TECHNICAL SPECIFICATION ELECTRICAL INSTALLATION SPECIFICATION

TCC-TTS-SPEC-E002

Revision History

Revision	Status	Prepared by	Reviewed by	Approved by	Date
0	Issued for Use	D Philipson	L Eastlake	T Laveti	25/09/2025

Contents

1. Introduction

1.1. Purpose

This standard covers the installation requirements for Townsville City Council Electrical Installations.

1.2. Scope

This standard specifies the Townsville City Council requirements for electrical installations, including but not limited to:

- Cabling
- Earthing
- Requirements for certain types of equipment
- Instrumentation Installation
- Inspection and Testing

1.3. Electrical Specification Manual

This document forms part of the Electrical Installation section of the TCC Electrical Specification Manual (ESM) and shall be read in conjunction with other documents in the ESM and the Job Specification to determine the requirements for a particular project.

The intention of the ESM is to provide consistency in electrical design and installation requirements that will better enable council to fulfil its duties in the delivery and implementation of their electrical works.

Contractors shall comply with all requirements in this document and the documents referenced in TCC-TTS-SPEC-E001 Introduction to Technical Specifications, unless specified otherwise.

1.4. Exceptions and Feedback

Should the contractor propose any exceptions, deviations or variations from this specification or referenced documents, such variations shall be submitted in writing to the TCC Nominated Electrical Representative for approval.

If there exists a requirement that is unclear or ambiguous, the Contractor shall contact the TCC Nominated Electrical Representative for clarification and feedback.

2. General

2.1. Quality of Materials and Workmanship

The quality assurance requirements of TCC-TTS-SPEC-E001 apply to this standard.

2.2. Qualified Personnel

All works shall be carried out by qualified personnel as specified in TCC-TTS-SPEC-E001 Workmanship.

2.3. Environmental Conditions

All equipment shall be suitable for operation in a tropical coastal environment.

Unless specified otherwise in the Job Specification, the environmental operating conditions are specified in TCC-TTS-SPEC-E001.

2.4. Service Conditions

Unless specified otherwise in the Job Specification, the Service operating conditions are specified in TCC-TTS-SPEC-E001.

All equipment shall be installed to minimise excessive vibration, noise, heating, and radio frequency interference.

2.5. Rating and Duty of Equipment

Unless specified otherwise in the Job Specification, the Rating and Duty of Equipment are specified in TCC-TTS-SPEC-E001.

2.6. Standardisation

All items of equipment having equal or similar functions will be of the one manufacture and of similar appearance, finish, mounting arrangement and the like.

2.7. Fire Protection

The contractor shall detail specific methods employed to limit the risk, effects and spread of fire. Refer to TCC-TTS-SPEC-E001.

2.8. Master Keying

Unless specified otherwise in the Job Specification, Master Keying will be provided as specified in TCC-TTS-SPEC-E001.

2.9. Corrosion Protection

Unless specified otherwise in the Job Specification, Corrosion Protection will be provided as specified in TCC-TTS-SPEC-E001.

2.10. Liaise with Distribution Network Service Provider

Unless specified otherwise in the Job Specification, Liaison with DNSP will be provided as specified in TCC-TTS-SPEC-E001.

2.11. Interruptions to Electrical Supply

Unless specified otherwise in the Job Specification, existing TCC installation supply will be managed as specified in TCC-TTS-SPEC-E001.

2.12. Point of Electrical Supply

The point of supply can be either a URD type pillar or a property pole as required to meet both supply authority requirements and site flood levels. If a property pole is used it must be positioned so that aerial cables are not installed across entrance roads, pump wells or vehicle working areas. Property poles and installation is to be certified by an RPEQ in accordance with Supply Authority requirements.

Where riser brackets are utilised, they are to be certified by an RPEQ in accordance with Supply Authority requirements.

Where underground conduits are installed for Supply Authority use, their position is to be accurately marked up on a site plan and certified by an RPEQ.

2.13. Installation Design Information

This is to be provided as per TCC-TTS-SPEC-E003.

3. Specific

Specific requirements are required only where particular equipment is used or specified by the Job Specification.

3.1. Cable Ladder

In secured areas of Council installations, Cable ladder shall be installed as the primary method of cable support. Cable ladders shall be installed as per the main cable routes on the drawings. Where cables leave the main cable tray routes, the Contractor shall submit to the TCC Nominated Electrical Representative proposed cable support methods required to access items of equipment. In the absence of cable ladder installation requirements specified by TCC, NEMA VE 2 shall be referenced.

Unless specified or directed otherwise, cable ladder shall be heavy-duty aluminium type NEMA 20B. Cable ladder to be installed in wet or corrosive areas shall be GR316 stainless steel. The TCC Nominated Electrical Representative shall make the decision as to what constitutes wet or corrosive areas.

Cable ladder shall be installed such that the Manufacturer's loading recommendations are not

exceeded and the ratio of maximum deflection to span length shall not exceed 1:200.

Cable ladders shall be supported at a maximum span of 3000mm for horizontal runs unless the ladder supports required by the Job Specification specify otherwise. However, in no case shall any span exceed 6000mm. For vertical and edgewise horizontal runs the maximum span shall be 1500mm.

Cable ladder joins shall be within 150mm of a support except for spans greater than 3000mm, which shall have joins at the centre line of the support. Where the ladder support provided does not allow the above specified supports, additional supports and brackets shall be installed.

Cable ladders fittings and supports shall be installed so that they cannot be bent out of position or distorted during the installation period.

All cable ladder, ladder cover, barrier strip and accessories shall be installed in accordance with the Job Specification and the manufacturer’s recommendations. Where components of cable ladder structure are in contact and of dissimilar metals, installation shall ensure galvanic isolation to prevent corrosion.

All racks, fixing brackets, nuts, bolts, spring and flat washers, etc. shall be stainless steel, unless specified otherwise.

Cable ladder systems shall be continuous and shall be built with standard proprietary fittings: all changes in direction being made with curved fittings and changes in ladder size being gradual.

Specially manufactured fittings or changes in direction with ladders on different vertical planes shall not be used unless approved by the TCC Nominated Electrical Representative.

Change in direction shall allow for the specified minimum bending radii for the largest cable but shall never be less than a bending radii of 450mm.

The minimum clearance to cable ladders including underside of supports shall be 2100mm above

floors, platforms, walkways and stairs.

In general, the vertical spacing between horizontal cable ladders shall not be less than 400mm bottom to bottom unless noted otherwise on the Drawings.

All ladder racks exposed to sunlight shall be fitted with covers regardless of the arrangement.

The covers shall have the same protective coating system as the cable ladders and shaped as

follows:

- Horizontal Ladder 30° peaked cover
- Edgewise-Horizontal Ladder Solid flat cover
- Vertical Ladder Solid flat cover

Covers shall be fixed strictly in accordance with the Manufacturer's recommendation; however, self-drilling screws shall not be acceptable.

Where the back of a ladder is exposed to direct sunlight, process material or mechanical damage, the back of the ladder shall be covered or otherwise protected in a manner approved by the TCC Nominated Electrical Representative.

Chairing brackets shall be provided on the bottom edge of horizontal edgewise cable ladders, to support the covers.

Welding or oxy cutting on cable ladder shall not be permitted.

Prior to installation, all cable ladder runs shall be checked for interference with piping, equipment and structures. Any changes to the cable ladder location shall only be made where approved by the TCC Nominated Electrical Representative.

Continuous runs of cable ladder exceeding 30m without 90° bends and exposed to direct sunlight, shall have provision for metal expansion.

Supports for cable ladders shall be arranged such that cables can be lifted onto the ladders rather than threaded through supports, unless shown otherwise on the drawings.

Cable ladders shall be installed to enter buildings with a rising gradient to prevent water ingress.

The ladders shall rise at least 50mm immediately prior to entering the building.

As an alternative to small cable rack and where not specifically detailed in the drawings, cables may be installed in stainless steel or aluminium conduit attached to the structure.

Where cables transition from cable tray to underground conduits or ducts, they shall be protected to a minimum 1500mm above FGL and 150mm below FGL.

3.2. Conduits and Culverts

3.2.1. General

Conduits and culverts shall be installed as shown on the Drawings and at any location where additional mechanical protection of cables is required.

Conduit material shall comply with the following:

- Underground conduits, for power circuits, shall be heavy duty, rigid UPVC to AS 2053, orange in colour.
- Above ground conduits shall be heavy-duty seamless GR316 stainless steel or aluminium for pumpstations and treatment plants. A suitable rigid conduit as required by Australian standards is acceptable in commercial and public installations.

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.

For above ground installations, 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 or pull in boxes.

The minimum nominal size of conduits shall be as follows:

- 25mm for lighting circuits and general purpose power and instruments.
- 32mm for all other circuits.

All underground conduits and ducts shall be buried to a minimum cover depth of 600mm or to a depth approved by the TCC Nominated Electrical Representative.

All UPVC conduits and ducts shall be sealed with permanently plastic waterproof compound, in particular spare conduits that are provided at the site.

Conduit runs shall be installed square to the equipment as far as possible and shall have a minimum of direction changes.

Metallic conduit ends are to be suitably covered to prevent cuts or damage to cables.

For in-ground installations, changes in direction of underground conduits may only be achieved by the use of approved draw-in pits, or as otherwise approved by the TCC Nominated Electrical Representative.

All in-ground buried conduits are to be fitted with a suitable non-perishable draw string.

In secured Council installations Conduits are not to be continuous to enclosures and are instead to be terminated prior to the enclosure with heat shrink applied to prevent moisture ingress. Where an area is unsecured or conduit is entering an enclosure via a floor level plinth then Conduits may continue to enclosures as long as appropriate sealing of conduit ends is provided, and the non-enclosure end of the conduit is not hydrostatically higher than the enclosure entry, and Approval obtained by TCC Nominated Electrical Representative.

3.2.2. Cable Culverts

Where cable tray routes intercept and crosses roads the cable trays shall be installed under the road surface in precast concrete culverts. The culverts shall be installed such that precast concrete covers provide a continuous, level road surface to the surrounding grade. Covers shall be load rated for the applicable traffic class.

Cable trays shall be continuous throughout the culvert and shall be supported on Unistrut or similar mountings. Where possible the culverts shall have the relevant Unistrut fittings cast into the walls. All vertical bends shall be fully supported on large radii cable tray bends. Cable tray covers shall be maintained continuously throughout the duct.

The culverts shall be installed with minimum 1:500 fall to one end and provision shall be provided to allow for the removal of water from the culvert i.e. drainpipe to adjacent drain or permanent sump for

installation of transportable pump. Surrounding pit structures shall be constructed proud of the surface to prevent run-off water entering the duct.

3.2.3. Underground Conduits

Prior to commencing any works associated with the installation of underground cable conduits, the Contractor shall make arrangements to inspect the route with the TCC Nominated Electrical Representative.

The Contractor shall make all necessary precautions and arrange for all necessary permits to ensure that all existing services are identified prior to commencing excavation and that adequate protection is provided to same services during trenching activities. The Contractor must also provide suitable exclusion barriers to prevent public access to the excavation.

The Contractor shall clear the area along the line of the trench to a minimum distance of 2m on both sides of the trench. If any vegetation is required to be cleared, approval must be sought, once approved all vegetation within the trench corridor shall be cleared and removed from the site. All stumps and roots with 1000mm of the sides of the trench shall be grubbed to a depth of 300mm.

Unless directed otherwise by the TCC Nominated Electrical Representative, all trenches shall be excavated in ground along the trench line to the depth and width as shown on the Drawings. The trench line shall be kept as straight as possible to the planned alignment.

The Contractor shall ensure that the trench profile is maintained as close as possible to the design requirements. Where trench depth exceeds the design requirement, the bottom of the trench must be filled with selected stone free material, properly compacted to the proper grade.

Where required the Contractor shall erect shoring to prevent the sides of the trench collapsing during trenching and cable installation activities. The Contractor shall be held responsible for keeping clean and the maintenance of the trenches in good order and condition between the time of excavation and cable installation. It shall be the responsibility of the Contractor to undertake works necessary to manage any water that interferes with work progress.

After completion of trenching, the Contractor shall arrange for inspection of the trench by the TCC Nominated Electrical Representative prior to installing any cabling or conduits. Following inspection and approval to proceed, the trench shall be cleared of any sharp objects and a layer of bedding material shall be placed.

The depth of bedding material shall be such that after the cable or conduit is laid, the minimum depth of bedding between the underside of the cable or duct and the trench floor is 50mm. Bedding material shall be free from any hard sharp or abrasive material such as rocks or stones shall be laid over the cables with a minimum cover of 50 mm. Bedding material shall be Sand if not in Job Specification.

All bedding material shall be compacted to a minimum of 90% standard compaction density.

General backfill may comprise the excavated soil or imported soil provided that any material in the soil will pass through a 50mm screen. Cable protection and marker tape shall be incorporated during backfilling.

The compaction of the backfilling shall be to a density not less than the density of the existing adjacent material and to the entire satisfaction of the TCC Nominated Electrical Representative.

Backfilling shall be carefully placed in layers not exceeding 150mm, well watered if necessary, then packed and compacted by mechanical means. In existing paved areas the surface shall be reinstated to the original level and finish to the satisfaction of the TCC Nominated Electrical Representative.

3.2.4. Cable Protection and Marker Tape

Mechanical protection shall be installed over direct buried cables for their entire route as required by AS 3000 and as shown on the drawings. Direct buried cables only to be used if required in Job Specification or approval is obtained from TCC Nominated Electrical Representative. Mechanical protection shall be of approved proprietary manufacture consisting of either:

- Polymeric cable protection covers manufactured from orange coloured material. Paint or other orange coatings on the covers is not acceptable.
- Precast bricks or precast concrete. Concrete covers cast on site or in situ are not acceptable.

Orange Polyethylene marker tapes, 150mm wide and 0.1mm thick, shall be laid in the trench directly over all underground cables at a depth of 150mm.

3.2.5. Cable Markers

Underground cable route concrete markers shall be installed above all underground cable joints, at every change of direction of underground cable and on straight runs at least every 30m.

Markers shall consist of a concrete block 300 mm square 100 mm deep with an engraved brass label attached. The marker shall identify the cable and indicate its direction of lay as indicated on the Drawings. Labels shall be fixed to the concrete block with screw fixings and epoxy adhesive.

In rough terrain where concrete marker blocks are unsuitable, galvanised steel signpost type markers shall be installed.

3.2.6. Cable Pits

Where possible, cable pits shall be proprietary supplied items. Where the installation of proprietary pits is not possible the Contractor shall install cable pits as shown on the drawings.

Pits, lids and the method of installation shall be suitable for the maximum wheel loadings in the area in which they are installed.

Lids to electrical pits shall be marked “Electrical”. Lids for communications pits shall be marked “Communications”. All Pit lids installed in unsecured areas are to be special tool lockable, refer to Job Specification.

Where underground conduits are longer than 2.5m and are terminated within freestanding enclosures (eg-lighting poles junction boxes or switchboards) a pit shall be installed within 1.5m of the enclosure.

Cable pits shall:

- Be adequately sized for the number of cable/tray/conduit entries
- Be adequately sized to allow personnel access to undertake maintenance activities
- Allow for the installation of cables without contravening the manufacturer’s recommended minimum bending radius of cables during both installation and setting
- Have bell mouth fittings on all conduit entries
- Be installed 30mm above the surrounding surface and the surrounding ground graded up to the pit for a distance of 1m

3.3. Cabling

3.3.1. General

Unless otherwise indicated all cables shall have stranded copper conductors. All cabling and wiring shall be designed, supplied, and installed in accordance with AS 3000 and AS 3008. Cabling design information must be supplied by the contractor as part of the detailed design information. Requirements of design as detailed in TCC-TTS-SPEC-E003.

The minimum sizes shall be:

Cable Type	Size
Lighting	1.5mm^2
Control	1.0mm^2
Power	2.5mm^2

3.3.2. Sheath Colours

To distinguish and identify cable type by colour, the sheath colour shall be as follows:

a) Single Phase:

- Red Active
- Black Neutral

b) Three Phase:

- Red A Phase
- White B Phase
- Blue C Phase
- Black Neutral

c) Green/Yellow Earth

3.3.3. Classification

As a minimum, all internal wiring shall conform to the minimum requirements of AS 3013 category WSX2.

Usage of double insulated cables with an outer sheathing of non-UV stabilised material shall not be accepted.

3.3.4. Segregation

The following groups of cables shall be segregated from each other by continuous barriers when installed in common ladder systems or by using separate ducts or conduits:

- 240/415V power supplies.
- 240V control supplies and systems.
- Instrumentation cabling.
- ELV control supplies.
- Signal and communications systems.
- Hazardous area Intrinsically safe cabling.

3.3.5. Underground Cables

TPS cables will not be accepted unless approved by the TCC Nominated Electrical Representative.

3.3.6. General/Commercial Light and Power Cabling

For light and power installations where full protection from mechanical damage is assured, PVC/PVC and TPS cables may be used in walls and ceilings of approved installations or where allowed otherwise by AS 3000 and the BCA.

The following wiring may be permitted for building services:

- TPS cables in false ceiling areas and partition walls.
- TPS or TPI cables protected by conduit, indoors, but external to ceilings or partitions.

3.3.7. Single Core Cables

Single core cables forming part of a three-phase system shall be clamped together in trefoil over their entire route to avoid derating. The configuration of parallel trefoil circuits shall comply with the recommendations of AS 3008 Appendix B.

The clamping of single core cables in trefoil shall be of sufficient mechanical strength to withstand the forces generated by fault currents. 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.

3.3.8. Armoured Cables

Armoured cables (where required) shall be 0.6/1 kV grade comprising stranded copper conductors PVC or XLPE insulated and bedded, galvanised steel wire armoured and PVC, black sheathed, UV resistant overall. Armoured cables shall comply with AS 5000.1. Armoured cables shall be terminated in heavy compression type glands having wedge type armour clamps for steel wire armouring.

An earthing lock nut shall be used on all armoured cable glands.

3.3.9. LV Instrument and Control Cables

LV instrument and control cables shall be PVC insulated, screened copper conductors suitable for

instrumentation applications. The cables are to be PVC, black

sheathed, and UV resistant. Instrument cable pairs used for analogue signalling are to be individually and overall screened unless exempted in the Job Specification.

Hazardous Area Intrinsically Safe cabling shall have a blue sheath.

Control cables need only be overall screened.

Minimum core size of 0.5mm2 is to be used.

3.3.10. Instrument Sensor Cables

Instrument sensor cables shall be as supplied without joints or as recommended by the relevant instrument manufacturers.

3.3.11. Antenna Cabling

Where the route length of antenna cables is less than 15m, RG213 coax is to be used to connect the antenna to the radio. If the route length exceeds this then a higher specification coax, such as LDF-4, shall be used. Refer to Job Specification.

The contractor is to submit calculations demonstrating correct cable selection in terms of signal strength and dB loss. Information about calculation and testing of coaxial cabling can be provided by TCC Electrical section on request.

All antenna cable connections are to be made by N type Male or similar connectors unless approved by the TCC Nominated Electrical Representative. The connectors shall be sealed to prevent ingress of moisture, e.g., 3M Scotch rubber tape or similar.

A suitable surge diverter is to be installed on the antenna cable to minimise the effects of lightning on the radio equipment and must be earthed via dedicated earthing cabling or in accordance with manufacturer's instructions.

3.4. Cable Installation

3.4.1. General

The Contractor shall select routes for all cables except where they are specifically marked in the Job Specification. Cables shall be installed on the cable ladders shown on the drawings. Cable routes from cable ladders to equipment shall be submitted for approval to the TCC Nominated Electrical Representative before installation.

Cables shall be run with all due care, which shall include the following precautions to prevent cable damage:

- Rollers including radius rollers shall be provided and used as required.
- Cables shall not be subjected to twisting and kinking or contact with sharp edges, or any other mishandling which may cause sheath or core damage.
- Cables shall be pulled in with less than the manufacturer's maximum pulling force.

It shall be the Contractors responsibility to ensure that cable to be installed is the size and type required.

The bending radii of cables shall not be less than the minimum recommended by the Manufacturer.

Instrumentation, telephone and radio communication cables shall be kept separate from power and control cables by a spacing of at least 150mm, unless approved otherwise.

If termination or jointing is not immediately performed after cutting, all cables subject to potential damage due to moisture absorption or dirt ingress shall be effectively sealed by attachment of heat shrink caps or other methods as approved by the TCC Nominated Electrical Representative.

Cables installed by methods not covered in the following clauses shall be fixed and supported in accordance with AS 3000 or as approved by the TCC Nominated Electrical Representative.

All cables exposed to sunlight shall be covered to the approval of the TCC Nominated Electrical Representative and have UV stabilised sheathing insulation.

3.4.2. General/Commercial Power and Lighting Cables

Where cables to light fittings and GPOs are not shown on the drawings, the cable routes shall be approved before installation.

Circuit cables shall not be looped at light fittings. They shall be teed off via an approved 3 way junction box, unless allowed otherwise by the TCC Nominated Electrical Representative.

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 is not permissible on outdoor and weatherproof fittings. Top entry into GPOs and welding outlets is only permissible when the outlets are housed inside a suitable splash cover to the approval of the TCC Nominated Electrical Representative.

3.4.3. Cable Winching

Winches may be used only to install armoured cables and if used, winch ropes shall be attached to the cable armouring with steel mesh sleeves. Cables shall be pulled under controlled conditions.

When pulling cables, any winch used shall have automatic tension limiters and the tension shall not exceed that specified by the manufacturer for the cable under installation and the conditions of installation.

The cables shall be supported along the run and at deviations, by rollers spaced at 5m maximum. In addition to the cable roller fixing to the cable support system, an approved safety chain must be fitted to each roller to prevent a fall due to a failure of the primary fixing.

3.4.4. Installation in Cable Tray and Ladder

Cables installed on cable ladders shall be neatly laid in parallel runs with a minimum of cross-overs.

Motor power and control cables shall be installed in accordance with the layout drawings. The routing of general/commercial power and lighting and earthing cables can be determined on site with the approval of the TCC Nominated Electrical Representative.

Cables laid on horizontal ladder shall be fixed with adequate cable ties to preserve a neat appearance, where there is no grouping required.

Where grouping or spacing is required the cables shall be fixed every third rung or closer if necessary to keep grouped cables neatly together.

Cable ties shall be stainless steel for all areas. Cable ties shall be cut with manufacturers special tools so that no sharp ends are left protruding. Nylon or other material cable tie may be used with the approval of the TCC Nominated Electrical Representative or detailed in the Job Specification.

Cables run on edgewise horizontal ladder shall be tied at every rung.

Cables run on vertical ladder shall be fixed with heavy duty stainless steel cable ties or cable clamps, KSV or approved equivalent type, every second (2nd) rung.

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

When run on the same cable ladder, LV control cables shall be segregated from instrument cables by a barrier strip.

Single core power cables shall be fixed in close trefoil formation by metal trefoil or four way clamps, up to as close as practical to the cable glands. Parallel trefoil circuits shall be installed with symmetric phasing.

3.4.5. Exiting Cable Trays

Where cables leave the main ladder, single, double and triple cable runs shall be supported in discrete lengths of GR316 stainless steel or aluminium conduit. Each discrete length of conduit shall be bushed at each end.

Four or more cables shall be run on subsidiary cable ladder-runs additional to those shown in the Job Specification.

Unless specifically approved by the TCC Nominated Electrical Representative for temporary installations, spring clips shall not be used as a means for fastening cables.

Cables shall be protected at all times from mechanical or physical damage. Where necessary that cables are installed over or around any sharp edge, the Contractor shall provide adequate protection to prevent the outer sheath being damaged by chaffing or cutting. The type of protection used shall be submitted to the TCC Nominated Electrical Representative for approval.

All installed cables shall be labelled in accordance with this specification.

3.4.6. Installation Underground

In-ground cables shall be installed inside conduits or ducts as specified in the Job Specification. Vinidex cable protective sheeting of adequate width to fully cover and protect the cable, or its equivalent, must be used.

In all locations where cables leave the ground, cables shall be installed inside heavy duty rigid UPVC ducts and conduits of 50mm minimum size, or heavy duty stainless steel or aluminium.

Conduits shall rise 500mm above and extend 500mm below finished ground level.

Where cables cross other services, cables shall be installed inside heavy duty rigid UPVC conduit of minimum length 3000mm. Cables shall pass below other services.

3.4.7. Jointing

All Cables shall be supplied and installed in one length without joints. However, the Contractor may submit to the TCC Nominated Electrical Representative for approval any intention to install in-line joints in cables where a demonstrated cost saving is detailed.

All joints shall be effected using an approved cable joint kit as specified in the Job Specification for preferred electrical equipment. The following precautions shall be strictly observed when making through joints:

- Cables shall be laid so that the lay of the cores is maintained throughout the length of the cable.
- Crossover of conductors within cable joints will not be permitted. Any crossover shall be carried out at the termination box.
- Continuity of core numbering shall be maintained in all joints unless otherwise allowed by the TCC Nominated Electrical Representative (i.e. Joining to existing cables).
- To ensure correct phasing out of power cables, the continuity of core throughout the cable shall be confirmed before cores are terminated.

3.4.8. Sealing Penetrations, Conduits and Enclosures.

Openings made to buildings to allow entry of cable ladders or conduit, shall be suitably sealed to prevent at a minimum the ingress of rain, dust and pests. Sealing shall also be performed to a standard that will maintain any pressurisation and/or fire ratings.

Conduit stub-ups and conduit entries to cable trenches and pits shall be sealed with 6:1 sand cement mix.

Unused conduits shall be capped with screw-on PVC conduit caps.

Spare holes in junction boxes, motor terminal boxes and field control panels shall be suitably sealed with appropriate screw plugs to maintain the IP ratings of their respective enclosures.

3.5. Cable Terminations

3.5.1. General

Terminating of cables to motors and other equipment, which have a requirement to be moved for maintenance or adjustment purposes, shall be such that the motor or equipment can be moved through its range of adjustment without disconnecting or damaging the cable. Note that SWA cable must not be considered as flexible cable.

Where practicable, motor cables are to be installed so that they can be connected to either side of the motor. This is to ensure that if the motor is changed out and the terminal box of the replacement motors are on the opposite side, cables do not have to be extended. Sufficient length of cable shall be left to allow for neat and safe terminations, and removal and replacement of all serviceable plant equipment.

Instruments shall be fitted with a service loop of cable to allow easy removal of the instrument and to assist with the exclusion of water ingress.

Where it is required that SWA or other large cables be connected to equipment that is too small to accommodate the gland, or if flying leads are provided with equipment (eg solenoid valves), then cables shall be terminated in a conveniently located 2-way junction box. Alternatively, in situations where there is a very low risk of mechanical damage, PVC/PVC cables may be used at the discretion and approval of the TCC Nominated Electrical Representative. In such instances the length of the PVC/PVC cable shall not exceed 300mm, and cables shall be terminated using glands.

3.5.2. Glanding

Cable terminations shall be carried out using approved glands and gland installation method.

When cable glands are installed on SWA cables, no armour shall be exposed, and cable glands shall have ingress protection of no less than IP66.

Cable glands installed on gland plates other than brass, shall be fitted with brass earth tags and brass locknuts. Earth tags shall be individually bonded to the equipment earth bar.

Cable glands shall be of an approved weatherproof type that is consistent with the IP rating of the enclosure and if used in hazardous area must be certified for that use.

Nickel plated brass glands shall not be used in conjunction with aluminium alloy boxes or Aluminium gland plates.

PVC weatherproof shrouds shall be provided and fitted for glands mounted outdoors or in readable visible areas. The shrouds shall be ALCO SG type or approved equivalent.

All gland plates shall be drilled to the sizes required by the cable gland.

The gland sizes shall conform to the manufacturer's recommendations for the required cable size.

Cable entries in switchboards and panels, shall be installed in such a manner as to permit the orderly accommodation of the total potential requirement for cable glands at each location. Each gland will have only one cable per gland, unless approved by the TCC Nominated Electrical Representative.

3.5.3. Cable Cores

All cable terminations shall be made using crimp lugs.

Crimp lugs shall be crimped with an approved crimp tool. Where hand operated crimping tools are used, the tools shall be of the type which will not release until full compression is applied.

Hexagonal crimping dies shall be used on all cables of 70mm^2 cross section and above.

Lugs shall be suitable for the cable, installed in line with manufacturers instruction and shall be tinned copper.

Only one wire/cable core shall be crimped into each connector.

Lacing of cores in control panels and switchgear panels, shall be carried out using an approved method (e.g. zip ties especially for flexible attachment to moveable parts & installation in slotted covered duct for fixed terminal strips etc.).

3.5.4. Terminal Strips

Terminal strips shall be provided within enclosures and equipment for control cable terminations.

Terminal strips shall be provided with the number of terminals required in the Job Specification plus 10% spare rail capacity. Terminal blocks shall be coloured as follows:

- White/Grey/Beige -LV wiring/ELV/Analogue Signal Wiring
- Blue -Intrinsic safety circuits
- Green/Yellow -Earth wiring

Where control cables and power cables (above 50Vdc) are connected to terminal strips in the same enclosure approved protective covers and warning labels shall be installed over power connections.

Similar voltage and wiring should be grouped into blocks where practical. Eg-All LV circuit terminals, all Control terminals, all I/O terminals, grouped.

Each terminal strip shall be identified with a number in accordance with the Job Specification using permanent, non-flammable terminal strip labels with black characters on a white background.

Each terminal shall be identified with a number in accordance with the Job Specification using permanent, clip-on, non-flammable terminal markers with black characters on a white background.

3.5.5. High Voltage Terminations

High voltage cable terminations shall be performed only by HV certificated cable jointers who shall be approved by the TCC Nominated Electrical Representative prior to commencing work.

High voltage cable terminations shall be made using an approved crimping method. Equipment of an approved Manufacturer shall be used in accordance with the Manufacturer s instructions.

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

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.

Bolts shall be fitted with Belleville washers. Once tightened, bolts must show at least two threads past the nut. Brass nuts or bolts shall not be permitted. All connections must be suitable tensioned in line with manufactures instructions.

3.6. Labelling & Identification

Each component or item of equipment used in a project shall have a unique tag name and wire numbers. The use of a unique prefix in front of the tag name or wire number is acceptable for multi-cell MCC type switchboards.

3.6.1. Cables

All cables shall be labelled. Each label shall be identified with the cable number or title as called for in the Job Specification. Labels shall be affixed to cables at both ends. Additionally, labels shall be affixed at cable tray junctions, at entries to and exits from trenches, walls and other obstructions, wherever labels are not visible either side of obstructions and at any point beyond which the cable may not easily be traced.

All floor mounted bottom entry equipment shall have cable identification both inside and outside the enclosure.

Cable numbers shall be read from left to right and bottom to top.

The cores of all cables shall be numbered with white engraved ferrules with black numbers to correspond to the relevant termination diagrams and equipment drawings. Wrap around adhesive markers are not acceptable.

The Contractor shall ensure that the component numbers of the identifier are aligned and that the identifier is clearly visible.

Ferrules shall be of a sleeve type which will not slip off the ends of the cables.

Unless otherwise specified, all control cables core terminating within switchboards, control panels, junction boxes, etc. shall be fitted with ferrules and identified in accordance with the Job Specification.

Wire numbers for spare cores not shown in the Job Specification shall be labelled SP or SPARE.

3.6.2. Equipment

Outdoor equipment labels shall be engraved GR316 Stainless Steel.

Indoor equipment labels shall be three ply, engraved traffolyte or similar material.

All labels should be attached to the equipment with stainless steel screws, unless the IP rating is likely to be compromised, where upon an epoxy resin glue may be used.

All items of equipment shall be labelled:

- GPOs and light switches shall be labelled by means of cable labelling and by a separate label adjacent to the device. Labels shall indicate the MCCB switchboard and breaker of origin for that circuit and the relevant circuit diagram drawing number.
- Field devices shall be labelled as per the Job Specification or as directed by the TCC Nominated Electrical Representative (tag numbering or device numbering).
- Motors shall be labelled with a 180mm x 80mm label fastened with four stainless steel screws to the drive support steelwork and positioned such that it is visible from the local control unit. Label designation shall match that of the drive LCS and with letters sized to fill label.
- Instrumentation shall be labelled with a 80mm x 25mm labels fastened with four stainless steel screws to the instrumentation support or nearby steelwork. The use of flexible connecting wires or ties is not acceptable. Instrument labels shall not be affixed to the actual instrument.

If necessary, a 3mm GR316 stainless steel mounting plate shall be fixed in position to provide a suitable mounting.

Labelling of equipment shall be the responsibility of the Contractor performing the electrical installation (i.e. connecting to the equipment).

MCCB switchboard circuit identification shall be by means of an individual label for each circuit Breaker, which must align with the switchboard legend affixed adjacent to, or on the door of the switchboard containing the circuit breakers.

In the event that suitable tags are not already fitted, the Contractor shall record all nameplate details of the equipment to submit to the TCC Nominated Electrical Representative. The Contractor shall then arrange for suitable tags to be installed.

3.7. Earthing

3.7.1. General

Earthing shall be strictly in conformance with the AS 3000 Australian/New Zealand Wiring Rules.

All earth connections, including earthing connections between dissimilar metals such as copper and stainless steel, shall be protected against corrosion by painting with zinc rich paint.

Earth connections within equipment shall be terminated at earth bars, with one conductor per screw or stud. Earth terminals, such as rail mounted terminals, are not acceptable. A common connection via the terminal mounting rail is not acceptable. Similarly, a loop of earth connections is also not acceptable.

The main earth is to be installed in an accessible position and be protected from damage by mowers, line trimmers and the like. The protection must provide adequate room to allow disconnection of the earth for testing purposes. A commercial earth pit is preferred. The earth stake is not to be installed in a location where it is likely to become embedded within a concrete slab, bitumen or landscaping.

Connections to the earth electrodes, shall be by means of stainless steel "V" bolt clamps which shall be housed in an earth electrode pit and fitted with a lid at ground level. The connections shall be painted with a suitable product to prevent corrosion.

Where the substation is within the TCC installation and solely used for the installation, the earth grid will have:

- Radial connections to the earth grid system shall be PVC yellow/green insulated. Connection shall be with an approved heavy-duty compress-on profile C copper connector to the grid conductor, and lug bolted to equipment. Conductor size shall be 120mm^2 copper.
- An earth conductor shall be connected to all high voltage cable glands unless otherwise required by the protection system.

3.7.2. Equipotential Bonding

Values for touch and step potential for all electrical installations in case of a fault shall be kept within the limits required by legislation and the relevant Australian Standard.

Where the substation is within the TCC installation and solely used for the installation:

- The main equipotential conductor(s) shall be connected to the relevant sub-station main earth bar. It shall be installed in cable ladders along the main cable routes. The conductor shall be 120mm^2 copper, with green/yellow insulation.
- On multiple supply systems, where the supply of power to a plant originates from more than one substation, the main equipotential conductor(s) shall be connected to all relevant substation main earth bars. Regardless of the number of substations providing power to that plant, only one equipotential bonding system for that plant is required.
- As a minimum, the main equipotential conductor shall be labelled with approved identifying cable markers, which shall include the lettering EQ-POT at each connection to the main substation earth bar(s) and at the location of each branch off to the building structure.
- Reinforcing steel with the substation building or structure shall be installed such that it is electrically continuous and shall be bonded to the earth grid or earth bar using a commercial earth bonding system, similar to Dulmison C70. Reinforcing steel shall be connected to the earth system at a minimum of two separate points using 120mm^2 Cu/PVC cable.

Conductors connecting individual equipment and cable ladder to the main equipotential conductor shall be a minimum of 35mm^2 copper or same size as the main Neutral Conductor for the installation, whichever is the smaller, with green/yellow insulation. Similarly, any section that is not electrically continuous (i.e. hinged swivel plates, fish plates on painted ladder, etc.) shall be made continuous by bridging with a bonding earth cable.

In exceptional situations and with prior approval by the TCC Nominated Electrical Representative, alternative bonding may be installed, e.g.:

- flexible cable with green/yellow insulation or sleeving of cross-section equivalent to required conductor size.
- smaller size flexible cable (minimum size 6mm^2) for small equipment and instrumentation.

In addition to making all cable ladder runs electrically continuous and connected to the Main earth bar, cable ladder runs containing an equipotential conductor shall be bonded to the equipotential conductor at intervals not exceeding 50m.

Where Hazardous areas exist within an installation, equipotential bond shall conform to the standards for Hazardous areas.

3.7.3. Instrument Earthing

Where the installation has instrumentation the earthing design for each instrument installation shall include for the provision of two separate earthing systems. These being:

- the main electrical safety earth and,
- the instrument system earth.

In this case the instrument system earth shall be bonded to the main electrical safety earth system only at the main electrical safety Earth bar at the main distribution board. This equipotential bond connection shall be a PVC green/yellow stripe insulated copper conductor having a minimum cross sectional as specified by AS3000.

Instrument earth cables from instrument system earth bars in marshalling and equipment cabinets shall be connected to the instrument system earth at the main distribution board.

All earth cables from electrical safety earth bars in marshalling and equipment cabinets shall be connected to the electrical safety earth grid as required by AS3000.

3.7.4. Cabinet Earthing

All instrument marshalling and equipment cabinets shall have two separate earth bars as follows:

- An electrical safety earth bar for the connection of earths for mains powered equipment and instruments, earth wires from multi-core cables, cable armouring, gland plates and the cabinet frame.
- An instrument system earth bar for the connection of shield (drain) wires from shielded signal cables. The instrument system earth bar shall be isolated from the cabinet by insulated mounts.

3.7.5. Cable Shield Earthing

The shields of instrument cables shall be earthed at the marshalling cabinet only.

The shield wire of instrument cables shall be cut off and insulated at the field instrument end of the cable.

The continuity of shields of instrument cables shall be maintained through all junction boxes and terminal strips.

3.8. Specific Electrical Equipment Installation

3.8.1. High Voltage Switchgear

All high voltage switchgear shall be installed in accordance with the manufacturer's recommendations.

Floor mounted panels shall be packed levelled to the tolerances specified by the manufacturer to ensure the alignment of busbar connections and the easy withdrawal of vacuum contactor carriages. After levelling, they shall be fixed in place by bolting to the floor.

Busbar joint preparation and contact pressure shall be in accordance with the recommendations of AS62271 and the manufacturer's instructions. A calibrated torque wrench shall be used to ensure correct bolt tightening.

Floor ducts for HV and control cabling (where required) shall have neatly cut and fitting chequer plate covers.

3.8.2. Power Transformers

All transformers shall be installed in accordance with the Manufacturers recommendations.

It shall be the Contractor's responsibility to store drums of insulating oil, under cover, from the date of delivery to the Contractor at site, during storage, and during construction until date of completion of the installation work. The drum shall be placed such that there is a head of oil on the bung. Oil shall be handled in accordance with the relevant Australian Standard.

The transformers shall be securely fixed in position to the satisfaction of the TCC Nominated Electrical Representative.

3.8.3. Transformer Medium Voltage Busduct

Where specified, busducts shall be installed between transformers and MSBs/MCCs.

Coupling of the busduct sections and connections to the MCCs and transformers shall be carried out strictly in accordance with the Manufacturer's Instructions and the vendor drawings.

The connection to the transformer terminals shall be by flexible copper links provided with the busducts.

All busduct flange joints shall be fitted with neoprene gaskets to maintain the busduct enclosure degree of protection of IP65.

Copper earthing jumper straps shall be installed across all joints fitted with gaskets.

Where busducts enter through substation walls, the wall openings shall be made good to the requirements of the TCC Nominated Electrical Representative.

The fixing of the MSB/MCC, busduct, transformer shall be done progressively from one end of the line to the other.

3.8.4. Main Switchboards & Motor Control Centres

The general requirements for switchboard location are covered under AS3000 clause 2.10.2.

When a switchboard/MCC is to be located adjacent to a pump well/valve chamber it is to be installed so that the switchboard doors open away from any hatch openings. Access to the switchboard is not to be impeded by mechanical equipment, safety rails (which may not be a permanent installation), landscaping etc.

No trip hazards are to be present in the area in front of the switchboard. A suitable concrete slab is to be provided in front of the switchboard as a work area for electricians when working on the switchboard. The area in front of the switchboard is to be at one level-no step.

After assembly and prior to the testing, all accessible bolts shall be checked for tightness.

Following checking, the bolts shall be distinctly marked to verify that they have been checked.

Field cables shall be neatly bunched or loomed within the MCC cable compartments. Cables shall be supported within the cable compartments by perforated tray and the use of PVC cable ties to avoid strain on field terminals.

All circuit breakers must be capable of being locked in the off position.

3.8.5. Local Control Stations

The installation of a LCS or LCP shall be taken to include all associated works including mounts/foundations, base, stands, sunhoods, equipment and enclosures.

Where a plug and socket connection is shown on the single line diagram, the plug socket shall be surface mounted on the side of the LCS. The plug socket shall be a 60° or 90° model such that bending stresses from the attached cable are eliminated.

Decontactor plug and socket connections shall be keyed such that each pair is matched, so as to prevent an isolated motor being plugged into a non-isolated socket assembly.

Where link bolts are shown on the drawings, the LCS shall consist of the standard LCS with a segregated, separately lockable compartment containing the link bolt terminals.

The LCS shall be provided with labelling. External labelling shall consist of the following:

- LCS Number
- Equipment Name & Rating
- Source of Supply Switchboard/MCC Module Number
- Electrical Schematic Reference

A sample LCS shall be submitted for approval to the TCC Nominated Electrical Representative prior to mass fabrication. This sample shall be of the type to be provided under the Contract and include typical equipment, terminals, ferrules, internal wiring and glanded external wiring with cable protection.

The LCS shall be provided with an earth bar of satisfactory dimensions to accommodate all relevant earth cables. The LCS shall be earthed.

Where LCS contains isolators for motors and equipment they shall be dedicated to each individual item of equipment.

3.8.6. Junction Boxes

Junction boxes shall be used for the marshalling and looping of all field cabling, and housing of field surge protection devices. They shall be constructed from 2mm grade 316 stainless steel.

Junctions shall be effected through terminal strips within the junction box. The terminal strips shall be provided with 25% spare terminals in addition to that provided for initial requirements.

Separate junction boxes shall be provided for each different drive or equipment system and for sections of different systems which are not able to be isolated at one location.

3.8.7. Distribution Boards

Refer to TCC-TTS-SPEC-E004.

3.8.8. Lighting and General Purpose Power

Light fittings, light fitting supports and switches shall be located and installed as shown on the

drawings. Lighting equipment, GPOs and welding outlets may be subject to minor relocation on site to avoid conflicts, or to suit site conditions and specification requirements, as approved by the TCC Nominated Electrical Representative.

All GPOs shall be fitted with an isolating switch.

Outdoor GPOs shall be hose proof and weatherproof to IP56 degree of protection, high impact polycarbonate.

Three phase outlets shall be hose proof, dustproof and weatherproof to IP56 degree of protection. They shall be switch interlocking plug.

All outlets installed in direct sunlight shall have additional sun protection in the form of an approved sunshield.

Switched socket outlets located in industrial environments like Treatment Plants and Pump Stations, shall be mounted 1300mm above the operating floor unless shown otherwise on the drawings. Outlet locations shall be generally as shown on the drawings. Approval shall be obtained from the TCC Nominated Electrical Representative before the location of any socket outlet is changed.

Outdoor lighting shall be PE cell and timer in parallel to give redundancy and eliminate need for timing changes on change of season, the only exception being emergency lighting.

Indoor lighting shall be switched from strategic points located adjacent to access/exit points.

Light switches shall be mounted approx 1300mm above the operating floor level.

All light fixtures and accessories including circuit junction boxes shall be readily accessible for maintenance either from floors, landings, crane, machinery platforms or ladders. Prior to installation, the location of all light fittings shall be checked for interference with structures, piping, equipment or personnel in the performance of their normal duties off the floor, platform or walkways. Approval shall be obtained from the TCC Nominated Electrical Representative before the location of any light fitting is changed.

Where Unistrut or other metal duct is used to contain and support cables and fittings, the distance between supports shall be approved by the TCC Nominated Electrical Representative and shall not exceed 3000mm.

3.8.9. Fire Protection

Fire detection systems shall be installed by a competent and registered fire protection system Contractor.

All fire detection equipment and installation thereof shall be in accordance with AS 1670, and other relevant Australian Standards.

Refer to TCC-TTS-SPEC-E010 for additional information.

3.8.10. Cranes and Hoists

Installation of cranes and hoists shall comply with the SAA Crane Code AS 1418.

Each crane power supply isolator located near the crane access ladder shall be clearly labelled "Crane Supply Isolator". The equipment number and source of supply shall also be detailed on this sign.

3.9. Instrumentation and Telemetry/PLC Installation

3.9.1. Power Supply

All instrumentation requiring auxiliary power shall be fed via dedicated circuit breakers in instrumentation power distribution boards. Lighting and general purpose power distribution boards shall not be used for the purpose of supplying power for instrumentation.

All circuit breakers must be capable of being locked in the off position.

All instrument power distribution boards shall contain suitably rated, DIN rail mounted, moulded case, miniature circuit breakers, each clearly and permanently labelled as to their purpose.

All 24Vdc supplies shall be individually fused for each instrument or for each common grouping of Discrete I/O. Common grouping of Discrete I/O would typically be for one I/O module of the PLC or Telemetry unit.

Surge reduction filters shall be provided as necessary to protect all instrument power supplies against input overvoltage and mains borne sags, surges and impulses originating from lightning, switching operations or other causes.

Also refer to TCC-TTS-SPEC-E004 sections 5.4.27 and 5.4.28 LV switchboards and TCC-TTS-SPEC-E009.

3.9.2. Mounting of Instruments, Controls and Accessories

Installation of instrumentation shall be in accordance with P&ID s and Manufacturer s Instruction Manuals.

Except as otherwise directed by the TCC Nominated Electrical Representative, all equipment shall be installed as near as practicable to the position shown on the drawings. Small variations to facilitate fixing of equipment are permitted subject to approval of the TCC Nominated Electrical Representative. Preference shall be given to mounting Instrument electronics in switch rooms where practical.

Instruments shall be rigidly supported, level and plumb, in such a manner as to provide accessibility; protection from damage; and freedom from interference with other equipment, piping and electrical work.

All instrument devices including accessories shall be located where they shall be accessible from structural platforms, permanent ladders, or final grade. Height for mounting instruments shall be 1300mm above grade or platform, to the centre of the instruments.

All locally mounted Displays and HMI’s for instruments shall be in line of sight and within reading distance of normal operating area.

Sufficient clearance shall be provided for the removal of transmitters, level probes, displacers and floats, control valve diaphragms and plugs, belt scale load cells and transmitters, orifice plates, density transmitters and temperature elements.

Where sunlight or spillage on to field items, either primary or secondary, is likely, these shall be fitted with shields for protection.

No structural member may be drilled, chipped or torch cut without specific prior approval by the TCC Nominated Electrical Representative.

Handrails shall not be used for mounting or supporting instruments. Where instruments are installed adjacent to handrails, minimum of 150mm clearance shall be maintained.

All Junction Boxes shall be securely mounted in a workman like manner and shall be installed plumb with surrounding structural steel members.

No Instrument or Instrument Stand shall be mounted directly on the floor of a bunded area.

All Field Instruments are to be tagged with their relevant Instrument Tag number. The Tag name plate shall be made from stainless steel, with characters not less that 5mm high and secured with stainless steel hardware.

Tag Name Plates shall not be mounted directly on any instrument housing. Where instrument stands are required, the name plate shall be affixed to the front plate provided for this purpose.

3.9.3. Instrument Junction Boxes

Junction boxes shall be fitted out to provide a fully functional assembly ready for field termination. Any instrument and control equipment specified for the box shall be wired to terminal blocks as detailed on the drawings.

The junction box arrangement, outside dimensions and layout shall be suitable for the installation of the nominated equipment and termination of relevant cabling.

All junction boxes shall be of appropriate dimensions to allow for approximately 25% spare capacity and ensure neat appearance.

Wiring between the cable entry and the terminal strips and between terminal strips shall be enclosed in closed slotted PVC cable duct. The ducting shall be supplied, sized and installed to carry at least double the maximum cable capacity of the adjacent terminal strip unless otherwise specified in the accompanying documentation.

Terminal rail shall be of a length to fill the useable space and not limited to the length required for the number of terminals nominated.

Cable duct, terminal rail and any other equipment that is to be mounted on the mounting pan shall use metal screws in pre-tapped holes. Screws with nuts behind the mounting pan or self-tapping screws shall not be used.

Unless otherwise specified in the Job Specification, cable duct shall be mounted so there is a clearance of at least 50mm between the duct and terminal strip.

3.9.4. Indicators

Indicators shall be of the digital display type of flush mounting pattern utilising an LCD or LED display and be sized to allow for reading from a distance of 2m.

Indicators shall be scaled from 0-100% or as otherwise specified.

Indicators shall include continuously variable span and zero adjustments. Adjustment shall be provided via inconspicuous front panel controls.

Indicators shall be shielded from direct sunlight.

3.9.5. Connection of PLC or Telemetry system

If the PLC or Telemetry system is to be connected to an existing system via a communications network, approval must be obtained from the TCC Nominated Electrical Representative. All new additional network equipment must remain off or disconnected until approval is received to prevent duplication of addresses which may cause network failures on the existing network. E.g.: Radios in new telemetry system switched off. New PLC additional expansions communications interface cables disconnected.

Also Refer to TCC-TTS-SPEC-E009 for more information.

3.9.6. Antenna Installation

Typically, a 6dB Yagi type antenna is used at TCC telemetry sites. The Yagi type antenna is to be mounted with Vertical polarisation (unless specified) on a bracket that can swivel through 180° to allow correct alignment. Higher gain antenna may be required at some sites and additional consideration must be given to their mounting requirements as they are physically larger and have a higher wind loading.

The requirement for a high gain antenna or greater antenna height should have been defined during the radio path design as per TCC-TTS-SPEC-E003.

Masting requirements will vary from site to site. In some cases, small Facia brackets will suffice while others will require pole type masts. Where pole type masts are employed, structural certification from a registered RPEQ will be required in terms of footings, wind loadings etc.

Generally, antenna masts and fittings will be constructed from hot dipped galvanised materials. In coastal or corrosive environments stainless-steel materials will be required (including the antenna).

When designing masts and antenna mounts consideration is to be given to access by maintenance personnel. Where antenna cannot be safely reached from a step ladder then the design must incorporate a means of lowering the mast to a safe working level (without exceeding the minimum bending radius of the antenna cable). The need of specialised access equipment such as EPV's should be avoided.

Consideration must also be given to vandalism. It shall not be possible for vandals to easily reach antenna or climb on masts. In some cases, the use of a concealed "whip" type antenna might present a viable solution.

3.10. Generator Installation Requirements

3.10.1. Permanent Generator installation

Where the Job Specification calls for the installation of a permanent generator it is the contractor responsibility to provide appropriate cable sizing and cable mounting for all cabling between the Main Switchboard and the Generator based on the Job Specification generator requirements. In addition to Generator mains cabling there may be a requirement for auto start and change-over control wiring, and telemetry signal monitoring of the generator status. These signals are defined within TCC-TTS-SPEC-E004. Low Voltage Switchboards.

Other Generator installation requirements are detailed in TCC-TTS-SPEC-E006. Auxiliary Power Supplies.

3.10.2. Mobile Generator Connection

Mobile generator connections are typically specific to pumpstations. Refer to TCC-TTS-SPEC-E011.

3.10.3. Hazardous Areas

Hazardous Areas (HA) shall be indicated within the site HA Dossier, Job Specification and drawings. Where a suspected HA exists (eg: Sewerage Inlet Works, Odour Control Equipment, Fuel Handling, Flammable Chemicals, Paints and Solvents), clarification must be sought from the TCC Nominated Electrical Representative.

Where possible all electrical equipment shall be located outside of the hazardous area. Where it is not possible to do this, equipment shall be located in an area with the lowest requirements.

Electrical equipment shall be installed in Hazardous Areas by suitably qualified installers only.

Electrical equipment shall be installed using the required mitigation methods as specified on the drawings and Job Specification. Intrinsically safe cabling systems shall have appropriate blue sheathed cable and shall have segregation from non-intrinsically safe cabling as per AS60079. Should there be any doubt about the installation methodology, advice must be sought from the TCC Nominated Electrical Representative.

Care should be taken to ensure that a suitable material of construction is chosen to reduce static electricity hazards for equipment to be used in hazardous areas.

Hot works permits must be sought and strictly adhered to for any hot work required in the HA.

Detailed inspection sheets noting the equipment tag, serial number, ICEX or AusEx certification (ATEX certification will not be accepted), protection technique and compliance must be submitted to the TCC Nominated Electrical Representative prior to energisation.

Energisation of equipment in a HA will not occur until a HA Audit has been completed by an accredited auditor.

Proof of any auditing must be provided to the TCC Nominated Electrical Representative prior to energisation.

Commissioning activities, including energisation may occur prior to a HA audit but only if hazardous gasses are not present (e.g.: plant is not fully operational) and under permission of the TCC Nominated Electrical Representative.

All required documentation shall be submitted to the TCC Nominated Electrical Representative to allow updating of the site HA Dossier.

4. HV Installations

HV installation must comply with Australian Standards and must be Audited by a suitably qualified person. Proof of auditing must be provided to the TCC Nominated Electrical Representative prior to energisation.

5. Inspection and Testing

5.1. General

The Contractor is solely responsible for the satisfactory installation testing and pre-commissioning according to the relevant Australian, IEC or other appropriate standard and to the requirements of the TCC Nominated Electrical Representative.

The Contractor shall provide the TCC Nominated Electrical Representative with a complete dossier of all electrical testing and pre-commissioning works to be completed prior to commencement if detailed in the Job Specification. This shall include a copy of the relevant test sheets to be completed as part of the works.

The TCC Nominated Electrical Representative reserves the right to inspect at any time, the shop drawings, equipment, materials and installation.

The Contractor shall keep testing and pre-commissioning records. Copies of these records shall be available for inspection/review by the TCC Nominated Electrical Representative or their Representative immediately upon request.

Where the installation includes high voltage or hazardous area installations, the Contractor shall be responsible for the preparation of relevant dossiers for submission to the High Voltage Auditor or Hazardous Area Auditor for approval of the installation. It shall be the responsibility of the Contractor to make all necessary arrangements for inspection of the installation.

All high voltage protection testing shall be carried out by accredited personnel.

All medium and low voltage installations shall be tested by experienced qualified tradespersons who are certified under the Electrical Safety Act.

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

Equipment shall be disconnected before and during testing as required by the relevant standards and as directed. All equipment disconnected shall be recorded on the test reports. Equipment to be disconnected includes electronic equipment during Insulation tests.

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.

5.2. Test Instruments

All test equipment shall have a current calibration certificate proving the equipment is in good working condition.

Copies of calibration certificates shall be produced as requested.

The Contractor shall provide all test instruments and equipment required to carry out the complete range of tests in accordance with this specification.

5.3. Testing Requirements

Statutory testing shall be carried out on every new installation and where alterations or additions have been made to existing installations.

At the minimum, the following testing and pre-commissioning shall be provided:

- Mandatory Tests in accordance with Clause 8.3.3 of AS/NZS 3000.
- Verification of the installation in accordance with the requirements of AS/NZS 3017.
- The insulation resistance of every complete lighting and power circuit including all machinery, cables and apparatus forming part of or in connection with such circuits either collectively or in parts.
- The electrical continuity of all earthing conductors and metallic coverings if used as such.

- The effectiveness of all electrical safety devices and protection systems.
- The effectiveness of earth leakage protection systems.
- The earth resistance of earth electrodes and other earthing systems.
- Instrument configuration and calibration.
- Other testing and pre-commissioning procedures to be completed as per the manufacturer's recommendation and/or Job Specification.

5.4. Point to Point Tests

Prior to energising any circuit, the Contractor shall carry out point to point continuity tests of all control and power circuits. Such tests shall be carried out with all control and power fuses removed.

5.5. Testing of High Voltage Switchgear

A suitable insulation test shall be performed when the equipment is handed over for installation and again immediately prior to energising. The tests shall be with the circuit breaker or contactor in the open and closed positions.

The switchgear assembly shall be subject to high voltage withstand tests in accordance with the requirements of AS2067.

Ductor resistance tests shall be performed on all busbar connections, and on the contacts of all isolators vacuum contactors and earthing switches.

5.6. Testing of Power Transformers

Upon taking delivery of the transformer, a Suitable Insulation test between windings and between windings and earth shall be performed.

The following checks and tests shall be performed before energising:

- Inspection for oil leaks and damage which may have occurred during transportation.
- General checks including checks for tightness of all bolts, damage to insulators, radiator valves, breathers, etc.
- A Suitable insulation test between windings and between windings and earth.
- Check of operation of Gas Pressure Relay, Buchholz, WTI and OTI devices to the terminal strip in the transformer marshalling kiosk. Set operating temperatures for oil and winding temperature alarms and trips.
- Measure cold resistance of windings and compare with the manufacturer's figures.
- Ductor resistance measurements of connections to transformer bushings and cable terminations.
- Check operation of the tap changer mechanism.

The following tests shall be performed after energising:

- Polarity testing.
- Select each tap in turn and measure no load voltage.
- Check the voltage & temperature after twenty-four hours on-load operation.

Transformer oil samples and oil drum samples shall be subject to an electrical strength test in accordance with AS 1767. The breakdown voltage shall be 30kV minimum.

Oil samples shall be taken from the transformer for a full analysis prior to and following energising.

5.7. Testing of Current Transformers

All current transformers shall be tested by primary injection, during which turns ratio, polarity, correctness and continuity of wiring up to the protection relays, indicating devices or metering shall be checked.

5.8. Testing of Protection and Indicating Devices

All current operated protection devices shall be tested by secondary injection. The test shall be for at least three current levels widely spaced on the relay setting range. One test point shall be the final setting.

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.

Thermistors and connecting cables shall be tested for insulation resistance and continuity. Operation of thermistor control units shall be checked by temporary disconnection of one wire at the motor thermistor terminals.

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

5.9. Testing of Cables

All testing shall be performed prior to the energising of any cable installation. After completing the termination of the cable at each end, the cable shall be disconnected from the termination points to enable testing.

High voltage cables shall be subjected to the following tests:

- Inspection for damage to the cable following installation.
- Insulation resistance testing between phases and between each phase and earth before and after the high voltage withstand test.
- Any other tests required to meet HV auditing requirements.

All low voltage power cables shall be subject to insulation resistance tests between

phases and between each phase and earth. The insulation test voltage output shall be at least twice the nominal voltage between conductors when energised. The minimum acceptable reading shall be 1 (one) megohm.

The continuity of the earth conductors shall be tested. Values measured shall comply with AS3000 requirements.

Following insulation and voltage withstand tests the cable shall be reconnected and the following tests performed:

- Check the torque of each connection and check the marking of the bolt and nut position with respect to the terminal using a marker pen.
- Ductor test of each connection if specified in the Job Specification.
- All power cables shall be checked for correct phasing.
- Instrument cables shall be tested in accordance with the relevant instrument/specification.

5.10. Testing of Busduct

All busducts shall be checked for correct alignment, assembly and bolt tightness.

Resistance Ductor tests shall be performed on all busbar joints and connections.

An insulation test shall be applied to busduct sections prior to installation and to the installed busduct system prior to energising.

5.11. Testing of Switchboards & Motor Control Centres at Installation

Insulation tests shall be performed after the installation is completed, with the main feeder cables and all outgoing circuits disconnected. All devices containing electronic components and other equipment as directed shall be disconnected during insulation tests.

Resistance tests shall be performed on all busbar joints and connections made during erection.

All thermal overloads shall be set at 110% motor full load current.

The phase rotation of incoming supplies at each MCC main circuit breaker shall be checked.

All switchboard equipment shall be tested to prove the correct operation of closing and tripping mechanisms, starters, protective functions, interlocks and switching functions.

All circuit breakers, operating mechanisms, withdrawable switchgear and the like shall be checked for alignment and adjusted where required.

All alarm circuits shall be tested by operating the relevant initiating device.

All switches, pushbuttons, control devices and the like shall be tested for correct operation.

All indicating lamps shall be tested for correct operation.

5.12. Testing of VSD Systems

Upon completion of installation such that the VSD System is fully assembled in its final configuration and the required parameters have been programmed, the following tests shall be completed:

- Cable insulation resistance tests.
- Mechanical operating tests.
- Testing of all Meters.
- Testing of protective circuits.
- Testing of all control and interlock circuits to ensure satisfactory operation.
- Operational check of the inverter.
- Operational test with connected motor at no load.
- Testing of communications (where required).
- Check of wiring and terminations.
- Check of nameplates and labels.
- Performance test at rated current for one hour, verifying cooling, air flow and temperature rise.

5.13. Testing of PLC/Telemetry Systems

Upon completion of each PLC installation such that the PLC System is fully assembled in its final configuration the following tests shall be completed:

- Testing of I/O connections to the PLC/Telemetry Data location.
- Perform any all functional test as required to prove the PLC/Telemetry system configuration and program correct operation. (The functions should be specified in the Job Specification.)
- Check of wiring and terminations.
- Testing of battery backup system (where required)

5.14. Testing of Batteries and Battery Chargers

The following tests shall be completed for any Battery Chargers/Battery Banks installed:

- Check and record specific gravity of batteries if applicable.
- Check voltage of each cell.
- Check float voltage of entire battery bank.
- Check boost voltage if applicable.
- Check all alarms indicated on the charger and output relays operate for remote alarming.
- Check load current.

5.15. Testing of Motors

The following tests shall be completed for all installed motors:

- Suitable voltage insulation test on windings with power cables connected, taken at the MCC outgoing terminals. The temperature at the time of testing shall be recorded. Where required, the motor insulation shall be dried out by an approved method.
- Insulation and circuit resistance of motor heaters including connected cable shall be tested.
- The resistances of thermistor circuits shall be checked.
- Bearings shall be checked for brinelling.
- The bearing temperature shall be checked and recorded after a four-hour run at no load.
- The no load current on all three phases shall be measured and recorded.

5.16. Testing of Distribution Boards

All distribution boards shall be subjected to a suitable voltage insulation check prior to energising.

All load circuits shall be tested.

Tests as described below shall be performed:

- Phase rotation of the incoming supply shall be checked.
- All protection devices such as fuses, circuit breakers and the like shall be checked for correctness of type, size and application as shown on the drawings.
- Circuit schedules shall be checked.

5.17. Testing of Lighting Systems

The insulation resistance of each circuit, including switch-wires shall be checked.

The continuity of the earth connections shall be tested.

The operation of all light fittings shall be checked.

A discharge test shall be carried out on all battery-operated emergency units to establish the capacity of the batteries.

The operation of the daylight switched and timer lighting circuits shall be tested.

5.18. Instrument Testing

The Contractor shall carry out pre-commissioning tests on installed instrumentation. Pre-commissioning tests shall include the following:

- Pressure testing to ensure that all instrument piping and tubing is pressure tight to the specified working/testing conditions.
- Check all electric and electronic instrument wiring for correct polarity, continuity and insulation resistance between conductors and earth.
- Carry out loop testing to prove that the installed instrumentation functions correctly and is in fit condition for plant commissioning to proceed.

The Contractor shall keep a record of all instrument pre-commissioning tests.

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