Construction Specification

Sewage Pumping Station Electrical Switchboards

Supplement to the
WSAA Sewage Pumping Station Code of Australia (WSA 04-2005 Version 2.1

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1 Scope of Specification

This specification covers the requirements for materials and the standard of workmanship to be employed in the construction of low voltage electrical switchboards. Note however that this document is not a complete electrical specification. A job specification will need to be provided for any given project. The checklist provided in Appendix G will provide some guidance on the elements required to be covered under the job specification.

Design of sewerage pumping station switchboards is to be carried out generally in accordance with WSA 04 Sections 6 – 8 (inclusive).

This specification should be read in conjunction with WSA 04 Sections 20.6, 20.9 and 21.6 and the job specification to determine the requirements for a particular project. Any conflict between WSA 04, this specification and the job specification should be referred to the Superintendents Representative for clarification.

Appendix F contains a schedule for the submission of design information, inspections, testing and as-constructed information.

While this specification represents the current preferred standards, Council is prepared to consider new developments that may offer advantages such as cost saving, improved control or reliability. Any such alternatives are to be submitted to the Superintendents Representative for approval prior to purchase.

2 Design Philosophy

This switchboard shall be designed and constructed to:

- Ensure safe, reliable and efficient operation;
- Withstand the electrical and mechanical loads, temperatures, pressures and vibration that will be encountered under normal service and fault conditions;
- Ensure that operation or failure of any component does not cause damage to other equipment;
- Minimise electrical interference;
- Require the minimum of maintenance;
- Prevent the ingress of dust, moisture, vermin or other foreign matter; and
- Facilitate operation, cleaning, maintenance and repairs.

The switchboard manufacturer shall confirm the electrical loads of all equipment supplied from the switchboard and shall determine the ratings of all switchgear and protective equipment.

3 Standards and Regulations

Design, materials and workmanship shall conform to the requirements of:

- WSA 02-2002 – Sewerage Code of Australia;
- WSA 04-2005 – Sewage Pumping Code of Australia;
- Queensland Electrical Safety Act, Regulations and Code of Practices;
- Ergon Energy;
- Australian Communications and Media Authority (ACMA);
- Any other Authority having jurisdiction over the works;
- All relevant Australian Standards;
- Relevant IEC Standard or British Standard where no Australian Standard exists; and
- To the satisfaction of the Superintendents Representative.

The contractor shall be responsible for ensuring that all equipment and materials supplied are in complete accordance with the requirements of all relevant authorities and that all required approvals are obtained.

4 Operating Conditions

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

Unless specified otherwise in the job specification the equipment will be required to operate continuously under the following conditions:

Minimum ambient temperature	4°C
Maximum ambient temperature	44°C
Minimum relative humidity	33%
Maximum relative humidity	100%
Elevation	Not exceeding 1000m
Atmosphere	Refer to job specification*
Location	Refer to job specification
Wind Loading	Refer to job specification

* Note that a corrosive gas (sulphide gas) environment is common at Council wastewater facilities

5 Materials - General

All materials used shall be new and of the best quality, manufactured and tested in accordance with the relevant Australian Standards.

6 Power Supply

Unless specified otherwise in the job specification the power supply will be 400/415V 3 phase 4 wire 50Hz. The switchboard shall be designed for the fault level present at the installation site - refer to job specification.

The control voltage will generally be 230/240V AC or 24V DC. In some cases, additional supplies of 24V AC, 24V DC or 12V DC may be required for instrumentation or telemetry equipment.

The switchboard shall be arranged for a MEN earthing system in accordance with AS 3000 and Supply Authority requirements.

The switchboard shall be constructed to withstand the short circuit stresses generated by the fault level stated in the job specification. If a fault level is not stated, the fault level shall be taken to be a minimum of 35kA rms for one second with a Peak Factor of 2.2 at the source of supply.

All sites operate on a 12V control supply with DC/DC converts as required to operate other low voltage equipment. The 12V battery system shall be sized such that it will run the sites SCADA and telemetry system for a minimum of 24hrs in the event of power failure.

6.1 Voltage Drop and General Cabling Requirements

- All cables shall be sized for 1.3 time's maximum demand of the nominal running currents;
- The maximum voltage drop for any circuit under normal load conditions shall be limited to less than 3½% of the no load voltage at the consumer terminals;

- Motor cables shall be sized such that the maximum voltage drop at the motor terminals under DOL starting conditions is not more than 20% relative to the consumer main no load voltage. This sizing requirement is regardless of whether the motor will be DOL or soft started, they must be sized to allow for DOL starting within 20% voltage drop limits; and
- Joining of cables is unacceptable, unless indicated on the design drawings.

7 Metering

Where kWh metering is required in the job specification it shall be installed in strict compliance with the Supply Authority requirements. Refer to Queensland Electricity Connection and Metering Manual. Special attention is drawn to the requirements for spacing / shielding meters from heavy current carrying conductors.

For external switchboards, Supply Authority meters shall be housed in a section of the switchboard with access via a dedicated door that can be fitted with a Supply Authority padlock. A glass viewing window is not required.

When the main switchboard is located inside a building the Supply Authority metering shall be located in a separate cubicle mounted in an external location accessible to the meter readers. The material of construction will be typically stainless steel. A propriety type metering enclosure can be used. Refer to the job specification for details of meter locations and metering cubicle.

The required metering tariff will be specified in the job specification.

8 Switchboard Enclosure

8.1 General Construction

The switchboard will be a cubicle type construction, fully front connected and present a complete dead front. Switchboards for a typical water or wastewater pumpstation will generally be constructed to Form 2 separation. Power distribution switchboards or motor control centres will have other form of internal separation specified, e.g. Form 3b or 4b. Refer to job specification (Form factors refer to AS3439).

Cubicles will generally be fabricated from 1.6mm grade 316 stainless steel and be constructed to IP56D to AS60529. Aluminium may be offered with prior approval of the Superintendents Representative. Other materials such as sheet steel may be considered when the switchboard is to be located in environments free of corrosive agents such as control rooms. The job specification will detail if materials, other than stainless steel, can be offered.

The cubicle will be constructed of folded and welded construction. All seams shall be a continuous weld and be ground smooth after fabrication. Spot welding will not be accepted.

Typically, the maximum dimensions for cubicles shall not exceed 2100mm high or 3000mm in length. Where length of the switchboard will exceed 3000mm, the switchboard is to be supplied with suitable shipping breaks complete with appropriate wiring harness, busbar joints and seals between sections.

Avoid contact between metals of widely dissimilar electrode potential to minimise electrolytic corrosion.

8.2 Mounting

Cubicles to be suitable for pole / wall mounting or plinth mounting as per job specification. Mounting brackets / bolts for pole / wall mounted cubicles are to be external to the cubicle.

Plinth mounted cubicles are to be fitted with a channel base fabricated from 75 x 40 (min) mild steel channel. The channel base shall have a suitable number of 40 x 40 tags welded to the external long-side edges. Each tag shall have 16Φ hole and shall be used for fixing down the switchboard. The tags shall be positioned so it is possible to drill through them perpendicularly into the supporting material (e.g. concrete) once the cubicle has been positioned. The channel base shall be hot dipped galvanised after fabrication.

Cubicles that cannot be safely lifted by two people shall be provided with removable eyebolts and plugs. Alternatively, for plinth mounted cubicles, tubes can be provided through the channel base to permit the insertion of lifting rods.

Freestanding cubicles shall be stiffened to ensure overall rigidity. Additional stiffening and support members shall be provided where necessary to support heavy equipment. Such members shall be fabricated to the same specification as the cubicle.

8.3 Sunhood

All external switchboards are to be fitted with a sunhood. The purpose of the sunhood is to limit the temperature rise within the cubicle caused by direct sunlight thus protecting the internal electronic equipment from adverse heating effects. Sunhoods shall be fabricated from the same material as the cubicle. The sunhood shall project beyond the vertical faces of the cubicle and provide an air gap between the sunhood and the cubicle roof.

The dimensions of the sunhood are to be such that the back, front and sides of the switchboard are protected from direct sunlight (between the hours of 9am to 4pm). It would be acceptable to install additional false plates on the back and sides of the cubicle to prevent direct sunlight falling on the cubicle walls. These false plates would be spaced from the cubicle wall so that a minimum air gap of 50mm is provided. The sunhood shall extend approximately 900mm in front of the switchboard to offer some protection from rain and allow operators to open the external door and access control switches and indicators during wet weather. The sunhood shall be fixed in a manner suitable for the cyclonic wind loading possible at the site. Additional support posts may be required. The support posts can be fabricated from mild steel sections and be hot-dipped galvanised after fabrication.
Sun hoods and standoff supports shall be made of the same material as the main switchboard.

8.4 Doors, Mounting Pans and Hat Sections

Each cubicle shall be accessible at the front by hinged doors. Doors shall be fabricated as per the cubicle. They shall be of folded construction and fitted with stiffening members to ensure adequate rigidity and freedom from warping. Alternatively, a heavier gauge material may also be used. Each door shall have an M6 stud welded on the inside (lower hinge side corner) for earthing purposes. A 6mm^2 spiralled flexible connection shall be fitted for earth bonding across the door hinges.

Typically, the width of any door shall not exceed 850mm.

Doors shall be fitted with chromium plated hinges of the lift off type. The hinge pins are to be stainless steel. Fixing screws are to be concealed when the door is closed. Door handles are to be chromium plated (unless otherwise specified) padlockable swing handles (e.g. Emka 1107). Detail of handles to be submitted for approval. Door handles are to be locked with Lockwood No. 234A long shank padlocks, keyed to Whitsunday Regional Council's (WRC) master system, with two keys to be supplied to WRC. Doors with a height greater than 600mm shall be fitted with a 3-point roller latch to secure the door at the top, bottom and middle. External doors shall be fitted with a catch stay or strut to hold them in the 120^o open position.

External doors shall be fitted with a resilient neoprene gasket retained by metal framing. The gasket shall be compressed when the door is closed to ensure a moisture and dust proof

seal. The gasket shall not be installed in a stressed condition.

Where escutcheon doors are required, they shall be manufactured from either 2mm grade 316 stainless steel or 2mm sheet steel (powdercoated after fabrication). Refer to job specification. They shall be fitted with a chromium plated "T" handle fitted with a standard L&F 92268 series lock. Escutcheon doors shall be fitted with a catch stay or strut to hold them in the 120^{o} open position.

Each cubicle compartment shall be provided with a mounting pan. The mounting pan shall be manufactured from either 2mm grade 316 stainless steel or 2mm sheet steel (powdercoated after fabrication). Refer to job specification. The mounting pan shall be of folded construction and have a 20mm return. Mounting pans will generally be removable to facilitate the initial mounting of switchgear and wiring. They shall be fixed to the rear wall of the cubicle by M6 studs and chrome acorn nuts. Mounting pans are to be of the maximum possible dimensions. Where two (2) or more mounting pans are located in the same compartment they shall neatly butt against each other.

Hat sections are to be manufactured from the same material as the mounting pans and have the same surface finish. Where hat sections are used to support switchgear they must be rigid and not flex when switchgear is operated.

The design of the cubicle shall incorporate sufficient ribs, channels, hat sections and the like to accommodate all equipment mounting and wiring requirements. Screws and bolts shall not project through the walls and doors of the cubicle (screws for labels and door hardware excepted).

Cubicles may be specified for either outdoor or indoor locations. Outdoor cubicles shall have blank external doors. The number of external doors is to be kept to a practical minimum with segregation achieved by internal partitions / escutcheon doors (exceptions - Supply Authority metering and cable zone). All control switches, indicators and the like shall be mounted on an internal hinged escutcheon door. With the prior written approval of the Superintendents Representative, indoor cubicles may have equipment mounted on external doors but such equipment must provide an IP56 seal.

8.5 Ventilation

All cubicles shall be provided with adequate ventilation to ensure that the internal equipment does not exceed the manufacturer's specified operating temperature range when installed on site and operating under typical conditions at full load for extended periods. The effects of heating due to solar radiation shall receive full consideration in the design.

As a minimum all cubicles shall be provided with ventilation openings in each compartment, including the cable zone. The vents shall provide a minimum of 22,500mm^2 total outlet area per cubic meter of internal volume. The ventilation openings shall be provided with a protective cover to prevent the entry of rain. The vents shall be fitted with insect and vermin proof stainless steel gauze and a removable dust proofing media. Ensure the cubicle design and equipment layout will allow the easy replacement of dust-proofing media once the switchboard has been put in to service.

Where increased cooling is required, quiet running forced ventilation equipment shall be employed. Ventilation fans shall be thermostatically controlled and operate under a positive pressure. High quality replaceable filters shall be provided to dust proof the air intakes. For some applications cubicle mounted air-conditioners may be required.

The supplier shall submit for review, drawings and calculations detailing the effectiveness of the proposed ventilation, prior to switchboard construction.

8.6 Cable Entry

Each switchboard shall be provided with a dedicated cable zone to facilitate cable entry and glanding. The cable zone is to be not less than 250mm in height (if horizontal) or 250mm in width (if vertical) and be of suitable dimensions to accommodate the field cables. The cable zone shall be fully segregated and shall have a gas-tight seal from the remainder of the switchboard. Access to the cable zone can be either via a hinged door or removable panel fixed with chrome acorn nuts. Gasket seal and earthing of cable zone access shall be as previously specified for external doors. In certain situations, it may be considered impractical to provide a cable zone. For such situations prior written approval is required from the Superintendents Representative before this requirement will be varied.

Cable entry shall generally be through the bottom of the cubicle. Non-magnetic gland plates are to be provided. Brass is the preferred material. Aluminium will be accepted in non-corrosive environments where only non-metallic glands will be used and adequate provision is made to minimise electrolytic corrosion. Gland plates shall be fitted with a neoprene gasket and be secured by screws and nuts. Nuts are to be welded to the underside of the cubicle. Ensure adequate clearance is provided to allow tool access to gland plate fixings, e.g. do not have fixings located under ducts.

For plinth mounted cubicles the gland plates shall be in two (2) sections – one (1) section for cable glands and the other to permit hand access below the cubicle with the other section in place. This is to facilitate cable installation and the tightening of glands.

8.7 Surface Finish and Completion

Upon completion of fabrication the cubicle shall be descaled and degreased then given a light buffing. All surfaces are to be free from blemish, scratches, welding splatter and the like.

Unless otherwise specified in the job specification, all cubicles (including stainless steel cubicles) shall be powder coated or painted with 2-pack polyurethane. Surface preparation and coating application shall be in accordance with the manufacturer's instructions. The colour of cubicles shall be specified in the job specification. Escutcheon doors, mounting pans, hat sections and the like shall be white. Powdercoating / painting shall only be done after all fabrication work including the punching of holes and cut-outs has been completed.

A PVC document holder for drawings and a circuit breaker schedule cardholder shall be provided on the rear of a cubicle door.

The cubicle shall be suitably crated / packaged to minimise damage during transportation.

8.8 Distribution Boards

Consideration would be given to use of a proprietary line of enclosures for circuit breaker distribution boards and small cubicles such as telemetry panels or marshalling boxes. Such enclosures are to be manufactured from a material suitable for and have an IP rating appropriate to the environment in to which they are to be installed. Full details are to be submitted to the Superintendents Representative for approval before use.

9 Switchboard Equipment

9.1 Main Switch

The main switch shall typically be a three pole moulded case circuit breaker. In certain circumstances a manual change over switch may be used as a main switch – refer to clause 9.1.1 below. Automatic changeover switches shall not be used as a main switch without written approval of the Superintendents Representative.

The main switch shall be capable of breaking an inductive current 20% (minimum) in excess

of the calculated maximum demand for the switchboard. The main switch shall have a fault rating higher than the prospective fault current at that point of the distribution network but shall not be less than 6kA at 250V A.C. (sym).

The main switch shall be mounted so that it can be operated without opening the escutcheon or exposing live terminals. Where extension shafts are used they are to be suitably supported so that they do not sag thus making door closing difficult. Extension shafts shall not exceed 100mm in length. Hat sections shall be used to mount the switch at a suitable position.

The handle of the main switch shall be padlockable in the off position. It shall be possible to open the escutcheon with the switch in the on position (by use of a tool to operate / defeat the door interlock mechanism).

Care shall be taken to ensure discrimination between the main switch and other downstream circuit breakers.

The line side terminals of the main switch shall be fully shrouded to IP4X such that with the main switch in the off position there are no exposed live terminals in the switch board.

The main switch shall be fitted with an auxiliary contact that is closed when the main switch is closed.

Residual current protection shall only be fitted to the main switch with the express permission of the Superintendents Representative.

9.1.1 Manual Change-over Switches

For switchboards that incorporate a generator inlet socket or link connection bars it may be preferable to utilise a manual change-over switch as the main switch upstream of the main circuit breaker. The manual change-over switch, whether used as a main switch or not, shall comply with the requirements of clause 9.1 above and the following additional provisions.

The three positions of the change-over switch shall be clearly labelled “Mains” – “Off” – “Generator”. It shall be padlockable in the off position.

The manual change-over switch shall have two (2) auxiliary contacts, one that is closed when the switch is closed on mains and the other that is closed when the switch is closed on generator.

9.2 Lightning and Surge Protection

Protection of circuits against the effects of lightning shall be provided on all switchboards. Protection systems shall be designed in accordance with AS1768 and be suitable for a location category C site.

Primary surge protection shall be provided on incoming mains. The surge protection devices (SPD) shall be of an approved type, housed in a metal enclosure and be segregated from remainder of switchboard equipment. The SPD shall be connected between phase and neutral or phase and earth, as per manufacturers recommendation. The primary SPD shall be located in close proximity to the main switch and the main earth bar. Connecting leads are to be a minimum of 6mm^2, be as short as practical (consideration to be given to the effect of lead inductance). They shall not be run in ducting or loomed with other wiring.

SPD’s shall be capable of discharging a minimum of 40kA (8/20μs waveshape) per phase and incorporate status indication, visible without the need to open the escutcheon door or expose any live terminations. SPD’s shall be protected by HRC fuses or circuit breaker in accordance with manufacturer’s recommendation.

In high risk installations, such as remote sites more than 150m from adjacent earthing, more stringent surge protection will be required. In these cases, it is recommended that the surge protection capacity be increased to a minimum of 85kA (8/20μs waveshape) per phase.

Secondary protection for communications, data and instrumentation shall be specified elsewhere in this document.

Total length of cable between the active conductors through the surge diverter to earth shall not be more than 50cm.

9.3 Busbars

Busbars shall be fabricated from high conductivity copper with radiused edges. The current rating of the busbars shall be minimum 20% higher than that of the associated switchgear. Busbars, where not enclosed within a segregated, earthed chamber, are to be fully insulated. Insulation shall be applied by a hot dip process or heat shrink unless otherwise approved by the Superintendents Representative. Insulation is to be phase coloured.

Connections between busbars shall be tinned. Where it is necessary to have tapped threads in a busbar then stainless steel inserts shall be used to ensure that screw threads do not bear directly on the conductor material. Busbars are to be supported on insulators and be capable of withstanding the stresses arising from the prospective fault currents.

Main busbars will be fully enclosed and with the exception of power take-offs be segregated from other wiring and equipment. Inspection covers are to be provided in each busbar enclosure and at each connection point.

Where flexible busbar is used then correct work practices shall be adopted when cutting, punching and terminating to minimise lamination damage.

9.4 Active, Neutral and Earth Links

All links shall be manufactured from brass or copper and have studs and/or tunnels of correct capacity for the wiring to be terminated. Each link shall have at least 20% spare capacity for the termination of future circuits. Links shall be mounted so that access to them is not obstructed by wiring or cables. Active and neutral links shall be mounted on insulated supports and be fitted with a coloured insulated cover (red for active links, black for neutral) over all live surfaces. Neutral and earth links shall have capacity for the individual termination for the maximum number of circuits that can be supplied from the switchboard.

9.5 Circuit Breakers (CB)

Circuit breakers are to be used for the protection of all circuits and shall be selected to provide reliable supply. Circuit breakers shall be selected to match the prospective fault current of the switchboard but shall not be less than 6kA at 250V A.C. (sym). Tripping characteristics shall be selected to suit the particular circuit it protects. When selecting circuit breakers consideration must be given to the cable the circuit breaker is protecting and the earth fault loop impedance of the circuit. Cascading of CB's in accordance with manufacturer's instructions is permissible. Circuit breakers shall be graded to ensure correct discrimination.

Circuit breakers used for motor protection shall be matched to the motor ratings and shall not trip on motor starting inrush current but shall trip on all overloads in excess of 125% of full load current. The CB shall not trip on 105% of the rated current continuously. Operating curves shall be submitted on request. Motor circuit breakers shall provide Type 2 short circuit coordination with the motor starter unless otherwise specified in the job specification. Circuit breakers used for motor protection shall have an auxiliary contact fitted to allow for remote signalling of closed status.

If circuit breakers are used as an isolating switch they must also comply with Section 9.6 below.

Circuit breakers will be mounted on a suitable chassis with a standard busbar assembly. Chassis shall have a minimum spare pole capacity of 25%. The operating tags of all circuit breakers are to be accessible without the need to open escutcheon doors or exposing any live terminals. Escutcheon cut-outs are to match the maximum number of poles on the chassis. Insulated pole fillers shall be installed to blank spaces. If mounted on sheet metal hat sections, then these shall be manufactured from the same material as the mounting pans and have the same surface finish.

9.6 Isolating Switches

Isolating switches shall be rated for utilisation category AC-23. They shall be padlockable, preferably by a device integral to the switch. Removable latch dog or clip-on type devices are not acceptable. Isolating switches are to be mounted so that they are operable without the need to open escutcheons or expose live terminals. Where extension shafts are used they are to be suitably supported so that they do not sag thus making door closing difficult. Extension shafts shall not exceed 100mm in length. Hat sections shall be used to mount the switch at a suitable position. It shall be possible to open the door with the isolator in the on position (use of tool to operate defeat mechanism is acceptable). The line side terminals of the switch shall be fully shrouded to IP4X. An auxiliary contact is to be fitted to allow for remote signalling of closed status. Every motor shall have a padlockable isolating switch rated to break the locked rotor current.

9.7 Combination Fuse Switches (CFS)

CFS units will only be used when specifically called for in the job specification. CFS units shall comply with AS60947.3 and be of the double break type. Full interphase shrouding is required throughout the travel of the switch. Utilisation category shall be AC-21 minimum and AC-23 for motor circuits. Fuses shall be of the HRC type and be replaceable without the use of special tools. CFS units shall be flush mounting, dustproof and be padlockable in the off position. On-off status is to be clearly indicated by handle position. An auxiliary contact is to be fitted to allow for remote signalling of closed status.

9.8 Fuses

Fuses shall only be used for circuit protection where approved in writing by the Superintendents Representative. Fuses shall be of the HRC type and comply with AS60269. Fuses selection shall suit the fault level of the installation. Fuse holders shall be a fully enclosed type and have fully shrouded contacts. One full set of spare fuses shall be provided for each rating used, (e.g. where fuses protect a 3-phase circuit then 3 spare fuses shall be provided).

Fault current limiting fuses are to be located in an accessible compartment of the switchboard.

9.9 Isolatable Fuse-carrier

Isolatable fuse carriers shall be used to provide short circuit and over current protection to circuits wired on the line side of main switches or metering equipment. The fuse-carriers shall be of fully insulated construction, have a switched disconnection function and be suitable for equipping aM or gG type HRC fuses. Fuses shall be captive. Merlin Gerin STI or equivalent.

9.10 Selector Switches

Selector switches shall be cam operated with a rotary snap action. Contacts shall have a minimum rating of 10A at 250V. Switches shall be suitable for flush mounting and incorporate an engraved escutcheon indicating switch function and its respective positions.

9.11 Pushbuttons

Pushbuttons shall be a heavy duty, IP66 industrial type with a shroud to prevent accidental operation. Contacts shall be rated at 10A minimum and be of the double make-break type with definite over travel limits. Pushbuttons will generally be 22.5mm dia. Colours shall comply with AS 60947.5.1. Start and stop functions shall not be combined in one pushbutton assembly. Emergency stop pushbuttons shall be red mushroom heads, twist to reset.

9.12 Indicator Lights

Indicator lights will be of an IP66 industrial type with a diameter of 22.5mm. Colours shall comply with AS 60947.5.1 as per the following table:

Lamp Colour	Function
Green	Off, Available, Safe condition
Red	Dangerous condition
Amber	Fault
White	Motor run
Blue	Miscellaneous, e.g. Duty selection

Lamps shall operate off extra low voltage (typically 24VAC) and be of the LED cluster type. Lens caps shall be of the optically enhanced type. Lamp brilliance and colour shall be readily distinguishable regardless of the effect of ambient light.

A lamp test button shall be provided to test all indicator lights. Relays shall be used in the test circuit for isolation purposes. The use of diodes will not be accepted.

9.13 Phase Failure Relays

Phase failure relays shall detect loss of phase, phase reversal, undervoltage and phase imbalance and sequence. The relay shall have an integral time delay to prevent spurious operation during momentary fluctuations and shall be self-resetting on restoration of supply.

Typically, a phase failure relay would monitor the main distribution bus within the switchboard to protect equipment from the effects of supply abnormality. A contact controlled by the phase failure relay shall operate in the control circuit of all motors and also a voltage free contact shall be provided for telemetry signalling. A 0-10 minute adjustable time delay shall be provided prior to control circuit re-energisation. The phase failure relay shall be protected by a suitably rated circuit breaker.

For some applications a separate phase failure relay may be required to protect each motor circuit. Where required this will be detailed in the job specification.

Where the switchboard incorporates a change-over switch (either manual or automatic) a separate phase failure relay shall be provided to indicate the status of the Ergon mains supply. This phase failure relay shall be connected to the mains line side of the change-over switch via an isolatable fuse carrier. A voltage free NC contact from this relay shall be wired as a digital input to the telemetry unit to indicate loss of Ergon supply.

9.14 Voltmeter

A voltmeter shall be installed to indicate the phase to phase and phase to earth voltage. The voltmeter shall be a 90^{o} quadrant type, scaled 0-500V. The meter shall be 72mm square (min), dustproof and have an accuracy class of 1.5 in accordance with AS 1042. Terminals on the rear of the meter case are to be shrouded. The voltmeter shall be protected by a suitably rated circuit breaker.

9.15 Ammeter

An ammeter shall be provided for each motor. The meter shall display the current in each phase of the motor circuit. The meter shall be a 90^{o} quadrant type, scaled so that the full load current is approx. 70% of the meter scale and incorporate a 5 times FLC over scale. The meter shall be 72mm square (min), dustproof and have an accuracy class of 1.5 in accordance with AS 1042. Terminals on the rear of the meter case are to be shrouded. Suitably rated current transformers shall be used where a direct wired type is not practical.

9.16 Hours Run Meters

An hours run meter shall be provided for each motor. The meter shall be a minimum 48mm square and consist of a non-resettable cyclometer showing 6 digits plus tenths. Terminals on the rear of the meter case are to be shrouded.

9.17 Contactors

Contactors shall be moulded block, electromagnetic, air break type incorporating double break contacts with arching enclosures. Utilisation category shall be AC-3 (AC-4 for duties involving inching or plugging operation). Coils shall be continuously rated to operate at the control circuit voltage. Contactors shall have a minimum of two auxiliary contacts (1 x N/O & 1 x N/C) over and above what is required for the control circuit. It shall be possible to fit additional auxiliary contacts to any contactor in the switchboard.

Special attention is required where ELV control circuits are used. The contactor may be wired to a 240V AC circuit and switched via a pilot relay from the ELV circuit. Alternatively, it may be possible to use contactors with electronic coil circuits.

9.18 Control Relays

Control relays will be of the plug in type and shall be rated for continuous operation. Each relay shall have an indicator to show state and be enclosed in a clear dust proof case. Contacts shall be rated for the required duty but shall not be less than 5A. Where current exceeds 12A then a contactor shall be used.

Timer relays will be solid state and of the plug in type or suitable for din rail mounting. They shall incorporate an LED to indicate timer operation. Multi-range, multi-function timers are preferred.

9.19 Control Transformers

Low voltage transformers shall be of the double wound type continuously rated with an earthed metal screen between the windings. Output load shall not exceed 80% of the transformers continuous rating.

9.20 Current Transformers (CT) (excluding Supply Authority CT's)

Current transformers shall be housed in a self-extinguishing flame retardant housing and be capable of withstanding the switchboard fault level. The rated primary current shall suit the rating of the controlling device. The secondary current shall be 5A and rated to suit the burden of the connected equipment. Measurement CT's shall have accuracy class 2 minimum. When installed the CT shall be easily removable by mounting on busbar links or short flexible cables.

9.21 Current Transducers

Current transducers shall be used to monitor current in one phase of a motor circuit via a suitable CT. The transducer shall accept either 1A or 5A CT input (selected by on board link) and provide a 4-20mA output that is proportional to the motor current. This output shall be used to provide remote signalling of the motor current via the telemetry system. Transducers shall be loop powered from a 24VDC supply and shall be easily adjusted to suit multiple current ranges. Devices with integral CT's are preferred.

9.22 Power Supplies

Power supplies for instrumentation, PLC or telemetry equipment shall provide a regulated DC output to suit the voltage requirements of the equipment, generally 12V or 24V.

Each power supply unit shall include non-sacrificial protection against input overvoltage and other mains borne transients. Noise rejection characteristics (common mode and normal mode) shall be at least 120dB. Isolation characteristics (input to output) shall provide a capacitance of less than 0.005pf.

9.23 Surge Reduction Filters (SRF)

All power supplies to electronic equipment or instrumentation distribution boards will be wired through a suitably rated surge reduction filter. The surge reduction filter shall have rapid response to transients and noise at any point on the sine wave and not be effected by line or load impedance. The SRF shall include MOV protection and LC filter stages and include status indication.

All contactors and coils larger than 5kW shall have surge suppressing snubbers fitted. The size and type selected shall be in accordance to manufacturer's recommendations.

9.24 Signal Isolators

Signal isolators shall be fully solid state and be capable of receiving a 4-20mA signal. They shall be installed where the loop impedance exceeds the source device capabilities or where specified. Front panel adjustments shall be provided for span and zero settings. Externally powered devices are preferred.

9.25 Transient Barriers

Transient barriers shall be fitted to each end of instrument signal lines, data-lines and communication circuits. The barriers shall incorporate 3 levels of protection (gas arrester, MOV and clamping diodes) and be housed in a DIN mounting enclosure with screw terminals. Current and voltage ratings shall suit the protected equipment.

9.26 Terminals

Terminals are to be din rail mounted tunnel screw type. Terminal housings are to be manufactured from 6.6 polyamide and metallic parts from non-corrodible copper with stainless steel screws. Minimum terminal size shall accommodate $4mm^2$ wiring. Terminals shall be grouped into sections of common voltage with suitable barriers separating them. An individual terminal shall be provided for each wire. Common terminals shall be linked with a bridging strip. All terminals shall have a clip in plastic number and shall match the numbering shown on the electrical schematics.

Where earth terminal blocks are used for the termination of earthing conductors, the terminal block connection to the rail shall not be relied upon to provide earth continuity. Separate earthing conductors shall be used to ensure continuity to the earth bar. An earth terminal shall be provided adjacent each outgoing circuit.

Special attention must be paid to effects of dissimilar metals when using aluminium din rail.

Knifes-edge type terminals are to be used on instrumentation analogue signals to permit isolation and testing. Fuse terminals incorporating HRC type cartridges may be used for instrumentation and I/O circuit power supplies.

9.27 Power Outlet

A 15A GPO shall be mounted on the escutcheon door of every switchboard. The GPO will be protected by a 30mA RCD.

9.28 3-Phase Power Outlet

When a 3-phase power outlet is specified in the job specification the following shall apply.

A 15A 3 phase, neutral and earth (5 pin) switched socket shall be provided mounted either on the escutcheon door or the side of the switchboard cubicle. A 30mA RCD shall be incorporated in to the outlet housing. The outlet shall be Clipsal 56 series or approved equivalent.

9.29 Lighting

An 18W fluorescent light shall be provided in each compartment of the switchboard. The light/s shall be switched by a 10A switch on the escutcheon.

Where a sunhood is fitted, an 18W vandal-proof fluorescent light shall be fitted under the sunhood and shall be switched by a 10A switch on the escutcheon.

External lighting shall not be wired on the same circuits as the switchboard lighting.

All lighting circuits shall be protected by a 30mA RCD.

9.30 RCD Test Socket

To facilitate the testing of RCD circuits a dedicated, round earth pin, unswitched socket outlet shall be provided on the switchboard escutcheon. All RCD circuits shall be connected to this test socket via a selector switch mounted adjacent to the socket. This will allow the test technician to quickly and safely carry out injection tests for all RCD circuits by plugging the test instrument into the socket outlet and using the selector switch to switch individual circuits to the socket for testing. A suitable warning label is to be fitted adjacent the socket outlet to distinguish its function from a standard GPO. A schedule card is to be provided showing switch position relative to the RCD circuit.

The number of circuits switched by a selector switch is to be kept within practical limits. For switchboards with a large number of RCD circuits multiple selector switches will need to be provided.

9.31 Intruder Switches

When intruder switches are specified in the job specification the following shall apply.

Each external door or compartment cover of the switchboard shall have a micro-switch fitted. The micro-switch would be closed when the door / cover is closed. This does not apply to Supply Authority metering compartments. The micro-switches shall be wired in series and connected to a telemetry input to provide remote signalling when a door or cover is opened.

External doors of switchrooms shall have magnetic reed switches fitted to show when a door is opened. These switches would be closed when the door is closed and wired in series with the switchboard micro-switches to a telemetry input.

9.32 Site Security Provisions

In addition to the conduit specified in clause 28.1.7, a 10A 1Φ circuit breaker shall be provided on the distribution chassis for a future security camera installation.

9.33 Anti-Condensation Heaters

Where indicated on drawings, supply and install anti condensation heaters which shall incorporate a thermostat and heat resistant leads. The wattage of the heaters shall have a minimum size of 20 watts per square meter of exposed surface area of the cabinet.

9.34 Circuit Terminations (Power and Control)

The number of terminals and terminal identification shall be based on the outgoing cable connected thereto as follows:

- Sufficient terminals shall be provided for the number of cable cores, including earth wire; and
- Terminals associated with one cable to be numbered consecutively 1, 2, 3 ...etc, with all terminals arranged in one block. The earth terminal shall be adjacent to the terminal containing the highest core number.

10 Motor Starters

10.1 General

Every motor supplied from the switchboard shall be provided with an automatic motor starter. The preferred type of starter is:

- <= 6kW – Direct On-Line (DOL);
- 6kW to 30kW – Soft Starter; and
- >=30kW – VSD

Or as directed by WRC.

When starting current limitations or other operational issues require the use of reduced voltage starting then soft starters shall be used. Only under extenuating circumstances will autotransformer or other starter types be considered.

10.2 DOL Starters

DOL starters shall comprise a contactor and motor protection device (see Clause 11). The starter shall be designed for utilisation category AC3 and an intermittent duty of up to 12 starts per hour. Type 2 coordination with motor protection and short circuit protection devices shall be employed unless otherwise specified in the job specification.

10.3 Electronic Starters

Electronic Starters include soft starters and variable speed drives (VSD) (also known as variable frequency drives (VFD)).

The starter shall be mounted in accordance with manufacturer's instructions paying due attention to the spacing and cooling requirements. The operating temperature of the unit must be maintained within the manufacturer’s specification, typically less than 40°C.

Electronic starters shall be protected by semi-conductor fuses in accordance with manufacturer’s recommendations.

Ensure that manufacturer’s directions are followed with regard to control circuit voltages. Some starters (e.g. AB SMC-Flex) will require the use of control transformers or ELV control voltage.
The disturbance to the electricity supply system due to harmonics generated by the starter shall not exceed the limits specified in AS61000. Radio interference external to the starter shall not exceed the limits specified in CISPR11. The Point of Common Coupling shall be the line side of the main switch of the switchboard that supplies the starter. The chassis of the starter shall be bonded to earth with an earth conductor 20% larger than normal. The supplier shall provide the anticipated harmonic voltages and currents and a conformance statement before construction and shall confirm the predicted values by test during commissioning.

10.3.1 Soft Starters

Soft starters shall have a microprocessor based thyristor control circuit for the control of induction motors operating on a three phase 400/415V 50Hz supply. They shall have a continuous rating, of not less than, the maximum input rating of the driven equipment after allowing for motor efficiency. Soft starters shall be selected for 3-wire connection only, utilisation category AC-53b and 12 starts per hour as a minimum duty.

Starters shall have two modes of starting, standard soft start and a current limiting soft start. In standard mode the terminal voltage shall be increased gradually over the selected ramp time. The peak motor starting current is a function of ramp time. In current limiting mode the peak current shall not exceed a user defined value. Starters shall have the provision for energy optimisation when the motor is running; i.e. the power factor is adjusted to suit the motor load conditions. The starters shall have provision for soft stop. Adjustable controls shall be provided for ramp time, acceleration, deceleration, current limit and stalled current.

The starter shall include protection for microprocessor error, phase loss, open circuit thyristor, short circuit thyristor, motor disconnected, controller temperature, locked rotor and thyristor transient voltage. Motor protection features shall include thermistor, undercurrent, and overcurrent. The starter is to include three CT's for accurate motor current measurement. An auxiliary trip input shall be provided to allow connection of external protection devices such as seal failure. Relay outputs shall be provided for run, fault and top of ramp. It shall be possible to reset a fault trip either via a local reset pushbutton or from a remote reset pushbutton. An analogue output shall be provided when specified in the job specification.

Where called for in the job specification the starter shall have a display panel that can be remotely mounted on the escutcheon door. The panel is to include LED's indicating motor status, starter status, trip status and output relay status. The panel shall also include pushbuttons for local motor control and parameter programming. The starter shall be suitable for local or remote control as selected via a control input.

Soft starters shall be wired via a line contactor to provide positive line isolation. A bypass contactor shall be wired to operate when the motor is up to speed. These contactors shall be controlled via outputs from the soft starter. Particular attention is to be paid to the current and voltage ratings of the starters control relays. Use interposing relays or CR circuit or diodes for inductive loads as recommended by the manufacturer. Where a starter incorporates an integral internal bypass, a separate bypass contactor is not required.

In certain applications the use of less featured soft starters may be considered. Written approval from the Superintendents Representative is required for the use of such equipment.

10.3.2 Variable Speed Drives (VSD)

Variable speed drives shall be of the solid state electronic type with pulse width modulated output suitable for use with squirrel cage induction motors. VSD's shall be suitable for operation from a 240/415V 50Hz mains supply. VSD's must comply with AS/NZS 61800 and AS/NZS 61000 in terms of EMC and harmonic performance.

The VSD shall offer selectable control methods including V/Hz, sensorless vector control and field oriented control. The drive shall have the ability to model the thermal capacity of the motor in order to calculate the motor temperature.

The VSD shall be C-Tick approved for use within Australia. EMC filters shall be integral to the drive and be in accordance with AS61800. Unless otherwise specified the VSD shall comply with the limits specified for installation in the First Environment. Harmonics shall be limited to the levels specified in AS61000. Special attention is required to applications where regeneration will occur. The use of active front ends or similar will be required. Output

chokes shall be used on installations where motor cable length exceeds the drive manufacturer's recommendation or the motor is not rated for use on a VSD.

The drive shall have a keypad for display of status information, fault messages, parameter programming, drive control and monitoring. It shall be possible to remote mount this keypad on the escutcheon door. It shall be possible to control the drive either locally from the keypad or remotely from a PLC, communications network, operator station or the like. Switching to / from local and remote shall be bumpless. The drive shall also have an integral status display visible when the keypad is removed.

The drive shall have the following I/O as a minimum requirement:

- 1 x Analogue input for speed reference – 4-20mA, 0-10V or -10V/+10V. It shall be possible to set reference speed via keypad, remote potentiometer and analogue signal from PLC;
- 2 x Analogue output – 4-20mA. Programmable for output speed, output current, torque, power;
- 8 x Digital inputs programmable for control signals or external trip signals (e.g. seal failure);
- 2 x Relay outputs programmable for fault or status conditions. Relays to have changeover contact available so they can be used as NO or NC; and
- Thermistor input – for monitoring motor temperature.

It shall be possible to add internal expansion cards to increase the I/O of any type above the minimum requirements. Analogue I/O shall generate an alarm for loss of signal or signal outside of range.

The VSD shall include comprehensive fault monitoring and protective functions. This shall include but not limited to:

- Hardware fault;
- Software fault;
- Phase failure;
- Over current;
- Over voltage;
- Over temperature;
- Cooling fan failure;
- Motor overload; and
- Motor over temperature.

A fault history shall record the last eight faults with a log detailing the operational status at the time of each fault. It shall be possible to reset fault conditions either locally or remotely.

The VSD shall have communications capability and support the following protocols:

- Modbus;
- Profibus DP; and
- Ethernet IP.

The use of an internally mounted option card would be acceptable if the protocol is not included in the basic unit.

It shall be possible to program the drive from a PC via suitable software and connection lead (USB connection preferred over serial). It is preferred that the software does not require the use of a software licence token or dongle. If the software is not available for free download, then a licensed copy shall be provided. The connecting lead shall also be supplied with the drive. The software shall provide the ability to upload, download, modify, store and print a full parameter list and be capable of full monitoring and control of the drive. The software must be downward compatible with earlier versions of the drive firmware.

In a switch room type environment, VSD's shall generally be mounted separate from the switchboard cubicle. The IP rating of the VSD enclosure is to be suitable for the environment but shall not be lower than IP44. Smaller drives (e.g. ≤ 7.5kW) may be installed within a segregated, screened compartment of the switchboard provided generous space provisions are made and an effective cooling system is installed. Where it is not possible to install drives in a switch room type environment they shall be enclosed within a cubicle constructed as per Section 8 of this specification with due consideration given to ventilation requirements. It is generally expected that such cubicles will be fitted with an air-conditioner unit.

Variable speed drives are not to be installed in any external cubicles that may be subject to direct sunlight, without prior written approval of the Superintendents Representative.

Care shall be taken to segregate power, control and motor cables. Motor cables for VSD's shall be of the screened type, designed for use with variable frequency motors and be terminated using correct gland types. Screened cables shall be continuous from the motor terminals to the VSD terminals. All wiring and termination is to strictly comply with the manufacturers recommendations.

Where VSD's are used to control sewage pumps, the initial start shall be at 100% to assist with moving potential blockages. After a 30 sec time delay the VSD shall ramp to the required control point as dictated by the control logic.

10.4 Autotransformer Starters

Written approval from the Superintendents Representative is required for the use of autotransformer starters.

Autotransformer starters are to be of the closed transition type. The autotransformer is to be isolated from the circuit once the motor has started. Autotransformers are to be copper wound, 3-coil type and have tapings at 50%, 65% and 80%. Manually reset over-temperature protection shall be provided for the transformer and shall be separately indicated on the switchboard escutcheon. The autotransformer is to be installed in a separately mounted enclosure remote from the switchboard. Where this is not practical the transformer shall be housed in a totally segregated section of the switchboard lined with fire resistant sheeting and have a separate access door. Adequate ventilation shall be provided to prevent excessive heat build-up in the autotransformer enclosure. All wiring between the autotransformer and the starter shall be insulated with fireproof material.

11 Motor Protection

All motors up to 45kW shall be protected by a thermal overload relay (TOL). The TOL shall provide single phasing protection as well as overload protection. The full load current of the protected motor shall be between 30 - 80% of the current range of the TOL. The TOL shall be ambient temperature compensated, have both N/O and N/C auxiliary contacts and shall be capable of both manual and automatic reset. On motors fitted with a soft starter the TOL shall remain in circuit when the starter is bypassed.
Motors with a rating of 45kW or greater shall be protected by an electronic motor protection relay. The MPR shall provide protection for thermal overload, thermistor, single phasing and asymmetry. The MPR shall have N/O and N/C auxiliary contacts, LED indication and be capable of both manual and automatic reset.

All motors shall be provided with over-temperature protection via sensors embedded in the motor windings, e.g. thermistors. The sensors shall be wired in series and connected to a monitoring relay. The monitoring relay shall have N/O and N/C auxiliary contacts and be capable of both manual and automatic reset. The monitoring relay shall incorporate a time delay function to mitigate unreliable operation on power up. The sensors shall be wired on an

ELV circuit. For motors with an electronic starter, separate monitoring relays need not be provided if the starter incorporates suitable inputs and monitoring functionality.

Submersible pumps (either wet or dry mounted) shall be provided with a means of detecting failure of the mechanical seal and/or ingress of moisture. This protection shall stop/inhibit pump operation via the motor fault circuit. A separate indication lamp shall be provided but it shall be common with other motor protection for telemetry signalling of motor fault.

Unless otherwise specified, conductivity type sensors such as Water In Oil (WIO) are to be used as a local warning indication only. Refer to job specification.

Where equipment is supplied with integral protection devices (e.g. thermal switches, moisture switches, insulation monitors etc.) these devices are to be wired in to the motor protection circuit as recommended by the equipment manufacturer.

Where pump monitoring relays (e.g. Grundfos IO111 or similar) are used, they shall be mounted so that the indicating lights are visible and controls are accessible without the need to open escutcheon doors and expose live parts.

All motor protection circuits shall be arranged for fail-safe operation. Generally, the protective devices will be wired in series to a common, maintained fault relay. Should any device trip, the fault relay would be de-energised and signal a fault condition. The motor would be unavailable for further operation until reset. The protective devices would generally be set for automatic reset but the fault relay shall require manual resetting by the operator. A reset pushbutton shall be provided on the escutcheon door. In addition to the reset pushbutton it shall also be possible to reset motor faults remotely via an output from the telemetry unit.

All circuits shall reset automatically after a power failure unless there is a genuine fault present.

For certain installations additional protection may be required for water void, undercurrent etc. Refer to job specification and consult with the suppliers of mechanical equipment to ensure all control and protection elements required for equipment warranty are incorporated.

Motor control circuits shall incorporate a timer function to prevent excessive, frequent starting of the motor. The time delay between successive start attempts shall be based on the duty rating of the motor (ie number of starts per hour). Where the motor is normally controlled via logic within the telemetry unit or PLC (ie system mode) this timer function will be provided by the control software. The start delay timer does not function in manual control mode.

Each motor shall be provided with an available relay which shall be energised when all protective devices are healthy, supply circuit breaker and motor isolator switch are closed and any process or operational interlocks are true.

12 Control Circuits

For basic Form 2 type pumpstation switchboard, there shall be one common control circuit that shall typically operate at 240VAC.

For an MCC style switchboard, Form 3 or Form 4, each motor shall have an independent control circuit that operates at ELV, typically 24VDC.

Circuits that interface to PLC systems shall operate at 24VDC.

A typical motor control circuit shall consist of:

- Duty or Mode selector switch;

- Auto / off / manual selector switch (where required);
- Manual pushbuttons for start, stop and reset;
- Indicator lights for run and common fault;
- Manually reset fault relay;
- Motor available relay;
- Hours run meter (where required);
- Ammeter reading current in each phase (where required); and
- Motor isolator (padlockable).

13 Mounting of Equipment

Equipment is to be arranged to prevent inadvertent contact with live terminals during normal operation of switches, resetting circuit breakers or the like.

All door mounted equipment is to have finger-proof terminals or be fitted with insulating boots / covers. Alternatively, the equipment can be completely screened by a clear, removable cover. Equipment mounted on doors shall be positioned so that the door can be fully opened without damage to the equipment. Adequate space shall be left between equipment for wiring and labelling. A minimum of 30mm shall be provided between ducting and equipment terminals.

All equipment shall be grouped in a logical order.

The term escutcheon shall also refer to the external door in an indoor cubicle.

The following equipment is to be fitted on the mounting pan on the rear wall of the cubicle:

- Main Switch*;
- Circuit breakers*;
- Isolator switches*;
- Motor starters;
- Motor protection relays;
- Control relays, timers etc;
- Current transformers, control transformers, power supplies;
- Neutral link, earth link; and
- Terminal strips.

* The operating handles / tags for switches and CB's are to be accessible from the front of the escutcheon door. Extension shafts are not to exceed 100mm in length. Where hat sections or similar are used they shall be manufactured from the same material and the same surface finish as the mounting pans.

When mounting the main switch and neutral link consideration is to be given to the size of the incoming mains cables. Sufficient space is to be provided for termination. Generally, no equipment is to be mounted within 150mm of the floor of a plinth mounted cubicle.

The following equipment is to be mounted on the escutcheon door:

- Voltmeters, ammeters and associated selector switches;
- Hours run meters;
- Selector switches;
- Pushbuttons;
- Indicator lights;
- GPO;
- Light switch; and
- Any other operating equipment that may be specified, e.g. level control relay.

It shall be possible to reset all protective devices from the escutcheon without the need to access compartments containing live terminals.

A minimum of 20% spare space is to be provided on all escutcheon doors and mounting pans for future equipment. This space is to be in a single, contiguous area and not achieved by multiple small areas.

All equipment is to be fixed with metal thread screws in drilled and tapped holes. Where panel thickness may not provide adequate thread depth to support the equipment then stainless steel threaded inserts may be used.

Use of non-conductive screws (e.g. nylon) will be permitted where insulated fixings are required.

14 Cabling

The circuitry, in conjunction with the components and accessories used, shall be arranged to prevent recycling and feedback and shall generally be fail-safe. Power and control wiring within the cubicle shall be minimum 0.6/1kV stranded copper conductor insulated with V75 grade PVC. Conductors shall be sized to suit the application in accordance with AS 3008. Minimum size shall be 7/050 or 30/025 where flexible conductors are required. Wiring from CT's shall be minimum 2.5mm^2 unless otherwise specified. Instrumentation wiring shall be screened twisted pairs – Olex Dekoron or equivalent. Communications wiring shall be suitable for the particular application. I/O wiring, instrumentation wiring and communications wiring shall be segregated from all LV wiring.

Wiring will generally be enclosed within slotted PVC ducting or neatly loomed using nylon cable ties. PVC ducts shall be adequately sized for the number of circuits within and shall be filled to no more than 75% of its capacity. Lids for ducts shall be neatly cut and mitred at corners. Cable looms shall be supported with PVC saddles as necessary. Where wiring is bundled together in either duct or loom all wiring shall be insulated for the highest voltage present. Wiring to equipment mounted on doors or hinged panels shall be of the flexible type and enclosed in PVC spiral wrap adequately fastened at each end.

Wiring from a circuit fitted with a surge reduction filter shall not be loomed with wiring from unfiltered circuits.

Wiring shall be colour coded as follows:

Function		Colour	Abbreviation
AC Power	3 phase	Red, White, Blue	R, W, B
	1 phase	Red	R
	Neutral	Black	Bk
DC Power	Positive	Brown	Br
	Negative	Orange	O
Control	240V Control	White	W
	ELV Control	Grey	Gr
	Analogue Signals	Black, White scr. pair	Bk, W
	Thermocouple	To suit T/C type	
Earth		Green/Yellow	G/Y

Every control wire is to be identified with a wire number that completely encircles the wire, Legrand Memocab or equivalent system shall be used. The correct sized sleeve shall be

used so that the ferrule is firm on the wire. The wire numbering shall match that shown on the electrical schematics and shall read from left to right, top to bottom. The wire numbering for each drive or device shall be unique.

Power wiring will be terminated on to equipment using suitably sized crimp lugs. Control wiring will be terminated with correctly sized bootlace pins crimped using the manufacturers recommended tool. Each core shall have sufficient length at each termination to allow a fresh connection to be made.

All field wiring, with the exception of power cables 10mm^2 or greater, shall be terminated at a terminal strip comprised of din rail mounted tunnel type screw terminals. A minimum of 10% spare terminals shall be provided at each terminal strip.

Wiring or 10mm^2 or greater can be terminated directly to switchgear using appropriate crimp lugs or similar.

15 Labelling

All equipment shall be identified with an engraved label of a rigid plastic laminate such as Twoplex. The labels shall be screw fixed. Self-adhesive labels or double-sided tape is not acceptable. Labels are to be positioned so that they are not obscured by equipment or wiring. Labels are not to be fixed to removable duct lids.

Labels will generally be black letters on a white background. Warning labels shall be white letters on a red background. Letter height will be selected to suit the particular equipment but as a guide the following shall apply:

Switchboard identification label	25mm
Major equipment labels	10mm
Equipment identification	5mm

The main switch and motor isolators are to be clearly labelled with 10mm white letters on red background. The OFF position shall be clearly marked.

Each item of equipment shall have a unique tag name and the label shall match the tag names shown on the electrical schematics.

Where a switchboard has multiple sources of supply or contains circuits supplied from other locations (e.g., control circuit interlocks) prominent warning labels are to be installed.

16 Fastenings

All bolts, nuts and washers shall be ISO metric complying with the relevant Australian Standards and be manufactured from 316 SS.

Bolts and studs used for constructional purposes shall be provided with a full nut and lock washer. The use of self-locking nuts would be permitted if they are of an approved type that can be used several times without deterioration and the connection is not one that would require frequent undoing. Electrical connections using bolts or studs shall be fitted with flat washer, lock washer and a full nut. Electrical connections using screws shall be fitted with a flat washer and a lock washer.

Screws and bolts shall project a minimum of one thread pitch and not more than three thread pitches beyond the nut or panel. Cover retaining screws shall be of the captive type.

Self-tapping or self-drilling screws shall not be used in any part of the switchboard.

Double-sided tape shall not be used in any part of the switchboard.

17 Electronic Equipment

Electronic circuits and components shall be high grade solid state discrete or integrated circuit devices having been substantially derated for the duty required. All components shall be assembled on high quality fire resistant epoxy fibreglass laminate or similar non-hygroscopic printed circuit boards. Each PCB shall be varnished or similarly protected for use in tropical and corrosive environments. Circuit board components shall be liberally spaced and shall have test points and links provided to assist with fault finding.

All equipment shall be suitable for operation in the vicinity of other electrical equipment and have a high degree of immunity to electrical transients and noise.

17.1 Telemetry Equipment

Where telemetry equipment is specified in the job specification then it shall be supplied, installed and wired by the contractor. Note that telemetry is required on every sewerage pumpstation switchboard. Unless otherwise specified, WRC technicians will carry out the software configuration and integration into the SCADA system. WRC technicians require a minimum of 6 weeks' notice prior to commissioning to allow for scheduling of tasks in to their works program.

A listing of approved telemetry equipment is provided in Appendix B2. Note that certain equipment is mandatory and no alternatives will be accepted. Possible suppliers are also listed but this does not imply they are the only suppliers that can be used.

WRC is progressively implementing a digital radio network to replace the old analogue radio network. It is expected that all new sites will be digital. Only under extenuating circumstances will new sites be added to the analogue network. In such cases, the job specification will detail requirements.

When telemetry equipment is to be located within the switchboard it shall be located in a dedicated section, preferably with a separate internal access door. The telemetry compartment shall be sized and equipment positioned so that it shall be possible to accommodate the future retrofitting of a Schneider Electric SCADAPack ES P500 telemetry unit or a Serck eNet type telemetry unit (including an additional din rail, terminals and wiring duct for the topside I/O connections). Approximate dimensions of this section would be 800mm x 800mm.

All telemetry equipment is to be wired through a terminal strip located in the telemetry section. Sufficient space shall be left on din rails and in wiring ducts to permit the future wiring of 50% additional of I/O of each type (DI, DO, AI and AO).

The signals would be voltage free contacts or analogue signals. If the analogue signal is part of a loop with several devices, it is to be wired via a signal isolator and the telemetry input shall be the last device on the instrument loop. Telemetry digital outputs would be wired through 12VDC interposing relays. A problem currently exists with SCADAPack P334 units. If the P334 losses power or fails, the analogue current loops will also fail. To ensure the integrity of critical instrument loops, a precision 255Ω resistor is to be wired across the analogue input on the P334. As an example, this will be required on the pump well level input on any sewerage pumpstation RTU.

The 240VAC supply to telemetry equipment power supply is to be supplied via a dedicated circuit breaker wired through a surge reduction filter.

When telemetry equipment is to be mounted in a remote cubicle the required signals shall be wired to a segregated section of the field cables terminal strip. The remote cubicle will be a

stainless steel type of appropriate IP rating, approximately 800 x 800 x 300. The cubicle shall be generally constructed in accordance with Clause 8. Sun protection as per Clause 8.3 is required on all external mounted telemetry cubicles.

The job specification will contain details of scope and location of equipment.

Appendix C contains tables showing the required I/O signals and address assignment for several sewerage pumpstation telemetry scenarios. These assignments are not to be varied without written permission of a Whitsunday Regional Council Electrical or Control Systems Engineer. For other telemetry installations the I/O signals and address assignment shall be detailed in the job specification.

Refer to drawings in Appendix A for a typical telemetry schematic for a sewerage pumpstation.

Note that for pumpstations incorporating more than two pumps, dual RTU's may be required. Refer to job specification.

Refer to Clause 28.2 for additional information relating to installation works associated with telemetry equipment.

17.2 HMI Screen

A HMI screen may be requested for an installation at the discretion of Whitsunday Regional Council. Where an HMI screen has been requested, it shall be programmed to show the status of all analogue and digital I/O, status of the PLC and status of the telemetry communications link. All programming delays, counters, offsets and totalisers shall be adjustable from the HMI with the use of a supervisory password, otherwise these parameters will be read only.

In the event where council deems an HMI unnecessary for any installation, spare space shall be provided within the switchboard escutcheon, mounting plane, marshalling, cable entries and door space for an HMI to be retrofitted at a later date. This extra capacity shall be additional to the spare space necessary to fulfil the requirements of the other sections of this specification.

17.3 PLC Equipment

PLC equipment shall only be used where complex control functions warrant. **The job specification will contain specific details if a PLC is required.**

When called for in the job specification the following general requirements must be satisfied.

PLC equipment shall be housed in a segregated section of the switchboard, preferably with a separate internal access door. This can be a shared compartment with telemetry equipment.

The PLC and I/O power shall be supplied through an approved surge reduction filter.
The PLC shall be programmed via an IBM compatible PC. A licensed copy of the programming software, a software manual and the correct programming lead shall be supplied as part of the works, unless the PLC is of an approved type and Whitsunday Regional Council Electrical or Control Systems Engineer gives written direction that it is not required.

A minimum of one complete set of PLC documentation shall be supplied including a descriptive functional specification, ladder diagram (anointed with ample notes, labels and comments to fully describe code), full label listing and full cross reference table. A backup copy of the PLC code shall be provided on CD-ROM.

17.4 Pump Control Relay

Refer to Clause 18 below for a discussion of pump control strategies. For installations where a pump control relay is required the following shall apply.

The preferred pump control relay is a Yokogawa UM33A Digital Indicator (with alarms). This relay will accept a 4 - 20mA signal from the level sensor and provide outputs to drive relays for pump control. Ensure that manufacturer's instructions are followed with regard to freewheel diodes or CR networks on outputs. The UM33A incorporates a digital display and is to be mounted on the escutcheon door.

17.5 Sump Pump Control Relay

In certain applications, such as sump pump control, electrode type level sensors shall be used in conjunction with an electrode relay to control the starting and stopping of the pump. The preferred type of electrode relay is a Multitrode MTR series.

18 Pump Control

This clause is mainly aimed at a sewerage pumpstation installation but could also be applied to other installations. The discussion refers to a typical pumpstation with 2 pumps. For stations with more than two pumps the job specification will detail the pump control requirements.

18.1 Pump Control Strategy

18.1.1 Telemetry Control with Local Control Backup

Unless otherwise specified in the job specification, this strategy would be the default method of controlling pumps at sewerage pumpstations.

A four-position selector switch shall be used to select between System / Off / Local Manual / Local Auto. This switch is to be of a distinct colour or have a distinctively coloured escutcheon plate so that it is readily identifiable to operations staff.

When System is selected the motors would be controlled via logic within the PDS telemetry unit. The logic would monitor the well level analogue signal and start / stop the motors by energising digital outputs. The selection of motor duty and level set points would be via remote SCADA system. All motor starter functions and motor protection functions will be incorporated in the system mode control circuit. Faults would be reset by either an escutcheon mounted reset pushbutton or remotely via the SCADA system. Programming of PDS logic and remote SCADA system would be carried out by WRC unless otherwise specified in the job specification. System would be the normal operating mode for a pumpstation.

When Local Manual is selected the motors will be under local manual control via escutcheon mounted start and stop pushbuttons. There will be no automatic or remote control in this mode however remote monitoring via telemetry would be active. All motor starter functions and motor protection functions will be incorporated in the local (manual) control circuit. Faults would be reset via an escutcheon mounted reset pushbutton. It is intended that this mode of control would only be used during maintenance activities or if there was a critical failure of the telemetry or the auto control equipment.

When Local Auto is selected, pump operation would be controlled by a Pump Control Relay (refer to Clause 17.4). Starting and stopping of pumps would be determined by the wet well level and the set points in the pump control relay. The pump control relay will energise interposing relays to operate in the pump control circuits. Duty selection would be via an escutcheon mounted selector. The duty selector is to have an adjacent label stating that it is

only for use in the Local Auto mode. There will be no remote control in this mode however remote monitoring via telemetry would be active. All motor starter functions and motor protection functions will be incorporated in the Local Auto control circuit. Faults would be reset via an escutcheon mounted reset pushbutton. The duty selector, pump control relay outputs and associated control relays will only be active when the selector switch is in the Local Auto position. A time delay is to be incorporated in the Local Auto mode to ensure that pump available relays and other circuitry has operated before the control mode becomes active.

It is only intended that this mode of control is used if there is a critical failure of the telemetry equipment.

18.2 Pump Operation Methods

This clause describes two (2) common methods of pump operation employed in WRC sewerage pumpstations. Other methods may be employed to meet the requirements of a particular pumpstation. (refer to the job specification).

18.2.1 Pump Operation Method 1

The pumps are configured to operate in a standard duty / standby arrangement. Typically, the two (2) pumps would be the same size. Duty selection is effected via SCADA in System Mode or by an escutcheon mounted selector switch in Local Auto Mode. This discussion assumes that Pump 1 has been selected for duty and Pump 2 for standby. The same principle applies if Pump 2 was selected as duty pump.

When the level in the pump well rises to the duty start level, Pump 1 will start and pump down to the stop level. If the level continues to rise and reaches the standby start level, Pump 2 will start and both pumps will operate in parallel until the stop level is reached. If the duty pump becomes unavailable, then the standby pump will be enabled to operate off the duty start level.

It shall not be possible for both pumps to start simultaneously, e.g. after a power fail when well level may be high.

In some circumstances it is not desirable to have the pumps operate in parallel. In these cases, the duty pump would be stopped at the standby level and after a short time delay the standby pump would start. If the standby pump becomes unavailable, then the duty pump would be re-enabled.

The job specification will detail if parallel operation is required or not.

18.2.2 Pump Operation Method 2

This method applies to stations where pumps are of different sizes. Typically, one pump would be sized for 2 x ADWF and would be the main duty pump. The second pump would be sized for 5 x ADWF and would only run during high flow periods (e.g. rainfall events) or when specifically selected by the operator. Pump 1 is always the small pump and Pump 2 is the large pump. Duty selection is effected via SCADA in System Mode or by an escutcheon mounted selector switch in Local Auto Mode. In normal operation Pump 1 is selected for duty. Pump 2 is only selected for duty for a short period each month to exercise the pump.

Normal operation is with Pump 1 selected for duty. When the level in well rises to the duty start level, Pump 1 will start and pump down to the stop level. If the inflow is greater than Pump 1's capacity and the level continues to rise to the standby level, Pump 1 will stop and after a short time delay Pump 2 will start. Pump 2 will pump down to the stop level and turn off. When the level next rises, Pump 1 will resume normal operation. Should Pump 2 fail after operation has initiated then Pump 1 must be re-enabled and start operation immediately. If Pump 1 becomes unavailable, then Pump 2 will operate off the standby level.

It shall not be possible for both pumps to start simultaneously, e.g. after a power fail when well level may be high.

When Pump 2 is selected for duty, Pump 1 will not run under normal conditions. Pump 2 will operate off the duty level. Should Pump 2 become unavailable then Pump 1 must be enabled to operate off the duty start level.

19 Miscellaneous Equipment

The equipment discussed in the following Clauses is generally only applicable to sewerage pumpstation installations however it can also be called for other types of installation.

19.1 Level Sensor

All sewerage pumpstations are to be fitted with a level sensor. For other facilities it shall only be provided when specifically detailed in the job specification.

Level sensors will be of the hydrostatic pressure measuring type. The housing shall be stainless steel with a capacitive ceramic sensor element and stainless steel diaphragm. This sensor connects to a separately mounted transmitter incorporating zero and span adjustments. Unless otherwise specified the sensor shall be ranged 0 -10m. The sensor shall be supplied with a minimum 12m of cable and a strain clamp for suspension in the pumpwell. In turbulent wells, a stilling tube or suspended weight may be necessary for a satisfactory installation. The transmitter is generally mounted in the switchboard. The transmitter will output a 4 - 20mA/HART signal in proportion to the level in the pumpwell. The preferred type of level sensor is a Vega Vegawell 52 with a VegaDis 62 Transmitter. Typical catalogue number for a Vegawell 52 with HART protocol, 0-10m range and 27m of cable is Vegawell 52.XXA4AMD1DD1X. The part number of the Vega transmitter is DIS62.XXKMCSX (with display). The Vega transmitter shall be positioned in such a way as to allow easy removal / replacement of the cover during installation and calibration work.

19.2 High Level Alarm (HL)

All sewerage pumpstations are to be fitted with a high level alarm.

A float switch shall be installed in the wet well to provide a high level alarm signal. The float switch will be a mechanical switch enclosed in a polypropylene ball, suspended by its own cable. The float switch contact shall be a change-over type. The float would operate on a battery backed 12VDC supply (typically the telemetry system power supply) and be an input into the telemetry system. In certain specific applications it may be used to initiate an alarm light as detailed below.

The preferred well High Level float switch is Flygt model ENM 10. The float switch shall be configured fail safe such that a normal well level is a closed input. This input shall be wired directly to the RTU.

19.3 Critical High Level Alarm (HHL)

All sewerage pumpstations are to be fitted with a critical high-high level alarm.

A float switch shall be installed in the wet well to provide a critical high-level alarm signal. The float switch will be a mechanical switch enclosed in a polypropylene ball, suspended by its own cable. The float switch contact shall be a change-over type. The float would operate on a battery backed 12VDC supply (typically the telemetry system power supply) and be an input into the telemetry system. In certain specific applications it may be used to initiate an alarm light as detailed below.

The preferred well High High Level float switch is Flygt model ENM 10. The float switch shall be configured fail safe such that a normal well level is a closed input. This input shall be wired directly to the RTU.

The flexible cables shall be capable of supporting the weight of the ball float and cable without the need for additional support. The ball bloat cable length shall be sized to allow position adjustment within the well entirety. This ball float shall be installed in accordance with the manufacturer's installation instructions at the RL of 300mm below the overflow for the station.

19.4 Alarm Light

This shall only be provided when specifically detailed in the job specification.

A flashing alarm light shall be installed to indicate high wet well level. This alarm light shall be a weatherproof (IP66D) and vandal proof fitting mounted on top of the cubicle (or external to building). A wire guard shall be fitted. It shall be connected to a flashing relay activated by the float switch detailed above and shall be manually reset by an escutcheon mounted pushbutton. The lamp shall be clearly visible from a distance of several hundred metres.

The alarm light shall operate off either 240VAC or 24VDC as specified in the job specification. Where a DC supply is specified it shall be supplied via a separate battery backed power supply (ie not the telemetry supply).

19.5 Diesel Pump

This shall only be provided when specifically detailed in the job specification.

A diesel pump is installed at some pumpstations to provide emergency pumping capacity when Ergon supply has failed. The diesel pump will have its own dedicated level sensors and control panel and will operate independently of the electric pumps.

A dedicated 240V 10A circuit breaker is to be provided in the switchboard for the diesel pump battery charger.

The following voltage free input signals are to be wired to telemetry terminal strip:

- Diesel pump started (1 x DI);
- Diesel pump failed to start (1 x DI);
- Diesel pump fault (1 x DI);
- Diesel pump flow (from limit switch on reflux valve) (1 x DI); and
- Starting battery low voltage (1 x DI via suitable relay).

The starting battery low voltage signal can be provided by a process relay similar to APCS PA201. The relay monitors the battery voltage and if it falls below the trip set point (e.g. 10.5V) then an output contact will be used to provide the signal to the telemetry system.

19.5 Disconnection Chamber

This shall only be provided when specifically detailed in the job specification.

The disconnection chamber shall be an extension of the switchboard cubicle and shall be fabricated from the same materials. The chamber will be fitted with a lockable door and would generally be located at the very bottom of the switchboard. It shall be completely segregated from the rest of the switchboard. The chamber would have no bottom but a gland plate would be fitted between the chamber and the cubicle proper. Cables from the sockets into the switchboard proper shall be fitted with a secure cable gland at the gland plate. The disconnection chamber will require ventilation openings as per Clause 8.5.

The chamber will house decontactor type sockets to allow the disconnection of pumps by non-electrical personnel. The sockets are to be Marechal or equivalent. Matching plug tops are to be supplied for fitting to pump cables. Ensure that the conduit access into the well can accommodate the plug size and can be easily pulled through with all cabling installed.

For some sites it may be preferable to have the pump disconnection chamber separate from the switchboard (e.g., where the switchboard is installed remote from the pumpwell). It would be acceptable to utilise an URD type distribution pillar or a 316 stainless steel cubicle to house the decontactor sockets.

19.6 Pumpstation Ventilation Fans

This shall only be provided when specifically detailed in the job specification.

The ventilation fans in pumpstation buildings shall have an Auto – Off – Manual selector switch. In manual they shall operate continuously. In auto they shall be controlled via a 24hour time clock such that they operate for a 30-minute period twice a day, once at 6AM and once at 6PM.

20 Emergency Power

Provision is to be made for emergency power at all WRC facilities. At critical sites a permanent standby generator will be installed. The full requirements for a permanent generator will be detailed in the job specification. Clause 20.1 below serves only to highlight some particular requirements. For other sites, provision is to be made for the easy connection of a transportable generator set – refer to clause 20.2 for requirements. There may also be a requirement to allow for future connection of a permanent generator at an installation, at the discretion of WRC. In this case, the switchboard modifications required for future connection of a permanent generator shall be outlined in the job specification, including all applicable parts of section 20.1 below.

20.1 Permanent Standby Generator

When a permanent standby generator is to be provided, the job specification will fully detail all requirements. The following are some of the general items required for a diesel generator installation:

- Generators will be supplied with a fuel tank with sufficient capacity for minimum 24 hours running at full load;
- The generator will have a circuit breaker to protect the output cable;
- An automatic transfer switch and logic panel is to be provided to detect loss / restoration of Ergon supply and switching to/from the generator supply. The transfer switch can utilise circuit breakers or contactors to suit the installation requirements. The logic panel is to be a commercially available type. A single switch shall be provided to allow operations personnel to test the generator and change-over function. This switch shall simulate a mains failure, start the generator and transfer site loads on to the generator. A contact from this switch shall be wired to a telemetry input for monitoring purposes;
- Due to the cyclic nature of pump operation it may be necessary to have an automatically switched load bank to prevent the generator running under light load situations. The load bank would typically comprise resistor elements mounted within the exhaust air ducting. The load bank shall be controlled by a load sensing controller. The load bank controller shall have facility to accept a disable signal from the site control system, e.g. this may be used to drop out the load bank prior to large loads coming on line;
- For installations where an internal load bank is not practical, the job specification may call for provision to be made for connection of a transportable load bank. In this case, connection to the switchboard shall be made via a 3-phase 150A decontactor inlet socket (e.g. Proconect 3PS9A3NE01) via a suitably rated circuit breaker;

- For other sites a stand-alone external load bank may be required. The job specification will detail requirements;
- A dedicated 240V 10A circuit breaker is to be provided in the switchboard for the generator battery charger; and
- The following voltage free signals to be made available at a terminal strip for wiring to the telemetry equipment:
    - Generator running;
    - Generator fault;
    - Generator failed to start;
    - Generator low fuel warning (approx. 2 hours' run-time left);
    - Generator starting battery voltage low (1 x DI via suitable relay);
    - Generator circuit breaker closed;
    - ATS Mains supply position;
    - ATS Generator supply position;
    - Generator test switch active; and
    - Load bank healthy.

If the generator control panel does not provide a starting battery voltage low alarm directly then a process relay as described in clause 17.4 above can be used.

- Where the generator is to be installed external to a building the following requirements shall apply:
    - The unit shall be fully enclosed in a vandal-proof, acoustic enclosure. The top of the enclosure is to be manufactured from stainless steel and painted;
    - The enclosure shall have no glass or perspex panels;
    - Lockable covers shall be provided for all access hatches including radiator filler and fuel filler – to suit WRC padlock system;
    - There are to be no exposed hot surfaces;
    - A cage shall be fitted over the exhaust cap; and
    - Noise rating is not to exceed 70dB at the boundary of the facility.

20.2 Mobile Generator Connection

For facilities where a permanent standby generator is not installed and the maximum demand is less than 110kVA (with due consideration for motor starting requirements) provision shall be made for the connection of a mobile generator set. Contact WRC's Electrical Technical Officer to verify what generator connection is required for any given site.

For sites with a maximum demand of less than 110kVA (with due consideration to motor starting requirements) a 150A decontactor type inlet socket is to be provided either fitted to the switchboard (for an external board) or, where the switchboard is located inside a building, mounted in an accessible, external location. The socket is to be a Marechal DS9-3198017, Cutler Hammer CH9A3NE01 or Proconect 3PS9A3NE01 and is to be mounted in a suitable wall box and fitted with an inlet cap.

For sites with a maximum demand of less than 65kVA (with due consideration to motor starting requirements) a 90A decontactor type inlet socket is to be provided either fitted to the switchboard (for an external board) or, where the switchboard is located inside a building, mounted in an accessible, external location. The socket is to be a Marechal DS6-3168017, Cutler Hammer CH6A3NE01 or Proconect 3PS6A3NE01 and is to be mounted in a suitable wall box and fitted with an inlet cap.

The following requirements are common to all sites to be fitted with a mobile generator connection:

- A suitably rated circuit breaker is to be fitted downstream of the inlet socket to limit the generator current to suit the switchboard wiring. This circuit breaker is to be suitable for a

fault level of 18kA minimum. The circuit breaker shall comply with Clause 9.5 and also Clause 9.1 in terms of mounting, extension shafts, locking and labelling;

- A manual change-over switch, rated to the generator full load current, is to be provided in the switchboard to select between Ergon supply, off or generator supply. It shall not be possible for both supplies to be selected at the same time. All line side terminals (Ergon and Generator) are to be shrouded to IP4X. The change-over switch shall also comply with Clause 9.1.1 in terms of mounting, extension shafts, locking and labelling;
- A set of three indicator lights are to be wired to the Ergon line side of the change-over switch via a suitably rated isolatable fuse-carriers. The purpose of these lights is to alert operators that Ergon power has been restored. A suitable warning label is required to show these indicators are not isolated by the main switch or change-over switch. Refer also to clause 9.13 regarding the provision of a phase failure relay on the Ergon line side;
- In addition to the inlet socket, a set of terminals shall be provided behind the escutcheon panel as an alternative generator connection point. This is to accommodate generators that do not have an outlet plug compatible with the inlet sockets stated above. Refer to drawing WRC24-R13-03. The cable connecting the generator inlet to the changeover switch, neutral link and earth link shall be flexible cable. The conductors on the socket end shall be terminated with bootlace pins. The cable shall be long enough to allow easy disconnection and reconnection between the inlet socket and the inlet terminals; and
- Provision shall be made in the side of the changeover section for temporary generator cable entry. Any holes or doors provided must not compromise the IP rating of the panel. The cable entry shall incorporate means to support the incoming cable (e.g. gland or clamp).

For certain installations it would be acceptable to have the transfer switch, circuit breaker and decontactor inlet socket mounted in a separate enclosure. The enclosure would be IP56, fabricated from 316 SS, have a blank external door (padlockable or require a special tool to open) and an internal escutcheon door. The inlet socket is to be mounted on side of cubicle and changeover switch and circuit breaker operable from the escutcheon. There shall be no exposed live parts when the external door is open.

20.3 Other Facilities

For facilities where a permanent standby generator is not installed and the total demand is in excess of 110kVA (with due consideration to motor starting requirements) or when specified in the job specification, generator connection links are to be provided. The purpose of the links is to permit the quick and easy connection of a transportable generator via a trailing cable. For an outdoor switchboard the connection links are to be housed in a dedicated section of the switchboard. For an indoor switchboard the connection links are to be housed in an IP65 stainless steel enclosure mounted in an accessible, external location.

The generator connection link shall be designed so that the cable termination is adequately protected and supported and all doors, covers and the like can be closed and secured with the trailing cable connected.

The trailing cable shall terminate on to copper busbar with brass studs, stainless steel threaded inserts or bolted connections. All necessary hardware is to be supplied including bolts / studs, flat washers, spring washers and nuts. Stud / bolt size is to suit the size of connected cables but shall be not less than M8. The terminations and busbar are to be shrouded to prevent inadvertent contact with live parts.

The busbar links are to be connected to a manual change-over switch via a circuit breaker using suitably rated cable. The circuit breaker is intended to limit the generator current to match the switchboard design specification and shall have a minimum breaking capacity of 35kA. The circuit breaker shall comply with Clause 9.5 and also Clause 9.1 in terms of mounting, extension shafts, locking and labelling. The connection links and wiring to the circuit breaker are to be rated for a minimum of 150% of the maximum demand of the switchboard.

The manual change-over switch shall be rated for the same current as the main switch. The change-over switch shall select between Ergon supply, off or generator supply. It shall not be possible for both supplies to be energised at the same time. All line side terminals (Ergon and Generator) are to be shrouded to IP4X. The change-over switch shall also comply with Clause 9.1.1 in terms of mounting, extension shafts, locking and labelling.

A set of three indicator lights are to be wired to the Ergon line side of the change-over switch via a suitably rated isolatable fuse-carriers. The purpose of these lights is to alert operators that Ergon power has been restored. Refer also to clause 9.13 regarding the provision of a phase failure relay on the Ergon line side.

For certain installations where the generator connection links are mounted in an external enclosure it would be acceptable to also have the transfer switch and circuit breaker located externally. The enclosure would be IP65, fabricated from 316 SS, have a blank external door (padlockable or require a special tool to open) and an internal escutcheon door. The changeover switch and circuit breaker would be operable from the escutcheon. There shall be no exposed live parts when the external door is open.

21 Inspection and Testing

During the construction of the switchboard every facility shall be accorded the Superintendents Representative to inspect the works in progress at any time. The following stages are mandatory inspections:

- Completion of sheet metal fabrication prior to installation of equipment; and
- Completion of construction prior to workshop testing.

Works shall not proceed past these stages until the Superintendents Representative has been advised and inspections completed or written confirmation is received from the Superintendents Representative that an inspection is not required. Note that inspections shall not take place until adequate workshop drawings have been submitted - refer clause 22.

The switchboard shall be thoroughly tested at the contractor's workshop at the completion of construction works. The Superintendents Representative shall attend, to witness the workshop testing (or shall notify the contractor in writing that witness testing is not required). All equipment and personnel necessary for carrying out the tests shall be provided by the contractor. A schedule of proposed testing shall be submitted to the Superintendents Representative for approval seven (7) days prior to the date of workshop testing.

The Superintendents Representative shall be given seven (7) days' notice in writing of the need for inspections and testing. The cost of the Superintendents Representatives' attendance will be borne by the Principal except where return visits are necessary due to the failure of equipment on the initial visit. In these cases, the costs incurred would be deducted from monies owed to the contractor.

Workshop test shall include but not be limited to:

- All routine tests to relevant Australian Standards;
- Operational test of all devices including interlocks, PLC's (Field I/O shall be simulated during these tests);
- Insulation resistance (excluding electronic equipment); and
- Earth continuity.

Where called for in the job specification, Type Test assemblies shall be used and certificates shall be provided on request.

The passing of inspections and tests at the workshop shall not prejudice the right of the

Superintendents Representative to reject whole or part of the switchboard if it does not comply when erected on site.

After completion of site erection, the installation shall be thoroughly tested. The Superintendents Representative shall attend to witness the site testing (or shall notify the contractor in writing that witness testing is not required). All equipment and personnel necessary for carrying out the tests shall be provided by the contractor. A schedule of proposed testing shall be submitted to the Superintendents Representative for approval seven days prior to the date of workshop testing.

The Superintendents Representative shall be given seven (7) days' notice in writing of the need for inspections and testing. The cost of the Superintendents Representatives' attendance will be borne by the Principal except where return visits are necessary due to the failure of equipment on the initial visit. In these cases, the costs incurred would be deducted from monies owed to the contractor.

Site tests to include but not be limited to:

- Check tightness of all electrical connections;
- Electrical safety tests as per AS3000;
- Insulation Resistance (excluding electronic equipment);
- Earth continuity;
- Operational tests of all circuits and devices including interlocks and fault circuits; and
- Analogue signal calibration at five points on scale (rising & falling inputs).

Where the Principal is required to carry out programming of telemetry equipment or control system elements a minimum of 6 weeks written notification of the anticipated date of commissioning is to be given to WRC's Electrical Systems Engineer to allow works to be scheduled.

Where required by the job specification a thermoscan shall be carried out of the switchboard at the completion of commissioning and 2 weeks prior to the end of the defects liability period.

The results from all tests are to be recorded on approved forms and included in the Operating and Maintenance Manuals.

22 Drawings

Electrical schematics are to be prepared in accordance with AS 4383 and preferably be of horizontal orientation. Symbols are to be in accordance with AS 1102, designated as per AS 3702 and be complete with line number cross-references for coil and contacts. Cubicle construction drawings are to be prepared in accordance with AS 1101. Drawings are to include provision for Council document number. The drawings included in Appendix A can be used as a guide for the standard of drafting required.

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.

Workshop drawings are to be submitted to the Superintendents Representative for review prior to construction. Workshop drawings are to include sufficient detail of switchboard components to allow design check including but not limited to:

- Design parameters for switchboard including ratings of mains, sub-circuits, motors etc;
- Make and model of key components, e.g. circuit breakers, contactors, motor starters, protective devices, isolators etc;
- Rating of power wiring / bus;

- Settings of protective devices; and
- Parameter settings for soft starters / VSD's.

The contractor shall allow a period of 14 days in their program for design review by Superintendents Representative. Construction of switchboard is not to proceed until design review has been completed.

After the completion of workshop construction/testing the drawings are to be revised to "As-built" status and a copy forwarded to the Superintendents Representative prior to commencement of site installation / commissioning. Once the site installation works are completed and commissioned the drawings shall be revised to "As-installed" status. Unless otherwise specified three copies of the as-installed drawings are required in addition to those included in the manuals described below. One set is to be laminated and be suitable for keeping in the switchboard cubicle on site.

In addition to the hard copies specified above the as-installed drawings shall also be supplied on CD-ROM as a vector file in *.dwg format that can be edited in AutoCAD 2012. All x-refs, fonts, linetypes etc. used in the drawings shall be included on the disk. To assist with plotting of drawings *.pcp files shall also be included.

(Note: Where the contract is for supply only of switchboard then the requirements for as-installed drawings shall apply to the as-built drawings.)

23 Manuals

Unless specified otherwise, three hard copies of an Operation and Maintenance Manual shall be provided. The manual shall be a hard covered plastic four ring binder and shall include as a minimum the following:

- Electrical schematics (enclosed in plastic envelopes);
- Equipment list detailing item designation, type, manufacturer, catalogue numbers, ratings and local supplier;
- Manufacturers literature all equipment supplied (in English language);
- Listing of all settings/set points for all protective and control devices including timers, relays etc.;
- Detailed, step by step, programming instructions for all devices;
- PLC documentation where applicable;
- Test results (workshop and site);
- Equipment warranties - in name of Principal;
- Circuit design data including breaker selection, cable sizing etc.;
- Electrical installation test results; and
- Maintenance instructions for all equipment including a schedule for when maintenance tasks are to be carried out.

Draft Operation and Maintenance (O&M) Manuals are to be submitted to the Superintendents Representative for approval six (6) weeks prior to commissioning. Within two (2) weeks of commissioning, the manuals are to be revised to as-constructed status and submitted for final approval. Practical Completion will not be granted until approved Operation and Maintenance Manuals have been received by the Superintendents Representative.

In addition to the hard copies specified above, one digital copy of the Operation and Maintenance Manual shall also be provided. The digital copy shall be supplied on CD-ROM and consist of pdf files, word documents, excel files etc. that can be opened with standard software programs such as Adobe Reader and Microsoft Office.

24 Certification by RPEQ

Where required by the job specification the whole of the electrical installation shall be inspected and certified by a Registered Professional Engineer (Queensland).
Unless otherwise specified the certification is to confirm:

- Compliance with the Electrical Safety Act;
- Compliance with applicable Australian Standards;
- Compliance with the contract documentation;
- Correct function of all circuits and equipment; and
- Suitability of installation test results and settings of protective devices.

It is recommended that a staged approach be used for RPEQ certification including:

- Review of workshop drawings and design information;
- Inspection of switchboard prior to delivery to site; and
- Site inspection and test review prior to final commissioning.

The RPEQ certification report is to be submitted to the Superintendents Representative prior to final commissioning and a copy included in the Operation & Maintenance Manuals.

Note that regardless of the requirement in the job specification, RPEQ certification may be required for other elements of the works to comply with Codes of Practice, Supply Authority requirements etc.

25 Preferred Suppliers

Appendix B contains a list of preferred equipment suppliers. This listing is provided to ensure that equipment supplied will be compatible with our existing plant and to minimise our stock holding of spare parts.

All equipment supplied should be available from Mackay suppliers who maintain stock so that replacement parts can be obtained at short notice in an emergency situation.

26 Spare Parts

Unless otherwise specified in the job specification the following spare parts shall be supplied with the switchboard as a minimum requirement:

- One contactor (complete assembly) of each size and voltage rating used;
- 4 off Thermistor relay;
- 1 off thermal overload relay;
- 2 off phase failure relay;
- 1 off seal failure relay;
- Six off control relay of each type and voltage rating used (including base);
- One timer of each type and voltage rating used (including base);
- Ten spare indicator lamps of each type / colour and voltage rating used, for LED indicators only four of each colour and voltage are required; and
- Six spare fuse cartridges of each type and rating used (including semi-conductive fuses).

27 Warranties

All equipment warranties, registrations etc. shall be made out in the name of the Principal and submitted in accordance with the supplier's instructions. Copies of all documents are to be included in the manuals.

28 Installation Considerations

This section is not a complete installation specification. It serves only to highlight certain issues that require consideration or have been recurring problems with recent contracts.

28.1 Electrical Installation

28.1.1 Electrical Work

All electrical work shall be performed by qualified electrical workers holding an appropriate certification / licence issued by the Electrical Safety Office, Queensland.

The person or firm responsible for the electrical work shall hold an Electrical Contractors Licence issued by the Electrical Safety Office, Queensland.

28.1.2 Design Information

The contractor is to supply full design information in regard to the electrical installation. This is to include but not limited to:

- Site power supply calculations including maximum demand and fault level;
- Cable calculations for all cables including current carrying capacity, voltage drop, short circuit and earth fault loop impedance. Spare cable capacity is also to be noted;
- Cable schedule showing size, type, route length, installation method, design load; and
- Circuit breaker selection data including cascade, discrimination, trip times, settings.

This information is to be supplied to the Superintendents Representative for review 2 weeks before the commencement of works / placement of orders.

28.1.3 Electricity Supply

Unless specifically excluded in the job specification the contractor is prepare the application for electricity supply, lodge the application with the supply authority and pay all associated fees. WRC will sign the form as required.

The point of supply can be either a URD type pillar or a property pole as required to meet supply authority requirements and/or 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 Ergon requirements.

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

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

28.1.4 Consumer Mains

Consumer mains are to be designed with a minimum of 30% spare capacity over and above the calculated site maximum demand.

Consumer mains are to be installed underground to the point of supply. Under no circumstances are aerial cables to be installed across entrance roads, pump wells or vehicle working areas.

28.1.5 Main Earth

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.

28.1.6 Switchboard Location

When a switchboard is to be located adjacent to a pumpwell / 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. A suitable concrete slab is to be provided in front of the switchboard as a work area for electricians when working on the switchboard. Often this slab is added after completion of installation works – refer to Clause 27.1.4 regarding earth stake location. The area in front of the switchboard is to be at one level – no step.

28.1.7 Conduits

Conduits are to be of an adequate size to suit the installation requirements. Particular attention is to be paid when sizing conduits between a switchboard and a pumpwell. If the pump cables are to be fitted with plugs, then conduit must be large enough to permit the passage of the plug top with all other cabling installed. The use of bends must be kept to an absolute minimum. All bends must be long radius type.

At sewerage pumpstations 2 off 25mm conduits are to be installed from the switchboard to the base of the vent pole. One conduit may be used for lighting or antenna cabling. The other conduit will be for a future security camera (to be installed by Council).

A non-corrodible draw wire is to be left in all conduits.

The ends of all conduits are to be sealed to prevent ingress of dirt, debris or vermin. Special attention is required for conduits going to a sewerage pumpwell to prevent ingress of sewerage gases into switchboard.

28.1.8 Underground Cable Routes

The routes of all underground cables (including the consumer mains) are to be accurately marked up on a site plan, complete with dimensions from permanent landmarks / features. A laminated copy of this plan is to be left in the switchboard and other copies included in the O&M manuals.

28.1.9 Submersible Pump Cables

Cables for submersible pumps are to be suspended in the pumpwell from SS hooks adjacent the hatch opening. Excess cable is to be neatly coiled (taking due notice of minimum bending radii of the cable) and tied to these hooks.

28.1.10 Level Sensor Installation

Level sensors are to be suspended in the pumpwell from SS hooks adjacent the hatch opening. Excess cable is to be neatly coiled (taking due notice of minimum bending radii of the cable) and tied to these hooks. It shall be possible to remove the level sensor from the pumpwell without any need to enter the well. Float switches are not to be installed in small diameter conduits fixed to the pump guide rails.

When installing the level sensors, measures must be taken to ensure that level sensors remain suspended vertically and are not affected by any turbulence within the pumpwell. The preferred method is to fix a smooth weight to a stainless steel cable and suspend this from a SS hook adjacent the hatch opening. The level sensor cable can then be tied to the stainless steel cable and lowered into the well. The whole assembly can be withdrawn from above the hatch opening. A large diameter stilling tube can also be employed however in sewerage wells these can become a trap for rags etc. and should be avoided except in extreme cases.

All level sensors shall be wired from an ELV power supply.

28.1.11 Documented Electrical Test results

At the completion of electrical installation works all circuits are to be tested for safe operation in accordance with the Electrical Safety Act and the requirements of this specification. The test instrument readings and results are to be recorded and documented in a report to be delivered to WRC's Electrical Technical Officer. The report is to include the electrical contractors licence number and be signed by the contractor.

The testing required will include but not be limited to:

- Earth continuity;
- Insulation resistance;
- Polarity;
- Earth fault loop impedance;
- RCD trip times; and
- Correct circuit connections.

Practical completion will not be granted until the documented test results are received by WRC's Electrical Technical Officer.

28.2 Telemetry Installation

28.2.1 Radio Path Survey

When telemetry equipment is to be installed the contractor shall be required to undertake a radio path survey to verify the suitability of the signal path and determine the requirements for antenna selection and masting. The radio path would be a line of sight from the facility location to one of the radio repeaters in WRC's existing network. Contact WRC's Electrical Systems Engineer to determine which radio repeater site is to be utilised.

An acceptable radio path would have a minimum fade margin of 25dB (with ALL attenuation and losses included). The Received Signal Strength Indication at the site is to be greater than -70dBm. If the signal is marginal it may be possible to improve the signal through the use of a higher gain antenna or increased antenna mast height. If an acceptable signal path cannot be established to the site, then the contractor must provide an acceptable alternative or contribute to the establishment of a new repeater site.

28.2.2 Antenna Installation

Typically, a 6dB Yagi type antenna is used at our telemetry sites. The Yagi type antenna is to be mounted with horizontal polarisation 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.

Masting requirements will vary from site to site. In some cases, small goose-neck type 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 SS 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.

28.2.3 Antenna Cable

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. The contractor is to submit calculations demonstrating correct cable selection in terms of signal strength and dB loss.

All antenna cable connections are to be made by N type or similar connectors. 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.

28.2.4 Additional Notes

Refer to Appendix B2 for additional notes in relation to the supply and installation of telemetry equipment.

28.2.5 Commissioning

WRC's Electrical Systems Engineer is to be given a minimum of six (6) weeks written of the anticipated date of commissioning to allow the works to be scheduled.

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Appendix B1 - Preferred Suppliers List

Switchboard and Equipment

Item	Manufacturer
Cubicle Hardware	Emka, Lockwood
Door Limit Switch	Telemecanique XCKP2145P16
Vent Fan	Pacific HVAC WQE Series
Lights	Rexel MIN8
Isolator Switches	Clipsal, Sprecher and Schuh, Socomec, Schneider
Circuit Breakers	Terasaki, Merlin Gerin, Cutler Hammer, Schneider
Lightning Protection	NHP, Heinemann, Critec, Novaris
Transient Barriers	Critec, Novaris
Surge Reduction Filters	Novaris SL36
Surge Diverter	Critec DSD160-1S-275
Signal Isolators	APCS, Weidmuller
Analog Signal Conditioner	Weidmuller 7940005554
Selector Switches	ABB OT Series, Kraus & Naimer CA10AU80R1-600-FT2
Pushbuttons	Sprecher and Schuh D7 Series 22.5mm
Indicator Lights	Sprecher & Schuh D7 Series w. BA9S Style Multichip LEDs
Phase Failure Relay	Schneider RM17TA00 – Zillio Control
Meters	Alstom, NHP, Carlo Gavazzi
Current Transformers	Crompton, IME
Relays	Sprecher and Schuh, Finder, Omron
Timers	Schneider Acti 9 Series
Power Supplies	NHP 2402440 – 24VDC
Power Outlets	Clipsal 2025 & 90B
Contactors	Schneider LC1D TeSys Series
Thermal Overloads	Schneider LDR Series
Thermistor Relays	Schneider LT3SM00M
Motor Protection Relays	Schneider TeSys T
Soft Starters	Zener 6000 Series Smart Start
Variable Speed Drives	Schneider ATV630 Series
Terminals	Telemecanique AB1 Series
Wire Numbers	Grafoplast, Legrand
PLC	Siemens S7
Pump Controller	Yokogawa UM33A
Sump Pump Controller	Multitrode MTR
Level Sensor	Vega Vegawell 52 or 72
Float Switch	Flygt ENM-10
Decontactors	Marechal, Cutler Hammer, Proconect
Current Transducers	Greystone CS475
Voltage Monitoring Relay	APCS PA201
Magnetic Reed Switches	Schmersal BN80-10Z / BP10
Sump pump level control	Multitrode MTR
Generator Inlet Socket	Clipsal WB Series 5 pin
Generator Autochangeover	Schneider UA Controller + ACP 240V AV
Flowmeter & Display	E & H Promag W 4000
Thermostat	Stego KTS1141
Micro-switches	Schmersal, Telemecanique

Appendix B2 - Preferred Suppliers List

Telemetry Equipment – Digital Radio Network

Equipment	Manufacturer	Cat No.	Supplier
Telemetry I/O Module	Schneider	Scadapack 6601	Schneider
Telemetry Processor	Schneider	Scadapack 535E	Schneider
Radio	Schneider	Trio QR Series Licenced Band	Schneider
Antenna [8)]	RF Industries	Yagi YB6-61	RF Industries
Lightning Arrestor	RF Industries	IS-B50LN-C2	RF Industries
Surge Filter	Novaris	PSF105DIN	PowerCom Solutions
Power Supply	Schneider	ABL7RM24025 - 24Vdc 2.5Amp	Schneider
Fuse & Terminals	Weidmuller	Z-Series	Ramelec
DC Converter		APK60-1224	Power House Qld
Battery	Yuasa	NP7.2-12	Battery World

Appendix C - Typical Telemetry I/O

Sewerage Pumpstation – I/O States

The On/Off states of telemetry I/O shall have the following meaning:

I/O Description	ON State	OFF State
AC power fail	Bus supply healthy	Bus supply failed
Intruder switch	Door closed	Door opened
Wet well level high	Well level normal	Well level high
Station system mode	System mode selected	Not in system mode
Station local manual mode	Local manual mode selected	Not in local manual mode
Station local auto mode	Local auto mode selected	Not in local auto mode
Pump run	Pump is operating	Pump is off
Pump healthy	Pump protection is healthy	Pump protection has tripped
Pump available	Pump is available	Pump is not available
Generator running	Generator set is operating	Generator set is off
Generator fault	Generator healthy	Generator faulted
Generator failed to start	Generator normal	Generator failed to start
Generator low battery	Battery voltage normal	Battery voltage is low
Generator low fuel	Fuel level normal	Fuel level is low
Ergon Supply Status	Mains supply healthy	Mains supply failure
ATS Ergon supply	ATS in mains position	ATS not in mains position
ATS Generator supply	ATS in generator position	ATS not in generator position
Generator Circuit Breaker	Generator CB closed	Generator CB open
Load bank healthy	Load bank OK	Load bank faulted

Note: I/O functionality is not to be changed without written approval from WRC's Electrical Systems Engineer.

Appendix C – Typical Telemetry I/O

Sewerage Pumpstation – Two pumps, no generator

Schneider Electric SCADAPack P334

I/O No	Description
DI1	Bus power fail
DI2	Intruder switch (where specified else spare)
DI3	Wet well high level (from ELV float switch)
DI4	Station system mode
DI5	Station local manual mode
DI6	Station local auto mode
DI7	Pump 1 run
DI8	Pump 1 healthy
DI9	Pump 1 available
DI10	Pump 2 run
DI11	Pump 2 healthy
DI12	Pump 2 available
DI13	spare
DI14	C/O switch in Ergon supply position
DI15	C/O switch in Generator supply position
DI16	Ergon supply status
DO1	Pump 1 system start
DO2	Pump 1 remote reset
DO3	Pump 2 system start
DO4	Pump 2 remote reset
DO5	spare
DO6	spare
DO7	spare
DO8	spare
DO9	spare
DO10	spare
AI1	Wet well level
AI2	Discharge pressure (where installed)
AI3	Pump 1 motor current
AI4	Pump 2 motor current

Note: I/O assignments are not to be changed without written approval from WRC's Electrical Systems Engineer.

Appendix C – Typical Telemetry I/O

Sewerage Pumpstation – Two pumps, with generator

Schneider Electric SCADAPack P500

I/O No	Description	I/O No	Description
DI1	Bus power fail	DI17	spare
DI2	Intruder switch (where specified)	DI18	spare
DI3	Wet well high level (from float sw)	DI19	spare
DI4	Station system mode	DI20	spare
DI5	Station local manual mode	DI21	spare
DI6	Station local auto mode	DI22	spare
DI7	Pump 1 run	DI23	spare
DI8	Pump 1 healthy	DI24	spare
DI9	Pump 1 available	DI25	spare
DI10	Pump 2 run	DI26	Load bank healthy
DI11	Pump 2 healthy	DI27	Generator CB closed
DI12	Pump 2 available	DI28	Generator running
DI13	Generator test switch	DI29	Generator fault
DI14	ATS Ergon supply position	DI30	Generator fail to start
DI15	ATS Generator supply position	DI31	Generator low battery
DI16	Ergon supply status	DI32	Generator low fuel
DO1	Pump 1 system start	DO9	spare
DO2	Pump 1 remote reset	DO10	spare
DO3	Pump 2 system start	DO11	spare
DO4	Pump 2 remote reset	DO12	spare
DO5	spare	DO13	spare
DO6	spare	DO14	spare
DO7	spare	DO15	spare
DO8	spare	DO16	spare
AI1	Wet well level	AI7	spare
AI2	Discharge pressure (where installed)	AI8	spare
AI3	Pump 1 motor current	AI9	spare
AI4	Pump 2 motor current	AI10	spare
AI5	spare	AI11	spare
AI6	spare	AI12	Discharge flow (where installed)
AO1	spare	AO3	spare
AO2	spare	AO4	spare

Note: I/O assignments are not to be changed without written approval from WRC's Electrical Systems Engineer.

Appendix C – Typical Telemetry I/O

Sewerage Pumpstation – Three pumps, with VSD and generator

Schneider Electric SCADAPack P500

I/O No	Description	I/O No	Description
DI1	Bus power fail	DI17	Pump 3 run
DI2	Intruder switch (where specified)	DI18	Pump 3 fault
DI3	Wet well high level (from float sw)	DI19	Pump 3 available
DI4	Station system mode	DI20	spare
DI5	Station local manual mode	DI21	spare
DI6	Station local auto mode	DI22	spare
DI7	Pump 1 run	DI23	spare
DI8	Pump 1 fault	DI24	spare
DI9	Pump 1 available	DI25	spare
DI10	Pump 2 run	DI26	Load bank healthy
DI11	Pump 2 fault	DI27	Generator CB closed
DI12	Pump 2 available	DI28	Generator running
DI13	Generator test switch	DI29	Generator fault
DI14	ATS Ergon supply position	DI30	Generator fail to start
DI15	ATS Generator supply position	DI31	Generator low battery
DI16	Ergon supply status	DI32	Generator low fuel
DO1	Pump 1 system start	DO9	spare
DO2	Pump 1 remote reset	DO10	spare
DO3	Pump 2 system start	DO11	spare
DO4	Pump 2 remote reset	DO12	spare
DO5	Pump 3 system start	DO13	spare
DO6	Pump 3 remote reset	DO14	spare
DO7	spare	DO15	spare
DO8	spare	DO16	spare
AI1	Wet well level	AI7	Pump 1 motor speed PV
AI2	Discharge pressure (where installed)	AI8	Pump 2 motor speed PV
AI3	Pump 1 motor current	AI9	Pump 2 motor speed PV
AI4	Pump 2 motor current	AI10	spare
AI5	Pump 3 motor current	AI11	spare
AI6	spare	AI12	Discharge flow (where installed)
AO1	Pump 1 VSD set point	AO3	Pump 3 VSD set point
AO2	Pump 3 VSD set point	AO4	spare

Note: I/O assignments are not to be changed without written approval from WRC's Electrical Systems Engineer.

Appendix D – Abbreviations Listing

The table below contains a listing of the abbreviations used in this document.

AC	Alternating Current
ADWF	Average Dry Weather Flow
AI	Analogue Input
AO	Analogue Output
CB	Circuit Breaker
CFS	Combination Fuse Switch
CT	Current Transformer
DC	Direct Current
DI	Digital Input
DO	Digital Output
DOL	Direct On-Line
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility
GPO	General Purpose Outlet
HMI	Human Machine Interface
HRC	High Rupture Capacity
I/O	Input / Output
LED	Light Emitting Diode
MOV	Metal Oxide Varistor
MPR	Motor Protection Relay
N/C	Normally Closed Contact
N/O	Normally Open Contact
PCB	Printed Circuit Board
PFR	Phase fail relay
PLC	Programmable Logic Controller
PV	Process Variable
PVC	Polyvinyl Chloride
RCD	Residual Current Device
RPEQ	Registered Professional Engineer (Queensland)
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SPD	Surge Protection Device
SRF	Surge Reduction Filter
WRC	Whitsunday Regional Council
TOL	Thermal Overload
VSD	Variable Speed Drive

Appendix E - Revision Record

Number	Date	Clauses Altered
12	30.11.09	New clauses added - 9.29, 19.6, 24, 28.1.0, 28.1.1, App E, subsequent clauses renumbered. Revised clauses – 1, 3, 4, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 20, 21, 22, 23, 26, 28, App A, App B, App C,
12.1	21.01.10	Minor revisions, Appendix D added, subsequent clauses renumbered
13	07.02.13	Major revision, alterations to most clauses and appendices

Appendix F – Summary of Document Submissions and Inspections

The following table is intended to summarise the requirements for submission of documentation through the switchboard project and tie in to inspections and progression of milestone dates.

Milestone	Document/Inspection	Clause	Comment
Tender submission	Technical Data	App G1 & G2	Required to allow assessment of what has been offered with tender. May also require drawings, supplier data and other information
Within * weeks of contract award	Detailed design calculations inc: Drive / load list • Maximum demand; • Load balance; • Cable schedule; • Circuit breaker selection; • Harmonic study (if applic); • Ventilation study (if applic); and • Radio survey (if applicable). Workshop drawings for switchboards RPEQ certified drawings (if applicable)	22, 28.1.2 10 8.5 28.2.1 22 24	Review of workshop drawings will not occur until full design information is provided. Allow 14 days for review
Switchboard Construction	Inspections required at: • Completion of sheetmetal • Completion of wiring		Minimum 7 days' notice required
Workshop Testing	Witnessed testing at place of swbd manufacture		Minimum 7 days' notice required
	As-built drawings for swbd		Required before commencement of site commissioning
Site Construction	Inspections during construction phase		As required
Site Testing	• Electrical safety testing; • Functional testing; • Commissioning of telemetry / control system; and • Thermoscan of swbd (if applicable).	28.1.11 21 17.1 21	Minimum 6 weeks' notice required
Practical Completion	• Electrical safety document; • As-constructed drawings; • Draft O&M manual; and • Supply of spares (if applic).	28.1.11 22 23 26	Practical completion will not be granted until satisfactory documentation has been received
Completion	• Final O&M manuals; and • CAD files for drawings.		
Final Completion	• Thermoscan (if applicable)		2 weeks prior to end of defects period

* Refer to contract document for submission dates.

Appendix G – Job Specification Checklist

1. Check operating conditions. Specify location (Indoor / Outdoor) ___
2. Specify Fault Level ___
3. Specify requirement for Supply Authority metering inc. tariff ___
4. Specify degree of segregation (i.e. Form 1, Form 2 etc.) ___
5. Specify how cubicle is to be mounted (i.e. pole, wall or plinth) ___
6. Specify material for cubicle, mounting pans & escutcheon door ___
7. Specify type of door handles and method of locking ___
8. Specify sunhood (if required) ___
9. Specify paint colours (if applicable) ___
10. Specify size and configuration of mains cables [1] ___
11. Specify lightning and surge protection requirements ___
12. Detail all electrical equipment that is to be connected
    - include current ratings of circuits, kW ratings of motors etc. ___
13. Specify how motors are to be controlled [1] ___
14. Specify requirements for motor starters and protection [1] ___
15. Detail any special control or instrumentation requirements [1] ___
16. Specify if telemetry is required and detail all required I/O signals ___
17. Specify telemetry installation requirements ___
18. Specify requirements for PLC (if applicable) [1] ___
19. Specify any other requirements (e.g. alarms, generator etc.) ___
20. Review preferred suppliers list and make alterations if necessary ___
21. Specify requirements for inspection and testing ___
22. Specify delivery address and time ___
23. Specify if RPEQ certification is required ___

[1] The design of these items may be the contractor's responsibility.
Refer to main project specification.

Appendix H1 - Technical Data Sheets

Switchboard and Equipment

The technical data sheets will detail the proposed switchboard equipment. The tenderer shall complete all sheets and submit with his tender/quotation.

==========

Switchboard Cubicle

Manufacturer _____

Place of Manufacture_____

Dimensions _____

Degree of Protection_____

Fault Rating _____

Material of Construction_____

Make of Cubicle Hardware _____

Main Switch

Make _____

Model_____

Fault Rating _____

Current Rating _____

Method of Mounting _____

Changeover Switch

Make _____

Model _____

Fault Rating_____

Current Rating _____

Lightning Protection

Make _____

Type_____

Rating_____

Busbars

Dimensions _____

Fault Rating _____

Current Rating _____

Type of Insulation _____

Active, Neutral & Earth Links

Make_____

Model _____

Rating_____

Fault Current Limiting Circuit Breakers

Make_____

Model _____

Fault Rating _____

Coordination Category _____

Distribution Circuit Breakers

Make _____

Model _____

Fault Rating _____

Coordination Category _____

Method of Mounting _____

Isolator Switches

Make _____

Model _____

Rating_____

Load Break Type (yes/no) _____

Method of Locking_____

Method of Mounting _____

Selector Switches

Make _____

Model _____

Pushbuttons

Make _____

Model _____

Indicator Lights

Make _____

Model _____

Lamp Type _____

Voltage Rating _____

Phase Failure Relay

Make _____

Model _____

Features _____

Voltmeter

Make _____

Model _____

Size/Scale _____

Ammeter

Make _____

Model _____

Size/Scale _____

Current Transformers

Make _____

Model _____

Rating _____

Current Transducer

Make _____

Model _____

Power Supply _____

Output Signal_____

Voltage Monitoring Relay

Make _____

Model _____

Power Supply_____

Output Signal _____

Hours Run Meter

Make _____

Model_____

Size/Type _____

Control Relays

Make _____

Model_____

Type _____

Timers

Make _____

Model_____

Type _____

Control Transformers

Make _____

Model_____

Primary/Secondary Voltages _____

Rating_____

Power Supplies

Make _____

Model _____

Output Voltage _____

Motor Starters

Type _____

Duty Rating and Class_____

Utilisation Category _____

No of Starts per Hour _____

Contactors

Make_____

Model _____

Duty Class and Rating _____

Utilisation Category _____

Soft Starters

Make _____

Model _____

Current Limiting Mode (yes/no) _____

Soft Stop Function (yes/no)_____

Features _____

_____

_____

_____

Thermal Overload

Make_____

Model _____

Current Range _____

Thermistor Relay

Make _____

Model _____

Seal Failure Relay

Make _____

Model _____

Motor Protection Relay

Make _____

Model _____

Features _____

_____

_____

Wiring

Materials and Grade of Insulation _____

Method of Termination _____

Make and Type of Ferrules _____

Make and Type of Terminals _____

Pump Controller

Make _____

Model _____

Digital Display _____

Signal Isolators

Make _____

Model _____

Rating _____

Transient Barriers

Make _____

Model _____

Rating _____

Decontactor

Make _____

Model _____

Rating _____

Name of Tenderer _____

Signature of Tenderer _____

Date _____

Appendix H2 - Technical Data Sheets

Telemetry Equipment

These technical data sheets will detail the telemetry equipment and associated works. The tenderer shall complete all sheets and submit with his tender / quotation.

==========

Telemetry Cubicle/Compartment

Integral to Swbd or Remote _____

Materials _____

Dimensions _____

Degree of Protection _____

Telemetry Unit

Make _____

Model _____

Type of Firmware _____

IsaGraf Targets _____

Telemetry I/O (List all signals)

DI _____

_____

_____

_____

DO _____

_____

AI _____

_____

AO _____

_____

Power Supply

Make _____

Model _____

Rating _____

DC Converter

Make _____

Model _____

Rating _____

Battery

Make _____

Model _____

Rating _____

Radio

Make _____

Model _____

Antenna

Type _____

Make _____

Model _____

Gain _____

Wind Loading _____

Dimensions _____

Antenna Cable

Make _____

Type _____

Rating _____

Coax Surge Diverter

Make _____

Model _____

Rating _____

Antenna Mast

Type _____

Materials _____

Mounting Height _____

Design Wind Loading _____

Other Details _____

_____

_____

Name of Tenderer _____

Signature of Tenderer _____

Date _____