



PROJECT

ACGS - GERALD & SCIENCE POWER UPGRADES

DOCUMENT

ELECTRICAL SERVICES SPECIFICATION

SITE ADDRESS

**OAKLANDS PARADE
EAST BRISBANE QLD 4151**

CLIENT

**ANGLICAN CHURCH GRAMMAR SCHOOL
OAKLANDS PARADE EAST BRISBANE QLD 4169**

DESCRIPTION

**REVISION: A
DATE: 07 FEBRUARY 2023**

[illegible]

ELECTRICAL DESIGN GROUP BRISBANE PTY LTD ACN 092 710 793
TRADING AS - ELECTRICAL DESIGN GROUP ABN 96 092 710 793

1.0 EXTENT OF WORKS

1.1 SCOPE

The electrical services sub-contract includes but is not limited to the following:

- Supply and installation of all components forming part of the electrical services.
- Replace the existing Science building MSB with a new MSB and MDB.
- Replace the existing Gerald building MSB with a new external MSB requiring new consumers mains and submains.
- Replace the existing Gerald building distribution board DB-G.
- Remove the existing Gerald building basement distribution board.
- Reconnection of all existing Science and Gerald circuits impacted by the works that remain.
- Associated building works.
- Attendance at a handover meeting.
- All onsite excavation and power supply interruptions are to be within the 2023 / 2024 summer school holidays.
- With the tender of the preferred power outage dates for the Science building and the Gerald building.
- Power interruptions must be less than two weeks.
- Co-ordination.
- Authorities' approvals.
- Approvals.
- Shop drawings.
- Installation drawings.
- Work-as-executed drawings.
- Inspections.
- Testing and commissioning.
- Programming.
- Cabling, cable support systems and access.
- Trenching, conduits and backfilling.
- Pits.
- Quality assurance.
- New building access.
- Remove all existing electrical services that become redundant due to the works and make good.
- The position of all existing conduits, pits and cables nominated on the drawings is for information only and the exact position must be accurately established on site.
- All minor components and incidental works not specifically referred to, however necessary to complete the electrical services installation such that it is handed over complete, operational and fit for the intended use.

Arrange new retail metering in the Science and Gerald MSBs and the removal of the existing associated retail metering. Coordinate the B2Bs and EWRs with the school's electricity retailer and Energex and provide all retail metering equipment / components necessary.

All making good after the electrical services installation is to be undertaken as part of the electrical services sub contract.

With the tender response provide a copy of the Electrical Contractors licence. Include a copy of all of the above licence in the maintenance manual.

Accept full responsibility for liaising, arranging and co-ordination all works that have an effect on or will be affected by the electrical services.

Should the Electrical Contractor not provide the information required to be submitted by this specification within two weeks of being requested to do so or as agreed to in writing, the Electrical Contractor is to agree to a variation credit of \$2,000.00 to the contract in lieu of the provision of such information.

Should the Electrical Contractor not provide the Work-As-Executed drawings within two weeks of practical completion or as agreed to in writing, the Electrical Contractor is to agree to a variation credit of \$2,000.00 to the contract in lieu of the provision of the Work-As-Executed drawings.

Should the Electrical Contractor not provide the Operation and Maintenance Manual within two weeks of practical completion or as agreed to in writing, the Electrical Contractor is to agree to a variation credit of \$2,000.00 to the contract in lieu of the provision of the Operation and Maintenance Manual.

All dollar amounts nominated within the electrical documents including credit variations, rates and provisional sums do not include Goods and Services Tax (GST).

1.2 ASSOCIATED WORKS

Co-ordinate with the relevant bodies for the following works associated with but excluded from the electrical services sub-contract.

1.3 CONTRACT DRAWINGS

The electrical services document schedule C2965a-0001.xls details the electrical drawings, details, schedules and associated documents that form part of the electrical service's sub-contract. The electrical services documents are diagrammatic only and the Electrical Contractor must familiarise themselves with all other project documents to establish the scope to be allowed for.

1.4 SITE CONDITIONS

As part of the tender, the tenderer is required to familiarise themselves with all site conditions and allow for such conditions within the tender. Changes or additions due to site conditions or requirements which could have been established during a tender period site inspection will not be accepted as the basis of a cost variation.

1.5 CORROSION AND UV PROTECTION

Ensure that all metal surfaces are suitably protected against corrosion, and that all plastic materials are UV stabilised. Repair to new condition or replace any components showing any signs of corrosion during the defect's liability period.

Ensure that all metal surfaces are suitably protected against corrosion likely to be experienced during the life of the installation. Cover all electrical terminations including terminal screws and exposed raw metal including exposed conductors with clear synthetic resin based insulating enamel before fixing the terminal covers in place. Provide all fixings exposed to the weather and those in potentially corrosive environments as stainless steel. Do not use materials that will react with or cause galvanic reactions with adjacent materials or surfaces.

Use only plastic materials, paints, insulation materials and coatings that are UV stabilised and will not break down with the normal exposure to ultra violet radiation during the life of the installation. Provide written evidence for approval that all such materials are UV stabilised. Do not install PVC in locations it will be exposed to direct sunlight.

1.6 WORKMANSHIP

Ensure that the work is performed by the holder of a current Electrical Contractor license. Provide a copy of the license before commencing work onsite and include a copy in the operating and maintenance manual.

Ensure the installation and all components, fixtures, fittings, outlets and cables are supplied and installed to a high standard throughout, and installed in a neat and tradesman like manner, to the current industry standards. Ensure all materials and components of a similar type are of the same manufacturer and installed in a uniform manner.

It is the Electrical Contractor's responsibility to ensure that the installation is fit for purpose and is provided as a complete working installation. It is the Electrical Contractors' responsibility to provide all components, fittings, fixtures, systems, programming etc irrespective of the level detailed in the documents such that the installation is provided as a complete working installation.

Irrespective of the information documented it is the Electrical Contractors' responsibility to ensure all aspects of the installation comply with and meet the requirements of all relevant authorities and the relevant current Australian Standards.

Provide all materials as new, and of the highest class available for their respective types.

It is the Electrical Contractor's responsibility to ensure all conduits are not damaged during concrete pours.

Within the tender allow to conceal all wiring and conduits unless specifically noted as being exposed.

Install components and equipment in accordance with the manufactures recommendations and ensure such components and equipment are not operated outside of the limits specified by the manufacturer.

Irrespective of the extent of information or the accuracy of such information it is the Electrical Contractor's responsibility to confirm the location of all existing services on site. The cost of repairing and of disruption to service due to damage to existing services is to be met by the Electrical Contractor.

Ensure all components, equipment and materials supplied are new, unused, designed and selected to ensure satisfactory operation under varying atmosphere, climatic, humid tropical conditions without distortion and deterioration in any part affecting efficiency and reliability of the systems. Design and select all equipment to provide the necessary safety to human life and property during operation and maintenance with particular attention given to electrical safety and segregation precautions.

Check the finished paintwork around the area of each installation and touch up all damaged parts and finishes after the installation of the electrical services.

Within the tender response provide a list of sub-contractors that will be engaged by the electrical sub-contractor including the postal address, fax number, telephone number and e-mail address. Within two weeks of being awarded the contract provide the names and contact phone numbers of the Electrical Contractor's supervisor and site foreman as well as the supervisor and site foreman of each of the sub-contractors that are to be engaged by the electrical sub-contractor.

Provide an electronic digital photograph for approval of all works that are carried out that will not be visible after installation, within five working days after the respective work has been completed. Each photograph is to electronically stamped with the time and date and be either named with descriptive name that allows the location to be simply identified or accompanied with a tabulated description. Include a copy of the photos in the operating and maintenance manual.

1.7 ALTERNATIVES

Alternative components and design will be considered with the cost of the consideration being borne by the Electrical Contractor. Any alternative may be rejected without a reason being provided. Alternatives which are used without written approval must be removed from the installation and replaced with the complying item at the Electrical Contractor's cost.

1.8 DEFECTS

Should more than two defect inspections due to poor workmanship, be required to be performed by the electrical engineer the cost of such inspections will be passed on the electrical sub-contractor. The approval of the contract payment will be dependent upon the rectification of such defects and the settlement of the respective inspection costs.

When advice of a defect is received by the electrical sub-contractor provide written advice within 24 hours of the date the defect will be rectified.

The expiration of the warranty period does not exclude the contractor or the electrical sub-contractor from the responsibility of latent defects discovered after the warranty has expired.

1.9 ANOMALIES

It is a requirement that the tenderer allow for within the tender, the most expensive solution to address anomalies which may exist between any of the drawings, the drawings and the specification or between any of the contract documents and an authority requirement or a relevant Australian Standard. The Electrical Contractor is to identify any anomalies and request in writing a direction on which option to proceed with. Any such direction will not constitute grounds for a variation or an extension of time.

1.10 APPROVALS

Where information has been nominated as requiring to be submitted for approval or the information must be approved, apply the following definition:

Each request for approval must be made in writing, accompanied with all necessary supporting information to allow for the prompt assessment of the request. Each request must be first approved by a senior member of the contracting firm prior to being submitted.

It is the Electrical Contractor's responsibility to seek approvals and do so in a timely manner with the understanding that approvals may not be given and the request for approval may have to be modified and resubmitted. Delays in submitting requests for approval and resubmitting revised requests for approval will not constitute grounds for an extension of time. Unless advised otherwise the Electrical Contractor must allow one working week for the approval to be given by the engineer, the project manager and the client.

1.11 CUSTOMER ACCEPTANCE

At the conclusion of the installation a preliminary walkthrough with the installation contractor and the customer's representative will be performed to check for installation quality, accurate performance of the work, and to verify the accuracy of work-as-executed documents. Complete any modifications to the documentation or the installation that may be required within a 2-week period from the walkthrough. Customer Acceptance will be given following a final walkthrough with the installation contractor and the customer's representative if all previously identified issues have been addressed.

If the Electrical Contractor has advised that the previously identified issues have been addressed and it is found they have not been, the Electrical Contractor is responsible for meeting the costs of subsequent customer acceptance inspections at the rate of \$250.00 per hour plus GST plus disbursements. The walk through will be scheduled within 3 weeks of the completion of the installation in order to turn the project and documentation over to the end user. Please note that "Customer Acceptance" does not release the Contractor from repairing any cabling errors or improperly labelled circuits, caused by the Contractor that may be discovered at a later date.

2.0 QUALITY REQUIREMENTS

2.1 STANDARDS

Irrespective of information contained in the electrical services documents or in instructions, it is the Electrical Contractor's responsibility to ensure all electrical services works are installed in accordance with the requirements of the following. Refer any discrepancies between the requirements of the following and/or the electrical services documents and instructions to the Architect for clarification prior to the placing of orders, fabrication or installation of the items/methods in discrepancy.

- NCC Building Code of Australia.
- Electricity Act.
- Electrical Safety Act.
- Workplace Health and Safety Act.
- Telecommunications Act.

It is the Electrical Contractor's responsibility to obtain from all equipment and component suppliers' confirmation that the equipment and components supplied as part of the electrical services installation comply with all of the following relevant standards and codes. Specific specification of equipment or a component does not alleviate the electrical sub-contractor of the aforementioned requirement.

2.2 AUTHORITIES

Jurisdiction over the site including but not limited to the following authorities, codes, standards and regulations:

- ACMA.
- Local Council.
- Energex.
- State Government Department of Environment and Heritage.
- Queensland Department of Justice and Attorney-General, Workplace Health and Safety Queensland
- Queensland Health
- Queensland Department of Justice and Attorney-General, Industrial Relations
- Building Regulations 2006
- Fire and Rescue Services Act 1990
- Building Fire Safety Regulation 2008
- Queensland Electricity Act
- Queensland Electricity Regulation
- Queensland Electrical Safety Act
- Queensland Electrical Safety Regulation
- Queensland Development Code
- Queensland Fire and Rescue Service (QFRS)
- Queensland Electricity Connection and Metering Manual
- SAA Communications Cabling Manual
- AS/NZS 3000 SAA Wiring Rules
- Queensland Building Act 1975

If any of the responsible Authorities, pursuant to the statutory powers vested in them, elect to perform, supply, inspect or test wholly or part of the works, make all necessary arrangements and co-ordinate with the Authorities.

Provide "for approval" copies of all Authorities' Approvals.

Pay all relevant authority fees and charges necessary to complete the electrical services installation to leave it in operating condition meeting all of the authority requirements.

2.3 SHOP DRAWINGS

Submit a dwg format electronic copy of detailed shop drawings of all switchboards via e-mail to brisbane@edg.net.au for approval. Prepare all drawings as A3 or A1 size to AS1100, AS1102, AS1103 and AS3702 with information detailed at the following minimum scales:

- Layout Drawings: 1:100
- Site Plans: 1:500
- Equipment Assemblies: 1:50

Ensure the shop drawings include the following information:

- General arrangement of all equipment: Include layout and clearances around equipment.
- Mounting details, structural details and calculations verifying the structural efficiency of load-bearing slabs, etc., footings and the like, supporting electrical equipment mounting structures, poles, lighting masts, etc.
- Supports: Details of equipment and cable support brackets and fixings including mountings.
- Physical cable layouts: Showing arrangement, location and identification of interconnecting wiring and cabling. All cable penetrations, connections and terminations details. Include all forms of conductors such as Bus Bars and Busducts.
- Labelling: Details of labelling and engraving.
- Earthing.
- The type, rating and capacity of all equipment and components.
- Comprehensive schematic diagrams showing the configuration and operation of all components.

2.4 OPERATING PARAMETERS

Ensure the electrical service's installation is installed in accordance with the following operating parameters and service conditions:

- Nominal voltages:
- Line: 400-volt
- Phase: 230-volt
- Frequency: (Hz): 50Hz
- Number of phases: Three
- Number of wires: Four
- Neutral Connection: Star Point
- Earthing System: MEN
- Ambient air temperature range: (°C): -5°C to 40°C
- Maximum relative humidity: (%): 90%

2.5 LABELLING

Permanently label and individually number all components, fixtures, fittings, outlets and cables installed as part of this contract such that they can be quickly and accurately identified. All labels must be permanent with the type and size of label appropriate to the location and conditions. The label type must be appropriate for weathering, UV exposure, vandalism and mechanical damage. Stick on and hand-written labels are not acceptable. The numbering and identification are to be consistent and consecutive for all items. Provide matching labelling and numbering where an existing numbering and labelling system exists. Submit all labelling types, identification schemes and numbering schemes for approval. Ensure all labelling is clearly identified and cross-referenced in the manual and on the work-as-executed drawing. Double sided tape is not acceptable as a method of securing labels.

2.6 KEYING

Ensure all of the lockable enclosures provided as part of the electrical installation are keyed alike and keyed as part of the site's master key system. Where enclosures are required to be accessed by authorities, key the enclosure to the authorities' requirement.

2.7 INSPECTION AND WITNESSING

Allow for inspections and witnessing.

Arrange for and give sufficient notice so that inspection for approval may be at the following stages:

- Concealed conduits: Prior to concrete pours, etc.
- Cables laid: After laying underground cables and before and after laying protective covering and marker tape.
- Roughin: Cables have been installed in walls and the ceiling space before the like has been sheeted.
- Connection: Connection of cabling and wiring.
- Factory testing of all control panels and switchboards.
- Factory inspection of all custom-made components.
- Earthing: Installation and connection of earthing system.
- Acceptance: Installation ready for acceptance.
- Inspections required by Regulatory Authorities prior to their approval of the installation or its stages.
- All testing and commissioning.

To prevent an abortive factory visits the manufacturer is to provide written evidence, including appropriate certification, that testing has been carried out to the required specification prior to the factory visit. As part of the factory testing and commissioning all operational, functional and safety sequences are to be simulated and checked. Should the factory testing and witnessing have to be repeated due to the manufacturer failing to provide the required written evidence or appropriate certification and or failing to carry out the testing prior to the visit, the Electrical Contractor is to agree to a variation credit of \$2,000.00 to the contract per repeated factory test.

The manufacturer is to undertake the following prior to the factory visit:

- Undertake all required tests and ensure that signed test sheets and relevant product documentation and certification are in place.
- Obtain copies of the latest design specification and drawings
- Confirm the 'as built' drawings incorporate the latest modifications to the design drawings.
- Wire external switches on a temporary basis to simulate operational conditions for testing. Note that external switches and pots can be connected for test purposes.

2.8 TESTING

Arrange for and give two weeks' notice so that, the tests may be witnessed for approval.

Undertake on site the following tests:

- Insulation resistance measurements: on motors and major medium voltage equipment items, at 1000-volt D.C.; on cables and wiring.
- Functional checks: Full functional and operational checks on energised control equipment and circuits, including adjustments for the correct operation of safety devices.
- Motor rotation: Checking and where necessary altering connections for the correct motor rotation.
- Earth resistance.
- Earthing: Confirmation of effective earthing of the exposed metal of electrical equipment.

During testing, replace fuses and equipment damaged as a result of incorrect installation work.

Provide all Test Results for approval within one (1) week of the test being undertaken on A4 paper and as an electronic PDF file copy on CD for approval.

Check control systems for correct operation under representative operational conditions. During the commissioning period these conditions may not arise because the building is unoccupied, and it is difficult properly to verify the performance of seasonal variations in control strategies. Control systems should therefore be checked when the building is occupied. In addition, illuminance cannot be checked until the space is completely fitted out and furnished. Representative operational conditions will often involve checks at dusk and/or night time.

The extent and frequency of post-occupancy checks should be included in the control system specification as part of the contract between the building owner and the construction supply chain and will depend on the nature and complexity of the control system. Lease documents should support any contractual requirements for post-occupancy evaluation and ensure that the leaseholder is required to provide reasonable access for their performance.

Post-handover checks comprise a continuation of functional checking relating directly to the lighting control system. Where a central control system is implemented, use should be made of its logging functions and the ability to display trend logs once it is confirmed that they are operating accurately.

2.9 COMMISSIONING

Commission all components of the electrical services to ensure the correct interfacing operation and control of all systems to the satisfaction of the engineer as per the approved commissioning method statement and commissioning plan. Arrange for and give two weeks' notice so the commissioning may be witnessed for approval.

Following the completion of the commissioning and prior to Practical Completion thoroughly clean all components of the electrical installation to the satisfaction of the engineer.

Following commissioning, operate each component and system at the convenience of the engineer to the satisfaction to provide evidence to the engineer that each component and system is working correctly.

A record of all settings, set point and offsets should be maintained throughout the commissioning period and included in the operation and maintenance manual. Update the operation and maintenance manual record following the completion of each of the post practical completion commissioning requirements. The defects and liability period will not end until the operation and maintenance manual has been updated.

The manufacturer is to check the switchboards at the factory. Specific items or routines to be checked include though is not limited to:

Visual outside

- The finish to ensure there are no sharp edges.
- The metalwork: hinges on doors, flush doors, opening and closing doors, no sagging or drooping of doors when open, interlocking of doors.
- The door seals and gland plate gaskets are in place and securely fixed.
- The common key for all panels.
- For secure operation of door locks.
- That safe access to the control equipment is possible without having to isolate the control panel where specified.
- That the physical arrangement of the panel will allow transport to site and mounting in the final location.
- If the completed panel weighs more than 50kg check that eyebolts are fitted.
- The location and labelling of switches and indicators (including colour).
- That plastic rivets or screws are used to mount labels.
- The scale of analogue devices and the status of digital devices.

Inside

- That all doors on any panel containing exposed dangerous voltages are provided with interlocking isolators so that the door cannot be opened except with the isolator in the 'off' position.
- That equipment that requires on-line adjustment and testing by non-electrically qualified personnel is accessible and usable without interrupting the supply or overriding the safety interlocks. (In general, outstations must not be located within control panels where isolation is necessary to gain access.)
- Access for incoming cables
- Access for outgoing power and control cables
- Provision of suitable gland plates
- All doors/gland plates to be earthed by cable links

- Bus bars and power cabling as specified
- Anti-condensation heaters and thermostats are included and correctly set where specified
- Ventilation grills, filters and fans and thermostats are included and correctly set where specified
- Panel ventilation is adequate for the heat load
- Tightness of all connections, bolted power connections and bus-bar bolts tightened to the correct torque
- Neatness of cable looms with no pinching
- Sufficient spare capacity in all cable trunking to comply with BS 7671(13).
- Colour coding and numbering of all cables where specified and corresponding with numbering of terminals.
- Numbering of all terminals
- Shrouding and labelling of non-isolated equipment
- Shrouding of switches, lamps etc on doors if low voltage
- Segregation of power cabling and switch-gear from control cabling and electronic equipment
- Trunking lids cross referenced
- Connections between panel sections are numbered as specified, accessible and physically simple to connect/disconnect.
- Link type terminals for control system cables if specified
- Spare fuses and fuse ways if specified
- Drawing holder
- Fuses (type and ratings) against fuse chart
- Layout of equipment against drawings
- Ensure spare back panel space is provided as specified
- Ensure no equipment is mounted on the bottom or sides of the panel (similarly terminations) unless back/side plates are fitted
- Labelling of equipment in panel
- Access to all equipment especially devices requiring adjustment
- Power outlet is provided complete with 30 mA RCD protection
- Flexible looms connecting door mounted to interior mounted components will not weaken or break with repeated door opening. Check that the loom is arranged to avoid pinching or looping when the door is closed and is fully supported at each end.
- Screen and earth connections associated with the control system equipment comply with the manufacturer's installation requirements
- Fuse or circuit breaker frame size, trip unit type and settings against the drawings.
- Correct labelling has been provided.

All wiring is to undergo though not be limited to the following checks and testing:

- Cable type as specified
- Cable identified at both ends
- Cable cores identified at both ends if not self-numbered or colour coded
- Security of fixing/protection of cables to walls etc where surface-run
- Cable carrier/container in accordance with the specification (tray, basket, conduit/trunking etc)
- Cable management in accordance with the specification
- Cables not damaged
- Secure termination of wires (using ferrules)
- Screening continuity
- Cable only earthed at one end (field controller) or as specified
- Electrical continuity ('belling out')
- Correct polarity where applicable
- Correct input/output (by briefly disconnecting cable)
- Correct and secure termination
- Separation of mains and signals cables
- No short circuits line-to-line and line-to-earth
- Volt-free contacts are volt-free (prior to the installation of the field controllers).

Undertake including though not limited to the following on site communications network checks and tests:

- All network devices such as routers and bridges are installed correctly.
- All control devices can be addressed over the communication network.

- When used in conjunction with an office IT network ensure that permission has been granted from the IT manager. All network data routing is correctly set up by the IT department including allocation of the appropriate TCP/IP addresses and default router addresses.
- For structured cabling systems ensure that all outlets are properly labelled and assigned. Ensure that any changes to the cabling system are reflected in the updated documentation.

Undertake including though not limited to the following on site insitu field control devices (controllers, outstations and unitary controllers etc) checks and tests using NATA approved testing equipment:

- Type as specified
- Size as specified
- Enclosures as specified
- Number and location (height, access) as specified
- Adequate mechanical fixing
- Identification by mnemonic labelling
- All cables terminated and identified
- All terminals used (check that any unused terminals are intended to be spare)
- Continuous power available and of an appropriate quality
- Fuse correct type/spares if specified
- hardware configuration agrees with the specification
- All printed circuit boards in place
- All connection cables plugged in
- Document wallet containing wiring diagram where appropriate, i.e., when located in a control panel

3.0 INSTALLATION REQUIREMENTS

3.1 UNDERGROUND SERVICES

3.1.1 EXTENT OF UNDERGROUND SERVICES

Provide a reinforced plastic, 150mm wide, underground, yellow or orange coloured marking tape with the words 'WARNING - ELECTRIC CABLES BURIED BELOW' or similar above all private underground conduits at a depth of 200mm below ground level for the entire length of all underground conduits.

The position of all new pits and trenching within private property is to be confirmed on site with the school prior to any excavation commencing.

Ensure all building access is weather proof to prevent water entry into the building under driven rain conditions and all penetrations into the buildings are sealed to prevent vermin entry.

3.1.2 TRENCHING

Unless noted otherwise provide all trenching, bedding, backfilling and reinstatement required to complete the electrical services.

Excavate trenches in sections of suitable length, lay and bed the relevant service length, and backfill the trench section, with the minimum of delay, and if possible, on the same working day, unless otherwise approved.

Provide all saw cuts in existing concrete or bitumen surfaces in a straight line to a minimum depth of 75mm before excavation is commenced. Lift and store paving slabs for later reinstatement.

Ensure all trenches are cleared of sharp projections.

Notify, and obtain approval from the appropriate owner or authority before any excavation is commenced beyond the site boundary. Carry out the excavation to the owner's or authorities' requirements. Reinstatement the surface to match existing.

Concrete that needs to be removed, must be saw cut along existing joints such that the entire panel is removed and replaced. The proposed saw cut positions and the extent of concrete to be removed must be submitted for approval prior to the works commencing.

3.1.3 BORING

Where specified or required, provide boring, by an approved specialist in lieu of trenches. Make the bored dimension to ensure a tight fit. If voids are encountered, fill by pressure grouting.

3.1.4 CONDUITS IN TRENCHES

Install all underground conduits 500mm below ground level and provide each conduit with a spare polypropylene draw cord.

Provide a minimum surrounding of 75mm clean sand around cables and conduits installed underground.

Under roadways and areas subject to traffic movement, install cables in a duct or conduit extending to not less than 1m on either side of the sealed surface or trafficable area and encase in concrete with a strength of 20MPa having a minimum cover thickness of 100 mm.

Seal the buried entries to ducts and conduits with a pliable non-setting waterproof compound. Seal spare ducts or conduits immediately after installation, and seal the other after the cable installation.

Install all conduits either straight or with large radius sweeping bends with a radius 40 times the diameter of the conduit. All conduits must be installed in such a manner to allow simple removal and installation of additional cables following the completion of the project. In cases where multiple conduits have been specified, install all initial cabling within the first conduit. Written approval must be obtained from the engineer prior to installing any cabling in the subsequent conduits.

Where underground conduit rise above ground, ensure they rise vertically and they are protected at ground level by a concrete plinth extending 250mm below ground, 100mm above ground. The plinth is to extend in each direction beyond the conduits more than three times the diameter of the largest conduit other than the side of the plinth / conduit that is against a structure. Provide the plinth with a fall such that water does not pool against the conduit or the adjacent structure.

3.1.5 BACKFILLING TRENCHES

Prior to undertaking any trenching, provided details of the proposed backfilling and compaction approach for approval.

Provide a written certification that the backfilling including compaction has been completed such that the trench will not subside.

Remove all excess soil and fill from the site unless otherwise directed. Reinstate existing surfaces and assets disturbed or removed as a result of the excavations of trenching. Reinstate concrete surfaces to the original level using approved reinforcing steel, keyed to the existing and laid to prevent the reinstalled concrete from subsiding and cracking.

Following backfilling of all excavations by the electrical contractor, reinstatement of the final soft or hardscape surface will be by the head contractor (builder).

3.2 CABLES

3.2.1 INSTALLATION

Unless otherwise specified, install and terminate cables in accordance with the manufacturers' recommendations. Unless noted otherwise joints are not acceptable. Install power wiring utilising the loop-in, loop-out system with joints in cables being affected at outlets.

Ensure oil, wax and powder based electrical cable lubricants are not used as cable lubricants. If cable lubricants are required to be used then use polymer-based for copper cables and silicon-based for optical fibre cables.

Handle cables so as to avoid damage to insulation and serving or sheathing. Replace all wiring with insulation damage after determining and removing the cause of damage.

Identify multicore cables and trefoil groups at each end and at crowded intermediate points by means of stamped, non-ferrous tags, clipped around each cable, or trefoil group.

Install and adequately support fixed wiring as specified throughout the installation. In accessible false ceilings, keep cables clear of all ceiling insulating material and/or removable ceiling tiles by securely fixing the cabling to permanent structural members. If the structural members are more than 1,200mm above the suspended ceiling, provide a catenary support system. It is not allowable to fix cables to the ceiling hangers.

Provide flexible connections or an approved form of vibration/movement isolation on the terminations of all cables that will experience vibration or movement under their normal operation.

Cable installation in areas where there are motors and/or generators shall comply with the guidelines set out in AS/NZS 3548 and AS/NZS 2834.

3.2.2 GENERAL CABLING REQUIREMENTS

The terms wiring and cabling are used interchangeably throughout this contract to refer to any cabling types and relevant standards.

Ensure all of the electrical services cabling comply with the following requirements:

- All cables are installed without joins.
- All cabling is concealed from view.
- All cabling installed externally is installed in conduit.
- All cabling that is installed in locations that are not concealed such as on exposed roof trusses, are to be run in conduit.
- Cabling fixed to trusses and beams in concealed ceiling spaces is to be fixed to the side of the truss / beam and not on top of the bottom cord of the truss / beam.
- Chasing is not to be permitted.
- Coordination of the installation of conduits and cables in the ceiling space does not interfere with the operation or maintenance of any equipment.
- Cables do not come into contact with hot water pipes.
- Above suspended ceilings, all conduits and cables are secured to the ceiling support members or roof structure above. Conduits and cables laid directly on the ceilings (on the ceiling suspension system or framing) are not acceptable.
- All cables in underground conduits are approved by the manufacturer for external underground use.
- Enclose cables from above down to switches, outlets and equipment in conduits where the equipment is installed on single leaf masonry walls or concrete walls. TPS power cables where installed in cavity walls may be unenclosed within the cavities, unless otherwise detailed.
- Cables are secured to prevent any strain on the cable terminations. Support cables at a maximum of 1200mm spacing with minimum sag.
- The use of spring clips is not to be permitted.
- Support all horizontal cabling via a dedicated catenary, cable tray, cable ladder, or via a structurally secure cable support system specifically installed to support cabling. All cable support systems must be submitted for approval. It is not acceptable to use double sided tape, stick on hangers to support cables or to support cables from the ceiling support system or any other services support system.
- All cables passing through a metal surface, any sharp surface or any surface that could damage the cable insulation over the life of the installation is to be protected by grommets or nylon bushes.
- Replace all wiring that contains kinks or abrasions.
- Unless otherwise approved, terminate copper conductors to equipment, other than small accessory and luminaire terminals, by means of compression-type lugs of the correct size for the conductor, compressed only by the correct tool.
- Loom and lace together, with PVC straps, all conductors from within the same cable or conduit from the point of cable sheath or conduit termination to the terminal block. Neatly bend each conductor to enter directly into the terminal tunnel or terminal stud section, allowing sufficient slack for easy disconnection and reconnection.
- Provide flexible connections on the terminations of all cables that would experience sufficient stress/force under a bolted line fault condition that would cause damage to the cable termination or the equipment.

Provide mechanical protection of all cables in the following locations:

- Within 2,400mm of any floor, platform or landing that is accessible under normal operation and routine maintenance.
- All locations it is reasonable to expect that the cabling would be interfered with.
- All locations the cable could be subject to damage during normal operation and maintenance.

Provide all power and lighting cabling in accordance with the following:

- All T.P.I and T.P.S power and lighting wiring is to utilise stranded copper conductors with a minimum size of 2.5 mm sq. with 0.6/1kV V90 PVC insulation.
- Provide PVC free cables as low smoke zero halogen with X-HF-110 insulation.
- Provide PVC insulated cables with 0.6/1kV grade PVC compound, type V-75 or higher insulation.
- Provide PVC insulated and sheathed flat cables and single double insulated cables up to 16mm with 450/750V grade PVC compound, type V-90 insulation and sheathing.

- Provide PVC insulated and sheathed circular cables with 0.6/1kV grade PVC compound, type V-75 or higher insulation and sheathing.
- All low voltage and extra low voltage (32Vac or 115Vdc maximum) circuits and/or fire services are to be provided with different colour sheathing.
- Provide XLPE insulated and PVC sheathed cables with 0.6/1kV grade XLPE compound, type X-90 insulation, and PVC sheath.
- Provide all flexible cords as ordinary duty 250/440V rated with V-75 PVC insulation and PVC a sheath.
- Use white insulation for all TPS power cabling. For all cables supplying essential equipment use fire rated approved cables.
- Ensure all power and lighting wiring and cabling utilises stranded copper conductors.
- Ensure all wiring is provided and installed in such a manner that its installed overload rating exceeds the overload rating of the protective device.
- For fixed power wiring, colour the conductor insulation or, if this is not practicable, slide not less than 150 mm of close-fitting coloured sleeving to each conductor at the termination points as follows:
 - Active conductors in single phase circuits: RED.
 - Active conductors in polyphase circuits:
 - A PHASE - RED
 - B PHASE - WHITE
 - C PHASE - BLUE

Run the consumers mains in dedicated conduits.

3.2.3 SETTING OUT OF RETICULATION

The routes shown on the Drawings are approximate only. Determine the final routes to suit the building structure or site conditions. Obtain approval for the final routes prior to installing consumers' mains and sub-mains. Unless otherwise specified, conceal and protect cables and conduits. Arrange cables and conduits parallel with walls, ceilings and floors. Provide the main switchboard with a diagram indicating the route of any underground consumers' mains, printed on a durable card or similar, and indicating run distances for each 'leg' of the consumers' mains route.

3.2.4 WIRING IN CONDUIT

Complete and permanently fix the conduit run before installing the wiring. Use draw wires to pull in the conductor groups from outlet to outlet. For vertical conduit runs in excess of 15m make adequate provision for supporting the weight of the wiring to avoid insulation damage. Run circuits originating at different distribution boards in separate conduits.

3.2.5 TERMINATIONS

Terminate all cables installed as part of this contract. It is the Electrical Contractor's responsibility to check and ensure the component or equipment the cable is being terminated to be appropriate and suitable for the cable to be terminated to. Advise the engineer of any concerns with the component or equipment prior to the cable being terminated.

Where core identification is required, fit to each core durable numbered ferrules permanently engraved with numbers and/or letters to suit the specified connection diagrams. Terminate and identify any spare cores into spare terminals, if available; otherwise neatly insulate and bind the spare cores to the terminated cores.

Insulation displacement terminations or connections are not acceptable for 240-volt cabling. All 240-volt terminations must be screw type.

3.3 CONDUITS

Ensure all conduits installed as part of the electrical services are installed in accordance with the following requirements:

- Conduits are sized to permit drawing-in of cables to finished conduit runs without damage to cables.

- Protect all PVC conduits against UV exposure.
- Steel and galvanized conduit are not installed underground.
- Rigid UPVC conduit fittings are fastened to the conduits by fresh solvent cement in accordance with the manufacturer's recommendations. The cement is to be a contrasting colour to the conduit.
- Corrugated UPVC conduit fittings may be fastened with solvent cement as above or by use of snap-lock connectors in accordance with the manufacturer's recommendations.
- Conduits, pipes and conduit fittings are not visible on any wall, floor or ceiling surface with the exception of Switch rooms, Plant rooms and risers.
- Installation of conduits enables wiring to be drawn in and out at any future time without damage to the building and cabling and without disruption of the conduit continuity.
- Only conduit, deep draw-in boxes and couplings are to be cast in concrete. Do not cast conduit tees and elbows in concrete.
- Constant supervision at all times is provided when concrete containing conduits is being poured.
- Conduits passing through expansion joints are provided in concrete slabs with approved flexible expansion couplings.
- Conduits with expansion joints are provided as required to accommodate the expansion of the conduits and the supporting surfaces with a minimum of an expansion joint in straight runs at intervals of no more than 12,000mm.
- Corrugated PVC conduit shall not be used unless approved.
- Unless noted otherwise, provide conduit located externally as PVC heavy duty (HD) conduit and stamped "underground" type.
- Conduits, fittings and welding solution of the same manufacture are used.
- Conduit ends are cut square and free from sharp edges, burrs, and the like.
- Where subject to mechanical damage, exposure to sunlight, weather and/or damp conditions and/or ambient or contact temperatures exceeding 60 degrees Celsius, use heavy duty galvanised screwed steel conduit. Provide mechanical protection to UPVC conduit for a height of not less than 3m above ground or platform level.
- Where PVC conduit is embedded in concrete which is screeded or vibrated after pouring, or where conduits may be subjected to heavy traffic prior to concrete pour, provide constant supervision by a tradesperson to ensure that conduits are not damaged.
- Proprietary sealing caps (or aluminised flashing tape if sealing caps are not manufactured) are fixed to all conduit ends prior to the commencement of pouring of slabs, laying of bitumen, gravel, and the like and are to remain in position until the conduits are finally terminated.
- All conduits cast into a concrete slab, protrude perpendicular 100mm above the surface of the slab and are located as close as practicable to a wall.
- Prior to the installation of wiring, ensure conduits are clear of debris and liquids.
- All underground electrical conduits and conduits/pipes for special services (including spares) are sealed internally to approval at switchboards and/or at special services enclosures and where entering buildings to prevent the ingress of water.
- Up to the commercially obtainable conduit lengths of run, conduits are installed without joints. Remove all jags, burrs, and sharp edges from each length before completing each conduit joint. Fit moulded plastic screwed bushes to the free ends of metallic conduit runs before installing the conductors.
- All inspection fittings and the like are accessible.
- Conduits are not run in topping slabs unless approved.
- After removal of sharp edges, burrs, etc., ends and joint threads of steel conduits are painted with a rust-inhibiting metallic paint, which maintains conductivity.
- Arrange conduits below 2,700 AFFL such that a person cannot hang from or climb from the conduit by using the conduit as a foot hold or hand hold.
- All conduits are installed such that any moisture in the conduit drains away from the electrical connections. Where required provide the conduits with weep holes and drip loops.
- All conduits are installed and sealed such that insects cannot nest or seek refuge in them.
- All conduits are sealed such that the sealant can be removed in the following locations to prevent vermin and moisture entering through the conduits:
 - Conduits passing between different functional parts of the building such as food preparation areas, plant rooms, service areas and public areas.
 - Conduits passing between levels.
 - Conduits entering or leaving the building.

- Do not use conduits smaller than 20mm diameter in any circumstance or conduits smaller than 25mm diameter underground.
- Do not use light duty (MD-UPVC) conduit underground or where it may be exposed to mechanical damage or to sunlight.
- Ensure all associated plastic conduit fittings are of the same material as the conduits.
- Install conduits directly from the entry point to the termination point, with the minimum number of sets ensuring the number bends does not exceed the equivalent of 3 x 90-degree bends.
- Do not install elbows, tees, etc. in inaccessible locations.
- Cap all conduits during construction.
- Do not run conduits in roof spaces directly below the thermal insulation or sisalation.
- Do not run conduits in roof spaces or ceiling spaces directly on top of the ceiling.
- Arrange conduits within concrete slabs such that cross overs are avoided and the number of conduits in one location is kept to a minimum.

Rectify all damage caused by flooding or vermin ingress that has occurred as a result of the conduits not being correctly sealed. Any such damage post practical completion is to be considered a latent defect and must be rectified as such.

3.4 PENETRATIONS

All penetrations that exit the building are to be waterproofed.

Seal all penetrations in a neat and tidy manner in such a way that the sealing material can be removed to allow future use of the penetration. Ensure all penetrations are sealed to at least the original integrity of the member or structure being penetrated. Provide independent certification of all fire rated and sound rated penetrations. Do not penetrate fire rated finishes, structural members, acoustically rated finishes or damp courses without approval. Run pipes entering a building at ground level under the waterproof membrane and vertically penetrate the membrane and the floor slab. Provide a suitable seal between the pipe and the roofing material.

Provide all outlets and switches flush mounted within floors, walls and ceilings that have an acoustic or fire rating with additional protection to achieve the same acoustic and / or fire rating as the base structure. Provide a copy of an independent certification for approval of the additional protection that the required acoustic and /or fire rating is achieved with the installation method and components employed. Provide a copy of the certification in the maintenance manual and indicate the location of all such additional protection installations on the as built documents. Surface mounted wall blocks are not acceptable as methods of achieving the required rating if the outlet / switch has been specified as flush. If additional furring channel and or wall / ceiling sheeting is required that is not part of the base design all such additional materials must be included as part of the tender price.

Provide ceiling roses or flush faceplates with a cable gland to trim all cables penetrating a wall or ceiling that are to be connected to equipment that is bracket mounted that does not inherently accommodate concealed cabling.

3.5 EARTHING

Provide earth electrodes as 19mm diameter of either copper or steel rod copper clad and will incorporate integral driving heads and points. Stainless steel rods grade 302 is also acceptable. Install earth electrodes vertically.

Run a PVC-insulated copper conductor from the main switchboard earth bar to the slab reinforcing mesh. Clamp conductor to mesh (one point of contact only required) with a brass earth clamp. Wrap clamp and exposed copper conductor with insulation tape. Provide a label engraved 'Slab Reinforcing Mesh Bond' adjacent to the termination on earth bar.

3.6 ACCESS

In non-habitable locations such as plant rooms and store rooms provide cable access to surface mounted electrical equipment such as switchboards, control panels, intruder detection panels and communication equipment by surface mounted PVC or metal duct. Provide the duct with a removable lid of lengths not exceeding 1,200mm and arrange the duct such that it runs square with the building. Silicon seal between the duct the wall, the floor and the ceiling. Cover all conduits entering through the floor with such duct. Where the duct abuts the boards/panels provide neat cut-outs free of burrs in the duct and boards/panels to allow cable access. Where the duct does not adjoin the boards/panels provide cable glands in the duct and the boards/panels for all cable access. Ensure all of the cables run within the duct are supported vertically and horizontally to the cable manufacturer's requirements and as a maximum such supports are not to exceed 1,200mm. Provide or paint the duct to match the wall colour.

3.7 MOUNTING REQUIREMENTS

As part of the electrical-sub contract works allow for all necessary mounting brackets, fixings, trims, cut-outs, block outs and any other incidental component that will be required to complete the electrical installation. Provide a shop drawing of all such components including how they are mounted for approval.

Fittings and components that have any moving parts or weigh more than 2.5 Kgs that are fixed to the lined ceiling or walls must be provided with independent support system connected to the structure.

3.8 PITS

Provide the new Science consumers mains pits with the following:

- 900 x 900 minimum plastic pit positioned over the existing consumers mains conduits.
- Provide a 150 wide x 150 deep reinforced concrete surround.
- Provide the pit with a reinforced concrete base with the plastic pit sides tied onto the bases reinforcing.
- The lid and surround of the pit is to be angled / fall to match the adjacent hardscape.
- Infill Class C lid provided to the school for storage.
- Temporary stainless steel checker plate lid to infill the pit not covered by the MSB.

Provide the two new Gerald consumers mains pits with the following:

- 900 x 900 minimum plastic pit positioned over the existing consumers mains conduits.
- Provide a 150 wide x 150 deep reinforced concrete surround around each pit.
- Provide the pits with a reinforced concrete base with the plastic pit sides tied onto the bases reinforcing.
- The lid and surround of the pits is to be angled / fall to match the adjacent hardscape.

4.0 POWER DISTRIBUTION

4.1 COMMISSIONING

As part of the commissioning of the power distribution undertake the following tests as relevant on all components of the power distribution installation:

- Has been fully commissioned in accordance with the requirements of AS3000.
- Phase rotation.
- Power availability.
- Resistance to earth.
- Voltage.
- Overload protection.
- Fault protection.
- All mechanical fixings.
- The accuracy of the private meters.
- The BMS is accurately recording and displaying all of the data from all of the private meters.

Schedule the results for each item and component and include a copy of all test results in the operation and maintenance manual.

Ensure the correct phase sequence at the main switchboard after connection of the supply.

Ensure the following components of the power distribution system installation are complete and have been checked and tested prior to the adjusting of the power distribution system installation to commence:

- Labelling.
- Correct operation of the power distribution system.
- All components have been installed and are operating.

Should these items not be complete prior to the adjusting of the power distribution installation the additional expenses in re-attending the installation to undertake the adjusting of the power distribution installation as incurred by the engineer will be charged to the Electrical Contractor.

Provide all equipment such as ladders, scaffolding and tools necessary for adjusting the power distribution installation. Should the Electrical Contractor not have available the necessary equipment to complete the adjusting and aiming of the power distribution installation, the additional expenses in re-attending the installation to undertake the adjusting and aiming of the power distribution installation as incurred by the engineer will be charged to the Electrical Contractor.

At practical completion provide a Queensland Government, Department of Local Government and Planning Form 16 certifying the power installation and include a copy in the operation and maintenance manual.

4.2 SWITCHBOARDS

4.2.1 OPERATIONAL MAINTENANCE

During the maintenance period, provide the following for each switchboard supplied or modified as part of the contract:

- Carry out periodic inspections and maintain the switchboard installation in a condition to meet the specified performance.
- Promptly rectify all faults.
- Replace faulty materials and equipment without charge.
- Provide a thermoscan report equal to that provided by undertaken by Thermoscan Inspection Services Pty Ltd www.thermoscan.com.au at Practical Completion, at 6 months and at end of Defects Liability Period.
- Provide written reports on maintenance activities.
- Provide on line chart recording using a Fluke 1735 of the mains supply for a period of one week at Practical Completion, at 6 months and at end of Defects Liability Period.
- Ensure the chart recorder includes the following information:

- A sample every 200ms.
- Data presented in 5-minute intervals including the minimum, the average and the maximum value recorded for each 5-minute interval.
- Voltage of each phase to earth and each phase to phase.
- Current of each phase and neutral.
- Power factor of each phase.
- Voltage and current harmonics to the 10th order for each phase.
- Frequency of each phase

Include the chart recorder and thermoscans information within the operation and maintenance manual with simple explanation of the findings of each.

4.2.2 EXTERNAL DESIGN

Ensure all cable connections, busbar joins and switchgear connections can be thermally scanned without having to isolate the power. IR scan windows will need to be provided in all authority sealed compartments.

Provide enclosures comprising panels, doors and the like, giving the specified enclosure, segregation and degree of protection. Provide separate compartments with metal segregation for all extra low voltage equipment.

Ensure the switchboard enclosure is appropriate for the location it intended to be installed in and has appropriate space and capacity to contain all equipment and cabling in the final configuration.

Fabricate supporting frames from rolled, cold formed or extruded metal sections, with joints fully welded and ground smooth. Provide concealed fixing or brackets located to allow the assembly to be mounted and fixed in the specified location without removal of equipment.

Machine fold sheet metal angles, corners and edges with a minimum return of 25 mm around the edges of front and rear panels, and 13 mm minimum return edge around doors. Provide stiffening to panels and doors where necessary to prevent distortion or drumming. All panels are to be continuously welded and ground smooth.

Provide equipment mounting panels, fixed to threaded metal inserts, located inside the enclosure at the rear of the mounting panels.

Provide fixings in the supporting structure, and removable attachments, for lifting switchboard assemblies whose shipping dimensions exceed 1.8 m high x 0.6 m wide.

Provide all switchboard fixings and door / panel hardware, as stainless steel.

Provide the switchboards with doors that are:

- Dished type
- Fitted with a combined lock and catch and a separate key
- Concealed door hinges

In locations the door covers a section of board where live terminations could be exposed once the door is opened, provide the door with the following engraved laminate red/white/red label with 10mm text;

**'DANGER'
LIVE ELECTRICAL TERMINATIONS**

**LICENSED ELECTRICIAN OR
SUPPLY AUTHORITY REPRESENTATIVE
ONLY TO OPEN.**

Ensure all busbar, switchgear and cable connections can be thermoscanned without isolating the power.

After the switchboards have been installed, repair all chips and scratches in the paintwork to an as new condition.

The Science MSB is to be free standing and bolted to the pit surround.

The Gerald MSB, Science MDB and DB-G are to be mechanically fixed to the existing masonry wall.

4.2.3 REMOVABLE PANELS AND COVERS

The maximum width of any removable panel is 750 mm. Hang panels and covers on fixed studs with captive stainless steel 8mm square quarter turn locks such that they remain part of the panel or cover when the panel or cover is removed. Provide two stainless steel 'D' type handles to each removable plate. Provide a resilient strip seal, of foam neoprene or the like, around each cover or panel, housed in a suitable channel or housing, fixed with an approved industrial adhesive. In indoor locations, provide certified smoke seals to all panels and covers. For external switchboards provide a continuous positive line of weatherproof contact.

All doors are to be locked using three-point locking system with ac stainless steel lockable swing handle. Supply four keys on individual stamped aluminium key tags. Ensure all of the switchboards are keyed alike and are keyed on the site master key system. All meter panels located externally and in areas subject to unauthorised access are to be locked to the supply authorities' requirements using the supply authority key.

Provide each door with a substantial internal stiffener fitted with plan pockets and wind stops.

4.2.4 ESCUTCHEON PLATES

The maximum width of any escutcheon is 750 mm and the maximum height is 1,200mm. Hang escutcheons on stainless steel lift off pintail hinges and provide captive stainless steel 8mm square quarter turn locks such that they remain part of the panel or cover when the panel or cover is removed. Provide two stainless steel 'D' type handles to each escutcheon. Provide the escutcheon plates with neat cutouts for circuit breaker handles and the like. Provide a continuous 12 mm wide support frame for the fixing of each escutcheon plate, including additional support where necessary to prevent panel distortion. Hang escutcheon plates on hinges, which allow opening through a minimum of 90 and permit the removal of the escutcheon when in the open position.

Provide cutouts in the escutcheons for all spare future circuit breakers. Provide blank fillers in all spare escutcheon cut-outs.

Ensure all circuit breaker labels and adjustment dials are visible through the escutcheon when the escutcheon is closed.

4.2.5 CONDUCTORS

4.2.5.1 BUS BARS

Provide bus bar systems as high conductivity copper capable of withstanding the thermal, magnetic and physical stresses set up by the fault level detailed for a period of one second. Provide fault level calculations with the shop drawings. Phase colour the bus bars at appropriate intervals for ease of identification over their entire length at any opening, to within 10.0mm of fixings and terminations. Ensure the connections from the bus bars to the equipment are as short as possible and made using bus bars unless the latter is physically impossible. Design bus bar systems for continuous full load operation over a 24-hour period at an ambient temperature of 40°C, with short time peaks of 50°C, resulting in a maximum final bus bar temperature of 105°C. Make allowance for totally enclosed cubicles and for cubicles installed within recesses with or without doors. Provide neutral links and earth bars with sufficient capacity and terminals for connection of all conductors, one conductor per terminal, with spare capacity as detailed and with each terminal being numbered by means of stamping. Clearly mark and number terminal connections. Provide neutral bars with a

current carrying capacity equal to that of the incoming phase conductors. Provide bus bar circuits within the switchboard, extending from the termination of the incoming unit to the line side of protective equipment for outgoing circuits. Provide stud connections for cables of cross section 16 mm² or larger.

Clearly label each segregated section of the bus bar system.

Pre-drill the Bus Bars for future extension and extend bus bar droppers to spare locations. Drill each dropper to suit connection of future equipment of the same type as that specified.

Radius all bus bar edges and corners to prevent damage to insulation. Provide support sufficient to withstand without damage, the maximum prospective fault currents. Make bus bar joints with high tensile bolts and nuts, locked in position with lock nuts or locking tabs. Tighten bolts to the manufacturer's recommendation with a tension wrench. Do not use tapped holes and studs or the like for jointing current-carrying sections.

Colour the insulation or bus bar as follows:

- Active Bus Bars: Red, white or blue.
- Neutral Bus Bars: Black.
- Earth bus bar: Green and yellow.

4.2.5.2 NEUTRAL AND EARTH LINKS

Locate neutral and earth links within 0.6 m of each cable entry. Provide terminals for incoming and outgoing neutral and earth conductors, including the MEN link. Provide additional terminals for future circuits. Provide a bolted removable copper bar link in the incoming compartment, between the neutral and earth Bus Bars in each main switchboard labelled "MEN LINK".

4.2.5.3 WIRING

Provide all wiring within switchboards as follows:

- Install all internal cabling neatly horizontally and vertically. Cable trough (PVC with slotted sides) may be used, or alternatively cables may be laced/loomed using proprietary cable ties, with adequate insulated supports being provided. Ensure laces/looms are not unnecessarily tight.
- Unless otherwise specified, provide PVC wiring ducts to support and manage all switchboard control wiring and outgoing sub circuits. Ensure the total cross section of the wiring within any one duct, including allowance for outgoing connections, does not exceed 40% of the duct cross sectional area.
- Support cabling to ensure that strain does not occur at terminations.
- Use crimp type lugs at terminations, unless equipment has been specifically designed to preclude terminations being made in this manner. Use lugs with insulated ends.
- Fix cables 25.0mm² and over in size to internal cable trays.
- Bush openings in internal barriers for the passage of cables to prevent damage to insulation using Wattmaster or equivalent 'movable' bushing, glue fixed in position.
- Install cables associated with metering equipment and current transformers in conduit.
- Identify wiring at each end of each conductor with a captive type marking ferrule. Horizontally mounted markings are read from left to right and vertically mounted markings are read from top to bottom.
- Provide the cable lugs associated with consumers' mains and/or submains with permanent identification to denote phase colours.
- Provide sufficient space on mounting rails for future outgoing circuits possible in any cabling compartment.
- Provide terminal blocks for interconnecting wiring on each side of shipping breaks.
- Identify, by markers, each control core using an approved numbering system.

Provide cables sized to suit a current carrying capacity of not less than the maximum continuous rating of the equipment mounted within the switchboard, or sized to withstand the 'let-through' energy of the circuit protective device, whichever is the greater. If the conductors are to be bunched or installed within wiring ducts, apply appropriate de-rating factors when determining conductor size. The minimum size power conductor is multistrand 2.5 mm².

Provide control and indication conductors of not less than 1.0 mm² with 32/0.2 stranding and otherwise sized to suit the current carrying capacity of the particular circuit.

Colour code the wiring as follows:

- A Phase: Red.
- B Phase: White.
- C Phase: Blue.
- Neutral: Black.
- Earthing: Green/Yellow.

If no provision is made in wiring ducts for external connecting cables, install a galvanised perforated cable tray between terminal blocks and cable entries, of a size, and with available access space, sufficient to permit ready installation of the external wiring.

Segregate electric circuits subject to possible interference, and the like.

Segregate terminal groups and install together terminals for each outgoing circuit, in the same order throughout, as follows:

- Terminals for power wiring: 3 phases or phase and neutral;
- Control terminals: In numerical or alphabetical order of wire identification, with the lowest number or letter next to the power terminals.

4.2.6 SWITCHGEAR

4.2.6.1 CIRCUIT BREAKERS

Provide all circuit breakers as Schneider Electric.

Mount the circuit breakers so that the 'ON-OFF' and current rating indications are clearly visible with the cover or escutcheon in position, and so that arc discharges from the circuit breakers are directed away from live metal and insulation. Align operating toggles in the same plane.

Maintain sufficient space around the circuit breakers to allow all incoming and outgoing cables, including cables to spare poles, to be installed and terminated without overcrowding.

4.2.6.2 MINIATURE CIRCUIT BREAKERS

For miniature over current circuit breakers provide clip tray assemblies, capable of accepting the installation of single, double, or triple circuit breakers, and related Bus Bars. Provide moulded clip-on pole fillers for all unused portions of the chassis.

Maintain sufficient space around the circuit breakers to allow all incoming and outgoing cables, including cables to spare poles, to be installed and terminated without overcrowding. For clip tray chassis mountings, the clearance between the circuit breaker terminals and compartment walls will not be less than 90 mm up to 36 poles and 115 mm above 36 poles.

Provide auxiliary contacts shunt trips, motor operators and other required accessories. All motor operated circuit breakers for load shedding switchboards to be fitted with under volts trips.

Provide all circuit breakers that do not have adjustable trip units that supply motors and / or inductive loads as D curve circuit breakers. All other fixed trip unit circuit breakers are to be provided as C curve circuit breakers. Advise the engineer in writing of the circuits that will be supplied with D Curve circuit breakers so the clearing times of earth faults can be checked.

4.2.6.3 RESIDUAL CURRENT DEVICES

Unless specifically noted otherwise provide residual current devices (RCD) with a maximum tripping current of 30milli-Amps and a maximum tripping time of 20 milli-seconds. Use RCDs specifically designed to be added to or integral to the circuit breaker and be suitable for mounting in the same manner as specified for moulded case and miniature circuit breakers. Ensure all RCDs have a test facility which can be operated with the escutcheon closed. Use RCD/circuit breaker combinations that do not use more than a single pole per single phase circuit and no more than four poles per three pole circuit.

Type AC RCDs are not permitted.

Ensure that short circuit, cascading, a discrimination performance of the circuit breaker will not be affected by the earth leakage device.

4.2.6.4 SWITCH-ISOLATOR

Ensure switch-isolator have a rated thermal current applicable to the unit when installed in the nominated enclosure and they have an uninterrupted rated duty. Ensure the rated short-circuit making capacity is not less than the switchboard fault level.

Ensure that independent manual operation with a positive manually operated on-off indicator facility to lock the unit in the OFF position is provided.

Use totally enclosed units incorporating arc control devices and shrouded stationary contacts.

4.2.6.5 CONTACTORS

Provide contactors with a minimum rating of 20A at AC-22 of the block type, air break rated for continuous duty. Ensure the contactor is rated above the full load current of the load controlled when mounted in the nominated enclosure. Provide contactors with a utilisation category above AC-3 or DC-3 as applicable. Provide auxiliary contacts for the specified control circuits. Where space is available, fit not less than two sets of spare contacts. Where the number of specified auxiliary contacts exceeds the number which can be accommodated, provide a separate slave relay. Ensure reversing contactors are mechanically and electrically interlocked.

Mount the contactor with sufficient clearance to other equipment and to its enclosure to allow full access for maintenance, removal and replacement of coils and contacts, without the need to disconnect wiring or remove other equipment. All contactors mounted in switchboards are to be extended through the escutcheon.

Do not connect contactors in series or parallel to achieve the specified ratings.

4.2.6.6 CONTROL RELAYS

Provide control relays with a minimum rating of 5A suitable for continuous operation under the specified conditions with operating characteristics suitable for the application. Use plug-in types latched to the receptacle base by a captive clip, which can be applied and released without the use of tools.

Ensure the control relays employ electrically separate, double break, silver alloy, and non-welding contacts.

For standard control relays, provide assemblies with a minimum of four sets of contacts and capable of being expanded to a total of eight contacts in the same assembly. Where space is available, provide not less than one normally open and one normally closed contact.

Provide contact blocks, which are readily convertible in the field to either normally open or normally closed contacts.

4.2.7 SURGE PROTECTION

Provide each main switchboard with surge protection in accordance with AS/NZS1768 with the following features and requirements:

- The Maximum Discharge Current, I_{max} , as defined in SANS 61643.1 must be 100kA, 8/20 μ s per phase.
- The Nominal Discharge Current, I_n , as defined in SANS 61643.1 must be 70kA, 8/20 μ s per phase.
- The Impulse Current, I_{imp} , as defined in SANS 61643.1 must be 20 kA, 10/350 μ s per phase.
- The Voltage Protection Level Up as defined in SANS 61643.1 must be less than 800V at 3kA 8/20 μ s and 6kV 1.2/50 μ s.
- The Voltage Protection Level Up as defined in SANS 61643.1 must be less than 1000V at 20kA 8/20 μ s and 6kV 1.2/50 μ s.
- The Maximum Continuous Operating Voltage, U_c must be 415 Volts.
- The products must be UL recognised under UL1449-2 standard.
- (The product must be equivalent to CRITEC TDS MT277 or the CRITEC TDS MPM)
- The surge diverter must have 5 Segment light indication and voltage free contacts. An alarm must be raised when there is approximately 50% depletion of the surge material on any phase.
- Provide a manufacturer's warranty of a minimum of 5 years for the surge diverter.
- Tested in accordance with the requirements of UL1449 Edition 2 and IEC 61643.12 Class I and II

Provide the Gerald distribution board DB-G with surge protection in accordance with AS1768 with the following features and requirements:

- The Maximum Discharge Current, I_{max} , as defined in IEC 61643-1 must be 50kA, 8/20 μ s per phase.
- The Nominal Discharge Current, I_n , as defined in IEC 61643-1 must be 25kA, 8/20 μ s per phase.
- The Voltage Protection Level Up as defined in IEC 61643-1 must be less than 750V at 3kA 8/20 μ s and 6kV 1.2/50 μ s.
- The Voltage Protection Level Up as defined in IEC 61643-1 must be less than 1200V at 20kA 8/20 μ s and 6kV 1.2/50 μ s.
- The Maximum Continuous Operating Voltage, U_c must be 415 Volts three phase 240 Volts single phase.
- The products must be UL recognised under UL1449-2 standard.
- (The product must be equivalent to CRITEC TDS 150 or the CRITEC TDS350)
- The surge diverter must have light indication and voltage free contacts.
- Provide a manufacturer's warranty of a minimum of 5 years for the surge diverter.
- Tested in accordance with the requirements of UL1449 Edition 2 and EC 61643-12 Class I and II

All surge protection devices are to be extended through the escutcheon.

4.2.8 LABELS

Provide a two-colour laminated plastic schematic for each switchboard. Provide additional control schematics as required. Securely fix the schematics to the front of the switchboard or behind the switchboard door if the switchboard is provided with a door.

Include the following information on the schematics:

- All installed cable types, lengths and cable sizes.
- All protective device frame sizes and settings.

Provide samples of proposed label material, label sizes, lettering sizes and lettering text for approval.

Screw-fix each label adjacent to its relevant item of equipment, but not on the equipment.

Provide warning notices as white letters on red background and other labels as black lettering on a white background.

Provide the lettering height not less than:

- Switchboard designation: 25mm.
- Main switches: 20mm.
- Feeder control switches: 10mm.
- Identifying labels: (on outside of cubicle rear covers, etc.): 6mm.
- Equipment labels within cubicles: 4mm.

- Warning notices: 4mm.

4.2.9 SWITCHBOARD OPERATING PARAMETERS

Provide the main switchboards and the Science MDB to the following requirements:

- Line: 400 v.
- Phase: 230 v.
- Frequency: 50 HZ.
- Number of phases: three.
- Number of wires: four.
- Neutral connection: star point.
- Earthing system: MEN.
- Ambient air temperature range: -5 to +45deg c.
- Relative humidity: 90%.
- Switchboard designations: main switchboard.
- Mounting: floor mounted.
- Degree of protection: IP66.
- Numerical designation: category 1.
- Equipment connection: front connected.
- Gland plates: 3mm thick brass or aluminium or 6mm thick grey UV stabilised PVC in internal locations. Provide all gland plates with a neoprene gasket.
- Rain / sun hood separate to the switchboard flashed to the wall behind / above the switchboard. The rain / sun hood is to be of the same colour, material and finish as the switchboard.
- Cable entry through the top of the MSBs and the science MDB is prohibited and the top of these switchboards is to be fully welded / sealed.

Provide the Gerald distribution board DB-G to the following requirements:

- Line: 400 v.
- Phase: 230 v.
- Frequency: 50 HZ.
- Number of phases: three.
- Number of wires: four.
- Neutral connection: star point.
- Earthing system: MEN.
- Ambient air temperature range: -5 to +45deg c.
- Relative humidity: 90%.
- Switchboard designations: DB.
- Mounting: wall mounted.
- Degree of protection: IP55.
- Numerical designation: category 1.
- Form 1.
- Equipment connection: front connected.
- Gland plates: 3mm thick brass or aluminium or 6mm thick grey UV stabilised PVC in internal locations. Provide all gland plates with a neoprene gasket.

4.2.10 MATERIALS AND FINISH

Provide the main switchboards and the Science MDB as:

- Enclosure: 316 Stainless steel, powder coat Light Grey, (AS 2700 - colour N35).
- Escutcheons: 316 Stainless steel, powder coat white.
- Doors: 316 Stainless steel powder coat Light Grey, (AS 2700 - colour N35).
- Plinths: 316 Stainless steel, Painted Black.

Provide the Gerald distribution board DB-G as:

- Enclosure: Zinccaneal, powder coat Light Grey, (AS 2700 - colour N35).
- Escutcheons: Zinccaneal, powder coat white.
- Doors: Zinccaneal, powder coat Light Grey, (AS 2700 - colour N35).

- Plinths: Mild Steel, Painted Black.

4.3 EARTHING SYSTEM

Provide a comprehensive earthing system throughout the project addressing all aspects of the structure, all services, all systems and components in addition to those forming part of the power distribution.

Create new MEN links within the new Science and Gerald main switchboards connected to new earth stakes.

Remove the existing Science and Gerald earth stakes and associated cabling.

4.4 BUILDING MANAGEMENT SYSTEM

Utilise the schools existing building management system (BMS) to monitor the private meters. Following are the new private meters to be provided as part of the works:

- Science MDB - connected to the existing Science building BMS panel.
- Gerald MSB - connected to the existing Gerald building BMS panel.
- Gerald DB-GP - connected to the existing Gerald building BMS panel.
- Gerald DB-GL - connected to the existing Gerald building BMS panel.
- Gerald DB-G Unit DB-G - connected to the existing Gerald building BMS panel.
- Gerald DB-G Unit DB-E - connected to the existing Gerald building BMS panel.
- Gerald DB-G AC1 - connected to the existing Gerald building BMS panel.
- Gerald DB-G AC2 - connected to the existing Gerald building BMS panel.

Provide the new private meters as NHP IME Nemo 96HD+RS485 connected to the BMS via Modbus.

Arrange for the connections to the BMS panels and the commissioning of the BMS to be undertaken by Environmental Automation, unit 37-1631 Wynnum Road, Tingalpa QLD 4173 contact Isaac Prior (07) 3648 5851 0488 207 151 isaac.prior@aragroup.com.au as a nominated sub-contractor to the electrical sub contract.