QUEENSLAND Urban Utilities

ABN 86 673 835 011

Electrical, Instrumentation and Control System Design Criteria

TMS1648

Standard Technical Specification

REVISION CONTROL

Revision Number	Date	Revision Details	Responsible Officer
0	March 2017	First Draft – Issued for stakeholder comments	Steve Bourke
1	May 2017	Issued for Use	Steve Bourke
2	Jan 2019	General Updates – Re-issued for Use	Steve Bourke

DOCUMENT CONSULTATION

Revision	Name	Position	Comments Received	Date
2	Mark Davanzo	Planner – Electrical Asset Maintenance Management	Y	Dec 2018
2	Gerard Anderson	Senior Electrical Engineer	Y	Dec 2018
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2	Craig Moir	Senior Electrical Engineer	Y	Dec 2018
2	TEG		Y	Dec 2018

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1 SCOPE

This specification outlines the minimum requirements for the design of Electrical, Instrumentation and Control Systems equipment installed at QUU assets. This specification is intended to complement the information contained in other QUU technical specifications and provide further clarity to Contractors when delivering design services. Contractors shall comply with the requirements of this specification and other technical specifications referenced by this document.

1.1 DEFINITIONS

In this document, the following definitions apply:

Project Documentation	Governing technical documents for the specific item(s) for the specific works included or referenced in the Contract
Contractor	The entity bound (including sub-contractors appointed by the contractor) to execute the work having responsibility for design, manufacture and supply, delivery, documentation and other functions as further defined in the documents related to the work.
Contract	The agreement between QUU and the Contractor to which this specification pertains.

1.2 ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
ACB	Air Circuit Breaker
mAHD	Meters elevation with respect to Australian Height Datum
ALARP	As Low as Reasonably Practical
ATS	Automatic Transfer Switch
CB	Circuit Breaker
CBF	Circuit Breaker Fail
CDEGS	Current Distribution, Electromagnetic Fields, Grounding and Soil Structure
CT	Current Transformer
CSA	Cross Sectional Area
DB	Distribution Board
DC	Direct Current
DOL	Direct On Line

DP	Differential Pressure
EF	Earth Fault
EI&C	Electrical, Instrumentation and Control Systems
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility
ESW	Earth Switch
FAT	Factory Acceptance Test
IEC	International Electro-technical Commission
HA	Hazardous Area
HVAC	Heating Ventilation and Cooling
I/O	Input / Output
IP	Ingress Protection
IRIG	Inter-Range Instrumentation Group
ITP	Inspection and Test Plan
LBS	Load Break Switch
LCP	Local Control Panel
LED	Light Emitting Diode
LFI	Low Frequency Induction
LV	Low Voltage
MCC	Motor Control Centre
MCCB	Moulded Case Circuit Breaker
MPR	Motor Protection Relay
MPPT	Maximum Power Point Tracker
MTS	Manual Transfer Switch
NC	Normally Closed
NO	Normally Open
OC	Over current
ONAF	Oil Natural Air Forced
PAGA	Public Address and General Alarm
PF	Power Factor
PFC	Power Factor Correction
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment

PQA	Power Quality Analysis
PRV	Pressure Reducing Valve
PSA	Power System Analysis
PV	Photovoltaic
RCD	Residual Current Device
REF	Restricted Earth Fault
RFI	Radio Frequency Interference
RMU	Ring Main Unit
RTU	Remote Telemetry Unit
QUU	Queensland Urban Utilities
SEF	Sensitive Earth Fault
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SDV	Shutdown Valve
SLD	Single Line Diagram
SPD	Surge Protection Device
SS	Stainless Steel
STP	Sewerage Treatment Plant
TCS	Trip Circuit Supervision
UCP	Unit Control Panel
UPS	Uninterruptable Power Supply
VRLA	Valve Regulated Lead Acid
VT	Voltage Transformer

1.3 REFERENCE DOCUMENTS

Document Number	Title
BMS04075	Energex Customer Performance Standards and Technical Requirements for Major Customers
FOR893	Instrument Schedule – Template
MP71	Electrical Safety Management Plan
MP183	Hazardous Areas Management Plan
PRO450	Electrical Safety Standard Operating Procedure
PRO521	Safety in Design Standard Operating Procedure

Document Number	Title
PRO363	WHS Hazard and Risk Management Procedure
PRO662	Safety in Design Guidelines
TEM336	Power System Analysis Guidelines
TEM514	Functional Specification Template for Complex Sites
TEM515	Sewerage Pump Station - Site Specific Functional Specification
TEM518	Hazardous Area Verification Dossier Template
TEM523	Cable Schedule Template
TEM587	Water Booster (MPC) – Site Specific Functional Specification Template
TEM588	PRV – Site Specific Functional Specification Template
TEM590	Water Booster (Lowara) - Site Specific Functional Specification Template
TEM591	Water Booster (VSD) - Site Specific Functional Specification Template
TEM592	Water Pump Station - Site Specific Functional Specification Template
TEM593	Reservoir - Site Specific Functional Specification Template
TEM596	Radio Network Desktop Design Report Template
TEM597	Radio Signal Site Survey Report Template
TEM598	Communications Network Design Report Template
TMS60	Low Voltage Switchboards and Enclosures Technical Specification
TMS62	Preferred Equipment List – Electrical and Instrumentation
TMS76	Corrosion Protection for Electrical and Mechanical Equipment and Structures
TMS117	Security, Access, Control and CCTV – Technical Specification
TMS200	PRV – Standard Functional Specification
TMS828	Standard Functional Specification Reservoir Sites
TMS1151	Preferred Equipment List – Control Systems
TMS1185	Distribution Power Transformer (Less than 5MVA) – Technical Specification
TMS1186	HV Switchboards – Technical Specification
TMS1187	AC Uninterruptible Power Supply (UPS) – Technical Specification
TMS1188	Transportable Switchroom – Technical Specification
TMS1200	Electrical Installation – Technical Specification
TMS1201	Instrumentation Installation – Technical Specification
TMS1202	Control System Implementation – Technical Specification

Document Number	Title
TMS1203	General Requirements for Hazardous Area Installation – Technical Specification
TMS1221	DC Power Supply Systems– Technical Specification
TMS1222	Control Panels – Technical Specification
TMS1404	HV Motors – Technical Specification
TMS1406	LV Variable Speed Drives – Technical Specification
TMS1589	LV Diesel Generator – Technical Specification
TMS1595	Pipeline and Structures Cathodic Protection – Technical Specification
TMS1621	Typical Pump Station Maximum Demand Template
TMS1625	Dry Type Distribution Transformers – Technical Specification
TMS1631	Vacuum Pump Station – Standard Functional Specification
TMS1637	LV Motors – Technical Specification
TMS1639	General Mechanical Works – Technical Specification
TMS1643	Water Booster Site (VSD) – Standard Functional Specification
TMS1645	Packaged Plant EI&C Requirements - Technical Specification
TMS1647	Equipment Tag Naming – Technical Specification
TMS1649	Standard MPC Water Booster – Functional Specification
TMS1650	Fixed Speed Sewage Pumping Station – Standard Functional Specification
TMS1651	Machine Safety Implementation– Technical Specification
TMS1654	Engineering Documentation Naming Requirements
TMS1706	Typical Water Pump Station - Functional specification
WI58	Arc Flash Assessment and PPE Selection
WI140	Access to LV Electrical Equipment for Visual Inspection

1.4 REFERENCE TYPICAL DRAWINGS

The typical drawings and other documentation is provided for information only to demonstrate minimum content and layout of information and may not represent all the requirements specified in the Project Documentation. The Contractor is responsible for the detail design.

1.4.1 Sewerage Treatment Plants

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QUU-STD-STP-03	Communication Network Architecture Diagram
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QUU-STD-STP-04	Protection Line diagram - HV/LV
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QUU-STD-STP-42	Schematic Diagram - UPS
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QUU-STD-STP-84	Termination Diagram - Digital Input Card - 16PT (GE Fanuc)
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1.4.2 Network Sites

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General	
486/5/5-0171-561	Field Instrumentation Installation Details Level Probes
486/5/25-0003-342	Valve Pit Pressure Sensor Installation and Details
486/5/7-0470-024	Field Instrumentation Installation Details
486/4/7-0032-016	Water Meters General Arrangement

Site Description	Electrical Drawings	Functional Specification	RTU Code
Trio Radio Repeater	√	NA	NA
Reservoir – Up to 2 off Reservoirs and Inlet Valves	√	√	√
Sewage Pump Station (Full option switchboard)	√	√	√
Sewage Pump Station (Reduced option switch board)	√	√	√
Sewage Pump Station (Low Risk switchboard)	√	√	√
Sewage Pump Station (Form 1 switchboard)	√	√	√
Vacuum Sewage Pump Station	√	√	√
Water Booster - Lowara	√	√	√
Water Booster - MPC	√	√	√
Water Booster - VSD	√	√	√
Water Monitoring Stations- PRV, FM, PG, Valves	√	√	√
Water Pump Station	√	√	√

√ - Available on request from QUU
NA – Not Available

2 STANDARDS AND REGULATIONS

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

Where conflict exists between different Codes, Standards or Regulations, the most onerous conditions of specification shall apply unless accepted otherwise in writing by QUU.

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

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

2.1 AUSTRALIAN STANDARDS

All equipment shall be designed in accordance with the latest edition of all relevant Australian and International Standards, Codes and Regulations except where modified by this specification.

AS 1000	International System of Units (S.I.) and its Applications
AS1319	Safety Signs for the occupational environment
AS 1020	Control of Undesirable Static Electricity
AS 1081	Acoustics - Measurement of airborne noise emitted by rotating electrical machinery – All Parts
AS 1101	Graphical symbols for general engineering
AS 1192	Electroplated coatings, Nickel and chromium.
AS/NZS 1158.3.1	Lighting for roads and public spaces Pedestrian area (Category P) lighting - Performance and design requirements
AS 1214	Hot-dip galvanised coatings on threaded fasteners (ISO metric coarse thread series)
AS 1275	Metric Screw Threads for Fasteners
AS 1284	Electricity Meters– All Parts
AS 1307.2	Surge Arresters – Metal-Oxide Surge arresters without gaps for A.C. systems
AS 1319	Safety Signs for the occupational environment
AS 1324	Air Filters for use in Air Conditioning and general ventilation – All Parts
AS 1345	Identification of the contents of piping, conduits and ducts.
AS 1359	Rotating electrical machines – General Requirements – Al Parts
AS 1428	Design for access and mobility – All Parts
AS/NZS 1429.1	Electric Cables- Polymeric Insulated – For working voltages 3.6kV up to and including 36kV
AS 1530	Methods for fire tests on building materials, Components and structures – All Parts
AS 1603	Automatic Fire Detection and Alarm Systems – All Parts
AS 1627	Metal Finishing – Preparation and pre-treatment of surfaces – All Parts.

AS 1657	Fixed Platforms, Walkways, Stairways and Ladders
AS 1660	Test methods for Electric Cables – All Parts
AS 1668	The use of Ventilation and Air-Conditioning in Buildings – All Parts
AS 1670	Fire Detection, warning, control and intercom systems – All Parts
AS 1680	Interior Lighting - All Parts
AS 1682	Fire Dampers – All Parts
AS 1767	Insulating liquids – All Parts
AS/NZS 1768	Lightning Protection
AS 1789	Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process)
AS 1824	Insulation Coordination – All Parts
AS 1841	Portable Fire Extinguishers – All Parts
AS 1897	Fasteners – Electroplated coatings
AS 1905	Components for the protection of openings in fire resistance walls – All Parts
AS/NZS 2053	Conduits and fittings for electrical installations – All Parts
AS 2067	Substations and High Voltage installations exceeding 1kV
AS 2239	Galvanic (sacrificial) anodes for cathodic protection
AS 2293	Emergency escape lighting and exit signs for buildings – All Parts
AS 2360	Measurement of fluid flow in closed conduits – All Parts
AS 2374.1.2	Power Transformers – Minimum Energy Performance Standard (MEPS) requirements for distribution transformers
AS 2374.8	Power Transformers – Application Guide
AS 2467	Maintenance of Electrical Switchgear
AS 2700	Colour Standards for General purposes
AS 2832	Cathodic Protection of Metals – All Parts
AS/NZS 2857	Timber Drums for Insulated and Bare Cables
AS 2865	Safe Working in a Confined Space
AS/NZS 3000	Electrical installations (known as the Wiring Rules)
AS/NZS 3008.1.1	Electrical Installations – Selection of Cables – Cables for Alternating Voltages up to and Including 0.6/1kV – Typical Australian Installation Conditions
AS/NZS 3010	Electrical Installation – Generator Sets
AS 3011	Electrical Installations – Secondary batteries installed in buildings – All Parts
AS 3017	Electrical Installations – Verification guidelines
AS/NZS 3100	Approval and test specification - General requirements for electrical equipment
AS/NZS 3111	Approval and test specification - Miniature overcurrent circuit-breakers
AS/NZS 3133	Approval and test specification – Air-break switches
AS/NZS 3190	Approval and test specification – Residual current devices (current-operated earth-leakage devices)s
AS/NZS 3808	Insulation and sheathing materials for electric cables
AS/NZS 3863	Galvanised mild steel wire for armouring electric circuits
AS 3894	Site testing of protective coatings – All Parts .
AS 3983	Metal drums for insulated and bare electric cables
AS 4044	Battery chargers for stationary batteries
AS 4009	Software reviews and audits

AS 4070	Recommended practices for protection of low voltage electrical installation and equipment in MEN systems from transient overvoltages
AS 4024	Safety of Machinery – All Parts
AS/NZS 4325.1	Compression and mechanical connectors for power cables with copper or aluminium conductors – Test methods and requirements
AS 4398	Insulators- Ceramic or glass- Station post for indoor and outdoor use – Voltages greater than 1000V AC – All Parts
AS 4428	Fire Detection, Warning, Control & Intercom Systems – All Parts
AS 4436	Guide for the selection of insulators in respect of polluted conditions
AS 4509	Stand-alone power systems – All Parts
AS/NZS 4534	Zinc and zinc/aluminium-allow coatings on steel wire
AS/NZS 4680	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS 4761.1	Competencies for working with electrical equipment for hazardous areas (EEHA) – Competency Standards
AS 4777	Grid-connections of energy systems via inverters
AS/NZS 4792	Hot-dip galvanised (zinc) coatings on ferrous hollow sections, applied by a continuous or specialised process
AS/NZS 4805	Accessories for Electric Cables-Test Requirements – Power Cables from 3.6kV up to 36kV – All Parts
AS 4827.1	Coating defect surveys for buried pipelines – Direct current voltage gradient (DCVG)
AS 4853	Electrical hazards on metallic pipelines
AS/NZS 5000.1	Electric Cables – Polymeric insulated for working voltages up to and including 0.6/1(1.2)kV
AS/NZS 5000.2	Electric cables - Polymeric insulated - For working voltages up to and including 450/750 V
AS/NZS 5000.3	Electric cables - Polymeric insulated - Multicore control cables
AS 5033	Installation of photovoltaic (PV) arrays
AS 6183	Fire protection equipment – Carbon dioxide extinguishing systems for use on premises – Design and installation
AS ISO 14520	Gaseous fire-extinguishing systems – All Parts
AS 60034	Rotating Electrical Machines
AS 60038	Standard Voltages
AS 60044.7	Instrument transformers - Part 7: Electronic voltage transformers
AS 60044.8	Instrument transformers - Part 8: Electronic current transformers
AS 60060.3	High-voltage test techniques Part 3: Definitions and requirements for on-site testing
AS 60076	Power Transformers – All Parts

AS/NZS 60079	Explosive Atmospheres – All Parts
AS 60265.1	High Voltage Switches Part 1: Switches for rated voltages above 1kV and less than 52kV
AS/NZS 60137	Insulated bushings for alternating voltages above 1000 V
AS 60146	Semiconductor Converters – General Requirements and Line Commutated Converters
AS 60214.1	Tap-Changers – Performance Requirements and test methods
AS 60422	Mineral insulating oils in electrical equipment – Supervision and maintenance guidance
AS 60470	High-voltage alternating current contactors and contactor-based motor-starters
AS 60529	Degrees of Protection Provided by Enclosures (IP Code)
AS 60849	Sound systems for emergency purposes
AS/NZS 60947	Low-voltage Switchgear and Control gear – All Parts
AS/NZS 61000	Electromagnetic Compatibility (EMC) – All Parts
AS IEC 61131	Programmable Controllers – All Parts
AS/NZS 61439	Low-voltage switchgear and control gear assemblies All Parts
AS 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
AS/NZS 61558	Safety of power transformers, power supplies, reactors and similar products - All Parts
AS 62040	Uninterruptible Power Supply (UPS) – All Parts
AS 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
AS 62271	High-Voltage Switchgear and Control Gear – All Parts
AS/NZS CISPR 11	Industrial, Scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurements

2.2 INTERNATIONAL STANDARDS

IEC 60034	Rotating electrical machines – All Parts
IEC 60038	Standard Voltages
IEC 60044.7	Instrument transformers - Part 7: Electronic voltage transformers
IEC 60044.8	Instrument transformers - Part 8: Electronic current transformers
IEC 60050	International Electro-technical Vocabulary – All Parts
IEC 60051	Direct Acting Indicating Analogue Electrical Measuring Instrument and their Accessories – All Parts
IEC 60060-1	High-voltage test techniques Part 1: General definitions and test requirements

IEC 60060-2	High-voltage test techniques Part 2: Measuring systems
IEC 60071	Insulation co-ordination All Parts
IEC 60228	Conductors of Insulated Cables
IEC 60269	Low Voltage Fuses – All Parts
IEC 60296	Fluids for Electro-Technical applications – Unused Mineral insulating oils for transformers and switchgear
IEC 60332	Tests on electric and optical fibre cables under fire conditions – All Parts
IEC 60417	Graphical Symbols for Diagrams – IEC database edition
IEC 60445	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors
IEC 60660	Tests on Indoor post insulators of organic material for systems with nominal voltages greater than 1000V up to but not including 300kV
IEC 60694	Common Specifications for high-voltage switchgear and control gear standards
IEC 60751	Industrial platinum resistance thermometers and platinum temperature sensors
IEC 61158	Industrial communication networks - Fieldbus specifications – All Parts-
IEC 61243-5	Live working - Voltage detectors - Part 5: Voltage detecting systems (VDS)
IEC TR 61641	Enclosed low-voltage switchgear and control gear assemblies - Guide for testing under conditions of arcing due to internal fault
IEC 61643	Low-voltage surge protective devices – All Parts
IEC 61850	Communications networks and systems for power utility automation – All Parts
IEC 62444	Cable glands for electrical installations
IEC 62443	Security for industrial automation and control systems.– All Parts
IEC 62541	OPC unified architecture – all parts
IEC TS 62941	Terrestrial photovoltaic (PV) modules - Guideline for increased confidence in PV module design qualification and type approval
IEEE 519	Recommended Practices And Requirements For Harmonic Control In Electrical Power Systems
IEEE Std 1815	Electric Power Systems Communications – Distributed Network Protocol (DNP3)
IEEE 802.3	Ethernet
ISO 13849	Safety Of Machinery - Safety-Related Parts Of Control Systems – All Parts
ISO 9001	Quality Management Systems
NFPA 70E:2015	Standard for Electrical Safety in the Workplace

2.3 ACTS AND REGULATIONS

The current regulations and statutory requirements of the State of Queensland, Australia, shall be complied with, including:

- Queensland Electricity Act 1994
- Queensland Electricity Regulations 2006
- Queensland Work Health and Safety Act 2011
- Queensland: Environmental Protection Act – 1994
    - Environmental Protection Regulation 2008
    - Environmental Protection (Air) Policy 2008
    - Environmental Protection (Noise) Policy 2008
    - Environmental Protection (Water) Policy 2009
- National Construction Code 2016, volumes 1, 2, 3 and The Guide
- Queensland Electricity Connection and Metering Manual (QECMM) Version 11
- Work Health and Safety Regulations 2011
    - Work Health and Safety Codes of Practice 2015
- Queensland Electrical Safety Act 2002
    - Queensland Electrical Safety Code of Practice 2013
- Queensland Electrical Safety Regulation 2013
- Queensland Professional Engineers Act 2002
- Queensland Professional Engineers Regulation 2003
- Queensland Workers' Compensation and Rehabilitation Act 2003 and Amendment Act 2015

2.4 SUB-CONTRACTORS

The Contractor shall disclose, at the tender stage, all sub-Contractors they intend to use for the contract works. The Contractor shall not sub-contract any work to any party without the prior written consent of QUU. It shall remain the Contractor's responsibility to audit and co-ordinate the performance of their sub-Contractors with results being disclosed to QUU.

All requirements applicable to the Contractor are applicable to sub-Contractors or sub-suppliers.

2.5 CONTRACTOR EXCEPTIONS

The Contractor shall be responsible to submit, together with the Tender, a list of deviations or exceptions to this Specification. In the absence of any exceptions, it shall be construed that the Contractor fully complies with this Specification.

2.6 ORDER OF PRECEDENCE

In the event of any conflict arising between this Specification and other documents listed herein, refer comments to QUU for clarification before design or fabrication commences.

The order of precedence that applies is as follows:-

- The Contract or Purchase Order Scope of Work
- Project Data Sheets
- This Specification
- Project Drawings
- Australian Codes and Standards
- International Codes and Standards

3 GENERAL DESIGN

3.1 OPERATING CONDITIONS AND DESIGN LIFE

EI&C equipment shall generally be designed for minimum service-life duration of 20 years in the environment and for the duty specified herein and on the Project Data Sheets. The equipment shall also be suitable for a minimum of 1 year normal continuous operation without maintenance at the duty specified herein and on the Project Data Sheets.

All EI&C equipment shall be designed to operate continuously at full load for 24 hours per day, 365 days per year under the climatic conditions detailed in this specification. All equipment shall be designed to perform this duty safely and without being attended.

Refer to the technical specifications in section 1.3 for minimum design service life of specific EI&C equipment.

3.2 SITE CLIMATIC CONDITIONS

Where equipment is installed in a temperature controlled weatherproof building, the design environmental conditions shall be as specified on the Project Data Sheets. For all other cases equipment shall be designed for the site conditions as defined below:-

Location	South East Queensland	
Altitude	above mean sea level.	0-300m
Ambient Temperature	Minimum	-5°C
	Maximum (dry bulb)	45°C
Relative Humidity	Minimum	26%
	Maximum	100% condensing
Solar Radiation	Black bulb design temperature - minimum mechanical design temperature for equipment exposed to solar radiation	85°C

Note: Corrosive environments are locations where H_2S gas or other corrosive chemicals and gasses can exist under normal operating conditions and can be both indoor and outdoor areas. This is applicable to all wet wells installations. All areas including inside air conditioned switch rooms at STP sites are considered corrosive environments. All materials installed shall be suitable for the environment.

3.3 OPERATING REQUIREMENTS

The equipment ratings shown on the design drawings shall be the required ratings after all derating factors have been applied.

All equipment shall be selected and installed so that all circuits can operate simultaneously at the full load rating shown on the drawings at the worst climatic extreme detailed in Clause 3.2 of this specification.

The full load rating for motor circuits shall be taken as the motor full load current while the rating for other circuits shall be the power or current rating nominated on the manufacturer's equipment nameplate or label. The maximum demand of DB's and associated circuits shall be as per AS3000 maximum demand calculations.

3.4 DESIGN SERVICE

Equipment shall be suitable for operation in water and sewerage facilities. Assets typically operated by QUU include the following:-

- Sewerage Treatment Plants
- Water Treatment Plants
- Sewerage Pump Stations
- Water Pump Stations
- Water Booster Sites
- Reservoirs
- Odour Control Facilities
- Valve Stations
- Water Sampling and Chemical Dosing sites

3.5 UTILITY DATA

The electrical system may have the following voltage levels:

High Voltage Power Supply	33 kV AC, three phase 3 wire, 50 Hz, 11 kV AC three phase 3 wire 50 Hz, 6.6 kV AC, three phase 3 wire, 50 Hz
Low Voltage Supplies	3 ph, 4 Wire, 400 Volt +10,-6% 50 Hz ± 2%, MEN System Voltage Unbalance <5%
Single Phase Power Supplies	230 V AC, +10,-6%, 2 wire, 50Hz ± 2%,
Control Power Supplies:	UPS 230 V AC, single phase 2 wire, 50 Hz Regulated 24 V DC
Special Purpose Power Supplies	Regulated 48VDC and 110VDC

The EI&C equipment shall be designed to operate continuously under the following conditions:-

- HV Distribution: Steady State Voltage ± 5% nominal voltage
- LV Distribution: Steady State Voltage +10,-6% nominal voltage
- Steady State Frequency ± 2.5% nominal frequency
- Transient Voltage ± 20% nominal voltage
- Transient Frequency ± 5% nominal frequency

The harmonic voltage and current distortion shall be provided as per TEM336 PSA Guidelines.

3.6 MATERIALS

All materials shall be as detailed on the Project Data Sheets and referenced specifications. When materials are not specified the Contractor may offer standard materials suitable for the environmental and operating design conditions. All materials shall be new and unused, free of defects and shall be supplied with relevant certification and documentation.

All supplied electrical equipment and instrumentation shall be selected from TMS62 Preferred Equipment List– Electrical and Instrumentation. The Contractor shall not deviate from these requirements without prior written approval from QUU. Where the required components are not specified the Contractor may offer standard components suitable for the application, environment and operating conditions.

Unspecified equipment shall be of the same type, grade and quality as similar items specified in the Project Documentation. Corresponding parts of similar equipment shall where possible be interchangeable.

All components shall be of standard manufacture and readily available from suppliers unless specified otherwise in the Project Documentation. All equipment to be supplied shall be sourced from local OEM (Original Equipment Manufacturer) Authorised Distributors within Australia.

The selected components shall be suitably rated for the application with particular attention given to the following:

- Process conditions
- Power rating
- Voltage rating
- Frequency rating
- Duty rating

- IP rating
- Temperature rating
- Corrosion protection

All equipment and materials shall be new and comply with the relevant specifications, regulations, codes and standards. All components and materials supplied by the Contractor shall be free from:

- Asbestos (all types)
- Ceramic fibre
- Chlorofluorocarbons
- Polychlorobiphenyls (PCB) and their isomers
- Radioactive materials (unless specified otherwise in Project Documentation)
- Mercury

3.7 MEASUREMENT UNITS

AS/ISO 1000 (metric SI system) shall be used. All documentation and correspondence shall be in the English language. Additional clarifications of units as follows:

Variable	Units
Flow • Mass • Liquids (volumetric)	 kg/h l/s, kl/day, Ml/day
Level	%, m, mAHD
Density	kg/m^3
Pressure • Gauge • Absolute • Differential	 kPag kPaa kPa
Temperature	°C
Conductivity	S/cm
Viscosity	cP
Analysers	% or ppm

3.8 DESIGN PERSONNEL

Personnel engaged for EI&C design services shall be accredited, suitably experienced, competent and skilled in the particular field of work in which they are engaged. All

design works shall be completed by or under the direct supervision of RPEQ Electrical Engineers.

3.9 WEATHER AND INGRESS PROTECTION

For ingress protection requirements of specific EI&C equipment refer to the technical specifications listed in section 1.3.

3.10 EQUIPMENT TAG NAMING

All EI&C equipment and associated cables shall be assigned unique tagnames by the Contractor and must be accepted by QUU. Tagnames shall be assigned to existing equipment and cables if not already assigned, where the project scope of work requires interfacing new equipment with existing operational equipment.

Equipment and cable tag names shall be presented in the following formats for QUU acceptance at the early stage of the design process:-

- Cable Schedule
- Instrument List
- Valve List
- Motor List
- Equipment Lists

Refer to TMS1647 Equipment Tag Naming Technical Specification

3.11 EQUIPMENT LABELS

Refer to QUU technical specifications in section 1.3 for labelling requirements to be provided to EI&C equipment.

All electrical enclosures including DB's, switchboards, MCC's, control panels and communications panels shall have a label clearly identifying the highest voltage level present inside the enclosure.

All sources of voltage supply shall be clearly identified on the label which shall be fixed to the front of the enclosure or adjacent to the enclosure. The label(s) shall indicate where all voltage sources are fed from.

Typical red label with white text enclosure label shall state:-

Danger ZZZ Volts

Fed from Panel XXX and CB YYY

Where XXX and YYY are equipment tag numbers assigned by the Contractor and used throughout the design documentation and ZZZ is the voltage level. Enclosures with ELV as the highest voltage source do not require "Danger" stated on the label and can be a white label with black text.

The design intention is that personal should not require to refer to electrical documentation to be able to quickly locate and isolate all voltage supplies to an enclosure.

CB's feeding fire services equipment; emergency lighting and other circuits related to personnel safety shall have warning labels that comply with relevant industry standards and in particular AS2293.1.

4 ELECTRICAL DESIGN

The electrical system shall be designed to be cost effective, with no technical compromise of the performance, operation and safety of the equipment or other assets.

Power system protection devices shall be selected to provide safe fast and coordinated operation, providing tripping of the upstream device nearest the point of fault or overload.

4.1 MINIMUM REQUIREMENTS

Equipment shall be designed to satisfy the minimum requirements listed in order of priority below unless specified otherwise in the Project Documentation:

- Safety of personnel,
- Protection of plant and environment
- Ease of operation to meet process requirements
- Reliability and continuity of supply
- Maintainability
- Minimisation of overall capital and operating costs, including replacement costs
- Ease of future expansion and upgrade

4.2 ENERGY EFFICIENCY

Energy efficient designs shall take budget constraints, industry norms, and good practice into consideration.

Wherever possible, designs shall incorporate all practical energy sources and design features in order to conserve natural resources and be environmentally conscious.

4.3 ELECTRICAL SAFETY

4.3.1 Protection from Live Parts

Equipment shall be designed and constructed to avoid direct contact with live parts. Protection shall be provided against injury that may arise from contact with parts of the electrical installation that are live in normal service or may become live under fault conditions. Accepted protection methods shall be one or combination of the following:

- Insulation
- Barriers/obstructions
- Enclosures
- Parts to be installed out of reach
- Earthing and bonding

Residual Current Devices (RCD's) are not accepted as a standalone basic protection; however RCD's may be used in conjunction with the aforementioned protection methods.

Consideration towards access, during fault finding and maintenance, must be taken into account during the design phases. This may include specifying a degree of protection IP2X when covers are removed.

Switchrooms, transformer enclosures and other electrical equipment shall not be accessible to unauthorised persons. Oil transformers are preferred to be installed outdoors within a fenced area or locked metal enclosure. Small isolation or dry type transformers may be located indoors. Switchrooms shall be lockable and provided with statutory signs in compliance with AS 1319.

4.3.2 Equipment Design and Location

Equipment shall be designed and installed to meet the following constraints:-

- Eliminate hazards that impact the safety and protection of the operators and other plant occupants.
- Ensure that dangerous forces and gases produced by electrical short circuit faults are contained or directed away from the operating areas of personnel. Gases which arise as a result of interruption of a short circuit shall be collected and controlled to safe temperatures and pressures before being allowed to escape from the equipment.
- Insulating and di-electric materials used in all electrical equipment shall be non-toxic and shall not contain chemical compounds which contain hazardous environmental contaminants
- Exposure to arc flash hazard risks, toxic or flammable substances when operating and maintaining equipment must be eliminated or minimised to as low as reasonably possible (ALARP).

4.3.3 Induced Voltage

In the design phase, consideration shall be given towards the following aspects of energising equipment and induced voltages:

- Malfunction of control systems equipment
- Back feed from instrument transformers
- Open circuiting of current transformers
- Capacitive coupling
- Induction via parallel circuits

It shall be possible through equipment selection, isolation and standard operating procedures to protect against these and associated hazards.

4.3.4 Evacuation

All services required for safe evacuation of the facilities shall be designed for 90 minute autonomy after loss of both main and emergency generation. Electrical power shall be provided for sufficient light fittings and communications systems to be available to allow personnel to be mustered and to be safely evacuated and to maintain contact with external emergency services.

Refer to section 4.15.6 of this document for emergency lighting design requirements.

Sufficient clearance for access and evacuation must be maintained, even with equipment doors open. Refer to AS 3000 and AS 2067 for minimum requirements.

Exits shall be arranged so that the maximum length of the escape route complies with the requirements of Section D of the National Construction Code.

Switchrooms shall have a minimum of two exits.

4.4 ENVIRONMENT

4.4.1 Audible Noise

Electrical equipment, especially rotating machines, rectifiers, transformers, inverters and VSD's shall be selected in consideration of the maximum permissible sound pressure level. Noise levels for electrical equipment shall be no greater than the levels stated in the relevant Australian Standards mentioned for that particular equipment.

Areas which require specific consideration include:

- Blower Rooms
- Air Compressors
- Diesel Generators
- Switchrooms
- Pump Rooms

The accumulated peak noise level (all equipment operating at rated load) shall not exceed 80db unless specified otherwise in the Project Documentation.

Refer to TMS1639 General Mechanical Works – Technical Specification for other design constraints regarding noise emission levels.

4.4.2 Spills and Emissions

The following measures shall be undertaken to manage the risk of spills and emissions:-

- Oil insulated transformers shall be situated within a bunded area to contain any spills and bund containment volume shall comply with AS2067.
- Wet cell batteries shall to be housed in a suitable enclosure such that spills are contained without posing a hazard to the environment
- Corrosive, toxic or flammable gases emitted by equipment in normal or abnormal operation shall be vented to areas not occupied by personnel and other equipment.

4.4.3 Pests

Pests normally encountered are rats, mice, birds, termites, insects, spiders, geckos, snakes, bats and burrowing animals. All installations shall be designed to prevent vermin from accessing equipment and cabling. If access cannot be completely prevented the equipment and cables must be resistant to attack or degradation from vermin.

Bird resistance barriers or made-for-purpose netting shall be installed on eaves, under roofs and around exposed beams where birds might roost.

4.5 CLASSIFYING LOADS

Electrical loads shall be classified as performing a service which is:

- Essential service – where required to meet a legislative requirement or when failing in operations or failing if called upon to operate and can affect the continuity, quality and quantity of the assets production.
- Non-Essential service

Essential loads shall be connected to a dedicated essential bus section of the main LV switchboard for the site or process area. The essential bus supply shall be backed up by a standby generator unless specified otherwise in the Project Documentation. For new assets the generator can be portable or permanently installed. For modifications to existing assets the generation spare capacity shall be assessed for any proposed new loads.

Network assets typically have a single bus arrangement and all connected loads are considered as essential services.

During the design phase the Contractor shall undertake a risk assessment with collaboration from QUU stakeholders to determine if a permanently installed generator or mobile generator connection facility is required. The Contractor shall select the generator rating required to meet the essential service loads. The generator design shall comply with TMS1589 LV Diesel Generator Technical Specification.

Unless specified otherwise in the Project Documentation the Contractor shall allow a fixed price provisional sum for a permanently installed generator with ATS connection to the essential services switchboard and an option price for a mobile generator connection plug at the essential services switchboard with a manual transfer switch. The generator connections shall be in accordance with QUU typical design drawings and shall be provided in an arc fault contained enclosure that complies with TMS60 LV Switchboard Technical Specification unless specified otherwise in the Project Documentation.

For mobile generators a permanent external socket outlet or termination box connection shall be provided for connection of the generator. Hard stand space shall be reserved for the generator in the plant layout, outside of hazardous zones and within the boundary of the buried earth grid for HV installations. Two accessible earth bonding points in the vicinity of the generator shall be installed - one for connection to the mobile generator and one for connection to diesel refuelling tankers.

4.5.1 Essential Service Supply

An uninterruptable Power Supply (UPS) shall provide the means to sustain loads requiring continuity of service under supply interrupt conditions. The back-up power supply system shall be designed with eight (8) hour backup battery banks, unless specified otherwise in Project Documentation. Battery Charger DC systems are only accepted for HV Switchboard installations.

4.6 SYSTEM VOLTAGES

The voltage and frequency variations given are the specified design values at the point of supply under steady state conditions. Momentary supply system disturbances shall not result in voltage and frequency variation in excess of steady state values

4.6.1 Voltage Level Definitions:

Voltage levels are as defined by AS3000:-

- ELV ≤ 50VAC or ≤ 120VDC ripple free
- LV Exceeding ELV, ≤ 1kV AC or ≤ 1.5kV DC ripple-free
- HV >1kV AC or >1.5V DC ripple-free

4.6.2 HV Network

Service	Voltage (kV)	Phases	Frequency (Hz)	Neutral-Earth Connection
HV Distribution	33 ± 5%, 11 ± 5%, 6.6 ± 5%, 3.3 ± 5%	3	50	Impedance or Solid and subject to PSA
Large HV Motors	6.6 ± 5%, 3.3 ± 5%	3	50	Impedance or Solid and subject to PSA

4.6.3 LV Network

Service	Voltage (V)	Phases	Frequency (Hz)	Neutral-Earth Connection
Low Voltage Distribution	400 + 10% -6%	3+ N	50	Solid
Emergency Generator	230 + 10% -6% 400 +10% - 6%	1+N 3 + N	50	Solid
Induction Motors	400 + 10% -6%	3+ N	50	Solid
Lighting and Small Power	230 + 10% -6% 400 +10% - 6%	1+N 3+ N	50	Solid
UPS Distribution	230 + 10% -6%	1 +N	50	Solid
Motor Heaters	230 + 10% -6%	1+ N	50	Solid
Instrument Power (not preferred)	230 + 10% -6%	3+ N	50	Solid

4.6.4 ELV Equipment

Service	Voltage (V)	Earth Connection
LV Switchboard and MCC Internal Controls	24 ± 5%	Negative
Motor Contactors	24 ± 5%	Negative
Motor Control Circuits	24 ± 10%	Negative
Instrument Power Supplies	24 ± 10%	Negative
HV Protection and Control	24 ± 10%	Negative
LV and HV Circuit Breaker spring charging	24 ± 10%	Negative
Instrument Power(preferred)	24 ± 10%	Negative
Digital I/O	24 ± 10%	Negative
Control Systems	24 ± 10%	Negative
Communication Equipment	24 ± 10%	Negative

4.6.5 Distribution Transformer Ratings

Secondary Voltage (V)	Maximum Rating (MVA)
400	2.5
3300	2.5
6 600	10

4.7 POWER SYSTEMS ANALYSIS

PSA shall be conducted as per TEM336 PSA Guidelines for all new sites and projects that require modifications to the existing power system installed at the site. Calculations and network modelling shall be provided in support of the electrical design and the Project Documentation will nominate the PSA deliverables required and may comprise of the following components:-

- Fault Level Calculations
- Load Flow
- Protection Co-ordination
- Arc Flash Analysis
- Harmonics Study
- Large motor starting and dynamic/static modelling
- Earthing system modelling including step, touch and transfer potentials
- Power cable sizing calculations (AC and DC)
- Maximum Demand (LV and ELV DB's)
- Power Factor
- Power Quality Analysis
- Generator and Transformer sizing calculations

PSA design scope of works related to development and updating the SKM Power Tools model and device libraries shall be undertaken by Contractors pre-approved by QUU to perform the works. Refer to QUU and Project Documentation for the list of pre-approved PSA consultants.

4.8 DESIGN MARGINS

The complete electrical system shall be economically designed for continuous and reliable service to ensure safety of personnel and equipment, ease of maintenance and operation, minimum power losses, mechanical protection of equipment, interchange ability of equipment and the addition of future loads.

The rating of electrical equipment shall be generally based of the maximum demand and also taking into account:-

- Diversity
- Utilisation
- Operating Time (duty/standby)
- Load Factor
- Efficiency
- Future Capacity
- Power Factor
- Insulation coordination

4.8.1 Normal Plant Loading

When evaluating loads the utilisation factors shall be applied as described in the following table:-

Operating Mode	Load Rating
Continuously operating equipment ie wet weather flows through assets	100% with conservative load factors applied and not less than 0.8
Intermittent equipment	Capacity to take into consideration configuration redundancy and process loads. Assume 50% of nominal loads in the absence of final design inputs
Standby plant operating	Nil additional allowance where mechanical, hardwired electrical or control system software interlocks prevent simultaneous operation with duty plant in all modes.
Minimum load condition	All transformers at the site loaded to 10% of rated secondary current

4.8.2 Motor Starting

Refer to TEM336 PSA Guidelines for design constraints and analysis when starting new and existing motors.

4.8.3 Maximum Demand

For LV distribution boards, the maximum demand shall be calculated to the requirements of AS 3000. Refer to TEM336 PSA Guidelines for details on maximum demand calculations.

4.8.4 Load Allocation

Where practical the power supplies to duplicated process plant items shall be designed such that for a single electrical plant fault or outage, at least 50% of the plant equipment installed shall remain in service.

4.8.5 Load List

All new and modifications to existing assets shall have a load list documenting existing and new loads. Refer to TEM336 PSA Guidelines for details required to be included in the load list.

4.8.6 Supply Capacity

The power supply capacity at the electrical point of supply from the utility and associated on site switchgear and transformers shall be capable of supplying continuously 120% of the sites maximum demand load, assessed according to the applicable load data, without exceeding specified voltage limits and equipment ratings.

Spare capacity shall be provided to cater for the possibility of future expansion of plant loads. Where future expansion plans are nominated by QUU as unlikely, unfeasible or specifically not catered for, the spare capacity at the finalisation of design may be reduced accordingly, but not less than 10% of the maximum demand load.

4.8.7 Equipment Loadings

4.8.7.1 *Feeders*

Feeders and related equipment serving individual loads shall not be sized for future growth. Where feeder circuits supply multiple loads consideration shall be given to accommodate potential load growth, to the extent of capacity of upstream supplies.

In cases where additional (as opposed to larger) equipment is required to provide reserve for future growth, the excess capacity shall not be installed, but the design shall facilitate expansion should greater capacity actually be required in the future.

4.8.7.2 *Transformers*

The rating of all new transformers shall be the nameplate rating at the ambient conditions specified in section 3.2. If the transformer forced cooled rating is only required for future load growth, provision only shall be made for future cooling fans.

For supply arrangements having more than one transformer serving interconnected buses with one transformer out of service, the remaining transformer(s) shall have sufficient installed capacity to serve the total operating load on the buses, including reserve for future load growth, within economic reason.

HV feeders serving unit substations shall be sized to carry the simultaneous full load current of the transformer(s) forced cooling (ONAF) rated currents.

4.8.8 Power Network Configuration

Power distribution features of the electrical network shall be consistent with the Protection Philosophy Design Report provided by the Contractor during detail design. Refer section 4.21 of this document for details on the content of the Protection Philosophy Design Report.

Power distribution systems (transformers, switchboards, cabling etc) shall be designed such that the largest load connected at each switchboard can be successfully energised with all other loads operating without causing disturbances to other connected loads(upstream and downstream).

In addition, the distribution system will be designed such that electrical faults are safely isolated with minimum disturbances to the healthy system, such that the power system has overall transient and steady state stability.

For large sites the main LV switchboard supply redundancy shall be provided where practicable by means of multiple feeders and associated bus ties. The configurations of the bus bars shall allow one switchboard bus section to be taken out of service while still maintaining some degree of plant operations.

The provision of stand-by generation capacity to supply non-essential service loads shall be subject to an evaluation of the load requirements in conjunction with the relevant factors that may affect process reliability and availability. In general a 100% redundant power supply is not required for non-essential loads.

4.9 FAULT AND INSULATION LEVELS

The maximum system fault level shall be calculated on the most onerous operating connections that can be configured in the power network and shall include emergency standby generator (permanently installed) and mobile generators (connection provision only provided) operating scenarios.

LV bus system fault levels shall be calculated using the maximum HV fault level with single transformer feeder connected to each LV bus segment (i.e. normal operating conditions) and all duty motors contributing to the fault. LV switchboards with operating modes that include closed bus ties, multiple feeders and/or interconnected back feeds shall be rated for the maximum feasible fault level.

The summary of applicable maximum fault and insulation levels for switchgear and bus bar system shall generally be as follows:

4.9.1 Equipment Fault Current Ratings and Insulation Levels

Service	Voltage (kV)	Max. Fault Withstand Current (kA)	Fault Duration (s)	Basic Insulation Level (kV- Peak)
HV Secondary Distribution	33	31.5	3	170
HV Secondary Distribution	11	25	1	95
HV Secondary Distribution	6.6	25	1	95
HV Secondary Distribution	3.3	25	1	95
LV Switchboard and MCC	0.4	80	1	3
Lighting and Small Power DB	.400/.230	20	0.2	NA

The design must allow for a 20% future increase in the maximum prospective fault level over the intended design life of the facility.

Derivation of short circuit currents shall be generated as a system modelling output in accordance with TEM336 Power Systems Analysis Guidelines.

4.10 ELECTRICAL PROTECTION

Protection features of the power system shall be consistent with the Protection Philosophy Design Report produced during detail design.

A Protection Philosophy Design Report is not required for Network sites with LV supply unless specified otherwise in the Project Documentation. For LV Network sites the Protection Co-ordination Report in compliance with TEM336 PSA Guidelines is adequate design documentation.

4.10.1 Primary Protection

The protective devices selected shall provide adequate safeguards against the effects of any fault occurring on the system or component parts.

Where appropriate unit protection schemes shall be utilised. All protective devices, including relays and current transformers, shall be adequately rated to withstand the prospective short circuit current which can flow or be induced in the power network.

Multifunction protective relays shall be implemented for HV protection schemes unless specified otherwise in the Project Documentation. The relay protection devices shall be such that a clear indication is given of the fault which caused a trip. HV circuit breakers shall not be capable of re-closure without first manually resetting the fault at the appropriate protection relay.

4.10.2 Secondary Protection

CB fail protection schemes shall be implemented to achieve the primary protection where practical. Secondary or back up protection shall be provided by time / current grading of upstream protective devices. The design criteria shall be to clear a fault as fast as possible and the total clearance time shall not exceed 0.5 seconds if the primary protection fails. Any deviation to this criteria must be accepted in writing by QUU.

4.10.3 Instrument Transformers

CTs and VTs shall be specified with characteristics, e.g. rated output and accuracy class, which are adequate for the associated protection, control and / or monitoring equipment. Separate CTs windings shall be used for metering and protection functions.

The rated output of CTs shall, as a minimum, be equal to the connected burden of the protection, control and/or monitoring devices, including the load burden, rounded up to the next standard rating. All CTs and VTs shall have complete saturation test sheets. CTs shall be suitable for use taking into consideration the future capacity of the system, within economic reason.

Refer TMS1186 HV Switchboard Technical Specification for other requirements when designing CT's and VT's to be installed in HV Switchboards.

4.11 POWER NETWORK TOPOLOGY

The structure of the electrical distribution system is generally based on the following criteria:

- The rating of the system is based on the specified power consumption of the electrical equipment and the allocation of this equipment to the production areas at the site.
- The power distribution system to switchboards with multiple incomers shall be selective. In normal operation, the bus tie breakers shall be open to minimise fault currents on the bus bar.
- The equipment shall be rated for the maximum short-circuit current that may occur in the respective section of the supply system, i.e. adequate thermal and dynamic short-circuit strengths are required. Parallel operation of incomers shall be prevented by means of mechanical and electrical hardwired interlocking. If parallel operation can occur then the fault current rating of downstream equipment must be assessed and confirmed adequately rated. This is applicable for short duration switching operations where switchboards are fed from multiple transformers simultaneously.
- Automatic load transfer schemes shall be implemented at 11kV and above voltage levels, where multiple utility incomers are provided to the site and the incomers are each rated to alone supply the site maximum demand load. The scheme shall be fully commissioned and disabled for future use if all incomers

or their required capacities are not available at the time of commissioning completion to supply the site.

- System protective devices including CB's and fuses shall be selected and coordinated to ensure that the interrupter nearest the point of fault (or high overload) shall open first and minimize system disturbance.

4.11.1 Point of Supply

All sites shall be supplied from utility (grid) connection unless advised otherwise in the Project Documentation.

4.11.2 Power Factor Correction

The formal Connection and Access Agreement with Energex requires power factor (PF) limitations at the point of common coupling. For modifications to existing operational sites the Contractor shall assess the actual PF range and any modifications to the existing site must ensure the entire site at the point of common coupling and within the plant power network is within PF limits specified in TEM336 PSA Guidelines.

If required the PFC shall be installed indoors in an air conditioned switchrooms. The capacitor banks shall each be provided with an integral control panel. The control panel shall be equipped with the main controller (auto control), auto/manual selector switch, PLC interface relays, induction lights, ammeter and selector switch and all necessary control equipment. The PFC unit controller shall be integrated into the site protection philosophy and site control system.

4.11.3 Harmonics Distortion

The specification of harmonic distortion producing equipment such as rectifiers, inverters, variable speed drives, power factor correction equipment, etc. shall give due consideration to the level of harmonic voltage and current distortion caused by the equipment.

The total harmonic voltage and current distortion at the point of common coupling on the network caused by the equipment shall be within values specified in TEM336 PSA Guidelines.

Harmonic mitigation techniques provided by the Contractor shall be in the following order of preference:-

- Specification of equipment which generates low levels of harmonic voltage and current distortion, or has integral harmonic filtering equipment.
- Provision of standalone harmonic filtering equipment including passive and active harmonic filters.

For addition of non-linear loads to existing operational assets the Contractor shall measure the actual harmonic distortion levels at the design phase and provide a Power Quality Analysis (PQA) Report. After the new equipment is commissioned the Contractor must ensure the entire site at the point of common coupling and other points in the site power network are within harmonic limits stated in TEM336 PSA Guidelines. A separate PQA report shall be provided by the Contractor when commissioning of the new equipment is completed to demonstrate harmonic distortion limits are not exceeded under all operational modes.

4.11.4 Electromagnetic Compatibility

For electromagnetic interference requirements of specific equipment refer to the technical specifications listed in section 1.3.

Measures shall be taken to reduce the probability of low frequency induction and radio frequency interference with regard to:

- Equipment specification
- Equipment location
- Cable installation segregation
- Earthing and bonding

The extent of any RFI shall be such that it does not interrupt normal operation of the process or process related equipment, including controllers, instrumentation and telecommunications. RFI shall be generally as specified in AS 61000 series on electromagnetic compatibility (EMC).

4.12 POWER CABLES

The LV and HV cables shall be standard types in regular production by reputable manufacturers with supply chains based in Australia. Manufacture of all cables shall be copper, circular cross section unless otherwise specified with a consistent diameter and profile for the full length of the supplied cable.

The following general criteria shall be adhered to for selecting power cables:

4.12.1 Power Cable Type and Design Constraints

Performance Criteria	Suitable for installation in water and waste water facilities with elevated levels of H_2S gas in waste water facilities and other environmental conditions present. Suitable for installation in HA's where present.
UV Rated Other Sheath	Where routed outdoors above ground with exposure to direct sunlight
Termite Protection – Nylon sheathed	All underground cables including those run in conduits
Flame Retardant	Yes – In accordance with AS 1660.5.1 Category C
Fire Resistant	Fire and Gas Detection systems and other special applications
Low Smoke Zero Halogen (<0.05%)	-All cables routed in control rooms and office buildings -Cables installed in switchrooms and where both ends of the cable terminate inside the switchroom.
Water IP Outer Sheath	All cables installed underground. HV cables shall have double water blocking where installed at sites with a high water table.
Insulation	XLPE/PVC for cables 16mm2 and above PVC/PVC for cables less than 16mm2
Steel Wire Armoured	Special situations only where accepted by QUU

Note that the following cable construction types shall not be accepted:

- Mineral insulated cable
- Lead and lead alloy sheath cable
- Oil impregnated paper insulated cable.

Nominal power cable ratings shall be based on:

- ambient air temperature of 45°C.
- maximum soil temperature 30°C for buried cables.

Derating factors shall be applied as necessary to take account of installation configuration and variation in ambient temperature, in accordance with AS 3008.1.

The minimum cross-sectional area for LV power cables shall be 1.5mm².

Direct buried cables are not accepted under any circumstances.

The design of power cables shall ensure compliance with TMS1200 Electrical Installation Technical Specification.

4.12.2 Power Cable Sizing

Refer TEM336 PSA Guidelines for details on HV and LV power cable sizing calculations. Cable sizing calculations are also required for ELV power cables.

4.13 EARTHING SYSTEMS

4.13.1 General

Earth grids for sites containing HV supply shall be designed strictly in accordance with AS2067. The HV and LV earth grids for new and modifications to existing sites shall be combined and the design shall ensure the earth system installation complies with TMS1200 Electrical Installation technical specification. Where an existing site has segregated LV and HV earth grids, any new design works to the site earth grids shall include for permanent continuous bonding of all the grids together at the site.

Bonding of new earth systems to building foundations and other structures shall be provided; however the connections shall not be relied upon in the design process to achieve safe step and touch voltage levels.

The earth grid design shall allow for 20% increase in prospective fault level at the site over its intended design life. The fault clearing time to be assumed for the basis of the earth grid design is the protection maximum back-up clearance time and in no cases shall the value be less than 0.5 secs, unless accepted otherwise in writing by QUU.

The soil testing methods, earth system testing methods and ultimate earth grid design shall comply with the requirements specified in TMS1200 Electrical Installation – Technical Specification.

Refer TEM336 PSA Guidelines for other design specifications and deliverables required for earth system design.

Refer to section 4.16 for bonding of the site lightning protection systems to the site earth grid.

4.13.2 LV Switchrooms

The earth grid for LV switchrooms shall consist of a minimum 120mm^2 bare annealed copper conductor routed underground around the switchroom perimeter and minimum 600mm^2 depth of soil cover. As a minimum the electrodes shall be located near each corner of the building and bonded to the underground earth conductor in an electrode pit. A minimum of two 120mm^2 PVC earth cable connections shall be run from the internal wall mounted LV switchroom earth bar to the underground earth grid.

The earth system for Network Assets typically containing a single LV switchboard (indoor or outdoor) shall have two earth electrodes in a separate earth pits bonded to the main earth bar in the switchboard.

For all sites the MEN connection shall be located in the main LV switchboard.

4.13.3 HV Substations and Switchrooms

HV substation earth grids shall be designed to consist of an array of electrodes (maximum spacing is 20m between electrodes) interconnected with 120mm^2 bare annealed underground copper conductors with minimum cover of 600mm. The grid spacing shall not be larger than 5m squares where practical to install. A minimum of two 120mm^2 PVC earth cable connections shall be run from the HV switchroom internal wall mounted earth bar to the new underground earth grid. All localised earth grids at equipment such as RMU's, transformers compounds etc shall be bonded to the main substation earth grid by minimum 2 off 120mm^2 earth PVC cables. For substations containing LV and HV switchrooms there shall be a separate LV and HV switchroom earth bar provided.

4.13.4 Existing Earth Systems

The physical condition and extent of the earth system components installed for existing assets cannot always be easily verified and the As Built design documentation is not always available or accurate. The design for new earth grids at existing sites shall not rely on or take credit for the performance of any existing earth grid members in near vicinity of the proposed new earth grid.

For modifications to earth grids at existing facilitates, the building foundations and all other underground structures in the vicinity of the proposed new earth grid shall NOT be considered when designing and modelling the performance of the new earth grid. The new earth grid design shall not rely on the connections to the existing earth grids and other underground structures to meet safe step and touch voltage levels. This condition must be clearly stated in the Earth Grid Design Report.

The As Built earth grid design drawings must show all bonds to existing structures and existing earth grid members that can be located at the site and are assessed by the Contractor as being in adequate physical condition for continued service. The Contractor shall de-commission and remove all earth system members that are no longer in service as a result of works performed under the Contract. The Contractor shall not bond existing earth grid components to the new earth system where the location and condition of the existing components cannot be verified and documented on the AS Built drawings. All existing equipment must have more than one earth bond installed to the new earth grid.

4.13.5 Equipment Earthing

Refer to TMS1200 Electrical Installation Technical Specification

4.13.6 Transfer Potentials

The effect of transferring potential rises due to earth faults shall be considered as per TEM336 PSA Guideline during the earthing system design.

The means of transferring potentials to be considered include:

- Metal fencing
- Piping
- Cable sheathing
- Earth and equipotential bonding

Insulated copper earth cables shall be run from the main HV switchroom earth bar to each distribution substation HV earth bar at the site. Where applicable the earth grid for a HV installation shall include a site perimeter underground loop located one metre outside the fence line and bonded to the fence at maximum 15m intervals, bonds are also required to gates and all metal structures within the facility.

Insulated copper earth cables shall be run from the main LV earth bar in each plant area to each LV switchboard in the same plant production area.

Metal pipes, fences and cable ladder crossing a substation boundary shall be provided with insulated sections at the boundary to prevent transferred potential.

Particular care shall be taken with design and bonding of electrical cable screens crossing a substation boundary that may bridge earth systems.

In any case the transferred potential shall not exceed safe levels.

4.13.7 Equipotential Bonding

Refer to TMS1200 Electrical Installation Technical Specification

All non-current carrying metallic parts and enclosures of electrical equipment and metallic structures used for mounting electrical equipment shall be effectively bonded to the earth grid throughout the site so as to ensure that all exposed conductive parts are at equal potential during normal operation and under fault conditions. All exposed conductive parts of equipment, piping, vessels and structural items shall be effectively bonded so as to prevent the accumulation of static charge. The Contractor shall provide standard earthing installation drawings for the types of equipment to be installed.

Unless otherwise required, metal sheaths and steel armouring of cables shall be connected at both ends to the switchboard earth bar via cable glands and gland plates. The continuity of metal sheaths and armouring shall be maintained across cable branches or joints.

To bridge the insulating effect of the anti-vibration mountings on mechanical packages, bonding conductors shall be used to connect the insulated equipment to the adjacent structural steel.

4.13.8 Low Frequency Induction

Assets including pipelines in vicinity of HV transmission of distribution lines can be exposed to Low Frequency Induction (LFI). CDEG modelling software shall be used to determine LFI voltage levels and an LFI design report shall be provided unless otherwise specified in the Project Documentation. LFI voltages imposed on equipment must be considered for both steady state and fault conditions in the HV lines.

4.13.9 Instrumentation Earthing

Instrument earth design shall be in accordance with the requirements of AS/NZS3000 and TMS1201 Instrumentation Installation - Design Requirements.

Conventional instrument earthing systems shall be designed such that each instrument control loop system is earthed at a single point and only at the instrument earth bar, through the cable screens/shields at the PLC or RTU control panel.

Screen earths shall be separated from 'dirty' equipment earths. Equipment earths are for electrical safety earthing only.

Field instrument bodies, junction box housings and any other control system enclosures shall be solidly earthed to the equipment earth. In addition, and not as a substitute for cable shields, cable armour shall be continuous and earthed via the glands at a junction box, instrument, and panel end of the cable.

Where earths are to be terminated in a junction box earth terminals shall be provided.

Instrument loop surge protection devices shall be connected to the control panel instrument earth bar as per the manufacturer's recommendations. Refer to other sections of this document for additional surge protection device design requirements.

4.13.10 Static Electricity

Static electricity shall be controlled in accordance with the requirements of AS 1020 by the provision of secondary earthing supplemented by the provisions of this section.

Particular attention shall be given to the provision of adequate paths to earth preventing the build-up of potentially hazardous static charge levels arising from the flow of gas and fluids under both normal and abnormal operating conditions.

All parts of metallic piping systems shall be earthed with a resistance to ground not exceeding 10 ohms regardless of whether the fluid being transported is conductive or not. Bonding is not required across joints in the metallic piping system, except for flexible, swivel or sliding joints. If the resistance across pipe connections is greater than 1MΩ, the pipes on either side of the connection shall be bonded together by a suitable conductor and earthed.

In HA's, all electrically isolated parts of metallic piping and components shall be bonded to the remainder of the piping system and earthed.

Any earthing shall not compromise sections of pipe that are to be electrically isolated, for example, insulating flanges on cathodic protection systems.

4.14 EARTH SYSTEM DESIGN DOCUMENTATION

The following is a list of the minimum design deliverables required for an earth system design:-

- Earth Grid Design Report including soil test results, step and touch and transfer potentials. Design report must state the test methods and pass/fail criteria for each test and the report shall be updated with As Built information.
- Earth Grid Layout Drawings showing earth bars, above and below ground earth conductors, earth tails to equipment and structures, joints and electrodes and MEN locations.
- Earth bar general arrangement drawings showing size, all conductor connections and tagnames and mounting details.
- Detail installation drawings for new electrodes and earth connection types.

4.15 LIGHTING

4.15.1 General

Light fittings shall be designed to provide illumination for safe access for operation and maintenance purposes in low natural light conditions. The Contractor shall design and supply lighting system to comply with the relevant Australian Standards.

Energy efficiency, ease of maintenance and reliability of the lighting system components shall be taken into consideration in the design. Light fittings shall be selected from suppliers listed in TMS62 Preferred Electrical and Instrumentation Equipment List. The lighting design shall ensure the luminaires can be installed in accordance with TMS1200 Electrical Installation Technical Specification.

In general, high bay and area lighting shall be LED. Low level lighting for switchrooms, control rooms, etc shall also be LED lighting.

All light poles greater than 1.8metres in height (e.g. walkways, outdoor work areas and general plant areas) shall be designed such that maintenance of light fittings may be carried out from the ground or walkways without the use of an elevated platform workstation or ladders.

All lighting columns shall be of the lowering type and shall not require an elevated platform to access the light fittings. The lowering apparatus shall be operable from

outside the fall zone. Any control gear associated with lighting poles shall be mounted at the base of the pole so that it is accessible from the ground for maintenance. Control equipment shall have a dedicated CB's provided at the base of the pole for local isolation. Poles which support multiple luminaires shall have an individual protective device per luminaire located at base of the pole.

Lighting levels in vicinity of CCTV cameras shall be selected so as to not diminish night vision of the cameras. Light fittings shall also be positioned to minimise glare and illumination of neighbouring properties.

Lighting lux level plots shall be provide for each site area using AGI32 or similar lighting design software. The luminaire locations shall be superimposed on the site layout drawings and indicate mounting height, angle of inclinations, fouling and aging factors allowed.

4.15.2 Lighting Intensities

The following (in-service) average lighting intensities are generally based on AS1680 series of standards. In order to allow for ageing and fouling, the initial average lighting intensities shall be 1.20 times the values shown in below table:-

Plant Area/Location	Minimum LUX Level
General Outdoor Process Areas	10
Compressor, large blowers and fans(indoors)	150
Interconnecting pipe ways and cable ladders	20
Open stairways (exterior)	55
Local control panels and operating points	150
Indoor facilities for personnel and other amenities	200
Switchrooms (interior)	300
Walkways and access areas (outdoors)	20
Walkways and access ways to buildings	40
General work areas	160
Pump House and Plant Rooms	160
Process plant items(occasional attendance)	80
Workstations (permanently occupied)	160
Control Room, measuring stations, control platforms and observation posts	320
Storage routinely involving reading tasks	160
Office General	320
Office Background	160
Office for Drafting Tasks	600
Computer/Control Rooms	320
Meeting Rooms	320

Plant Area/Location	Minimum LUX Level
Reception Area:	240
Photocopying / printing	240
Filing areas	160
Entrances	160
Waiting rooms	160
Gate houses	320
Corridors / passages	80
Loading bays	80
Stairs (interior)	160
Staff kitchen/dining areas	240
Staff rooms:	
• Locker	80
• Changing rooms	80
• Cleaners rooms	80
Store rooms	80
Car Parks	15
Vehicle Access Roadways	10

Lighting levels shall be measured 1m above floor level. Outdoor areas without buildings plant and equipment and no access pathways shall not be illuminated.

The design of pedestrian pathways including outdoor covered walkways shall comply with AS1158.3.1.

4.15.3 Gate Approach Lighting

At STP sites and other permanently manned sites a 3m pole mounted LED light at the maintenance gate entrance shall be operated by motion sensor activated by an approaching maintenance truck. An IP66 rated Automatic / Manual lighting selector switch box shall be installed at the gate post with local control switches to plant general area lighting and maintenance lighting circuits. The enclosure shall be designed to comply with TMS1222 Control Panel – Technical Specification.

4.15.4 Plant Area Lighting

Flood lighting luminaries for larger sites shall be fitted with LED lamps complete with integral control gear.

Outdoor car parks and vehicle roadway lighting luminaries shall comply with AS1158.3.1 and shall be HPS or LED lamps complete with integral control gear unless specified otherwise in Project Documentation.

Plant area lighting circuits shall be controlled by contactors located at lighting distribution boards as appropriate. All external lights shall be able to be switched

ON/OFF using the site control system SCADA system either in total or by plant area. The site control system shall automatically switch external lighting off in daylight hours via a day/night switch, with an override facility for testing purposes.

All external lighting shall also include manual direct switching facilities adjacent to the relevant local light and power distribution board. This switching shall operate independently of the site control system.

All external lights shall be able to be switched off after an adjustable time delay function (0-60 minutes) via SCADA operator control. External lighting SCADA controls shall also include the facility to select automatic operation of the lights whenever an area security alarm is active at night (as determined by a day/night switch).

Lighting poles shall not be fixed to handrails.

The preferred type of lighting is LED mounted to dedicated galvanised steel pivot poles that can be easily accessed for maintenance. Aluminium poles are required in corrosive environments.

Lighting poles shall be located outside HA's where possible and shall be designed and tested to comply with the requirements of AS 1170 when subjected to the site service conditions.

4.15.5 Maintenance Lighting

Illumination level at maintainable equipment including process areas for safe access and walkthrough shall be as per section 4.15.2.

Visual inspection or manual intervention of plant equipment shall be provided by task lighting. Lights shall be installed for maintenance lighting and task lighting located on 2.2m aluminium lamp posts attached to structures or mounted on platforms.

4.15.6 Emergency Lighting

Emergency and evacuation lighting shall be provided to comply AS 2293 standard and Australian Building Code requirements.

The site emergency lighting system shall employ standalone single two hour battery backed up maintained lighting luminaries. UPS's dedicated for emergency lighting circuits are not accepted unless specified otherwise in the Project Documentation.

Manual testing facility shall be provided at the plant lighting distribution boards as appropriate to comply with AS 2293 standard requirements.

Luminaires shall comprise, but not be limited to, batteries, automatic charger, supply failure relay and control switch.

The lights shall comprise LED lamps forming part of a luminaire containing 230 Vac lamps. All emergency light fittings shall be dual rated charge type for maximum battery life. Fittings shall have integrated battery cell in each luminaire.

4.15.7 Prefabricated Switchroom Lighting

Refer TMS1188 Demountable Switchroom Technical Specification

4.16 LIGHTNING PROTECTION

All major steel structures, platforms, equipment, machinery and other non-conducting metallic components of electrical equipment and instrumentation in buildings and plant sections shall be connected to the site earthing system via earthing and bonding in accordance with AS 1768 standard requirements.

Lightning risk assessment studies shall be undertaken to determine the level and extent of lightning protection. No separate earth connections are required for equipment, items, vessels and machinery which are bolted or welded to earthed steel structures.

Lighting protection design is required for all new assets and modifications to existing assets unless specified otherwise in the Project Documentation. The Contractor shall undertake a Risk Assessment (RA) to AS1768 and provide a Lightning Protection (LP) Design Report for the site. A RA is required for each production area on a large distributed site. Network sites can be covered by one common RA for the site.

For the purpose of the RA all sites and plant areas contained within shall be classified as industrial properties or premises in accordance with AS1768.

The RA and LP Design Report shall include all equipment on the site and extends to the perimeter inclusive of the site perimeter security fence.

The LP Design shall include drawings containing the following details:-

- Overhead earth wires and finials (air terminals) installation details and locations
- Down conductor installation details and locations
- LP test links installation details
- Earth grid bonds installation details
- Elevations and site plan view of the rolling sphere zones of protection

Overhead earth wires and finials are not to be proposed unless these are the only alternative to achieve acceptable level of risk. Finials and down conductors must be provided to roof of masonry buildings and structures in exposed areas and the rolling sphere method used to demonstrate coverage. An earth electrode with test links shall be provided in proximity to each down conductor. Steel structures are inherently self-protected and do not require additional finials and down conductors installed.

All structural steel work, hand rails, platforms, steel pipes, steel vessels etc. shall be equipotential bonded to the site earth grid throughout the site as per TMS1200 Electrical Installation Specification.

Dynaspheres and other LP methods, not recognised by AS1768 are not accepted.

All LV Switchboard, DB's and control panels with LV supply shall have surge arrestors on their incoming power supply regardless where located and surge arrestor status shall be monitored by a local PLC input and a surge arrestor general fault alarm configured to SCADA.

All above ground instruments (analogue, digital signals and power supply signals) in exposed areas shall have surge protection devices installed at the control panel. Instruments located underground or indoors or in sheltered areas (instrument and wiring not exposed) do not require surge protection on the PLC inputs. Sensitive analyser type instruments in exposed area shall have additional surge protection located at the instrument and connected to a purposely designed low impedance earth path.

All copper communications cabling routed exterior of building (above and below ground) shall be installed with surge protection devices with minimum 20 kA rating. All control system analogue input signals shall have surge protection installed within the marshalling panel with a current discharge capacity of 20 kA.

Pipelines with weld-neck flanges and screwed socket joints are regarded as electrically continuous. Piping does not require additional earthing connections, providing the pipe terminates to an item of equipment or machinery that is equipotential bonded to the site earth system.

Insulating spool pieces in pipelines or joints with slip-on flanges may be electrically bridged with transient suppressors.

Refer TMS1595 Cathodic Protection Pipelines and Structures Technical Specification for design of surge protection on cathodic protection systems.

4.17 ELECTRICAL EQUIPMENT

4.17.1 HV Switchboards and Ring Main Units

Refer TMS1186 HV Switchboard Technical Specification.

4.17.2 LV Switchboards

Refer TMS60 LV Switchboard Technical Specification which applies to all LV switchboards including DB's, MCC and also includes LCP's.

All design modifications that include additions or enhancements to the enclosure shall ensure the installation works when complete complies with the current version of AS3000 Wiring Rules and the relevant regulations and standards.

4.17.3 Variable Speed Drives and Soft Starters

VSD's can be wall-mounted when installed inside switchrooms. VSD's with minimum IP4x enclosure can be directly wall mounted where the arc flash incident energy at the VSD power terminals is less than or equal to 1.2 cal/cm^2. VSD's with incident energy exceeding 1.2 cal/cm^2 shall be installed in a dedicated control panel.

VSD's and soft starters shall only be installed inside switchboards that comply with TMS60 LV Switchboards with specific consideration to the validity of the Switchboard Design Verification Report.

VSD's and soft starters are only accepted to be installed in outdoor located switchboards at Network assets as per QUU standard design drawings.

Refer TMS1406 LV Variable Speed Drive Technical Specification for detail design requirements of VSD's.

Soft starters in STP's are generally only required on larger motors typically exceeding 30kW and if required shall be wall or floor mounted in a purpose built enclosure located in a switchroom. The control panel design constraints shall be similar for a VSD and refer to TMS1406 LV VSD Technical Specification.

4.17.4 Transformers

The design requirements for oil insulated transformers are included in TMS1185 Distribution Power Transformer (Less than 5MVA) – Technical Specification. The additional design requirements are as follows:-

- Transformer compounds shall have security fence with lockable access gates, and the transformers mounted on a concrete plinth within a bund area. The bund capacity shall be sized to hold 110% of the total tank volume and sized to capture any leaks from the tank in accordance with AS1940.
- Transformer compound clearances shall be in accordance with AS2067.
- Transformer enclosures shall have a sump pit to facilitate removal of oil and/or water from the transformer bay.
- A 2-hour fire rated wall shall be provided between adjacent transformers.
- Where transformers are installed adjacent to a non-fire rated building, a 2-hour fire rated wall shall separate the building and the transformer compound.
- The transformer compounds shall be filled with aggregate and the aggregate shall be retained by concrete retaining walls. The depth of aggregate shall be a minimum of 150 mm.

- Transformers may be enclosed "kiosk" padmount type, totally enclosed with an integral bund. A fence is not required for this type of installation.
- Noise walls shall be provided where required to meet the site noise emission constraints.

Where cost effective and practical to meet the project requirements dry type transformers are accepted and design requirements are included in TMS1625 Dry Type Distribution Transformer - Technical Specifications.

Special consideration for adequate ventilation is required where transformers are mounted in outdoor enclosures.

Pole mounted transformers are not accepted.

4.17.5 Motors

A general guideline for selection of motor ratings and voltage level is outlined in the following table:-

Voltages	Minimum Motor Rating	Maximum Motor Rating
230V 1ph	-	0.5kW
400 V 3ph	0.75kW	300kW
3.3kV 3ph	300kW	-
6.6kV 3ph	300kW	-

For motors of a given size range or for certain equipment furnished with speciality motors, the above voltage-motor size assignment may vary.

LV motors exceeding 300kW can be considered for particular projects. The Contractor shall provide a design report outlining the proposal to install LV motors in excess of 300kW and shall consider the alternative HV motor option. The report shall include sufficient detail to fully ascertain the relative benefits of an LV and a HV solution. A full life cycle cost analysis is required covering capital cost, maintenance costs, operating costs (energy), installation and cutover costs as part of the HV and LV options analysis. Following acceptance of the design report the detailed design shall progress with either the LV or HV motor solution.

Motor starting analysis shall be undertaken to determine the voltage drop when starting large motors as per TEM336 PSA Guidelines.

4.17.5.1 *HV Motors*

Refer TMS1404 HV Motor - Technical Specification

4.17.5.2 ***LV Motors***

Refer TMS1637 LV Motor - Technical Specification

4.17.6 Diesel Generators

Refer TMS1589 LV Diesel Generators – Technical Specification

Permanently installed generators shall consider the arc flash incident energy at the alternator terminals. The generator local HMI shall be located external of the arc flash boundary. Typically the generator components including the alternator and on-board switchgear are not contained within arc fault contained enclosures.

Refer TEM336 PSA Guidelines for additional requirements on arc flash hazard mitigation associated with generators.

4.17.7 Junction Boxes

For electrical equipment junction boxes refer TMS1200 Electrical Installation - Technical Specification.

For junction boxes associated with instrumentation refer to TMS1201 Instrumentation Installation - Technical Specification.

4.17.8 Uninterruptible Power Supplies

Refer TMS1187 AC Uninterruptible Power Supply – Technical Specification

The input power supplies shall be a solidly earthed three phase and neutral system, 400 V AC, 50 Hz or single phase and neutral, 230 V AC, 50 Hz fed from an essential supply bus. UPS's with rating exceeding 7.5kVA shall be three phase 400VAC input.

The UPS shall generally have operating output voltage level of 230VAC single phase.

A Battery Monitoring System shall be provided unless specified otherwise in the Project Documentation.

UPS systems shall include bypass circuitry to allow for maintenance/emergency activities.

A permanently installed label in close proximity to the UPS shall be installed that outlines the operating procedures for all modes of operation of the UPS and associated bypass switch.

At STP sites all new and modifications required to existing instrumentation, protection, control systems and communications equipment shall be 24VDC and the power supply fed from an upstream 230VAC or 400VAC UPS. All safety related equipment

excluding emergency lighting shall be fed from the UPS. This requirement extends to new switchboard control circuits. Process control and monitoring equipment operating at LV shall not be fed from general power and lighting DB's.

Typically each switchroom requires a dedicated UPS suitably rated to power all equipment mentioned above associated with the switchroom. Small dedicated UPS's for specific equipment and distributed throughout the site are not preferred and will only be considered where the localised load is small and it is not economically feasible or practical to install an LV supply fed from a larger centralised UPS in the nearest switchroom.

4.17.9 DC Power Supply

4.17.9.1 HV Switchrooms

The design requirements for the DC Power Supply for HV installation are specified in TMS1221 DC Power Supply Systems - Technical Specification.

The input AC power supply shall be fed from an Essential Services supply at 400VAC, three-phase, 4-wire, 50 Hz, for loads in excess of 7.5kVA and 230VAC 50Hz single phase for smaller size loads. The DC Power systems shall have an output voltage of 24VDC unless specified otherwise in the Project Documentation.

All the equipment associated with the HV installation shall be fed from the DC Power Supply with integrated 24VDC DB. This included PLC, HMI, IED, communications equipment, control and monitoring circuits associated with the HV switchroom.

4.17.9.2 Miscellaneous

DC power supplies for new installations (excluding HV switchrooms) shall be 230VAC/24VDC units selected from TMS62 Preferred Equipment List – Electrical and Instrumentation and fed from an UPS. Multiple power supplies shall be connected in parallel to offer N+1 redundancy. A redundancy module shall be installed on the output and located in the same enclosure as the power supplies.

For large installations the power supplies shall be installed in a dedicated enclosure (not contained within an LV switchboard or MCC) and fed from an upstream UPS with provision to isolate individual power supplies both input and outputs so a faulty unit can be removed from service without interrupting the operation of the other power supply units. Smaller DC power supply systems can be installed in the PLC control panel where space permits.

DC Power Supply design for Network assets shall be provided to QUU standard drawings. Network sites have a single battery back-up rather than a dedicated UPS. Refer to TMS60 LV Switchboards Technical Specifications for further design criteria.

The status of all DC power supplies shall be monitored by the local control system.

4.17.10 Batteries

Due considerations shall be given to size, number, location, ventilation, and temperature rise in the battery bank design. Lithium Ion or VRLA battery cell technologies only are accepted by QUU. Battery banks shall consist of multiple parallel strings of cells. Battery cells should be designed to offer 2 x 50% battery capacity unless specified otherwise in the Project Documentation.

Refer TMS1221 DC Power Supply Systems - Technical Specification for batteries required in HV switchrooms.

Refer TMS1185 AC Uninterruptible Power Supply – Technical Specification for UPS battery requirements.

4.17.11 Packaged Plant Equipment

Equipment packages may include, but not limited to the following skid mounted equipment:-

- Blower skids
- Centrifuge skids
- Multi Pump Manifold Pump Skids
- Waste Gas Burners(enclosed flares)
- Air Compressors
- Instrument Air Driers

Low voltage motor starters, instrumentation and proprietary control systems are generally supplied as part of the packaged equipment.

Refer to TMS1645 - Package Plant EI&C - Technical Specification for specific design requirements.

4.17.12 Socket Outlets

Circuits for socket outlets rated at 20A or less shall be protected by a separate circuit breaker with RCD at the point of supply. Outdoor socket outlets shall have IP66 rating as minimum. External socket outlets shall be installed in minimal quantities to avoid hazards associated with unauthorised hot live works.

RCD shall have 30mA setting for each individual circuit.

Unless otherwise specified, the following mounting heights shall apply.

- Socket outlets (Switchrooms) - floor level (200mm).

- Socket outlets (other) - 1000mm.
- Service outlets to water boilers etc. - 1300mm.
- Air conditioner and fixed high level equipment outlets 1800mm.

Three phase outlets shall be 4 pin for motors and 5 pin for connection of other speciality loads. The outlets shall be rated for maximum 63A and protected by a 30mA RCD installed upstream at point of supply. Three phase outlets shall have IP66 rating with integral cover facility.

Earth leakage protection shall be selectable up to 250mA for each individual welding outlet circuit.

4.17.13 Transportable Switchrooms

Refer TMS1188 Transportable Switchroom - Technical Specification. This specification shall be utilised for sea container switchroom enclosures with all departures nominated to QUU prior to contract award.

4.18 SWITCHROOM HVAC SYSTEMS

HVAC shall be installed in all new HV and LV switchrooms and where specified in Project Documentation for modifications to existing switchrooms. The HVAC system shall offer N+1 redundancy meaning if one HVAC unit is unavailable then the heat load of the switchroom under all operating conditions can be met by the other HVAC unit(s). HVAC units shall be inverter type and units in excess of 8kW rated electrical load shall have 3ph, 400VAC 50Hz supply.

On general power failure to the switchroom all the HVAC units can be shut down and shall restart automatically without operator intervention, when power is re-established to the building. The HVAC units are not considered an essential load and shall be fed from the general power and lighting switchboard in the switchroom.

On a confirmed fire the HVAC units must be shut down immediately. A confirmed fire is when the FIP and the VESDA both detect a fire and a voltage free contact shall be wired direct from FIP to the distribution board containing the HVAC unit power supply contactors.

Ventilation ducts between rooms (if any) shall be fitted with fire dampers controlled by the FIP.

The HVAC units shall be individually monitored by the control system. Voltage free contacts shall be provided for HVAC Running and separate input for HVAC General Fault. The signals shall be wired to the local PLC control panel for alarms to be provided at SCADA.

The HVAC units shall be provided with their own inbuilt temperature controllers. A battery powered portable remote controller for each unit shall be wall mounted near the switchroom personnel access door. Fixed hardwired wall mounted controller panel in the switchroom is also accepted.

The switchroom shall be provided with a wall mounted temperature sensor to provide an analogue 4-20mA temperature signal to the local PLC. The room temperature shall be displayed at SCADA and warning alarms produced if temperature exceeds 30°C in the switchroom.

The Contractor shall determine the maximum heat load on the building and the calculation and selection of HVAC units shall be approved by an RPEQ Mechanical Engineer. Engineering design software such as CAMEL or equivalent shall be utilised for the calculation.

The switchroom HVAC system shall be designed to maintain the switchroom at 24°C when external ambient temperature is between -5°C and 45°C and under maximum heat load conditions inside the switchroom i.e. all equipment operating maximum load rating simultaneously. Switchrooms are not permanently occupied by personnel. The heat load generated from personnel access can be ignored, unless the switchroom is provided with a permanently installed SCADA terminal. In this case the heat load from two persons must be considered in the calculation.

HVAC units shall be conformal coated where installed in switchrooms located on STP sites. HVAC units shall be procured from reputable supplies to meet design service life of minimum 15 years.

Conduits and cable supports from the building to condenser units shall be provided with a flexible gap to allow for differential movement of the building and condenser units. The condensers shall be mounted on rubber feet on a concrete pad or column mounted and shall be accessible from ground level with local isolator provided adjacent. The Contractor shall assess flood level when determining the final location of the condenser units. Refer to TMS1200 Electrical Installation Technical Specification for further information regarding the installation of HVAC units.

Refer TMS1188 Demountable Switchroom Technical Specification for HVAC requirements in demountable switchrooms. The HVAC design report and switchroom HVAC layout drawings must be accepted by QUU before commencing the demountable switchroom manufacture.

4.19 FIRE DETECTION SYSTEMS

A fire detection system shall be installed in all new HV and LV switchroom buildings and where specified in Project Documentation for modifications to existing switchrooms, buildings and plant process areas. The fire detection system shall be networkable and microprocessor based with a Fire Indication Panel (FIP) hardwired signals to the site PLC control system.

The fire detection system including VESDA, MCP's and smoke detectors shall be fed from the FIP. The FIP shall be fed from the Essential Services LV Distribution Board which shall have a UPS back-up supply.

Fire suppression systems are not required unless specified otherwise in the Project Documentation. Facilities shall be provided at the FIP for Emergency Warning System functions. An I/O interface card shall be provided in the FIP to connect to the site PLC control system.

A battery backup power supply housed within the FIP shall be provided for the fire detection system. The battery shall be rated to provide maximum demand of all connected equipment to the FIP such as smoke detectors, MCP's etc. A maximum demand calculation in accordance with TEM336 PSA Guidelines shall be provided to determine battery size required.

The FIP shall be constructed to AS1670, AS1603.4 and AS1428.1. It shall be capable of a minimum of 8 inputs, 8 outputs and a redundant path network module suitable for multi-mode fibre optic connection to the Master FIP and shall incorporate emergency warning facilities to AS2220. The existing site master FIP may require modification to allow communications to any new FIP's. The Contractor shall provide all dedicated fibre optic communication cables between FIP's and the site Master FIP.

The FIP shall monitor:

- Manual call points
- Smoke detectors
- Other input devices such as VESDA

The FIP shall have direct control over the switchroom building. The status displayed on the FIP local indicator such as warning alarms, faults etc shall be wired through volt-free contacts rated at 24VDC to the PLC Control System.

The site PLC control system shall monitor the following FIP signals as a minimum:-

- FIP Power On,
- FIP General Fault,
- FIP Battery Fail

- FIP Fire Alarm.
- VESDA General Fault
- VESDA Smoke Alarm
- Any MCP Activated
- Smoke Detector Activated

Two spare unused volt free fire alarm contacts in the FIP shall be provided for interfacing other signals to the site control system in future.

The switchroom shall be provided with at least two off smoke detectors, actual number and location shall be indicated on the Project Drawings. Status and alarms shall be configured to SCADA and at the local HMI in the switchroom.

The FIP shall be installed inside the switchroom building in a metal wall mounted enclosure complete with digital display and LED indicators and control pushbuttons. The enclosure shall be key lockable.

The condition for a confirmed fire in the switchroom is when any one of the following occur:-

- MCP is activated or
- VESDA system detects smoke and one smoke detector is activated

On confirmed fire detected in the switchroom the fire systems shall:

- Shutdown all HVAC units in the switchroom
- Activate a local strobe light mounted external above the switchroom access doors
- Activate a local siren
- Activate PAGA speakers through PLC/ SCADA interface

Refer TMS1188 Demountable switchroom – Technical Specification for fire detection systems in demountable switch rooms.

4.19.1 Manual Call Points

Where manual call points are specified they shall be located at each exit door to HV and LV Switchrooms and wired to the switchroom FIP. MCP's located internal to switchroom shall be to AS 1603.5, and surface mounted. All cable penetration to MCP's shall be bottom entry.

Refer TMS1188 Demountable switchroom – Technical Specification for fire detection systems in demountable switchrooms.

4.19.2 PAGA Speakers

PAGA speakers shall be provided in the switchroom and shall be wired individually for connection to the local PLC network. Wiring from the PAGA Speakers to the PLC shall be of minimum type WS51W in accordance with AS1670.4.

4.19.3 Very Early Smoke Detection Apparatus

The VESDA system shall consist of a highly sensitive laser based smoke detector complete with an aspirating fan and filter connected to a network of pipe and sampling points and detector displays. The VESDA shall only sample air within the switchroom and NOT within switchboards or other enclosures.

The system shall be modular in design and the detector shall be monitored by a display dedicated to a specific detector to show a visual representation of smoke levels detected by a particular detector.

The VESDA shall be of a type designed, manufactured and tested to comply with AS1603. The detector shall be provided with LED indicators.

Each detector shall provide the following features at a minimum:

- Independent high intensity alarm indicators for Pre-Alarm and Fire (Alert indicated by the Pre-Alarm LED flashing) corresponding to the alarm thresholds of the detector:
    - Fault indicator
    - OK indicator
- Isolate indicator
- Controls supporting the following features:
- Reset – Unlatches all latched alarm conditions
- Isolate – Isolate (inhibits Alarm and Fault relays and initiates the Fault relay)
        - The unit shall be equipped with configurable relays for signalling alarm and fault conditions. Initial settings for the alarm levels shall be determined by the requirements of the fire zone.
        - Default settings of the unit shall be:
- Alarm Level 1 (Alert) 0.08% Obs/m with a delay of 10 seconds
- Alarm Level 2 (Pre-Alarm) 0.14% Obs/m with a delay of 10 seconds
- Alarm Level 3 (Fire) 0.2% Obs/m with a delay of 10 seconds

The detector fault relay shall be connected to the addressable interface device located in the FIP in such a way that a detector fault would register a fault condition on the FIP. The fault relay shall also be connected to the appropriate control system.

The VESDA System shall be powered from regulated 24V DC supply from the FIP.

The response time for the least favourable sampling point in the system shall not exceed 90 seconds.

Refer TMS1188 Demountable switchroom – Technical Specification for VESDA requirements in demountable switchrooms.

4.19.4 Smoke Detectors

Smoke detectors shall comply with AS3786.

4.20 SOLAR PHOTOVOLTAIC SYSTEMS

4.20.1 General

The design of photo voltaic power system shall be undertaken to Australian Standards and by Clean Energy Council accredited Engineers. The Clean Energy Council has compiled a list of approved products - including solar PV modules (panels) and grid-connect inverters that meet the relevant standards. Contractors must use equipment on the Clean Energy Council list of approved products in order for QUU to qualify for government incentives for solar PV systems.

www.solaraccreditation.com.au/approvedproducts

The Contractor shall design and install the PV system in accordance with the Clean Energy Council's Installation Guidelines for Accredited Installers and Supervisors. The design deliverables shall be approved by an electrical RPEQ with the nominated accreditation. Where grid connection is required the Contractor is responsible for all applications, negotiations with Energex and other costs required to connect the PV system to the grid.

4.20.2 Inverters

Inverters shall be 3 phase, 400VAC, 50Hz output and transformerless type and in compliance with AS4777. Inverters shall be sourced from OEM with registered supplier outlets in Australia. The warranty offered for the inverter shall be unconditional and minimum 10 years for industrial use. The inverter enclosure must be minimum IP4X and be wall mounted inside a building not exposed to the weather or direct sun light. Inverter enclosures with IP rating less than IP4X shall be installed in a purpose built forced ventilated metal enclosures. Inverters shall not be installed in outdoor exposed locations.

Inverters shall accept multiple strings of PV panels. A minimum 2 off MPPT channels rated up to 1000V is required per inverter. The total harmonic voltage distortion at the inverter LV terminals shall not exceed 2%.

A full load current DC isolator and AC isolator shall be provided adjacent to the inverter or located on the front door of the inverter panel. The inverter shall connect directly to the site LV main switchboard through a 400VAC 3 pole CB.

Inverters shall be provided with CAT 6 communications port and support Modbus /TCP and shall be interfaced to the site control system for diagnostics and status monitoring to SCADA.

Hybrid inverters to charge batteries are not required, however the PV system shall be expandable to include battery connection in future as well as additional inverters to increase generation capacity.

4.20.3 Photovoltaic Panels

PV panels shall be mono crystalline type and comply with AS5033 and IEC62941. Panels shall have minimum unconditional 12 year warranty in industrial installation. Panels with unconditional warranties exceeding 12 years are preferred.

PV panels shall be high power density type available from Tier 1 manufacturers and sourced from OEM with registered outlets in Australia. Panels shall comply with the following minimum specifications:-

- 20 year design life
- Electrical connections minimum IP65
- Power output degradation maximum 0.25% per year
- Power temperature co-efficient < -0.4%/°C
- Power tolerance maximum +5%/-0%
- Voltage temperature co-efficient <180mV/°C
- Current temperature co-efficient <4mA/°C
- Panel efficiency > 20%
- Salt Spray test compliance IEC61701 (maximum severity)
- Impact resistance minimum 25mm diameter hail at 23m/sec
- Wind rating minimum 2400Pa, 240kgm2 front and back

The design shall include PV panels connected in multiple strings and each string shall have a DC isolator located adjacent to the panel strings.

Panels shall be mounted on fixed permanently installed galvanised steel structures. Other mounting methods can be considered and must be accepted and fully costed before Contract award. Small kW systems (not exceeding 10kW) are permitted on building roof tops where roof space permits. Permanent access to the roof top must be provided to the relevant design standards and included as part of the design.

Panel arrays shall be arranged for optimum solar exposure and design must avoid direct reflection onto residential dwellings and road ways. The area under and around the panels shall be a low maintenance surface treatment and accessible to control weeds. Equipment shall not be susceptible to mechanical damage from machinery and power tools required to control vegetation under the structures.

4.21 PROTECTION PHILOSOPHY

The Contractor shall provide a Protection Philosophy Report for the power distribution network. The document must be specific to the site and outline how any proposed network changes will integrate with the existing protection schemes. An existing asset may not necessarily have a Protection Philosophy Report available and the Contractor shall discover and document the existing as installed protection schemes as required.

The topology of the HV and LV network shall be described in detail and the protection schemes discussed for each equipment type. All operating scenarios including emergency generation shall be disclosed and outline what operational limits are proposed. The Protection Philosophy is a key document that shall be submitted early in the design phase of the project.

Refer to QUU for typical Protection Philosophy Reports for indicative minimum content and detail required.

Network sites are typically LV installations and do not require a Protection Philosophy Report and in this case the Protection Co-ordination report is adequate documentation.

4.21.1 HV Protection Schemes

4.21.1.1 HV Incomers and Feeders

For protection schemes applicable to HV switchboards refer TMS1186 HV Switchboard Technical Specification and following table provides further clarity of the minimum requirements:-

Equipment	Metal Clad Switchboard	RMU
Single Incomer	3 phase OC and EF	Fuse only
Two Incomers and Bus coupler	3 phase OC and EF plus directional OC. Auto transfer scheme and bus differential	N/A
Feeder	3 phase OC and EF plus SEF(configure as alarm and trip) where CB installed	3 phase OC and EF plus SEF(configure as alarm and trip where CB installed
Transformer Feeder (less than 1MVA)	3 phase OC and EF plus SEF(configure as alarm and trip) where CB installed	3 phase OC and EF plus SEF(configure as alarm and trip) where CB installed
Transformer Feeder (greater than and equal 1MVA)	3 phase OC and EF plus SEF(configure as alarm and trip), REF (secondary side)	3 phase OC and EF plus SEF(configure as alarm and trip), REF (secondary side)

Equipment	Metal Clad Switchboard	RMU
Transformer Feeder (greater than 2.5 MVA)	3 phase OC, EF plus differential protection and thermal protection	3 phase OC, EF plus differential protection and thermal protection
TCS	Required	Required
CBF	Required and utilise IEC 61850	Required and utilise IEC 61850 where CB installed
Blocking Schemes	Required and utilise IEC 61850	Required and utilise IEC 61850 where CB installed

4.21.1.2 Transformers

For protection schemes applicable to distribution transformers refer to TMS1185 Distribution Transformers(less than 5MVA) – Technical Specification and TMS1625 Dry Type Distribution Transformers – Technical Specification.

HV Feeder CB's shall be installed where the transformer nameplate rating exceed 500kVA.

4.21.1.3 HV Motors

For protection schemes applicable to HV motors refer TMS1404 HV Motor Technical Specification. DOL HV motor starters are not accepted unless specified otherwise in the Project Documentation.

4.21.1.4 Circuit Breaker Fail

To enhance the HV protection scheme, the CBF protection in the outgoing feeder IED's shall be used to back trip the incomer CB. The scheme design shall back trip all of the CB's connected to a common section of Bus-bar in the event of one breaker failing. When CBF is triggered by protection functions, blocking signals on the IED shall be removed. This scheme requires status of bus –ties to operate effectively to isolate bus sections.

4.21.1.5 Trip Circuit Supervision

A standalone trip circuit supervision relay and hardwired circuit can be accepted rather than the TCS configured in the IED. Under healthy conditions a constant low level supervision current is maintained regardless if CB is open or closed to avoid nuisance tripping.

4.21.1.6 CB Lock-out

CB lockout shall be provided to main incomers and feeder CB's.

4.21.1.7 Thermal Overload

Thermal overload protection utilises RMS load current to model the heating of the connected loads and shall trip both incomer and feeder CB's as required. Thermal overload protection of HV cables is required.

4.21.1.8 Negative Sequence

Provide trip signal to site main incomers.

4.21.1.9 Bus Zone Protection

Bus Zone Protection shall be provided for all HV switchboards and shall utilise IEC 61850 goose messaging exchanged between incomer and feeder IED's. Bus bar blocking shall be implemented for faults external of the bus zone.

4.21.1.10 Under Voltage and Over Voltage

Alarm only shall be provided for main incomers to local HMI and SCADA.

4.21.1.11 Transformer Feeder 2nd Harmonic Blocking

Second harmonic blocking shall be provided where required to distinguish between fault current and transformer inrush current due to the different natures of both current types. An inrush current waveform is rich in harmonics (particularly the second), whereas an internal fault current consists only of the fundamental.

Second harmonic blocking shall be applied where required to the following overcurrent protection types:

- Phase Over Current
- Earth fault

The setting for 2nd Harmonic Blocking should not be too low, because the 2nd harmonic blocking may prevent tripping during some internal transformer faults. If the setting is too high, the blocking may not operate for low levels of inrush current which could result in undesired tripping of the over current element during the energisation period. In general, a setting of 15% to 20% is suitable.

4.21.1.12 HV Generators

HV generators are not preferred and where required the protection scheme shall be to the generator manufacturer's standard offering configured in the generator on-board control system. The generator protection schemes shall be co-ordinated with the site protection schemes and suitable for the site earth grid.

4.21.2 LV Protection Schemes

4.21.2.1 Motors

Refer TMS1637 LV Motors Technical Specification, TMS1406 LV VSD – Technical Specification and TMS60 LV Switchboard - Technical Specification.

4.21.2.2 LV Main Incomers and Feeders

Refer TMS60 LV Switchboard Technical Specification

4.21.2.3 LV Generators

For protection schemes required for LV Diesel Generators refer to TMS1589 Diesel Generator - Technical Specification.

Permanent installed generators shall be connected to the site LV switchboard through a 4 pole ATS in the switchboard. A 4 pole MTS shall be provided where provision is made for a mobile generator to be connected to the LV switchboard.

The MEN shall reside in the LV switchboard and a warning label shall be provided at the switchboard connection point to disconnect the MEN from onboard the mobile generator.

Refer TMS60 LV Switchboard Technical Specification for other requirements when connecting generators to LV switchboards.

For permanently installed generators the load shedding or pre-determined maximum demand control shall be provided where required to minimise the rating of emergency generators required. Unless specified otherwise the load shedding algorithm for non-essential loads shall be programmed in the site PLC control system. The control system shall be delivered in accordance with TMS1202 Control System Implementation - Technical Specification.

4.21.3 Metering

4.21.3.1 Check Metering

Check metering data for HV switchboards shall be accessed from the IED's and displayed at the local HMI and site SCADA.

Refer TMS1186 HV Switchboard Technical Specification for data to be accessed.

Check meters shall be provided on all main LV Switchboards in a metering section of the switchboard. Check meters shall be provided in other LV switchboards and DB's exceeding 250A rating, unless specified otherwise in the Project Documentation. The

meters shall be selected form TMS62 Preferred Electrical and Instrumentation List. The metering data shall be displayed and trended at the STP site SCADA.

4.21.3.2 **Revenue Metering**

Utility owned revenue meters and instrument transformers shall be located in a standalone panel in accordance with Energex standard design.

Revenue meters for new outdoor LV switchboards at Network Asset sites shall be integrated into the switchboard in accordance with the Utilities' requirements and QUU standard design drawings. Where the switchboard is installed indoors a standalone metering panel shall be installed on the external wall of the switchroom building that is readily accessible by the Utility.

Revenue metering sections of a new switchboard require provision of an upstream and downstream isolator that can be both pad locked in the "isolated/off" position.

4.22 COROSION PROTECTION

Refer to QUU technical specifications listed in section 1.3 for corrosion protection and paint systems accepted for EI&C equipment.

4.23 CATHODIC PROTECTION

For the design of cathodic protection systems refer to TMS1595 Cathodic Protection Pipelines and Structures - Technical Specification.

5 INSTRUMENTATION DESIGN

5.1 GENERAL

Instrumentation signal types shall comply with following table:-

Parameter	Signal Type
Operating Voltage	24VDC
Analogue I/O Signals	4-20mA
Digital I/O signals	24VDC volt free
Process Communication Signals	Modbus TCP DNP3 HART Ethernet/IP

Note 1**:** LV single phase supply to instruments, process control solenoids and motorised actuated valves shall only be proposed where the 24VDC supply option is not cost effective or practical due to cable length voltage drop or other constraints and must be accepted by QUU in writing. An RCD shall be provided at the point of supply to all equipment that requires an LV supply
Note 2: Profibus and Profinet are only accepted where minor modifications to an existing control system network are required and only where the protocols are already in service at the site.

5.2 INSTRUMENT OPERATING RANGE

Instruments shall be factory calibrated, unless specified otherwise in the Project Documentation. The operating range and set points shall be included in the project instrument schedule. Refer QUU for a typical instrument schedule template.

Refer to QUU for standard instrument data sheet templates to be completed by the Contractor. In the absence of a QUU instrument template the instruments shall be provided with the manufactures generic data sheet and information on the data sheet not relevant to the instrument supplied shall have strike through text or other method accepted by QUU.

For instrumentation installed at various Network Asset types refer to the asset type functional specification documents listed in section 1.3 of this document.

5.3 INSTALLATION AND INTERCONNECTIONS

The design and selection of instruments shall ensure compliance with TMS1201 Instrumentation Installation - Technical Specification. Typical instrument process connection or hook-up drawings shall be provided by the Contractor for all instruments to be supplied or modified under the project.

P&ID's shall be provided for all projects where new or modification to existing instrumentation is required. Unless specified otherwise in the Project documentation the Contractor shall produce As Built P&ID drawings for existing assets where QUU is unable to provide the P&ID drawings.

5.3.1 Tubing and Fittings

Polyethylene tubing and compression fittings may be utilised for instruments to general purpose electromechanical actuator valves and other equipment.

Tubing and fittings shall be in imperial sizes and SS316 Swagelok® compression fittings for instrument air supply to API 607 fire rated control valve installations and compressed air tubing up to the air dryer. The tubing shall be seamless cold drawn, annealed and pickled, ASTM A269 TP316/316L with a minimum molybdenum content of 2.6% (hardness maximum of 80 HRB), unless another material is required for corrosion or other reasons. Alternatives tubing and fitting materials shall require QUU's acceptance.

5.3.2 General Requirements

For non-specified instruments in the Project Documentation the instrumentation selection shall be based on TMS62 Preferred Equipment List Electrical and Instrumentation Technical Specification. Any deviations from this list must be accepted by QUU based on equipment with field proven ability for the application and manufacturer's technical support.

Smart HART analogue transmitters shall be used in preference to digital switches wherever possible. Process variable alarming or switching shall be achieved via software alarms and switches configured in the local PLC.

Instrumentation in safety applications shall be provided with dedicated instrumentation and process tapping points that are separate from instrumentation and tapping points in normal control services.

Monitoring and recording of data of all process variables shall be performed by the site PLC control system.

Field transmitters shall be provided with integral digital indication except where specifically noted otherwise in the Project Documentation.

Loop powered local indicators that are required to be mounted externally to the transmitters shall be series connected local to the transmitter and not reside in cable junction box or local control panels.

Local PLC based control systems shall be utilised. Local field controllers shall only be used where accepted by QUU.

The materials of construction shall be suitable for the process conditions. Where there is a conflict between suitable materials of construction and this document, the suitable material shall take precedence, unless otherwise approved by QUU.

DC relays shall be fitted with free-wheeling diodes. Solenoid coils shall also be fitted with suppression protecting diodes, located within the local control panel.

Instruments shall be installed to enable calibration and testing without shutting down the process.

Instruments shall be lagged, or heat traced and lagged, where the process liquid would otherwise condense, solidify or be otherwise adversely affected by low or high ambient temperatures.

The methods to be used for density measurement shall be accepted by QUU and shall have a track record of reliability and repeatable measurements in similar service conditions in the water industry.

All analogue field instrumentation shall be individually fused at the point of supply by a suitably rated CB.

5.3.3 Flow

5.3.3.1 Vortex Meters- Volumetric Flow

Particular attention shall be paid to the minimum flow of a vortex installation to determine suitability for application. Where vortex flow-meters are used, the Reynolds number at minimum flow shall not be less than 20 000.

5.3.3.2 Differential Pressure - Volumetric Flow

Flow orifice plates and orifice plate flow meter installations shall comply with AS 2360. The material for orifice plates should be compatible with the fluid handled. The preferred material is type 316 SS.

For liquids with entrained solids, eccentric orifice plates may be used subject to the acceptance of QUU. Alternate design (multi-hole) orifice plates which may reduce the straight run piping requirements may be used subject to the acceptance of QUU. No drain or weep holes shall be made in any flow orifice plate. Square root extraction shall

be performed in the transmitter. Use of straightening vanes shall be subject to the acceptance of QUU.

The flow rates and choice of differential pressure transmitters shall be as follows:

- Normal flow rate shall be between 70% and 80% of the full scale flow provided that the anticipated minimum and maximum flow rates shall be between 33% and 95% of the full scale flow and the accuracy of the transmitter is at least 0.2% of the calibrated span.
- Where the required range is required to be between 33% and 95%, a single transmitter may be used.
- Where the required range is exceeds 33% and 95%, dual transmitters may be required and shall be submitted for approval.
- Where a differential pressure transmitter is used as a flow input to safety system, the transmitter range shall be such that the trip point is at least 33% of the full scale calibrated span.
- Orifice plate Beta ratios (orifice diameter/pipe inside diameter) shall be limited to values between 0.3 and 0.7.
- The preferred DP cell range is 25 kPa. Common alternatives are 10 kPa & 50 kPa and shall be subject to acceptance by the QUU correspondent.
- Orifice size, flange size, flange rating and instrument number shall be stamped on the upstream side of each orifice plate and shall be visible when the orifice plate is installed.

Orifice plate flow meter flanges shall have the following requirements:

- Flanges shall be in accordance with ASME B16.36.
- Flanges shall be weld neck type.
- Pressure taps shall be equipped with round head or stock plugs.
- Flange rating, facing and finish shall be as per the piping specification, or ASME Class 300 minimum, whatever is greater.
- Flange tapping arrangement shall be utilised for all orifice plate installations.

Differential pressure (DP) transmitters shall be remote mounted to minimise or eliminate vibration issues and lengths of impulse piping should be kept to a minimum.

The following guidelines shall be used to determine limitations for direct mounting of transmitters:

- DP transmitters to be direct mounted in lagged service up to process temperature of 250°C.
- DP transmitters installed on process temperatures above 250°C shall require remote seals of fill fluids suitable for such temperatures.
- DP transmitters to be direct mounted in flushed services for process temperatures of flush fluid within the Vendor supplied temperature limits for the

transmitter fill fluid (no dead legs exist for these installations and therefore no cooling).

- For installations in vertical pipelines the direction of flow shall be downwards for wet gas or saturated steam and upwards for liquids.
- Upstream straight length requirements shall be in accordance with AS 2360.
- DP transmitters in gas service shall be mounted above the flow element.
- DP transmitters in liquid service shall be mounted below the flow element.
- DP transmitters for use in flow applications shall have a five-valve manifold

5.3.3.3 *Magnetic Flow Meters*

Magnetic flow meters may be used in water and sewerage services. Magnetic flow meter excitation shall not exceed 24 VDC. The flow transmitter shall be mounted remotely in a suitable electrical enclosure and not integral to the meter body. An earthing ring with protecting edge shall be supplied and installed as per the flow meter manufacturer's recommendations. The electrodes shall be fixed type. The electrode material of construction shall be 316 SS, unless other material is required for corrosion resistance.

5.3.3.4 *Other Flow Meters*

Ultrasonic flow meters are the preferred measurement technique for flow measurement. Alternatives to ultrasonic flow meters shall be subject to the acceptance of QUU.

Averaging pitot tubes or thermal dispersion meters may be used in particular applications is subject to QUU acceptance. Installation of averaging pitot tubes shall be such that they are removable on line, unless indicated otherwise.

In-line variable area flow meters shall only be used on non-critical processes and these shall have 316 SS bodies with magnetic followers (unless other material is required for corrosion resistance). The use of glass tube type shall be subject to the acceptance of QUU. In-line variable area flow meters shall be installed in the vertical position.

Positive displacement flow-meters may be used for local flow indication/totalising in non-critical process lines.

5.3.3.5 *Mass Flow*

Coriolis type mass flow-meters are preferred for liquid mass flow applications. Straight tube-type Coriolis mass flow-meters are preferred over bent tube type.

5.3.4 Level

Where more than one level transmitter is required on a vessel, both shall be calibrated to the same operating span and level wherever possible. Where level gauges (magnetic or

glass) are installed alongside other level instrumentation the level gauge span shall match or exceed that of the vessel operating range. Where vessels have both level instruments in control and shutdown applications, different types of level transmitters shall be installed to reduce common mode failures.

For continuous level measurement, the following level transmitter types are the preferred choice:

- Magnetic follower style gauges with magneto-restrictive level transmitters for use in shutdown applications
- Hydrostatic Pressure
- Ultrasonic
- Capacitance
- Conductive liquid
- Guided wave radar level transmitters

Use of capillary filled DP transmitters with diaphragm seals may be considered subject to the acceptance of QUU. The lower connection point to a vessel shall not be taken from the bottom of the vessel to minimise fouling of tappings and ensure full range of measurement. Where bottom of vessel nozzle connections cannot be avoided, an up-stand in the vessel should be installed.

All level instruments shall be located such that they are visible and accessible for calibration, maintenance, or repair from grade or from a permanent platform.

All continuous level measurement instruments shall be provided with a means of in-situ range checking and testing.

On liquid/liquid interface service the vessel top instrument connection shall be submerged in the lower density fluid under all normal operating conditions. Level in vessels and equipment shall be displayed in terms of 0-100% working range unless specified otherwise by QUU. Operating range must be less than the working range capacity of the vessel.

Any special applications for a level switch (e.g. sump pump auto-start/stop) shall be accepted by QUU.

5.3.4.1 ***Guided Wave Radar***

Radar level measurement shall only be considered where the relative dielectric constant of the measured medium is suitable for this technology and other level measurements are considered not suitable for the application. Radar transmitters shall be installed in a manner that allows the instrument removal on line without impact on the process.

Installation of radar element shall meet manufacturer's criteria for clearance from sidewalls and internal obstructions.

5.3.4.2 ***Level Bridles***

Level bridles shall be utilised to minimise the connections on a vessel and to facilitate instrument testing. Sufficient block, vent, and drain valves shall be installed to permit in-place testing of instruments without the need to shut down the process.

Where several level instruments are required on a vessel, a separate bridle shall be used by each level instrument.

Bridle process interfaces shall be via DN50 flanges having a minimum rating of ASME class 300. Level bridle material of construction shall be 316 SS unless another material is required for corrosion resistance. Bridles shall be equipped with DN20 (minimum) vent and drain valves.

No bridle may connect across more than two adjacent phases on a three-phase vessel. In this event, a third balancing connection is required to accommodate the middle phase. Careful consideration must be given to the placement of the taps in relation to the normal location and range of the interface. In some cases, additional taps may be required to ensure continuous and correct measurement of the interface No vertical dog-legs shall be permitted in making level connections to bridles.

Bridles shall not be used under the following circumstances:

- In service at low temperature (<0 °C)
- In viscous service and in applications where materials being handled contain high concentrations of solids.

Level bridles and gauges shall be supplied with vent and drain valves.

5.3.4.3 ***Differential Pressure (DP) Level***

Response times and temperature effects shall be calculated (as % of span) for each remote seal application by the instrument supplier, over the range of process and ambient temperatures for the application. In particular, the effects on accuracy shall be reviewed for the case when the top seal temperature increases suddenly as the hot process liquid rises. Where the effects on accuracy are unacceptable alternative measurement techniques shall be provided.

5.3.4.4 ***Level Gauge Glasses***

Excess flow type isolation cocks shall be fitted as standard Reflex type gauges are only suitable for clean liquid services. Transparent sight glasses shall be used for other services. No vertical dog-legs shall be allowed in making level connections to gauge glasses.

Gauge glass shall be of such quality that it shall break with an interlocking crystalline fracture without loose, flying particles (normally referred to as tempered glass).

Gauge glasses shall be equipped with DN20 vent and drain valves. Drain valves shall be piped into the facility drain system.

5.3.4.5 ***Nuclear Level***

Nuclear type level measurement shall be used only when other methods cannot provide the required accuracy or reliability. The use of this type of measurement requires QUU's acceptance..

Compliance with the statutory and site requirements for handling radioactive devices shall be ensured at all times. Al lspecific design documentation and regulatory approvals shall be provided by the Contractor. The operations and maintenance requirements of the instrument must be accepted by QUU.

5.3.5 Pressure

5.3.5.1 ***General***

Pressure elements shall be specified such that the steady normal operating pressure does not exceed 75% of the maximum range.

Pressure elements shall be such that the process pressure does not exceed the maximum rating of the element. If the process pressure can exceed the instrument rating pressure then an adequate overpressure protection technique shall be provided. For each application, QUU shall accept the technique proposed to be implemented.

Pressure sensor material of construction shall be 316 SS unless another material is required for corrosion resistance. Pressure instrument process connections shall be ½" BSP.

In corrosive services where a direct mounted pressure element is not appropriate, a diaphragm seal shall be used. Where the pressure element shall be subjected to pulsating pressures (e.g. inlets and outlets) the following steps are to be taken:

- Element shall be specified such that normal operating pressure does not exceed 60% of maximum range.
- A pulsation damper shall be used. Dampers shall be of the non-adjustable type.

Unless specified otherwise in the Project Documentation a method to depressurise the process line or vessel to gain access to disconnect the instrument shall be provided.

5.3.5.2 *Pressure Gauges*

Pressure gauges shall comply with AS1349 and have the following features:

- ½ ” BSP bottom entry
- 316 SS movement
- Oil filled housing
- 100 (or 115) mm diameter dial
- Weather proof 316 SS (IP65 rating or better)
- Solid front
- Shatter proof glass
- Blow out back (or pressure relief vent for the cases)
- White dial with black lettering and black pointer
- Isolation valve

Pressure gauge measuring elements shall be the C-type or helical Bourdon type. The measuring element shall be 316 SS, unless process fluid requires the use of other materials.

Pressure gauges shall be selected so that the normal operating pressure is 50-70% of the full range of the gauge. Pressure gauges shall be able to withstand over-ranging to a pressure of 1.3 times the maximum scale reading without a permanent set that affects gauge calibration. In moderate vibration service (e.g. centrifugal pump suction), the gauges are to be liquid filled with glycerine or equivalent.

5.3.6 Temperature

All temperature instruments (dial thermometers, thermocouples and RTDs) shall be installed in flanged thermowells. Exceptions (e.g. skin temperatures) can be proposed for QUU review. Temperature instruments shall be ranged to include start-up and abnormal operating conditions unless otherwise specified by QUU.

5.3.6.1 *Dial Thermometers*

Field temperature indicators (dial thermometers) shall be of the bimetallic type, with a 125 mm dial size unless otherwise specified. Dial thermometers shall have adjustable every-angle heads. The element diameter is nominally 6mm with a ½” BSP connection.

In applications where bi-metallic thermometers are not suitable, filled systems may be used. The preferred materials for filled systems are 316 SS wetted parts with gas fill. All such applications are to be accepted by QUU.

Where required for readability or protection from vibration, indicators shall utilise a fully compensated filled system with a 316 SS armoured capillary tube and with a remote reading dial.

Mercury thermometers shall not be used. Where possible, dial thermometers shall comply with the manufacturer's standard ranges.

5.3.7 Temperature Elements and Transmitters

Dual sensor 3-wire Pt100 RTDs are the preferred option. 4-wire RTDs may be used where required. The use of 2-wire RTDs requires acceptance by QUU. Where RTDs are not suitable, i.e. due to required measuring range, Type K thermocouples can be used.

Where process temperatures allow, elements shall be direct connected to the temperature transmitter. Where remote indication is required a loop powered indicator shall be installed.

RTD's shall have 6mm O>D316 SS sheaths. Sensors shall feature spring loaded heads in their assemblies. Thermocouples shall be mineral insulated metal sheathed (MIMS). These thermocouples shall be 6 mm O.D with insulated junctions and 316 SS sheathed. Thermocouple terminal heads shall be spring loaded.

When Vendor packages include the supply of tube skin thermocouples (e.g. fired heaters) the thermocouples shall be installed with thermocouple heads to allow remote mounting of temperature transmitters. Where tube skin thermocouples during plant shutdown.

Use of high temperature rated cable shall be considered if thermocouple extension and RTD cables are run close to hot surfaces.

5.4 ANALYSERS

The design and selection of analysers is viewed as warranting special consideration. All proposed analysers, including sampling handling systems must be accepted by QUU. Unless the actual analyser model number is currently proven on QUU sites, no analyser or sampling handling and recovery system shall be introduced to a QUU site without it first complying with a guaranteed Performance Test; in agreement with QUU and the equipment Vendor. The Performance Test shall be carried out on site by the analyser supplier, or their nominated agents, and all the costs shall be included in the Contract for the analyser supply.

If the initial Performance Test fails, all modifications and subsequent Performance Test shall be undertaken by the analyser Supplier at no additional cost to QUU. Lab sample points shall be provided on all analysers. Auto changeover manifolds to be provided on carrier gases. Low carrier gas pressure shall be alarmed to SCADA. Low sample flows shall also be alarmed to the SCADA.

In general, analyser outputs shall be 2 wire 4-20 mA loops. Where an analyser reports multiple analyses the use of a communication link shall be provided. Refer TMS1202 Control System Implementation – Technical Specification for acceptable

communication protocols. Common hardware alarms for each analyser shall be provided and alarmed to the site SCADA.

Liquid samples shall be returned to process. Only where accepted by QUU shall bio-gas be vented to site flares or the atmosphere.

Analysers shall be mounted as close as practical to the sample point in a weatherproof naturally vented shelter or prefabricated enclosure subject to acceptance by QUU. Local flow, pressure and temperature indications shall be provided on analyser sample handling systems. Analysers shall have power isolators mounted adjacent to each analyser in the field.

The analyser shall have a local shutdown and start-up facility, allowing the operator to take the analyser out of service during unit upsets etc.

Where product sampling is required the sampling shall be continuous and independent of the main process.

5.5 INSTRUMENTATION AND CONTROL CABLES

5.5.1 General

Refer TMS1201 Instrumentation Installation - Technical Specification

High Frequency pulse signals shall be transmitted via a dedicated cable wired direct from the field device to the end device e.g. flow computer. Intermediate cable breaks, i.e. wiring via junction boxes, shall be avoided to maintain signal integrity.

5.5.2 Process Control Network Cabling

Refer TMS1202 Control System Implementation - Technical Specification.

Fibre Optic (FO) cables shall be multi-mode fusion splice terminated with Straight Tip (ST) connector break out boxes by specialist contractors.

Dedicated FO cables shall be provided for fire system communications. Signals for the fire detection system shall not be run in the same cables used for the process control network and other site communications.

5.5.3 Junction Boxes

Refer to TMS1201 Instrumentation Installation Technical Specification and TMS1203 General Requirements for Hazardous Area Installation – Technical Specification.

6 CONTROL SYSTEM DESIGN

This section is intended to complement information contained in TMS1202 Control System Implementation – Technical Specification. The information provides further clarity for the control system design associated with particular electrical and instrumentation equipment types.

6.1 CONTROL PANELS

Control Panels shall be designed to comply with TMS1222 Control Panel Technical Specification. All new standalone control panel enclosures shall have minimum dimensions 1800mm(H) x 900mm(W) x 450mm(D) and floor mounted on a plinth unless specified in the Project Documentation.

The PLC control panel shall not be integrated into the same enclosure as the LV switchboard at STP sites. Control panels associated with HV and LV Switchboards at STP sites shall contain a 15" touch screen terminal for remote control and monitoring of the switchgear items. The HMI shall be selected from TMS62 Preferred Equipment List Electrical and Instrument unless specified otherwise in the Project Documentation.

6.2 SWITCHBOARDS

The control system for new LV switchboards shall be designed to comply with TMS60 LV Switchboard Technical Specification.

The reference to LV switchboards applies to MCC's and vice versa throughout all Project Documentation.

6.2.1 LV Switchboards for STP's

Motor Protection Units (MPUs) shall be installed in each 3 phase DOL motor starter for new switchboards to be installed at STP sites. Refer TMS62 Preferred Equipment List – Technical Specification for MPU model numbers preferred. The site PLC control system shall communicate with the motor starters MPU's over a standard industrial network protocol accepted by QUU.

Remote I/O modules shall be provided in the switchboard for I/O signals not related to DOL motor starters and these would normally be located in a separate compartment of the switchboard.

MPU's shall communicate over a copper cable bus or star network topology to the local PLC control system. All motor starter diagnostics including control and status is provided over the network to the PLC and signals displayed at the local HMI and site SCADA. The design intent is to minimise control wiring between the switchboard and the PLC panel and to streamline FAT of the control system.

All motor process control functions shall reside in the PLC processor. No control logic shall reside in the MPUs or other programmable devices. Exceptions to this rule would be considered for Packaged Plant equipment supplied with proprietary control systems.

6.2.2 LV Switchboards for Network Assets

The control system for new LV switchboards for Network Assets shall be designed as per QUU standard design drawings. The standard designs are based on conventional I/O control wiring between motor starters and the PLC or RTU control system and suitable for Arc Flash Category 0 switchboards.

For new switchboards exceeding Arc Flash Category 0 PPE, the PLC, RTU and other control system components shall be in a separate standalone Control Panel. The control panel shall be manufactured to TMS1222 Control Panel Technical Specification.

6.2.3 HV Switchboards

HV switchboard remote control and status monitoring by the site control system shall be implemented unless specified otherwise in the Project Documentation.

This includes the following:-

- Monitoring and trending of voltage, current, frequency, power, power factor etc. of all incomers and feeders at local HMI and SCADA. Trends only provided at SCADA terminals.
- Monitoring of the status of all devices including CB's, LBS's, and ESW's, IED's, surge diverters etc at local HMI and SCADA
- Remote Control (Open and Close) of CB's and LBS's at the local HMI only. The local HMI shall not have control capability of HV equipment located in other plant areas

6.3 DOL MOTOR STARTERS

For outdoor switchboards the local control and monitoring functions shall be provided for DOL individual motors using start/stop pushbuttons on the escutcheon of the motor starter functional units unless advised otherwise in the Project Documentation.

For indoor switchboards located at STP's a local HMI terminal is required for remote control and monitoring of all components installed in the LV switchboard including motor starters. The HMI shall be mounted on the PLC control panel located within the same switchroom as the switchboard. Mounting the local HMI terminal on the front door of an arc fault contained switchboard is NOT accepted. The control and monitoring features of the local HMI shall be replicated at SCADA.

Auto control of motors is by the site control system sequence logic programmed in the PLC. The Auto/Manual and Remote/Local mode selections shall be performed at the local HMI and at SCADA.

Summary of motor control features as follows:

Control Mode	Control Facilities
Auto	Process control from PLC sequence logic
Remote Manual	Control using motor START/STOP pushbuttons at the local HMI or Motor START/STOP pushbuttons at motor starter escutcheon or Motor START/STOP pushbuttons at SCADA
Local Manual	Control using motor START/STOP pushbuttons at the LCP

When selected in Auto mode all START/STOP pushbuttons for manual control are disabled.

Emergency stop pushbuttons and other safety function devices shall be hardwired to the motor starter and monitored by the local control system for deploy of alarms at the local HMI and SCADA. Refer TMS1651 Machine Safety Implementation – Technical Specifications for implementation of emergency stop circuits.

Refer TMS60 LV Switchboard Technical Specification for further design requirements related to control and monitoring of motor starters.

6.4 VSD AND SOFT STARTERS

VSD and soft starters for motors shall have facility to be controlled similar for DOL motors. The manual speed control for VSD's shall be provided at the local HMI or at the VSD starter panel using a potentiometer. All process control functions shall reside in the PLC processor. No control logic shall reside in the VSD or soft starter unless otherwise accepted by QUU.

VSD's supplied with Packaged Plant equipment can be located on the skid with the mechanical equipment and provided with a UCP. It is preferable to have VSD's located within air conditioned switchrooms.

Emergency stop pushbuttons and other safety function devices shall be hardwired to the VSD and soft starter and monitored by the local control system for deploy of alarms at the local HMI and SCADA. Refer TMS1651 Machine Safety Implementation – Technical Specifications for implementing emergency stop circuits.

Refer TMS1406 LV VSD – Technical Specification for other VSD control system design requirements.

6.5 EMERGENCY MOTOR CONTROL

Where operation of a motor is considered critical to safety of personnel, plant or is essential for production availability the MPU display or VSD keypad may have facilities to select LOCAL mode of operation to override the HMI and SCADA mode selection. The LOCAL mode may also be selected at the LCP using a hard wired LOCAL/OFF/REMOTE selector switch to the MPU.

The intention is to operate the motor under an emergency scenario from the field LCP control pushbuttons and/or pushbuttons on the MPU. This feature would be utilised when the PLC is out of service or local HMI and SCADA is unavailable. Other equivalent design solutions can be proposed for emergency local mode of control.

6.6 SINGLE PHASE MOTORS

Controllers for single single-phase motors shall be manual controls and located near the motor and provided with CB short circuit protection and thermal overload protection relay mounted in a suitable enclosure. The enclosure shall be SS316 where located outdoors or in corrosive environments with STOP/START pushbutton controls. For packaged plant the motor starters can be located in close proximity to the mechanical equipment.

6.7 LV SWITCHING

LV switchboard incomers, bus ties and feeder CB's and isolators exceeding 400A rating shall be remotely operated using the local HMI. Local control pushbuttons mounted at the switchboard escutcheon to open and close the motorised Isolators, MCCB's or ACB's shall be provided. The switchboard mounted controls are intended to be only used in an emergency if the local HMI or control system is unavailable.

Operation of LV protective devices and isolators exceeding 400A while energised shall be performed with personnel removed outside the arc flash boundary using the local HMI. The PLC panel containing the local HMI shall be located external of the switchboard arc flash boundary. A warning label shall be provided at the switchboard that directs operators to use the HMI rather than the switchboard controls for LV switching operations.

MCCB's and isolators rated up to maximum 400A can be manually operated and do not require motorised control facilities. PPE as specified on the switchboard arc flash label shall be used when performing manual switching tasks at the switchboard.

6.8 HV MOTOR CONTROL

Where the HV motor is part of a large vendor package such as air blowers the control shall be from the package UCP. The control system shall be delivered in compliance with TMS1645 Package Plant EI&C Requirements - Technical Specification.

6.9 AUXILIARY DEVICES

The control system shall supervise and acquire data from auxiliary devices such as UPS's, DC Supply Systems, battery monitoring systems and other diverse equipment such as vibration monitoring systems directly via Modbus TCP Ethernet communications or other accepted communication protocols. Accepted protocols are listed in TMS1202 Control System Technical Specification.

6.10 LOCAL CONTROL STATIONS

The design requirements for motor LCP are outlined in TMS60 LV Switchboards - Technical Specification.

Motors shall have a dedicated LCP installed adjacent to the motor unless specified otherwise in the Project Documentation.

The LCP START/STOP pushbuttons are only enabled when the motor is selected in Local mode. The LCP STOP pushbutton can be omitted and replaced by an Emergency Stop pushbutton where accepted by QUU. Refer TMS1651 Machine Safety Implementation – Technical Specifications for machine safety design requirements.

HV motors and large LV motors (greater than 30kW) shall generally not have STOP/START pushbutton controls provided at the LCP unless specified otherwise in the Project Documentation. The Local Manual control facilities of HV and large LV motors must be carefully considered in the design phase with input from QUU operators.

Local Emergency Stop pushbutton(s) shall be provided at all motors. Refer TMS1651 Machine Safety Implementation – Technical Specifications for emergency stop circuit design requirements.

6.11 EQUIPMENT INTERLOCKING

An Interlocking Technical Specification shall be developed for all new HV switchboards, RMU's and LV switchboards with multiple incomers, ATS or MTS. The document shall describe the following in detail:-

- Mechanical interlocks between CB, ESW and LBS, as well as between incomers, bus ties and feeders. The interlock key system shall be simple and easy to

follow. The preferred key type is RONIS for new switchboards and RMUs. The implementation of lock boxes and complicated key interlocking schemes is not preferred and the Contractor shall offer simple and effective key interlock systems where possible.

- Hardwired electrical interlocks
- Control System software interlocks programmed in IED devices. Software interlocks should not be programmed in the PLC.

All the mechanical, electrical and control system interlocks must operate to reinforce each other. Hard-wired electrical and mechanical interlocks shall also be programmed where possible in the IED devices. The PLC control system shall not be used alone to implement interlocks that can impact safety of persons. For new HV installations the reliance only on administration procedures is not accepted in order to prevent HV equipment being operated to an unsafe mode or cause an unexpected trip.

The interlocking specification must provide step by step tasks for how to isolate and de-isolate equipment safely under all operational scenarios. The interlocking specification must be complemented by interlocking drawings showing hardwired and key interlocks superimposed on the switchboard SLD.

Interlocks between upstream and downstream devices must be provided and is applicable to interlocks between LV and HV network devices.

The Contractor is responsible to design and install interlocking to all existing equipment upstream and downstream of new equipment provided under the Contract. The Contractor shall also make adequate provisions in the design for potential future expansion of the site when designing the interlocking system.

6.12 FUNCTIONAL SPECIFICATIONS

Refer to TMS1202 Control System Implementation Technical Specification for minimum content and detail to be included in a control system functional specification document. The QUU templates for functional specification documents are listed in section 1.3 of this document.

6.13 IEC 61850 IMPLEMENTATION

New HV Switchboards shall be fully compliant with the IEC 61850 standard. This encompasses communications, control, protection and monitoring of the switchboard's operation.

New IED's shall be provided with an IEC 61850 communications port and linked with CAT 6 communications cables through to an IEC 61850 network switch. The network switch shall be located in a dedicated communication panel in the HV switchroom.

IEDs shall be networked in a star network topology using the IEC 61850 protocol. Goose messaging shall be used for communications between IEDs for protection schemes. The site PLC control system shall supervise, control and acquire data from all IED's also over the IEC 61850 communications network. MMS messaging shall be used for communications between IED's and the site control system.

For new HV installations a dedicated HV PLC shall be provided to control and monitor the HV switchboard and associated components inside the HV switchroom. The PLC shall be located inside the HV switchroom in a full height floor mounted control panel with 15" touchscreen HMI mounted on the door. The HMI shall be configured to control and monitor all equipment associated with the HV installation on the site including switchboards, transformers, RMU's and building services equipment associated with the HV switchroom. The PLC Panel shall be designed to comply with TMS1222 Control Panel Technical Specification.

The IEC 61850 network can be extended to include an IEC 61850 to Modbus/TCP gateway device if required to allow the PLC to communicate with the IED's, however direct IEC 61850 communications between IED's and PLC is preferred. The PLC and HMI shall not be configured to provide any HV or LV protection functions. The protection scheme shall be configured in the IED's. Failure or unavailability of the PLC or HMI shall not diminish in any way the capability of the HV protective devices to clear faults in the power network.

All new HV switchboards and RMUs shall be provided with capability under normal operation to remotely operate CBs and LBSs with operators removed from the arc flash hazard. The switchgear devices shall also be possible to be operated locally (from the front of the HV switchboard) under emergency situations if the control system is unavailable.

The HMI must provide adequate information and diagnostics for HV Authorised Persons to perform HV switching operations. Only persons with HV Authorisation are permitted to perform HV switching tasks and the HMI terminal shall be secured behind a security key lockable panel door so that the panel touch screen is only accessible by HV Authorised Persons. The local HMI only has control capability of the local HV switchgear and has monitoring capability of all other HV switchgear and associated equipment located elsewhere on the site.

Where IED's have limited I/O capacity, the switchboard shall be fitted with IEC 61850 Block I/O located in the same tier as the IED. Block I/O shall also be provided in a common area of the switchboard to gather I/O signals that are not associated with any particular feeder or incomer. Control wiring between feeders and incomer tiers shall be minimised.

The following functions shall be provided at the local HMI and the control and monitoring capability shall be replicated at the site SCADA.

CBs and LBSs shall be motorised and have facility to be remotely operated from the local HMI. Status shall be provided at the local HMI and SCADA.

ESW's shall be operated manually at the switchboard and the status of the switch position displayed at the local HMI and SCADA.

The local HMI shall display extensive fault finding information. All interlocks that are preventing a device from operating shall be displayed. All signals and alarms associated with the HV equipment, switchroom facility shall be displayed at the local HMI and SCADA.

The CB Trip Circuit Supervision (TCS) can be a dedicated relay separate from the IED. The status of the TCS relay shall be provided at the local HMI and SCADA. The TCS scheme shall be tested and faults reset using controls on the TCS relay accessible from the front of the switchboard with doors closed. The TCS can be incorporated into the IED and in this case testing and monitoring shall be undertaken using the IED keypad with status also provided at the HMI and SCADA.

Refer TMS1186 HV Switchboard - Technical Specification for other design features required in HV Switchboards.

Refer to TMS1185 Distribution Transformer(less than 5MVA) - Technical Specification for status signals to be connected to the PLC for oil insulated transformers.

Refer TMS1625 Dry Type Transformers – Technical Specification for status signals to be connected to the PLC for dry type transformers.

Time stamping for Sequence of Events data is not required unless specified otherwise in the Project Documentation.

The IED's shall be programmed from the local communications port and are NOT required to be configured remotely over the IEC 61850 network. The data log and other information stored in the IED's will be accessed if required from the communications port on front of the IED using a portable programming terminal.

The Contractor shall design and deliver all control system works in compliance with TMS1202 Control System Implementation - Technical Specification.

6.14 CLOSED CIRCUIT TELEVISION

A Closed Circuit Television (CCTV) system shall be provided where specified in the Project Documentation. The CCTV cameras with night vision capability shall be installed at key process points and site access ways.

Refer TMS117 Security, Access, Control and CCTV – Technical Specification for specific design requirements. The CCTV design must ensure the equipment can be installed as per TMS1200 Electrical Installation Technical Specification.

CCTV system shall not utilise spare network switch ports or spare fibre cable cores which are used for process control or other services. Dedicated network switches and fibre cables shall be installed for all new and modifications to CCTV systems.

7 COMMUNICATION SYSTEMS

7.1 GENERAL

This section is intended to complement information contained in TMS1202 Control System – Technical Specification. The information provides further clarity for the communication network design associated with particular electrical and instrumentation equipment.

Communication links may be used between component parts of a proprietary control and information system for data gathering, operator commands and supervisory control.

Communication links shall not be used for equipment basic stop/start, reset of faults or for any automatic shutdown functions related to safety systems.

7.2 COMMUNICATION CABLES

Communications cables that are routed external of switchrooms and building in process areas shall be multi–mode fibre optic cables. The cable installation shall comply with TMS1200 Electrical Installation – Technical Specification. The fibre cables shall be metal sheathed rodent proof or SWA cables.

CAT 6 and other screened copper communications cables are only accepted where both ends of the cable terminate in the same building or switchroom. For short communications links, not exceeding 5m between equipment in process areas, copper serial or CAT 6 communication cables can be installed.

Rugged multi-mode fibre optic patch leads or rugged CAT 6 cables shall be installed when patching signals between enclosures separated by short distance of less than 5m. Rugged patch lead data sheets must be accepted by QUU.

7.3 COMMUNICATION PANELS

New communications equipment where installed in switchrooms at STP sites and switchrooms at other larger assets shall be mounted in standalone rack unit type enclosures. The communications panel shall be 42 rack units unless specified otherwise in the Project Documentation and accessible from front and rear. Only communications equipment shall be installed in the communications panel and this includes termination facility for communication cables.

Communications Panels shall be designed to comply with TMS1222 Control Panel Technical Specification.

New communications equipment installed at Network Assets or located in the field, such as within the process areas of STP's may have the communications and control system equipment integrated into a PLC control panel or switchboard compartment.

7.4 PRIVATE RADIO AND 3G/4G COMMUNICATIONS

QUU has an existing extensive private radio telecommunications network. QUU's private radio network is the preferred communications link for RTU/SCADA sites.

Two communication options exist within QUU, with private radio being the preferred link and 3G or 4G are viable options if the radio solution is found not to be feasible for the site.

The Contractor shall design new and modifications to existing radio networks so as to not degrade the current performance and reliability of the existing network. New equipment shall be selected from TMS1151 Control Systems Preferred Equipment List. The equipment must be designed to comply with TMS1202 Control System Implementation – Technical Specification.

For the replacement of "like for like" remote radio sites where the new antenna will be located in the same position as existing, monitored path loss diagnostics can be utilised to provide a suitable radio signal strength.

For new sites or where the new radio antenna cannot be mounted in the same position as the existing antennae, a radio network desktop design must be performed by the Contractor to determine which repeater within the area will provide a suitable communications link. From the desktop design and once a suitable link is proposed a radio signal site survey shall be performed to confirm the proposed radio design solution.

The preferred option is for the desktop design to achieve a target RSSI of -80dB or better and the antennae pole height to not exceed 6m in height from finished ground level of the site. A 6m pole is the maximum height which a pole mounted on the side of a switchboard will be accepted by QUU.

Standalone poles should be located in near vicinity the switchboard and generally be installed 2m higher that the local council Town Plan building height restriction so as to allow the antennae to be mounted at the maximum height possible and reduce radio signal interference and loss from any nearby tree foliage or buildings.

The Contractor shall only proceed with a Telstra 3G or 4G communications design solution for a site where the Radio Network Desktop Design Report demonstrates that a private radio network link is not feasible and the report is accepted by QUU or the site requires dual communications links based on site criticality. A desk top determination if 3G or 4G communications to the site is feasible shall be performed by the Contractor

that utilises the Telstra network coverage map followed by a site survey by the Contractor to confirm the Telstra network signal strength.

A 3G/4G site survey shall be performed at each site and whenever a radio signal site survey is performed at the site. A 3G site survey and design solution shall only be required where a site does not have Telstra 4G signal coverage.

7.4.1 Radio Network Desktop Design

When modifying existing radio networks or proposing new radio networks, the Contractor shall undertake a radio network desk-top design analysis. The analysis shall be undertaken using one of the radio network design software packages accepted by QUU as follows:-

- ICS Telecom,
- Mentum Planet
- Pathloss

Alternative modelling software can be proposed by the Contractor and must be accepted in writing by QUU before any design commences.

Prior to radio network design commencing the Contractor shall enquire with QUU and request the existing radio network software model. QUU will only provide the model(s) where available and the information contained in the model must be verified by the Contractor.

The Contractor shall produce the model when is not available from QUU. The Contractor when compiling the model shall provide GPS co-ordinates, radio type, antenna heights etc and shall allow for all necessary site visits to collect and verify the required data.

The minimum base station data required to be confirmed by the Contractor is as follows:-

- Transmit power
- Antenna gain
- Antenna model and coverage pattern file
- RF feeder type and length
- Antenna height

In order to get consistent results with the radio path modelling software, the Contractor shall utilise digital terrain databases accepted by QUU.

The Radio Network Desktop Design Report shall detail the repeaters within the area, a path profile view and a link detail table with a recommendation table. The engineering calculations showing path loss, cable loss, transmit power, antennae types/gains, length of transmission paths, obstructions, RSSI for different antenna heights etc shall be stated in the report for the proposed radio frequencies.

QUU will provide the existing QUU private radio base station locations and frequencies upon formal request by the Contractor. The digital terrain models shall be nominated within the report to understand the level of accuracy for the terrain. Clutter shall be included in the point to point link which can be manually inputted if no clutter data is available.

QUU must accept the Radio Network Desktop Design Report before the radio signal site survey is commenced.

QUU will provide TEM596 Radio Network Desktop Design Report Template and is issued for information only to the Contractor.

7.4.2 Radio Signal Site Survey

The Contractor shall attend the site to undertake site measurements of the radio signal strength and confirm the parameters calculated in the Radio Signal Desktop Design Report. The location of the switchboard containing the radio equipment and antenna location shall have been generally accepted by QUU before the site survey commences. The Contractor shall consider the removal of trees and foliage that may impact or cause future interference with the radio signal. Contractor must also consider proximity to overhead power lines and public road ways to ensure adequate access to maintain and inspect the antenna.

The Contractor shall test at a range of antenna heights, above and below the height calculated in the Radio Network Desktop Design Report. If it was found within the desktop design that more than one repeater was available, signal strengths shall be recorded for each repeater.

The Contractor shall prepare a Radio Signal Site Survey Report and shall submit the report to QUU for review. The report shall as a minimum nominate the radio frequencies assessed on the site, antennae heights and RSSI recorded at each antennae height. The report shall contain photos of the testing as performed and shall reference the test plan document.

The Contractor shall only proceed with a 3G or 4G communications network design solution for a site, where the Radio Site Survey Report demonstrates that the private radio network link is not feasible and this is accepted by QUU. On all sites the Contractor shall measure the 3G or 4G signal strength using the Cybertec 2455 modem which is specified by QUU for the Telstra mobile network. The site measurements must verify the feasibility of a 3G or 4G design solution if it is required for the site.

QUU will provide TEM597 Radio Signal Site Survey Report Template and is issued for information only to the Contractor.

7.4.3 Communications Network Design Report

The Communications Network Design Report is relevant to a private radio and/or a 3G/4G communications solution. The report shall nominate the proposed mast height, the actual antenna mounting height, assess susceptibility to network frequency interference from external noise sources and consider the feasibility of erecting the antenna mast in the proposed location.

Antenna masts shall not be proposed in vicinity of HV transmission lines. Section clearance as per AS2067 must be maintained during installation and while accessing the antenna and mast for maintenance.

Provision for lightning protection of the network components shall also be detailed in the design report. All coaxial cable connections to antennas shall have a suitable surge arrestor installed in the switchboard or control panel.

An options section shall be provided in the report that details the communication path options available, details possible alternative antenna heights, antenna supports/structures and radio link signal strengths for each option. The report shall also contain a recommendation that details the preferred solution. The report and recommendation must be accepted by QUU before the Contractor proceeds to finalise the design drawings and procure the radio equipment for the project.

The Communications Network Design Report shall be updated to As Built status and this shall require a final signal survey undertaken by the Contractor during the site commissioning phase of the project. The radio software model shall also be updated to As Built and provided to QUU with the As Built documentation for the site. The radio network software model filenames and versions shall be nominated in the report.

QUU will provide TEM598 Communications Network Design Report Template and is issued for information only to the Contractor.

8 HAZARDOUS AREAS

8.1 GENERAL REQUIREMENTS

Plant areas where the formation of gases, vapours or mist that may occur in such quantities that explosive mixtures with air are likely to occur, shall be classified as Hazardous Areas (HAs) in accordance with AS60079.10.1.

Electrical equipment and instrumentation shall as far as practicable, be located in the least hazardous area zone. Switchrooms and instrument air packaged plants shall be located in non-hazardous areas.

HA installations shall be designed to ensure compliance with TMS1203 General Requirements for Hazardous Area Installation - Technical Specification. Projects with HA scope shall be delivered in compliance with MP183 HA Management Plan.

8.2 CLASSIFICATION

The HA Classification shall be completed to the latest edition of AS 60079.10.1. QUU requires to standardise on the HA Classification Report content and layout and will provide a report template that shall be utilised by the Contractor. The HA Classification Report minimum contents are specified in MP183 HA Management Plan and TEM518 HA Verification Dossier Template. Existing HA Classification Reports shall be updated by the Contractor to comply with TEM518 where required.

8.3 EQUIPMENT EX CERTIFICATION

Refer to TMS1203 General Requirements for Hazardous Area Installation - Technical Specification for equipment Ex certifications.

8.4 PROTECTION TECHNIQUES

The Ex protection techniques for new equipment that are accepted by QUU are outlined in TMS1203 General Requirements for Hazardous Area Installation - Technical Specification..

8.5 HAZARDOUS AREA DOSSIER

The site HA Verification Dossier shall be updated for any equipment located fully or partially within HA's. The site HA Verification Dossier shall be updated by the Contractor in compliance with TEM518 HA Verification Dossier Template.

The Dossier shall be issued to QUU prior to the commencement of the project commissioning phase. All equipment decommissioned shall have the relevant

information removed from the site HA Dossier. The Contractor is responsible for the completeness and accuracy of the HA Dossier.

The information provided in the HA Dossier shall not be duplicated in any other documentation deliverables provided by the Contractor.