastic	Component and circuit identification on as applicable
Control Cable cores	Ferrules with black lettering on white background	Core number of connection diagrams
Cable number tags	Non-ferrous	Cable number as on cable schedule
General Purpose	Engraved W-B-W	Board of origin
Outlets, light switches	Laminated Plastic	Fuse or circuit breaker number
Fuses and MCB's	Engraved W-B-W laminated plastic	Circuit and rating
Instruments	Engraved W-B-W laminated plastic	Instrument tag number per instrument list.

Colours shall be permanent and free from fading. All designation labels shall be engraved with black lettering on a white background and each shall be of an approved size and material.

Labels for outdoor use shall be brass or stainless steel infilled black.

Plastic labels shall have bevelled edges and slotted fixing holes to allow for differential expansion of label and base without distortion of label. Label retaining screws shall leave the label free to slide as it expands.

Labels shall be securely fixed to the equipment, using not less than two stainless steel fastenings. Label fixings shall be such as to allow ready replacement without damage to the label or fixing.

14.6 Signs

The Contractor shall supply and install approved resuscitation signs in all Control rooms, Switchrooms and Substations.

14.7 Instrumentation & Marshalling Panels and Junction Boxes

14.7.1 Instrumentation & Marshalling Panels

The panels shall be designed, constructed, and installed in accordance with the tender drawings and clause 7.4 of this specification except where modified below.

Panels shall preferably be proprietary units as nominated in TSC Standard Specification EL03 – Preferred Electrical and Instrument Equipment.

There shall be 20% spare space on terminal rails for the installation of future terminals.

The internal control wiring shall be terminated on rail-mounted terminals and ferruled in accordance with the Contract drawings.

Where terminals are linked in a marshalling box, they shall be linked using the correct proprietary link strips, not by use of looped wire connections.

If the box contains wiring at voltages above 120V A.C. then live terminals shall be shrouded to IP20 to protect against accidental contact when the door is open. These shrouds shall have danger labels in accordance with this specification. In addition, the door of the box shall be labelled with a red/white/red label marked “DANGER 240V or 415V, ISOLATE ELSEWHERE”.

A stainless steel (infilled with black) label complying with this specification shall be fitted to the marshalling box, bearing the equipment number in 7mm letters and the equipment title in 5mm letters.

Marshalling boxes shall be fitted with an overall door with a minimum of two lift-off pintle hinges, and which is held closed by 4 acorn headed nuts or 6 such nuts if the box exceeds 1000mm in any direction. The door shall be sealed to IP65.

Marshalling boxes shall be fitted with gland plates manufactured from a single piece of 6mm thick aluminium plate.

In addition to the above general requirements, marshalling boxes shall comply with the following requirements depending upon their location.

14.7.2 Instrumentation & Marshalling Panels for Outdoor Location

The enclosure shall be constructed from 1.6 mm minimum 316 Stainless Steel and sealed to IP65 to AS 1939.

The hinges and all fittings on these boxes shall be 316 stainless steel and the enclosure shall be bottom entry unless approved by the Council.

14.7.3 Instrumentation & Marshalling Panels for Indoor Locations

The enclosure shall be constructed from 2.00mm minimum, non metallic material (FRP or equivalent) and sealed to IP65 to as 1939. The hinges and all fittings on these boxes shall be 316 stainless steel.

14.7.4 Junction Boxes

Junction boxes shall be of robust construction and of adequate size suitable for the application.

Internal mounted junction boxes shall comprise a polycarbonate enclosure, "Fiskars", "Vynckier" or approved equivalent, with an opaque lid.

External junction boxes shall be stainless steel grade 316.

A 3 mm or 6 mm removable aluminium gland plate shall be fitted to the bottom of each junction box, of sufficient size to accommodate all cables with 25% spare space.

Each junction box with more than four terminals shall be fitted with vertical terminal strips of sufficient length to accommodate all terminals with 25% spare rail space.

14.7.5 Junction Box Lids

Lids of all junction boxes shall be fitted with gaskets. All boxes shall have a degree of protection of IP65 or better.

14.8 Instrumentation Panels & Marshalling Panel

Instrumentation Panels are required to house transmitter and analysers that do NOT have an IP65 rating and are located external to any building.

Marshalling panels are required to house transient barriers and marshalling terminals for any instruments that are supplied with 4-20mA cables external to the building.

15 CONTROL, PLC AND COMMUNICATION INSTALLATION

15.1 PLC Hardware

The Contractor shall supply all PLC hardware unless otherwise notified by the Council. The Contractor shall install this hardware in the appropriate MCC/PLC cubicle. Refer to TSC Standard Specification EL03 – Preferred Electrical and Instrument Equipment for the type of PLC hardware to supply.

The PLC I/O to be wired shall be as per the I/O lists.

Signal voltages for digital inputs shall be 24V DC. Digital outputs shall be the relay output type. Analogue inputs and outputs, where required, shall be 4-20mA, fully isolated.

I/O density of cards shall be as follows:

- 32 point digital input cards
- 16 point relay output cards
- 8 point analogue input cards
- 4 point or 8 point analogue output cards

For digital input and output cards, dedicated wiring looms from cards to marshalling terminals shall be provided.

All digital and analogue external circuits shall be powered from a 24V DC power supply provided by the Contractor.

Spare capacity in the PLC system shall be provided as follows:

1. Installed spare I/O shall be 20% of each type used.
2. Spare rack/backplane space shall be 20%

15.2 Devicenet network

The Contractor shall install the Devicenet data network in accordance with the network diagrams,

The Contractor shall supply and install the nominated Devicenet cable, connectors, and equipment. The Contractor shall follow best practice installation techniques for the DeviceNet networks according to the equipment suppliers and standards as per the Open DeviceNet Vendor Association. (ODVA)

The Contractor shall demonstrate to the Council that the Contractor has fully complied with the requirement of the equipment suppliers with regard to earthing.

Any DeviceNet network external to the MCC switchroom shall be primarily run in plastic fibre-optic cable. Link Modules shall be installed where required to provide any interface connections. Each Link Module not in the switchroom shall be installed in a junction box located next to associated equipment to minimise the RS485 cable lengths.

The Contractor shall use the nominated DeviceNet cable stripping tool when fitting the cable connectors.

16 DELIVERABLES BY THE CONTRACTOR

16.1 Tender

The following information shall be supplied with the tender:

1. Letter of Offer;
2. Company Details;
3. Structure of the proposed work team including CVs of all supervisors/leading hands;
4. Details of five (5) reference projects including project description, contract value, duration and referees;
5. Completed technical schedules;
6. Completed pricing schedules;
7. Detailed program of works.

16.2 Post Award

The following information shall be provided by the Contractor after contract award. Drawings shall be electronically supplied using either AutoCAD Electrical or Lite.The Contractor shall nominate the dates for each item to be delivered on the detailed program of works to be provided:

1. Electrical drawings including:
    1.1 General arrangement layouts for MCC, LCSs, Control Stations and junction boxes;
    1.2 Label Lists

1.3 Equipment schedules

1.4 Single line diagram;

1.5 Schematics diagrams;

1.6 Termination diagrams,

1.7 Cable schedule

1.8 Cable block diagram;

1.9 Cable and cableway layouts;

1.10 Equipment and instrument layouts.

2. Quality Assurance documentation;
3. Safety Plan;
4. Construction plan;
5. Detailed programme of work;
6. Training plans
7. Test and commissioning plans
8. Operations and Maintenance Manuals

Draft copies of all documents shall be submitted for approval. Comments from Council shall be incorporated before final documents are submitted.

16.3 Final Design

The final design outputs shall include but not be limited to:

1. A complete set (paper copy and AutoCAD Electrical for Electrical Drawings drawing files) of fully detailed “As Constructed” drawings
2. Quality Assurance documentation (including test plans).
3. Test and Commissioning Plans.
4. Operations and Maintenance Manuals

16.4 As Constructed Drawings

1. During all stages of the work, the Contractor shall maintain as constructed records on site. Records shall be available for inspection by the Council at any time.
2. Further to the requirements of the General Conditions of Contract regarding the Certificate of Practical Completion, the Contractor shall be required to provide "As Constructed Drawings" approved by the Council prior to the issue of the certificate.
3. As constructed information shall be amended on AutoCAD drawing files of the contract drawings. As-constructed amendments shall be identified by clouding on the drawings. Drafting standards shall be equal to the standard of the base drawings.
4. As constructed drawings shall be marked "As Constructed", signed and certified by the Contractor as being a true representation of the works as-constructed

16.4.1 Drawings

Drawings supplied by Council shall be marked-up by the Contractor to serve as an accurate record of underground services on site that shall indicate:

1. Relative location of cable conduits and pits
2. Cables numbers and cable details installed in each conduit
3. Spare conduits

The Contractor shall confirm cable and termination requirements with a Council site representative prior to ordering and installation to ensure that requirements at the time of writing the specification have not altered.

16.4.2 Schematic and Termination Drawings

The Contractor shall mark-up all site installation details on schematic drawings supplied by either Council or the equipment supplier showing:-

1. Termination details such as cable number, cable details, spare cores, wire numbers and terminal numbers
2. Any authorised circuit changes found necessary
3. Any other drawing detail changes or errors that have been picked up during the contract.

16.5 Submission of Drawings and Data

Drawings and data is to be submitted in stages for review as follows:

Approved For Construction Drawings and Data

Within two (2) weeks after receipt of the Contractor drawings listed above, the Council will return 2 copies of the drawings to the Contractor with one of the following endorsements:

(i) Accepted

(ii) Accepted subject to incorporation of comments - resubmit after corrections

(iii) Not accepted - resubmit.

The Council's review is only for acceptance of general conceptual design and for suitability in terms of dimensional constraints, e.g. overall arrangement, location of access, etc. It does not in any way diminish the responsibility of the Contractor to comply with any of the specified requirements.

Following receipt of accepted drawings, the Contractor shall resubmit each drawing to the Council, endorsed "For Construction".

16.6 Project Scheduling

The Contractor shall provide a detailed program of works in their offer.

The work shall include but not limited to dates for:

- Contract Award
- Quality Assurance Documentation, Safety Plan, Construction Plan
- Electrical Drawings For Approval
- MCC Metalwork inspection
- Submission of copies of draft O&M manuals
- MCC Factory Inspection & testing

- Access to Site
- Installation Work
- Commissioning Plan
- Submittal of O&M Manual
- Completion of rectification work (if necessary)
- Submission of final O&M manuals.
- Practical Completion

16.7 Operation and Maintenance Manuals

Operation and Maintenance manuals shall be produced in electronic and hardcopy format.

Operation and Maintenance Manuals shall be in accordance with TSC Standard Specification EL18 – Operating and Maintenance Manuals.

17 TESTING AND COMMISSIONING

17.1 Inspection and Testing

Workshop and site testing of MCCs and electrical installation works shall be carried out as per the details listed in this specification.

17.2 General

This section describes the project specific commissioning requirements to achieve Completion. Construction and commissioning testing shall include, but not be restricted to:

1. Design acceptance operation to demonstrate that all equipment and systems can be successfully and reliably operated under working conditions.
2. Submission of final Operations and Maintenance manuals.
3. Submission of any outstanding Work as Executed (WAE) records for all work under the contract including re-submission of any WAE drawings that may require amendment as a result of changes during the commissioning process.
4. Continuous operation of the whole of the works for seven (7) consecutive days without any faults. During this period, if any faults occur, the 7 day test shall recommence for a further 7 days, after the fault has been rectified.

The Contractor shall produce all necessary documentation records as verification that Installation Testing and commissioning has been successfully completed. An up to date copy of developing test records shall be present on site at all times during construction and commissioning for information and review.

As a minimum, testing/commissioning records shall contain the following information:

1. Description of the test or commissioning function.
2. Applicable ratings, equipment numbers and location of facilities.
3. Minimum test values that comply with the codes, standards and regulations.
4. Test results, including comments where necessary, for clarification.
5. Details of any corrective action taken.

Where facilities fail to meet acceptable standards or the intended function during testing and commissioning, the Council shall be immediately advised.

All high voltage testing and protection testing shall be carried out by experienced personnel who are certified by a recognised testing authority to carry out such work.

All high voltage tests shall comply with the requirements of AS 1931.

Relay settings to which high voltage protection relays shall be calibrated, will be advised.

The Contractor shall provide all temporary barriers and warning signs, including signs on switchboards, MCCs etc., to adequately protect and warn of danger during testing and commissioning periods as directed by the Engineer.

Should the plant fail any test, the Contractor shall take any actions deemed necessary by himself or the Council to correct the failure and repeat the test.

All necessary tests shall be performed and recorded before energising any equipment or circuit.

Should any dispute arise from test results so recorded, such tests shall be repeated by the Contractor as directed by Council.

The results of all tests shall be retained by the Contractor for handing to the Council. These tests shall be of a form, type and presentation as approved by the Council. The test sheets shall be witnessed and dated. Failure to supply these test certificates shall result in the tests being repeated at the Contractor's expense.

17.3 MCC Workshop Inspection and Testing

17.3.1 General

The Contractor shall carry out inspections and routine testing in accordance with AS 3439.1.

The Contractor shall give written notice to advise the Council 5 working days prior to the commencement of testing so that testing may be witnessed by a representative of the Council. The tests shall include the following:

17.3.2 Inspections

Equipment shall be checked against the Single Line Diagram to ensure that the correct type, rating and number of circuits has been installed. The Single Line Diagram shall be marked up to properly reflect the finished switchboard and copies forwarded to the Contractor.

The following items shall be checked:

1. busbar configuration and support system for consistency with Type Test Certificates;
2. sealing of fully welded seams is satisfactory;
3. equipment mounting and cable supports to ensure adequate fixing and bracing;
4. operating handles and interlocks for correct functioning;

5. withdrawable equipment for free movement, operation of shutters and interlocks;
6. clearance and creepage distances and degrees of protection;
7. doors and access covers for sealing;
8. bolted and screwed connections for tightness and adequate contact;
9. label wording and annunciator window engraving against relevant schedules.
10. I/O spare capacity

17.3.3 Electrical Testing

Power circuits insulation shall be tested using a 2500V 'Megger' or approved equivalent voltage test unit. Control wiring shall be tested at 500V only.

Semiconductor equipment such as variable frequency drives, programmable controllers and instruments shall not be voltage tested.

High current micro-ohm resistance tests shall be carried out individually on all joints in the main circuit supply including connections to each outgoing unit. For outgoing units larger than 150A, all power connections in the outgoing unit shall be tested. Resistance measurements shall be recorded and examined for inconsistent and unusually high readings.

17.3.4 Required Test Instruments

All test instruments and equipment shall be provided by the Contractor as required to carry out the complete range of tests in accordance with this specification.

Test equipment shall include but shall not necessarily be limited to the following:

- A suitably rated 3 phase primary injection test set.
- Secondary injection test set Freja or Dobel Type, NATA certified.
- High potential DC cable test set NATA certified.
- Insulation resistance testers (Meggers) rated at 500V, 1kV and 5kV.
- Earth resistance tester

17.4 Protection and Indicating Devices

All current operated protection devices shall be tested by secondary injection.

Protection systems, in particular differential protection systems, shall be tested as a complete system from the current transformers back to the protection relay.

All earth leakage relay units shall be checked for correct setting and installation of wiring, and shall be tested by both primary injection and operating the test trip button.

Connecting cables shall be tested for insulation resistance and continuity in accordance with Clause 3.2 of AS 1023 Part 1. Operation of all alarms & trips shall be checked by safely simulating a fault condition.

All ammeters, transducers and other current operated metering devices shall be tested and calibrated by secondary injection testing.

17.4.1 Functional Checking

Each and every control wire in the switchboard shall be checked for correct function and checked against the schematic drawings. These drawings shall be amended to reflect the final connections of the switchboard as despatched from the workshop. Copies of these marked schematics shall be submitted to the Council.

If the Council carries out spot checks of the completed switchboard and discovers inconsistencies with the drawings provided, then the Contractor shall retest the whole switchboard in the presence of the Council.

All control circuits shall be energised at their operating voltage and pushbuttons, and indicating lights and switches installed to fully simulate all field devices. Each feature of the circuit shall then be checked by operation of the switches and pushbuttons.

Variable frequency drives shall be tested by monitoring speed changes of a small three phase motor while the VF drive input signal is being varied. The Contractor shall provide the motor.

All protective relays shall be tested at three points on their protection curve by secondary injection.

All current transformers and direct connected metering and protection equipment shall be tested by primary injection to prove correct polarity and CT ratios for ratio error and phase angle error.

Each analogue loop shall be injected with a variable input signal equivalent to its specified input and the signal shall be varied over its entire range to test the operation of associated indicators, controllers and recorders. In the case of controllers, outputs shall be monitored and the setpoints checked for correct operation including the operation of any associated process alarms.

The Contractor shall provide marked up drawings and test sheets detailing the results and extent of the above tests.

17.5 Testing - At Site

17.5.1 General

Comprehensive electrical tests, as listed below, shall be performed to prove correct operation of the system.

All equipment which fails the tests shall be repaired and/or replaced and then re-tested until the tests are passed successfully.

All tests shall be recorded on approved test report forms. Where testing involves insulation or current measurements then actual readings shall be recorded on test report forms.

Sample forms shall be submitted for approval at least six (6) weeks prior to commencing any tests.

The Council reserves the right to witness any test. The Contractor shall give written notice of intention to test, not less than seven days prior to commencing any test.

When conducting continuity and high voltage tests, particular care shall be taken to avoid subjecting semiconductor devices such as variable frequency drives, earth leakage circuit breakers, thermistor relays and PLC inputs and outputs to a test voltage exceeding the rating of the device.

17.5.2 Power Transformers

The following tests shall be performed immediately following the taking of delivery of the transformers.

1. Inspection for oil leaks and damage which may have occurred during transportation.
2. A 1000V Megger test between windings and between windings and earth.
3. Check dielectric breakdown strength of insulating oil.

The following checks and tests shall be performed before energising.

1. Check all terminations are correct, covers applied and bolts tight.
2. Check the taps and set as directed.
3. Check the pressure of sealing gas and recharge if necessary as directed.
4. Check operation of all auxiliary alarm and trip devices such as winding temperature indicators and pressure switches.
5. Perform a 1000V Megger test prior to energising.

The following test shall be performed after energising.

1. Check the voltage after twenty-four hours on-load operation.
2. Monitor for 24 hours after energisation for oil leaks and temperature rise.

17.5.3 High Voltage Circuit Breaker Panels

The following tests shall be performed on high voltage circuits as a minimum requirement.

1. A 5000 V Megger insulation test shall be performed on site handover of the equipment for installation and immediately prior to energisation.
2. The power frequency test voltage shall be applied for 1 minute and shall be the 90% value as given in Table 11.1 of AS 2067.
3. Phase rotation of potential transformer secondaries and phasing of all HV circuits shall be checked.

17.5.4 Switchgear - Low Voltage

1. Inspect for damage and missing parts.
2. Check line out of switchboard for level, vertical alignment and continuity of level between panels. Results shall be within the manufacturer's required tolerances, and no deviation will be accepted.
3. Check tightness of foundation and structural bolts.
4. Check tightness of busbar connection bolts.

5. Check tightness of cable and wire terminations.
6. Check all earth connections are correct and are connected to the earth grid. Check resistance of main earth cable from earth busbar to earth grid.
7. High voltage insulation tests on busbars between all phases and from each phase and neutral to earth, and across circuit breaker and switch open contacts using 1000 V test voltage and one minute test duration.
8. High current microhm resistance test across incomer cable termination, across incomer switch in closed position, and from incomer to outgoing terminals of every power circuit over 150A.
9. Check phasing of all incoming and outgoing circuits.
10. Operate each device (switch, circuit breaker, contactor, overload, etc,) to prove correct operation.
11. Check operation of door handles, mechanical interlocks, etc and freedom of operation of electrical switches.
12. Check operation of key interlocks, where installed.
13. Check fuse holders for damage and fuses for continuity and correct rating.
14. Check and adjust setting of circuit breakers, thermal overloads, timers etc.

17.5.5 Cables - High Voltage

1. Carry out high voltage tests and insulation resistance checks between all cores and between each core and ground in accordance with AS1026 and AS1459.
2. Power frequency test at a voltage level recommended by cable supplier.
3. A 60 second 5000V insulation resistance test and sheath integrity test before and after the Voltage test.
4. Carry out continuity check on each core.
5. Check tightness of all terminations.

17.5.6 Cables - Low Voltage

1. Insulation resistance test between all cores and between each core and ground, using 1000 V test voltage and minimum one minute test duration.
2. Continuity test on each core.
3. Check all cable terminations are in accordance with termination diagrams. Termination diagrams shall be marked up, signed and handed to the Council as evidence of these tests.
4. Check cable size and cable number labels against cable schedule. Cable schedules shall be marked up, signed and handed to the Council as evidence of these tests.
5. Check tightness of all terminations.

17.5.7 Instrument Cables

1. Continuity test on each core.
2. Check all cable terminations are in accordance with termination diagrams. Termination diagrams shall be marked up, signed and handed to the Council as evidence of these tests.

3. Check cable number label against cable schedule. Cable schedules shall be marked up, signed and handed to the Council as evidence of these tests.

4. Check tightness of all terminations.

17.5.8 Motor Circuits

1. Insulation resistance test of motor between phases and ground, using 1000 V test voltage and minimum one minute test duration.
2. High voltage resistance test across open local isolator contacts (if applicable).
3. Resistance test of motor windings, between phases.
4. Resistance test of motor winding for each phase compensate for 25°C
5. Earth conductor resistance measurement from motor to MCC earth busbar. Resistance shall not exceed one ohm.
6. Full simulation test of all control devices, operating all devices individually and in combination to prove correct operation.
7. Motor rotation direction test.

17.5.9 Earth System

Earth resistance tests shall be carried out using a recently calibrated earth tester, in accordance with manufacturer's directions.

Measure earth resistance at switchboard earth busbar, when connected to the station earth grid.

Where earth electrodes have been installed, the following tests shall be carried out:

1. Measure earth resistance of each electrode, with electrode isolated.
2. Measure earth resistance of local earth grid with all electrodes connected together but isolated from other earth connections.

17.5.10 Specialised Equipment

Equipment not covered by the general tests listed above shall be fully tested in accordance with the manufacturer's directions and as directed by the Council. Information supplied with the tender shall be grouped and arranged as per the following grouping.

APPENDIX A – Technical Tender Schedule – Instrumentation Technical Schedule

APPENDIX B – INSTRUMENTATION LIST

APPENDIX C – I/O LIST

APPENDIX D – STANDARD SPECIFICATIONS

APPENDIX E - TENDER DRAWINGS

APPENDIX F – CABLE SCHEDULE

APPENDIX G – SAMPLE PHOTOGRAPHS