Section 6 - Employer's Requirements

CONTENTS

1 Scope of Supply of Facilities and Services

1.1 Project Description

The aim of this project is to Design, Supply, Construct and Install Samoa's first Power Generation Gasification Facility to be located at Afolau. The Power Generation Facility will be rated no less than 750kW. The 22kV transmission lines will connect the Biomass Facility to the EPC electricity distribution system.

Afolau is located on the western part of the Island of Upolu; Samoa's most populated Island. Diesel provides over half of the Island's energy generation with contributions from Hydro, Solar and Wind Farm forming less than 50% of the Island's demand. In the recent years, the development of Small Hydropower Schemes contributes close to half of the Island's energy demand. The development of a Biomass Gasification Plant will contribute in stabilising Upolu's electrical network to counter the increase in Variable Renewable Energy Sources and replace diesel generation.

The Facility upon completion will beoperated by the Electric Power Corporation (EPC) with the feedstock to be prepared and supplied by the Samoa Trust Estate Corporation (STEC)

The Site Plan and the Ultimate Analysis for the different Feedstockis shown in Section 6 – Part 4.

1.1.1 AfolauGasification Plant

1.1.1.1 Facility Description

Afolau Gasification Plant will have a generation capacity of no less than 750kW.Plant shall be designed with maximum efficiency and use less energy for its auxiliaries and power house lightning. LED lights, soft start motors, design of power house to utilise natural light and ventilation, pre-drying of wood fuel feed stock to reduce moisture content with hot air from the plant, etc must be considered.

The facility will comprise of the key features as follows:

1. Drying Shed

The contractor shall be responsible for the design, procure, and construct of a biomass drying shed for fuel feed stock and install proposed drying units for the wet biomass. The drying shed will house the dried biomass feedstock together with the unit(s) used for drying the high moisture content biomass already processed for drying. The contractor shall also size the drying shed to allow mobility of small earth moving machinery no more than 2000kg in operating weight to move feedstock from one location to another.

2. Conveyance/Administering System

The contractor shall design, procure, and install an administering system for the dried biomass to be fed into the gasifier. The contractor shall design such a system to ensure the plant is able to deliver rated capacity for diurnal and nocturnal peaks at sustained intervals of 3 hours per peak period.

3. Gasifier

The contractor shall design, procure, and install a gasifier unit that will be able to yield the required syngas to sustain the syngas engine at rated capacity atall times (continuously). The gasifier shall be fabricated according to relevant referenced standards and be able to withstand maximum operating temperatures required for synthesis.

The gasifier shall be able to produce the quality gas required to operate the gas engine from the variety of feed stock provided by the employer in 1.1.1.2 below.

The contractor shall provide the Employer with the particle size distribution required for the biomass.

4. Gas Cleaning and Cooling System

The contractor shall design, procure, and install a syngas cleaning system to be coupled with the gasifier and gas engine. The cleaning system shall be designed to condition and extensively clean the raw syngas to meet the required specification for use in the proposed gas engine.

The contractor shall install closed circuit radiator type cooling systems/heat exchangers for the syngas. The cooling system shall be designed to reduce the temperature of the gas to allowable operating temperatures to avoid premature ignition in the gas engines.

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5. Gas Engine

The prime mover for the gasification plant shall be in the form of a gas fuelled reciprocating engine. The contractor shall design, procure and install an Internal Combustion Gas Engine ~~with provisions for dual fuel system in the future~~ for syngas ONLY..

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6. Exhaust Gas Cleaner and Cooler

The contractor shall install and exhaust gas cleaning system and cooler to comply with the World Health Organization's air quality guidelines stipulate annual mean concentrations of PM2.5 should not exceed 10 µm/m3 and 20 µm/m3 for PM10.

The key parameters are:-

Employers Minimum Total Acceptable ~~Station~~ Generator(s) Net Power Output taking into consideration generators' parasitic load of about 15% at 0.8 lagging power factor read on KW meter on generator panel ~~at transformer 22kV terminals~~. (Note: Two (2) about 450-500kw generators to be installed instead of one 900KW - 1000KW generator)	450-500~~750~~kW per generator
Employers minimum acceptable generator efficiency at Rated Output	95%
Employer's Minimum Plant Capacity ~~Load~~ Factor	70~~95~~%

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~~1.1.1.2~~1.2.1.1 **Feedstock**

The species of biomass to be used for feedstock are as follows:

1. Puluvao (Ultimate Analysis Provided)
2. Pulumamoe (Ultimate Analysis Provided)
3. Tamaligi (Ultimate Analysis Provided)
4. Elephant Grass (PennisetumPurpureum)
5. Coconut Shells

Heat contents of these wood species is available.

Puluvao, Pulumamoe, and Tamaligi are classified as invasive species in Samoa. These particular species of feedstock will be cultivated by STEC on a 5000 Acre plot on which the Power Plant is located. Upon their depletion, the cultivated plots of land will be planted with PennisetumPurpureum (elephant grass) - an energy crop widely used for biomass gasification projects. Coconut shells will also be collected and used in conjunction with the elephant grass to ensure that the availability factors are maintained.

~~1.1.2~~1.2.2 Design and Construction of the Facilities

~~1.1.2.1~~1.2.2.1 Access Roads

~~There is established permanent access via 4x4 tracks to the vicinity of the powerhouse. A short section of new permanent access will be required to construct from where the established access roads finish to where the Powerhouse location will be.~~

~~The Contractor is also responsible for maintaining all other project roads during construction and handing them back in condition no worse than at the beginning of the Contract. This will be recorded by photographic record at the beginning and end of the Contract, with the Contractor responsible for any repairs required.~~

~~The Contractor is responsible for obtaining all necessary permits and approvals for constructing such access and must also remove the temporary works following Operational Acceptance.~~

~~1.1.2.2~~1.2.2.2 Water Requirements

The scope of work for the Contractor is to design and build a water storage tank to accommodate for all the plant operational needs and fire fighting requirements.

~~1.1.2.3~~1.2.2.3 Drying Shed

The scope of work for the Contractor is to design and build a new drying shed comprising:-

- A steel clad or concrete blockwork building with a reinforced concrete foundation. The building shall have a single room that houses all the M&E equipment and associated balance of plant. The powerhouse shall be designed and constructed to be cyclone resilient.

~~1.1.2.4~~1.2.2.4 Powerhouse

The scope of the work for the Contractor is to build a new Powerhouse which will house the M&E equipment and associated balance of plant comprising:-

- Access and parking around the powerhouse.
- A steel clad or concrete blockwork building with a reinforced concrete foundation. The building shall have a single room that houses all the M&E equipment and associated balance of plant. The powerhouse shall be designed and constructed to be cyclone resilient.
- An external concrete pad for the transformer with bund wall to contain full volume of transformer oil when it leaks.
- Lifting equipment, via an overhead crane.
- Powerhouse and generators shall be designed to meet international environmental and safety standards for noise attenuation. Noise level at the boundary fence shall be no more than 65DB and 50DB to the nearest neighbour house.
- Exhaust stack for each of the two engines/generators shall be ~~30~~ 5 meters higher than the ridge of the power station roof to allow for good mixing of exhaust fume with tradewinds. Use residential snubber type silencers with high noise attenuation ratings for noise reduction. .
- ~~Fencing around the powerhouse compound.~~

~~1.1.2.5~~1.2.2.5 Mechanical &Electrical

The scope of work for the Contractor is:-

- Provide/install ~~a~~ two (2) ~~a~~ syngas engines and generators ~~nominally~~ rated at ~~750~~450-500kW, ~~938~~ or 560 - 625kVA each at 0.8 lagging power factor read at the ~~generator terminals~~ panel KW gage at the generator panel. ~~comprising gas engine~~ Use synchronous generators, complete with auto synchronizing system, electronic governor system and automatic voltage regulation system for integration with EPC SCADA system.
- Provide 415V switchgear.
- Provide a 415V/22kV step-up padmount oil type transformers nominally rated at ~~1,000~~700kVA each. Each generator has its own transformer.
- Provide a PLC based control system for generator start/stop, governing and mechanical protective functions and for interfacing Afolau with the Employers remote control center.
- Provide an industrial touch screen computer based HMI screen, interfaced to the PLC and protection system for alarm annunciation, trending, plant operational status display and for start/stop and loading control of the facility.

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- Provide an "all in one" electrical protection relay system for providing generator and step-up transformer protections.
- Provide a 24V DC battery system for the powerhouse control and protection systems.
- Provide a 415V local service switchboard, powerhouse lighting and general power systems.
- Provide a digital VHF radio system for communicating with the Employers control centre.
- Supply and installation of approximately 100m of overhead 22kV distribution line, and connections to the existing EPC 22kV system.
- Provide all required interconnecting cabling.
- Undertake all factory and site testing.
- Commission the Afolau power plant.
- Provide technical support and backup for a period of one year following completion.

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2 Specification

2.1 Performance and Design

2.1.1 Guarantees

2.1.1.1 Plant Load Factor

The Contractor shall guarantee the Load Factor of the Plant at 95%. The Load Factor will be calculated in accordance with IEEE762.

The Employer may reject the Plant if it fails to achieve 7095% of the guaranteed Load Factor.

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2.1.2 Statutory Requirements

2.1.2.1 Background to Environmental

The Project has been the subject of an Initial Environmental Examination (IEE), which included an Environmental Management Plan (EMP) for the projects. The full IEE is included in Section 6 Part 4 - Supplementary Information.

The relevant Environmental Impacts and Mitigation Measures are detailed in the following Sections of the IEE:-

- 5.3 Construction Impacts on Physical Environment.
- 5.4 Construction Impacts on Biological Environment.
- 5.5 Construction Impacts on Social-economic Environment.

The Contractor is responsible for the implementation of construction and rehabilitation activities for the sites and for implementing the impact mitigation measures in the construction phase. The Contractor is also responsible for the Monitoring activities as detailed in Section 6.5 of the IEE. The Contractor shall include staff to be specifically responsible for preparation and implementation of the Construction Environmental Management Plan (CEMP), which describes the Contactor's construction methodology and measures and plans for implementing the EMP. This includes maintaining a site diary and a grievance registry. The CEMP shall be approved by the Employer prior to the Contractor's mobilization to the site. The contractor will be required to report on the implementation status of the CEMP to the Employer.The damages due to the violation of the stipulations by the Contractor shall be compensated and/or restored by the Contractor at his or her own expense.

2.1.2.2 Health and Safety

Health and safety procedures on the site shall comply with the Samoa Occupational Safety & Health (OSH) Act 2002 and any associated codes together with any additional requirements specified in the Contract. The Health and Safety plan shall be part of the CEMP as detailed in the IEE.

In order to formulate a specific and competent safety plan, the Contractor shall carry out a detailed risk assessment against the scope and nature of the contracted Facility and the particular site conditions. The documentation arising from this process shall contain a comprehensive schedule of all perceived risks

and the proposed elimination and mitigation measures necessary to reduce the risk to a minimum. Risk assessment documentation shall form part of the auditable safety records.

The Contractor shall appoint a Site Safety Officer who will be responsible for the management and control of safety on site. All staff and workers will undergo a site safety training programme developed by the Contractor specifically for the Contract. Tool-box talks on particular safety hazards will be conducted by the Site Safety Officer on a regular basis in order to ensure that a proactive safety culture is maintained on the site through the period of the contract.

The Contractor shall provide a safety training induction to all visitors before they are permitted to enter the site.

2.1.2.3 **Emergency Response and Callout**

Throughout the contract period, the Contractor shall make contingency arrangements for 24 hour per day, 7 days per week availability of emergency response labour, plant and supervision to respond to emergency situations as may affect the Contract Facility, to ensure the safety and protection of them and adjacent property.

The Contractor is to develop a Site Wide Emergency Evacuation Plan. This plan is to apply to and be available for all personnel on site, Contractors own employees, and the employees of the Employer, Project Manager and any other contractors on the Site.

2.1.2.4 **Quality Assurance**

The Contractor shall establish, maintain and monitor a Quality Assurance Plan (QAP) which meets the requirements of ISO 9000 and ISO 9001. The QAP shall cover all elements of the permanent Facility.

The Contractor shall submit the QAP to the Project Manager prior to work commencing on site.

2.1.3 **Resources**

2.1.3.1 **Contractor Supplied Materials**

The Contractor shall supply all materials required for the execution of the Contract Facilities and for any temporary works and shall remove surplus materials from the site prior to completion of the Contract.

Materials awaiting incorporation into the Facilities shall be stored off site in secure premises until required for use on Site. On arrival at the Site, locations for storage shall be identified and planned by the Contractor so as to minimise interference with both the Facilities and other uses of the Sites.

2.1.3.2 **Employer Supplied Materials**

There are no Employer Supplied Materials

2.1.4 **Key Personnel**

The Contractor shall engage the Key Personnel and the Contractor shall promptly appoint suitable people (and any replacements) who shall be notified to the Project Manager in writing. Key Personnel are nominated in the Technical Proposal.

Technical personnel (engineers, technicians, etc) engaged in the works shall be registered under Institution of Professional Engineers of Samoa (IPES). This is a requirement of the Samoan Professional Engineers Registration Act. Refer to IPES website, *www.ipes.ws* for details.

2.1.4.1 **Local Resources**

As is standard practice in Samoa, the Contractor is expected to utilise local resources (labour, equipment, engineers, surveyors, etc) as much as possible, in so far as the skills and abilities of the local workforce allow.

Failure of the Contractor to correctly manage the local resources, which results in disruption and delays to the Project, is not deemed valid basis for a time extension claim.

2.1.4.2 **Immigration / Work Visas**

It is the responsibility of the Contractor to be fully acquainted and in compliance with the Samoa Immigration Department rules regulations and procedures applicable to immigration and work visa issues.

Failure to obtain work visas for the various staff required on the project is not reason for claims for either time or cost.

2.1.5 The Site

2.1.5.1 Site Definition and Access

The rights or customs of adjacent property owners and occupiers for access shall not be infringed by the Contractor.

2.1.5.2 Tolerances

The Contractor shall propose tolerances to be used for the Facilities that shall be subject to the Project Manager's approval.

2.1.5.3 Temporary Works

The Contractor shall ensure that all temporary works are properly designed and constructed so that the safety of persons and Plant has been properly taken into account. The Contractor shall be responsible for all costs associated with the design, construction, and performance of the temporary works.

2.1.5.4 Protection of Facilities

All finished Facilities shall be protected from damage which could arise from other construction activities.

Work shall not be carried out in weather conditions that may adversely affect the quality of the Facilities unless proper protection, acceptable to the Project Manager, is provided.

Facilities under construction and materials for such Facilities shall be protected from exposure to weather conditions, which may adversely affect the quality and performance of the Facilities and the materials.

2.1.5.5 Mobilization and Demobilization

Contractor shall furnish all the labor, materials, equipment and shall perform all work required for mobilization to and demobilization from the Project Site.

Mobilization shall include, but not be limited to: moving personnel, plant, and equipment to the Site; arranging for necessary Site utilities; ~~establishing camps, shops, offices and administrative facilities; and obtaining all required permits, licenses, and other regulatory authorizations required for the~~ and obtaining building permits for construction of the Project. Employer will prepare and make application for Development Consent for the Project with Contractor providing details of plant design and equipment to be installed.

A brief outline of the required permits, and the process and costs associated with obtaining them can be found at:-

http://www.doingbusiness.org/data/exploreeconomies/samoa/dealing-with-construction-permits/

The Contractor shall provide the Basic Design Report to the Employer for the Employer to use in the Development Consent application. The Contractor shall also provide any other reasonable information requested by the Employer in support of the application.

The Contractor is responsible for obtaining the Building Permit, including all necessary endorsements and inspections.

Demobilization shall include, but shall not be limited to: removing all plant, equipment, and temporary works from the Site; disconnecting temporary utilities; relocating personnel from the Site; cleaning-up and restoring all areas occupied by the Contractor; closing out permits, licenses, and other regulatory authorizations; and disposal of all waste materials and excess construction materials which are not the property of the Employer.

2.1.5.6 **Clearing and Leveling of Project Site**

Employer will issue a separate bid for the clearing of the project site, levelling, compacting, and grading and building drainage and security fence around entire project site. Total size of property assigned for plant is 3 acres. This work will not be part of the Biomass Gasification Plant scope of work.

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~~2.1.5.6~~2.1.5.7 **Site Signage**

Prior to the commencement of work at the Site, the Contractor, at the direction of the Project Manager, shall supply and erect three site signs for the information of the public at the entrance to each power station site, containing the following information, clearly visible and legible to passers by intended for the information of those affected by the Facilities, for the guidance of those making deliveries and for general public safety:

- Name of Project;
- Name and logo of Employer;
- Names and logos of the funding agencies;
- Name and logo of Project Owners Engineer.
- Name and logo of Contractor;
- Contractor's contact person and after hours contact details; and
- Restrictions on access and appropriate safety warnings.

The Contractor shall maintain such signs throughout the contract period with up to date information and free from disfigurement.

The Contractor shall also supply, erect and maintain appropriate site signage and safety warning signs as are appropriate for the nature of the work being undertaken. No other signage or advertising materials shall be permitted on the Site, except with the specific consent of the Project Manager.

~~2.1.5.7~~2.1.5.8 **Working Hours**

Normal working hours are Friday to Saturday 9am to 5pm. However, the Contractor is free to vary working hours provided there is no disruption to the adjacent villages outside normal working hours. Any work on Sundays or at night must be approved beforehand by the Project Manager. It is the Contractors responsibility to understand, and comply with, all local labour rules and laws.

~~2.1.5.8~~2.1.5.9 **Contractor's Compound**

The Contractor shall provide a secure enclosure for the parking of movable Contractor's Equipment, storage of Plant and Materials, fuels and other consumables within the boundary of the Site at a location agreed with the Project Manager which will maximise convenience and minimise interference with the execution of the Facilities.

~~2.1.5.9~~2.1.5.10 **Site Office, Messing and Sanitary Facilities**

a) The Contractor shall supply, maintain and at the end of the Contract period remove all necessary temporary sheds, offices, meal rooms, sanitary facilities and other temporary buildings required for storage, management of the site and the welfare of personnel employed on the Facilities. Such buildings shall be maintained secure, tidy and fitted out with appropriate furniture and services.

b) A temporary site office with the following specification shall be provided by the Contractor and maintained for exclusive use by the 2 or Employer's personnel during their attendances at the Facilities:

   i. building plan area not less than 4m x 2m,

   ii. plan table, meeting table, 3 chairs,

   iii. mains voltage electricity supply for lighting,

   iv. lockable doors and window,

   v. shared access to sanitary facilities and meal rooms as provided above.

~~2.1.5.10~~2.1.5.11 **Site Security**

The Contractor shall have full responsibility for the care of the Site and the Facilities from the time of obtaining possession of the Sites until the time of Operational Acceptance.

The Contractor shall provide and maintain appropriate fencing, gates, lighting, security visits and personnel as are appropriate to the risks of loss and the location of the Site. The Contractor shall regularly monitor such fencing and other security arrangements to ensure its effectiveness throughout the contract period.

2.1.5.112.1.5.12 **Protection of Land, Flora and Fauna**

The Contractor shall plan and implement its occupation of the Site to the minimum extent necessary to provide access, turning, parking, material storage, and working space for the construction of temporary and permanent Facilities.

The Contractor shall not damage or destroy natural features of the Site except to the extent described on the Drawings as being part of the Facilities or approved by the Project Manager as essential needs for temporary works. Parts of the Site where work is otherwise complete shall have specified landscape treatment or other finishes applied as soon as this can be done without undue risk of damage or interference with other work.

2.1.5.122.1.5.13 **Noise, Dust, Vibration and Damage or Nuisance**

The Contractor shall minimise the generation of noise, dust, vibration and other potential causes of damage or nuisance, to the extent that is feasible given the nature of construction activities, statutory requirements and any other special protection specified in the Contract, statutory approvals and consents.

2.1.5.132.1.5.14 **Dangerous Goods**

No dangerous goods, explosives, chemicals, fuels or similar items shall be brought onto the Site unless the Contractor has advised the Superintendent of the intention to do so, and has complied with all statutory requirements for its safe storage and security.

The Contractor shall minimise the use of the Site for the storage of fuels, explosives and other dangerous goods as may be required for the construction of the Facilities and shall not use the site or allow access for any purpose not connected to the Contract.

Dangerous Goods are only to be stored in nominated and approved storage areas and must comply with the Samoa regulations governing such goods.

2.1.6 Design Principles

2.1.6.1 Lifetime Requirements

The design of the civil, and structural features shall provide a 100-year service life, while the electrical and mechanical systems shall be designed for a service life of at least 40 years.

The design service life of a structure or equipment is the period for which it is to be used for its intended purpose. Regular maintenance is anticipated but structural reliability and operational integrity shall be maintained.

The Contractor shall inform the Project Manager of specific parts or components of the design that have a shorter technical life than stated above. Such parts or components shall be included in the Facilities only as approved by the Project Manager.

All materials and equipment used in the Project shall be of acceptable quality and proven design, and shall be furnished by a recognized manufacturer or supplier.

2.1.6.2 Standards

All design and construction work, including the materials used and methods applied, shall be in accordance with one or more internationally recognized standards of practice. By definition, such standards comprise organizations such as the AS (Australian Standards), NZS (New Zealand Standards), ASTM (American Society for Testing and Materials), ISO (International Organization for Standardization), DIN (German Code), BS (British Standard), SS (Swedish Standard), EN (European Standard), or equivalent.

Should the Contractor request alternatives to the above standards, other relevant standards may be used subject to Employer's approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Employer for review and approval.

The latest editions on the Base Date of the standards and codes, including amendments, shall be used by the Contractor, unless expressly stated otherwise.

An English translation shall be submitted if the standards and codes proposed by the Contractor are in a language other than English.

All specific references to standards and codes throughout these Employer's Requirements are governed by this Part.

The Facilities shall be constructed in accordance with the laws of Samoa and associated Acts and Regulations. These include:-

- National Building Code 2002
- Electricity (Safety) Regulations 2010
- Occupational Safety & Health (OSH) Act 2002
- Environment Management Act

In order to achieve Regulatory compliance under the Electricity Regulations, the Facilities shall comply with the Electricity Regulations and AS/NZS 3000:2007 "Wiring Rules".

The standards under which the work is to be performed or tested are specified throughout these Employer's Requirements. Where such standards are in conflict with the provisions of these Employer's Requirements, the Employer's Requirements shall govern. In case of conflicting requirements that are not specified definitely in these Employer's Requirements between the standards of above authorities, such disagreements shall be resolved by the Project Manager, and the Project Manager's decision shall be final. It is understood that the latest revision or edition of such standards at the time of Tender shall apply.

In the absence of specific standards being nominated in the specifications, the following Standards shall apply:-

Australian/New Zealand Standards

AS/NZS	1170	Structural Design Actions
AS/NZS	1429.1	Electric cables - Polymeric insulated - For working voltages 1.9/3.3 (3.6) kV up to and including 19/33 (36) kV
AS/NZS	1768	Lightning Protection
AS	1824	Insulation coordination – Definitions, principles and rules
AS	1940	The storage and handling of flammable and combustible liquids
AS	2067	Switchgear Assemblies and Ancillary Equipment for Alternating Voltages above 1kV
AS/NZS	2312	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
AS/NZS	2373	Electric cables – Twisted pair for control and protection circuits
AS/NZS	2650	Common specifications for high-voltage switchgear and controlgear standards
AS	2676.2	Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings: Sealed cells
AS/NZS	3000	Wiring Rules
AS/NZS	3008.1.1	Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1 (1.2) kV.
AS/NZS	3010	Electrical Installations – Generating Sets
AS	3011.2	Electrical installations – Secondary batteries installed in buildings, Part 2: Sealed

		cells
AS/NZS	3080	Telecommunications installations - Generic cabling for commercial premises
AS/NZS	3155	Approval and test specification - Electric cables - Neutral screened - For working voltages up to and including 0.6/1 kV
AS/NZS	3191	Electric flexible cords
AS/NZS	3439.1	Low voltage switchgear and control gear assemblies
AS/NZS	3439.2	Low-voltage switchgear and controlgear assemblies - Particular requirements for busbar trunking systems (busways)
AS	3607	Conductors-Bare overhead, aluminium and aluminium alloy – steel reinforced
AS/NZS	3835	Earth potential rise - Protection of telecommunications network users, personnel and plant
AS/NZS	3947	Low voltage switchgear and control gear, (all relevant parts)
AS	4024.1	Safety of machinery, (all relevant parts)
AS/NZS	4026	Electric cables - For underground residential distribution systems
AS	4044	Battery chargers for stationary batteries
AS/NZS	4961	Electric cables – Polymeric insulated – For distribution and services applications
AS/NZS	5000	Electric cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV.
AS/NZS	60265.1	High-voltage switches - Switches for rated voltages above 1 kV and less than 52 kV
AS	60529	Degrees of protection provided by enclosures (IP Code)
AS	60870	Telecontrol equipment and systems (All parts)
AS/NZS	60898	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Circuit-breakers for a.c. operation
AS	ENA C(b)1	Guidelines for design and maintenance of overhead distribution and transmission lines.
AS	HB101	Coordination of power and telecommunications - Low Frequency Induction (LFI): Code of practice for the mitigation of hazardous voltages induced into telecommunications lines.

International Electrotechnical Commission (IEC)

IEC	11801	Information technology – Generic cabling for customer premises
IEC	14763	Information technology – Implementation and operation of customer premises cabling
IEC	24702	Information technology – Generic cabling – Industrial premises
IEC	60034	Rotating Electrical Machines – all relevant parts
IEC	60038	IEC Standard Voltages
IEC	60041	Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines
IEC	60044	Instrument Transformers
IEC	60051	Direct acting indicating analogue electrical measuring instruments and their accessories
IEC	60060	High Voltage Test Techniques
IEC	60076	Power Transformers
IEC	60085	Thermal Evaluation And Classification of Electrical Insulation.
IEC	60086	Primary Batteries
IEC	60099	Surge Arrestors
IEC	60137	Bushings For Alternating Voltages Above 1,000 V
IEC	60193	Hydraulic turbines, storage pumps and pump-turbines - Model acceptance tests
IEC	60228	Conductors of Insulated Cables
IEC	60255	Electrical relays

IEC	60269	Low-voltage fuses
IEC	60304	Standard colours for insulation for low frequency cables and wires
IEC	60308	International Code for Testing of Speed Governing Systems for Hydraulic Turbines
IEC	60354	Loading Guide For Oil Immersed Transformers
IEC	60364	Electrical installations of buildings
IEC	60502.1	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)
IEC	60502.2	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
IEC	60551	Determination Of Transformer And Reactor Sound Levels
IEC	60664	Insulation coordination for equipment within low-voltage systems (All Parts)
IEC	60715	Dimensions of low voltage switchgear and control gear
IEC	60793-1	Optical fibers – All Parts
IEC	60794	Optical fiber cables – Part 1-1: Generic specification - General
IEC	60794-1-2	Optical Fibre Cables - Generic Specification - Basic Optical Test Procedures
IEC	60794-4-1	Optical fibre cables - Part 4-1: Aerial optical cables for high-voltage power lines
IEC	60896	Stationary Lead-Acid Batteries
IEC	60898	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations
IEC	60909	Short-circuit current calculation in three-phase AC systems
IEC	60934	Circuit breakers for equipment
IEC	61009	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)
IEC	61660	Short-circuit currents in DC auxiliary installations in power plants and substations
IEC	62063	High-voltage switchgear and controlgear - The use of electronic and associated technologies in auxiliary equipment of switchgear and controlgear
IEC	62271	High Voltage Switchgear and Controlgear (All parts)
IEC	62305	Protection against Lightning

Institute of Electrical and Electronic Engineers (IEEE)

ANSI/IEEE	Std 1050	Guide for Instrumentation and Control Equipment Grounding in Generating Stations
ANSI/IEEE	Std 450	Recommended Practice for Maintenance, Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations
ANSI/IEEE	Std 484	Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations
ANSI/IEEE	Std 485	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations
ANSI/IEEE	Std 665	Guide for Generating Station Grounding
ANSI/IEEE	Std 80	Guide for Safety in AC Substation Grounding
ANSI/IEEE	Std 81	Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Ground System
ANSI/IEEE	Std C37.101	Guide for Generator Ground Protection
ANSI/IEEE	810	Standards for Hydraulic Turbine and Generator Integrally Forged Shaft Couplings and Shaft Runout Tolerances

ANSI/ICEA	S-87-640	Standard for Fibre Optic Outside Plant Communications Cable
ANSI/ICEA	S-83-596	Standard for Fiber Optic Premises Distribution Cable

British Standards (BS)

BS	148	Unused Mineral Insulating Oils For Transformers And Switchgear
BS EN ISO	1461	Hot dip galvanized coatings on fabricated iron and steel articles
BS	6231	Specification for PVC-insulated cables for switchgear and controlgear wiring
BS	6651	Protection of structures against lightning.
BS	7354	Code of Practice for Design of high-voltage open-terminals stations, Section 7: Earthing.
BS	7430	Code of Practice for Earthing.

International Standards Organisation (ISO)

ISO	6826	Reciprocating Internal Combustion Engines - Fire Protection
ISO	8528	Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets – all relevant parts.
ISO	1000	SI units and recommendations for the use of their multiples and of certain other units

ITU

ITU-T Recommendation	G.650	Definition of a single-mode optical fibre cable
ITU-T Recommendation	G.652	Characteristics of a single-mode optical fibre cable
ITU-T Recommendation	G.655	Characteristics of a non-zero dispersion shifted single-mode optical fibre cable

ASTM

ASTM	A27	Specification for Mild to Medium-Strength Carbon-Steel Castings for General Application
ASTM	A36	Specification for Structural Steel
ASTM	A53	Specification for Welded and Seamless Steel Pipe
ASTM	A148	Specification for High-Strength Steel Castings for Structural Purposes
ASTM	A167	Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM	A176	Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip
ASTM	A181	Specification for Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service
ASTM	A213	
ASTM	A269	Specification for Soft Annealed Stainless Steel Tubing
ASTM	A275	Standard Method for Magnetic Particle Examination of Steel Forgings
ASTM	A282	Forged Stainless Steel Fittings, Socket-Welding and Threaded
ASTM	A285	Specification for Low and Intermediate Tensile Strength Carbon Steel Plates for Pressure Vessels (Plates 50 mm and Under in thickness)
ASTM	A312	Specification for Seamless and Welded Austenitic Stainless Steel Pipe
ASTM	A345	Specification for Flat Rolled Electrical Steel
ASTM	A388	Standard Practice for Ultrasonic Examination of Heavy Steel Forgings
ASTM	A403	Specification for Wrought Austenitic Stainless Steel Pipe Fittings
ASTM	A420	Specification for Stainless and Heat-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels

ASTM	A516	Specification for Carbon Steel Plates for Pressure Vessels for Moderate and Lower Temperature Service
ASTM	A517	Specification for High Strength Alloy Steel Plates, Quenched and Tempered, for Pressure Vessels
ASTM	A582	Specification for Free-Machining Stainless and Heat- Resisting Steel Bars, Hot-Rolled or Cold-Finished
ASTM	A668	Specification for Steel Forgings, Carbon and Alloy for General Industrial Use
ASTM	A743	Specification for Casting, Iron-Chromium, Iron-Chromium-Nickel, and Nickel Base (Corrosion-Resistant) Alloy Castings for General Application
ASTM	B21	Specification for Naval Brass Rod, Bar, and Shapes
ASTM	B31.1	Power Piping
ASTM	B42	Specification for Seamless Copper Pipe, Standard Sizes
ASTM	B88	Specification for Seamless Copper Water Tube
ASTM	B127	Specification for Nickel-Copper Alloy Plate, Sheet, and Strip
ASTM	B230	Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes
ASTM	B232	Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)
ASTM	B241	Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM	B498	Standard Specification for Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR)
ASTM	B584	Specification for Copper Alloy Sand Castings for General Applications
ASTM	R0027 Vol	Standards Related to Nondestructive Testing Developed by ASTM Committees Other Than Committee E-7
ASTM	03.03	Nondestructive Testing

Other

ASCE	79	"Manuals and Reports on Engineering Practice No. 79," (Steel Penstocks)
ASME		American Society of Mechanical Engineers, "Boiler and Pressure Vessel Code," Division 2.
AWS		American Welding Society, "Structural Welding Code."
ASME	PTC Code 18	Hydraulic Turbines

All other equipment furnished under this section shall conform to the requirements of applicable Standards.

In addition to the Standards listed in the specification, and the Standards listed, above all other aspects of the Facilities shall be designed, manufactured and tested in accordance with the pertinent provisions of the codes and standards of the following listed institutes, associations and other organizations:

Name	Abbreviation
American National Standards Institute	ANSI
American Society of Mechanical Engineers	ASME
American Society for Testing and Materials	ASTM
American Welding Society	AWS
Australian Standards	AS
Australia/New Zealand Standards	AS/NZS
Institute of Electrical and Electronics Engineers	IEEE
International Electrotechnical Commission	IEC
Specifications for Inspection of Steel Castings for Hydraulic Machines	CCH-70-2
Steel Structures Painting Council	SSPC

New Zealand Standards NZS

2.1.6.3 **Design and Planning of the Facilities**

2.1.6.3.1 General

The Contractor shall be responsible for the design and planning of the Facilities in accordance with the Contract. The Contractor shall further establish and execute a Quality Assurance Plan to ensure and verify that his work is in accordance with the requirements of the Contract.

The Contractor shall prepare the design of the Facilities which shall consist of the following:

- Tender Design, performed during the bidding process and submitted with the bidders Technical Proposal.
- Basic Design, performed immediately after the Contract is let. The Basic Design Report shall be submitted in draft form within 6 weeks of the Commencement Date.
- Detailed Design, performed before and during the construction of the Project.

The Contractor shall perform all additional field and laboratory investigations needed to fulfill the design and construction requirements given in the Employer's Requirements.

All design shall be performed in accordance with the requirements given in the Employer's Requirements. The Contractor shall design all Facilities and all necessary temporary works.

2.1.6.3.2 Contractor's Technical Proposal

The Contractor shall prepare and submit to the Employer for his review as part of the bidding process a Contractor's Technical Proposal that shall include the following as a minimum:

- A description of how the design requirements will be achieved including a description of design inputs and their sources, proposed design methods, techniques and software as well as a list of all references to be used for design of all Facilities., including:
  - Dryer Design and Methodology
  - Biomass Administering/Conveyance System
  - Gasifier Design
  - Syngas Cleaning and Cooling System
  - Gas Generator Design and Specification
  - Concept Powerhouse Layout.
  - Control and protection design concept and equipment selections.
  - Approach to testing and commissioning
- A description of all exceptions to, or deviations from the Employer's Requirements.
- Principal outline drawings (plans, profiles, sections) of the project layout and all structures with main measurement data, water levels, etc. as well as principal drawings, schematic line diagrams etc. for all mechanical and electrical deliveries.
- Summary of all tests and investigations planned to be carried out in connection with the Detailed Design.
- Quality Assurance Plan.
- Any other information specified in Employer's Requirements.

Drawings shall be appended to the Contractor's Technical Proposal

The Technical Proposal shall include the following Schedules:

Supplier Schedules, with details of the supplier for all key equipment items for the project including:-

- Dryer
- Conveyance Systems
- Gasifier
- Cooler/Cleaning System
- Syngas Engine and Generator
- Governing Systems
- Excitation Systems
- Control and Protection Systems

- Electrical/Mechanical Design Services

Equipment Schedules, completed data sheets for all of the major equipment items. Blank data sheets for this purpose are provided for:-

- Dryer
- Conveyance Systems
- Gasifier
- Cooler/Cleaning System
- Syngas Engine and GeneratorGenerators
- Governing Systems
- Excitation Systems
- Control and Protection
- DC Station Service
- Step-up Transformer
- E&M Auxiliary Services
- Powerhouse Electrical Systems

2.1.6.3.3 Design Documents and Construction Drawings

Design documents and construction drawings shall be prepared in the English language.

Design documents and all computations shall be initialled and dated by the designer and checker, and shall clearly state the Project name, calculation number and title, calculation description/objective, revision number (where revision 0 is the original submission), key assumptions, references, and a summary of the calculation conclusions/results.

All construction drawings shall be produced using the latest version of AUTOCAD. Each drawing shall be initialled by the designer and drafter as well as their respective checkers. The drawings shall include a revision number (where revision 0 is the original submission), a brief description of revision(s), and all revisions must be clearly identified on the drawing.

The Contractor shall have staff at the Site to prepare and to revise drawings and documents during construction as needed to document "as-built" conditions. Contractor shall provide three (3) copies and one (1) reproducible of final "as-built" plans for the civil works, electrical single-line drawings, and control logic diagrams, prior to issue of the Operational Acceptance Certificate for the whole of the Facilities.

All design documents and construction drawings shall be delivered in digital form to the Employer. In addition, unless otherwise specified, three (3) printed copies of each drawing and document shall be submitted to the Employer.

2.1.6.3.4 Units of Measure

The system of measurement to be used in the Project shall be in SI units. Angles shall be given in the 360-degree system.

The coordinate reference system to be used for all Facilities shall be defined by a quadrant grid system. Each drawing shall contain a scale reflecting the appropriate meter spacing. The grid system shall be defined in accordance with the Samoa national grid system.

2.1.6.3.5 Seismic Design Requirements

All designs of the Facilities shall consider earthquake loadings such that performance of the Facilities is not adversely impacted under the design seismic event. The Plant shall be designed for the following Seismic Events:

- Strength and Stability: Annual probability of exceedance of 1 in 25 years,
- Operability (including deformation, water tightness and other fit for purpose requirements): Annual probability of exceedance of 1 in 25 years

The design earthquake parameters shall be in accordance with those given in the National Building Code for Samoa. Alternatively, design to AS/NZS 1170 Part 5, Structural Design Actions - Earthquake, shall also be deemed to comply.

2.1.6.3.6 Basic Design

The Basic Design Report shall be developed from the Contractors Technical Proposal, updated as necessary. The report shall include all information required under Part 2.1.6.3.2~~2.1.6.4.2~~

2.1.6.3.7 Detailed Design

The Contractor shall make the necessary Detailed Design for construction of the Project. For each feature of the project, the Contractor shall submit to the Project Manager for his review and approval, Detailed Design documentation to include as a minimum:

- A description of each structure/feature of the Facilities.
- Assumptions, design objectives, methods and philosophies adopted.
- Design criteria, parameters, loads and load cases used.
- Applicable codes, standards, and references used.
- A short description of each method of analyses, computer programs, etc. used.
- Calculations and results of the detailed design analyses for each structure/feature of the Facilities.
- Testing requirements and criteria.
- Detailed design drawings and specifications ready for construction.

2.1.6.3.8 Design Submissions

The Contractor shall present the detailed designs, specifications and drawings for each aspect of the scheme. Each submission shall provide a complete package of information that is complete in itself and allows a full understanding of the design, drawings design criteria and applicable codes and standards that have been used in developing the design.

In general, the initial documentation for each aspect of work should consist of the items listed in the first five items above. Drawings will be rejected if this initial documentation is not available.

All drawings and design must be submitted for review. The Project Manager and his representatives will comment within the time prescribed in the Contract if there is any matter that they require attention or additional information is required to be submitted. If no comment is received from the Employer within the allowed time, the Contractor may proceed with the aspect of the Facilities covered by that particular submission.

2.1.6.3.9 Value Engineering

The Contractor may, at any time, submit to the Project Manager a written proposal which (in the Contractor's opinion) will, if adopted, (i) accelerate completion, (ii) reduce the cost to the Employer of executing, maintaining or operating the Facilities, (iii) improve the efficiency or value to the Employer of the completed Facilities, or (iv) otherwise be of benefit to the Employer.

2.1.6.3.10 Construction Methods

The Contractor shall prepare and submit to the Project Manager for his review and approval a Construction Method Report and Project Implementation Plan in conjunction with and related to the Contractor's Technical Proposal, Basic Design or Detailed Design as appropriate. The report shall include the following as a minimum:

- A description of how the construction requirements will be achieved.
- A description of construction methods to be used for all major works.
- A procurement plan for major equipment.
- Layout drawings for all temporary works.
- Principal items of construction plants to be used.
- Description of Quality Control and Quality Assurance.
- Construction Environmental Management Plan (CEMP).

The Contractor shall not start any major permanent construction work until the Contractor's Construction Method Reports, Project Implementation Plan and Construction Environmental Management Plan have been reviewed and approval by the Project Manager.

2.1.7 Construction Services

2.1.7.1 Scope of this Specification

This Specification covers requirements of the Contract for the services to be provided by the Contractor during the construction period.

2.1.7.2 General Requirements

This Specification provides an outline of the minimum construction standards required for the services facilities for the duration of the Project.

No accommodation facilities shall be erected on the Project sites, the expectation is that the Contractor will accommodate staff at commercial accommodation facilities.

2.1.7.3 Electrical Requirements

The Contractor shall provide all arrangements for temporary power supply for all sites as required for the construction activities.

Where portable diesel electric generators are used for temporary power, they shall be fitted with residential class silencers and shall only be used between the hours of 7AM and 7PM to avoid disturbing local villagers.

2.1.7.4 Potable Water Supply

Employer will engage a separate contractor, not part of this bid, ~~The Contractor shall~~ to extend portable water from a ~~provide all arrangements for the supply of potable water as well as disposal and treatment of used water.~~well and distribution system nearby to supply water for the plant. Contractor for biomass plant will install a 0.5 milliion liter water tank at the plant and connect all roof rainwater to it.

2.1.7.5 Toilet Facilities

The Contractor shall provide portable chemical toilets at each work location and arrange for their regular cleaning and emptying at an approved facility

2.1.7.6 Fire Protection

Fire extinguishers shall be provided within each building.

2.1.7.7 Communications

The Contractor shall be responsible for providing all communications (connections and hardware) to the work sites and site offices.

2.1.7.8 Office Facilities

The Contractor shall provide the office facilities which he requires for the Project.

The office facility shall be sized to allow for project meetings, including staff from the Contractor, Employer, Project Manager and other Contractors employed on the project.

2.1.8 Pre-Commissioning, Commissioning, Guarantee Tests and Tests on Completion

2.1.8.1 General Requirements

During the erection and before Operational Acceptance of the Facilities, tests shall be performed by the Contractor under the direction of the equipment manufacturers' test engineers to determine whether the Employer's Requirements have been fulfilled.

This Part describes the minimum field tests to which the equipment shall be subjected. In addition to the tests listed below, the Contractor shall perform any other tests required by the Employer to establish conformance of the equipment with the guarantees and Employer's Requirements. The provisions of this Part augment any similar requirements in other Parts of the Employer's Requirements. In case of conflict, the detailed requirements of the particular equipment Part shall prevail. The waiver of any test shall not relieve the Contractor of its responsibility to meet fully the requirements of the Employer's Requirements. The Contractor shall coordinate with the Employer, and the equipment manufacturers involved establishing mutually satisfactory dates for field tests.

2.1.8.2 Responsibility

The Contractor shall be responsible for supervision and for test procedures for all field tests on the Facilities and shall furnish the necessary calibrated test instruments and equipment.

Test Equipment. All necessary test equipment shall be provided, including wire and cable for temporary connections. The test equipment shall meet the requirements of the standards specified herein and shall be properly calibrated in a qualified laboratory. The Employer shall be given catalogues and complete specifications of all test equipment and complete certificates of calibration. Test equipment shall remain the property of the Contractor following the tests.

2.1.8.3 **Outline and Schedule of Tests and Test Plan**

At least 90 days prior to the start of testing for each part of the Facilities, the proposed schedule for performing the specified tests shall be prepared and submitted to the Employer for approval. Not later than 60 days prior to the start of testing, a complete Test Plan outlining the test objectives and requirements, the proposed methods and the field procedures to be followed for the specified tests. This Plan shall be submitted to the Project Manager for review, including:

- Test procedures and scope of tests
- List of equipment required for each test.
- Number of skilled and unskilled personnel required for each test.
- Input required from other Contractors involved in the Project and the Employer
- Schematic and circuit diagrams showing connections to be used for each test.
- Test forms and summary sheets to be used for recording data.
- The minimum/maximum acceptable test values in order to meet specified requirements for the equipment.

After the Project Manager's review, six (6) copies shall be furnished to the Project Manager for distribution to participating parties.

2.1.8.4 **Organisation**

During the testing period, starting from Pre-Commissioning through to the Guarantee Tests, the Contractor shall establish a start-up organization including all personnel, their responsibilities and the hierarchy of the organisation.

The Contractor shall appoint a Commissioning Manager, who shall be responsible for the Contractor's obligations during compliance checks, initial tests, system demonstrations and performance tests. The Contractor shall be solely responsible for testing of all systems and subsequent performance tests.

2.1.8.5 **Factory Tests**

- Factory tests shall be performed for main components and systems including Gasifier, generator(s), ~~governors,~~ switchgear, control and protection systems. The Contractor shall allow in their bid for 2 representatives of the Employer to witness and inspect works on equipment at Factory Acceptance Tests on the following
- Gasifier, Engine, ~~and~~ Generator(s), and switchgear.

The Contractor shall pay for the travel, hotel accommodation, transport, food and other incidental expenses for the employer's representatives. In addition, the contractor shall provide the Employers representatives with a $50 USD or equivalent per diem for the duration of the trip. It is the Contractors responsibility to schedule manufacturing so that the Employers representatives can witness the Factory Acceptance Tests for the turbines and generators for all three Parts of the Facilities in one trip of not more than one week duration. Should the Contractor fail to coordinate the manufacture to permit all inspections within the one week period, then the Contractor shall be responsible for all costs associated with any additional trips required.

2.1.8.6 **Testing Sequence**

A system testing schedule shall be prepared by the Contractor and reviewed by the Project Manager.

As detailed in the General Conditions of Contract there are three phases to the Facilities gaining Operational Acceptance:-

1. Pre-Commissioning. Prior to the Contractor notifying the Project Manager that the Facility is Complete, the Contractor shall have completed all Pre-Commissioning.

2. Commissioning Tests

3. Guarantee Tests.

The Operational Acceptance Certificate will be issued on the successful completion of the Pre-Commissioning tests, Commissioning tests and Guarantee Tests.

Where testing, pre-commissioning and commissioning procedures are discussed in the various more-detailed Sections and Parts comprising the Employer's Requirements, those procedures are to be followed.

2.1.8.7 **Completion of the Facilities**

The following Sections of the Plant shall be completed with separate Completion and Operational Acceptance for each Part, as individual Parts of the Facilities as permitted under the GCC:-

2.1.9 O&M Capacity Building and Knowledge Transfer Programme.

The Contractor is responsible for conducting an O&M Building and Knowledge Transfer Programme in order to advance the Employers corporate capabilities in asset management as relates to biomass gasification power facilities. The knowledge transfer programme will include:

- Preparation of an Asset Management Plan for the Facilities
- Training on biomass gasification asset management, starting at least three months before commissioning of the Facilities.
- Undertaking twice yearly reviews and refresher asset management training for a period of two years following Operational Acceptance in order to facilitate effective asset management becoming 'business as usual' for the Employers personnel overseeing the operation and maintenance of the Facilities.
- Provide a one year service contract to operate and continue training of Employer operating staff and providing technical service. At least 1 or 2 staff of Contractor will be on island during the service contract period.

At least three months prior to commissioning the Contractor shall interview key personnel in the Employers workforce in order to gain an appreciation of the current understanding of asset management processes and techniques. The Contractor shall then develop a training programme for the Employers personnel that focuses on the key areas where development and training is required.

The Contractor shall prepare an Initial Assessment and Report that:
- Provides an initial assessment of key issues to be addressed to provide data for the Asset Management Plan;
- Includes a work plan for the development and implementation of the Asset Management Plan;
- Includes an outline asset management training plan and training content details.
- Identifies issues, potential solutions and any risks;

The Initial Assessment Report be written in collaboration with the Employers personnel.

The Asset Management plan shall cover at least the following activities:
- Relevant Strategies, Policies and Plans.
- Safety audits from a civil, geotechnical, electrical and mechanical perspective.
- Plant condition assessments including analysis of Non-Destructive Testing (NDT).
- Maintenance strategy planning.
- Operational methodology.
- Risk identification and management.
- Life cycle management.
- Analysis of plant operating parameters to detect long-term deterioration of performance.
- Refurbishment.
- Asset Register including Condition Data.

It is envisaged that there will be a single Asset Management Plan and Register for the Facilities.

The Contractor shall also provide twice yearly Progress Reports that detail:

- Summary of activities for the reporting period;
- Expected activity for the coming reporting period;
- Key issues;
- Any other relevant issues.

At the end of the two year period the Contractor shall provide a Completion Report that outlines the Contractors overall judgement of success of the O&M Capacity Building and Training Programme, any critical issues and recommendations for future activities.

2.1.10 **Contractors Documents**

2.1.10.1 **General**

The Contractor shall submit Contractor's Documents as specified in these Employer's Requirements and other portions of the Contract. Unless otherwise specified below, the Contractor shall provide each Contractor's Document to the Project Manager within the time period specified.

Project Manager's review period and provision to comment shall be to confirm the Contractor's compliance with the Contract. It is intended that Project Manager shall have at least one review and comment opportunity for each Contractor Document.

Technical Submittals shall be provided as a complete package for each major system or subsystem. For avoidance of doubt the major system/subsystems shall be:-

-
- Biomass Gasification Power Plant
- Mechanical and Electrical equipment.
- Powerhouses.

The package shall include all relevant calculations, specifications and drawings. The Project Managers review/approval period for any submission will not commence until all required components of the package have been received.

2.1.10.2 **Monthly Progress Report**

Within 28 days after the Commencement Date, and at monthly intervals (by the 5th day of each month) thereafter, the Contractor shall provide a Monthly Progress Report. Such report shall include project progress, problems, significant decisions, corrective action required, supplier status, schedule analysis, and other critical project information. Three (3) original copies of each report shall be provided. The following is a suggested outline for the Monthly Report:

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY
   - A. Narrative
   - B. Contract Invoice Summary
   - C. Executive Summary Schedule
2. ENGINEERING STATUS REPORT
   - A. Narrative
   - B. Document List
3. PROCUREMENT STATUS REPORT
   - A. Narrative
   - B. Major Equipment Manufacturing Status
   - C. Procurement Log
4. CONSTRUCTION STATUS REPORT
   - A. Narrative
   - B. Quality Summary
   - C. Sub-Contractor List
   - D. Photographs
   - E. Progress Curves (Plan vs. actual "S" curves) for each major feature and for summary of project
5. ENVIRONMENTAL AND SOCIAL SAFEGUARD STATUS REPORT
   - A. Narrative
   - B. Non compliances

6. SCHEDULE
   - A. 90 Day Look Ahead Schedule
   - B. Engineering Schedule
   - C. Equipment Procurement and Manufacturing Schedule
   - D. Construction Schedule

2.1.10.3 **Monthly Project Meeting**

Approximately 5-10 days after receipt of the monthly invoice, a Project Management Meeting shall be held to review the Monthly Progress Report with the Project Manager.

2.1.10.4 **Integrated Project Schedule**

Within 28 days after the Commencement Date, Contractor shall submit an Integrated Project Schedule, including engineering, procurement, manufacturing, fabrication, transportation, construction, and testing, commissioning activities. The schedule shall be presented in electronic format as well as hardcopy. Electronic copies shall be Microsoft MS Project format to the Project Manager. The Contractor is free to use any other package such as Primavera as their main scheduling tool for the project. If a package other than MS Project is used the Contractor must provide paper copies in color, at a scale able to show the detail inherent in the schedule.

The Contractor shall utilize the Critical Path Method (CPM) of planning and scheduling to produce the Integrated Project Schedule.

The Contractor shall develop a detailed construction plan covering the entire scope of the work. Each task shall include relevant information, such as description and duration, work relationships, material or equipment deliveries, access limitations, and other details that affect the sequence and duration of the work. Negative lags and constraining dates shall not be allowed. Duration of individual activities shall not exceed 30 calendar days.

Monthly Progress Reports shall include a schedule update and progress tracking to compare the actual status of the Project with the scheduled baseline progress. Actual status shall be measured and reported using Earned Value techniques approved by the Project Manager.
The Project Manager may require the Contractor to modify any portion of his schedule and work plan, judged impractical, unfeasible, unreasonable, or not in compliance with the Contract.

2.1.10.5 **Safety Plan**

Within 42 days after the Commencement Date, Contractor shall provide a Safety Plan applicable to this Project.
The Contractor is responsible for the health and safety of all persons on the Site. All necessary precautions shall be made to prevent accidents and personal injuries. The Contractor shall present his planning and organization for the health and safety in advance of the actual construction works.

The Contractor shall make plans for dealing with emergencies at the Site, the Contractor's work areas, and during transportation. The plan shall include first aid, transporting accident victims to hospital, first aid education for employees, dealing with fires, etc. Such plans shall provide for all types of weather and working conditions which will be encountered at the Site and the Contractor's work areas.

In case of an accident connected with the execution of the Facilities, the Contractor shall immediately notify the Project Manager of the accident and shall provide full details of the circumstances and events regarding the accident.

2.1.10.6 **Quality Assurance Plan**

Within 42 days after the Commencement Date, Contractor shall provide a Quality Assurance Plan applicable to this Project.

The Contractor's Quality Assurance Plan shall comprise procedures for Quality Control and Quality Assurance. The plans shall include both design requirements and construction materials and workmanship requirements.

The Quality Assurance Plan shall define and document the Contractor's commitment to and policy for quality. The Contractor shall ensure that the policy and the associated procedures are understood, implemented and maintained at all levels in his organization, including all subcontractors. The Contractor's Quality Assurance Plan shall be based on well-established principles and proven performance.

The Quality Assurance Plan shall be supplemented as work proceeds with specific work and inspection procedures for all major activity. The work and inspection procedures shall include:

- Acceptance criteria, witness points and hold points specified in the construction requirements or in any standard or code adopted by the Contractor.
- Witness points for all the stages in the construction process where subsequent activities will disguise the quality and/or quantity of the previous activity thus making inspection and testing unfeasible, and/or where the subsequent activities will prevent correction of non-conformities.
- The Contractor shall issue relevant work procedures and inspection plans for the Project Manager's review prior to the commencement of each main activity, unless stricter demands are specified in special cases.

The Contractor's Quality Assurance Plan shall be submitted to the Project Manager for review. The Contractor shall monitor and approve his own work using the Quality Assurance Plan. The Project Manager will monitor the Contractor's ability to follow approved plans and procedures throughout the entire project. The Contractor shall provide copies of review reports and test reports to the Project Manager on a monthly basis. The Project Manager may audit the Contractor's records at any time to verify that sufficient reviews, checks, and tests are being performed. The Project Manager reserves the right to:

- Include further stages as witness or hold points if these are considered to have been omitted by the Contractor;
- Change the designation of any stage from a witness point to a hold point should this be deemed necessary.
- Require all materials to be identifiable and traceable, unless otherwise stated.
-

2.1.10.7 **Construction Environmental Management Plan**

Within 42 days after the Commencement Date, Contractor shall provide a Construction Environmental Management Plan applicable to this Project.

The requirements of the Construction Environmental Management Plan are detailed in the IEE – refer Section 6 Part 4 - Supplementary Information.

The Contractor's Construction Environmental Management Plan shall be submitted to the Project Manager for review. The Contractor shall monitor and approve his own work using the Construction Environmental Management Plan. The Project Manager will monitor the Contractor's ability to follow approved plans and procedures throughout the entire project. The Contractor shall provide copies of review reports and test reports to the Project Manager on a monthly basis. The Project Manager may audit the Contractor's records at any time to verify that sufficient reviews, checks, and tests are being performed

2.1.10.8 **Test and Commissioning Plan**

Contractor shall provide a plan to perform Pre-commisioningand Commissioning of the Facilities.

2.1.10.9 **Guarantee Test Procedures**

Contractor shall provide procedures to perform the guarantee tests.

2.1.10.10 **Training Program**

Contractor shall provide a plan to train the Employer's O&M personnel in the operation of the Plant.

2.1.10.11 **Materials**

Current certificates of tests by manufacturers shall be available for inspection by the Project Manager. Such certificates shall relate to the materials delivered to the Site and Contractor's work areas. Certified true copies of certificates may be submitted if the original certificates cannot be obtained from the manufacturer. A letter from the supplier certifying that the certificates are related to the delivered materials shall be submitted with the certificates.
Parts and/or materials which are to be assembled on the sites and Contractor's work areas, shall be marked to identify the component parts.

Materials which are specified by means of trade or proprietary names may be substituted by the equivalent materials from a different manufacturer provided that the materials are of the same or better quality and comply with the specified requirements.

All materials and goods shall be stored strictly in accordance with the manufacturer's instructions so as to insure no deterioration occurs prior to incorporation in the Facilities.

Materials and goods shall be stored to prevent harm to people's health or the environment.

2.1.10.12 **Supplier Information**

Contractor shall submit two (2) copies of technical data for major materials and equipment procured, including shop drawings, erection drawings, and supplier manuals.

2.1.10.13 **Purchase Orders**

Unpriced purchase orders, shall be submitted by the Contractor for all purchased materials and equipment and any subcontracted services. Every 30 days Contractor shall update and submit two (2) copies of the purchase order log.

2.1.10.14 **Spare Parts Lists**

Contractor shall provide a recommended priced spare parts list no later than 120 days after its placement of orders for materials and equipment.

2.1.10.15 **Geotechnical Surveys**

Contractor shall submit two (2) copies of the results, reports or recommendations of any additional geotechnical surveys or investigations that the Contractor shall perform at the Site for the purposes of design of foundation for power plant and gasifier or construction of the Facilities.

2.1.10.16 **Notice(s) of Equipment Inspections**

Project Manager will review purchase orders and advise Contractor of any tests or inspection hold points specified in the purchase orders that Project Manager desires to witness. Contractor shall provide Project Manager reasonable notice to witness these inspections and tests designated to be witnessed at suppliers' works.

2.1.10.17 **Shop Inspection and Test Reports**

All shop inspection and test reports for Materials and Equipment shall be submitted to Project Manager for review.

2.1.10.18 **Quality Control Reports**

The Contractor shall submit two (2) copies of quality control records such as, concrete test reports, structural steel bolting, weld inspections (visual, magnetic particle, X-ray), stress relieving, pump alignment, motor meggering, continuity wiring checks, etc.

2.1.10.19 **Manufacturer Field Service Reports**

All manufacturers' field representatives shall provide field inspection reports upon completion of each Site visit. Contractor shall submit these reports to Project Manager.

2.1.10.20 **As-Built Drawings**

Contractor shall provide three (3) copies and one (1) reproducible of final plans for the civil works, P&ID's, electrical single-line drawings, and control logic diagrams, prior to issuance of the Operational Acceptance Certificate.

2.1.10.21 Technical Documentation

2.1.10.21.1 General

The Contractor shall submit to the Project Manager Technical Documentation in accordance with the requirements of the Employers Requirements.

2.1.10.21.2 Specifications

Contractor shall submit to Project Manager for review all specifications issued by the Contractor to suppliers for procurement of major permanent equipment materials or subcontract services, conformed for purchase.

Contractor shall submit detailed technical specifications. The Contractor's specifications shall be used to ensure that construction of the Facilities satisfies the design requirements, achieves acceptable quality goals, and is consistent with good quality industry standard practices. Specifications shall include sections relevant to:

- Site preparation.
- Temporary works.
- Excavation and filling.
- Foundation preparation.
- Concrete including cement, reinforcing steel, formwork, joint treatments, placement, and all other details required for the Facilities.
- Structural steel and miscellaneous steel works.
- Masonry construction.
- Supply and Installation of biomass gasification equipment.
- Supply and Installation of mechanical equipment.
- Supply and Installation of electrical equipment.
- Any other necessary sections.

Construction specifications shall include:

- Materials to be incorporated in the Facilities.
- Standards and codes.
- Requirements for material placement and installation.

All technical specifications shall, as a minimum, be prepared in the same standard format and organization. The organization and format shall be consistent with international practice for projects of this type and acceptable to the Project Manager.

2.1.10.21.3 Outline Drawings

Outline drawings shall be drawn to scale and denoted with critical or major dimensions. Drawings shall include estimated weights, external forces, anchoring details, overall dimensions and information on oil, compressed air and cooling water requirements for the equipment.

2.1.10.21.4 Detail Drawings

Detail drawings shall consist of general assembly Drawings, subassembly Drawings and details to demonstrate fully that all parts will conform to the provisions and intent of these Employer's Requirements and to the requirements of their installation, operation and maintenance. The Drawings shall show all necessary dimensions and fabrication details, including type and grade of materials, the design of welded and bolted joint connections and tolerances on fits and clearances; all field joints and subassemblies in which the Contractor proposes to ship the equipment; locations and sizes of auxiliary connections for oil, grease, water and air; and, piping and process flow diagrams. Detailed specifications shall be submitted by the Contractor for the design of all major components and for other features or details when requested, including the stress levels calculated by the Contractor. The Project Manager shall have the right to request the Contractor's design calculations, which clearly indicate all assumptions, methods and results. The Contractor shall provide English translations of any non-English text as required to explain the calculations to the Project Manager satisfaction.

2.1.10.21.5 Single-Line Diagrams

Diagrams shall show the power connections, location of instrument and control transformers, and connections to transducers, meters, relays and instruments.

2.1.10.21.6Schematic/Elementary Diagrams

Diagrams shall demonstrate the operation of the supplied control equipment. They shall include:

- Range, operation and setting for time delay relays and timers.
- Set and reset points for process instruments.
- Protective relay settings.
- Fuse and circuit breaker ratings.
- Control voltage and, if source of control voltage is not supplied by manufacturer, recommended overcurrent protection and conductor size for supplying the circuit.

2.1.10.21.7Wiring Diagrams

Diagrams shall show the point-to-point interconnections of the control and power equipment. Control devices and terminal blocks shall be shown in their correct relative positions. One side of the terminal blocks shall be clearly identified for external wiring connections and shall be free of any manufacturer's wiring. Control devices and terminal blocks shall be identified in accordance with schematic/elementary diagrams.

2.1.10.21.8Front-of-Panel Layouts

Equipment and nameplates mounted on the fronts of control cabinets and switchboards shall be shown. Diagrams shall be drawn to scale.

2.1.10.21.9Nameplate Schedules, Meter Scales, Engravings and Switch Handles

Schedules for all front-of-panel devices and equipment shall be provided. Nameplate schedules shall include dimensions and lettering size. Scale markings for meters and other indicating instruments shall be shown. Escutcheon plate and legend plate engravings and type and color of switch handles shall be shown.

2.1.10.21.10 Design Calculations

The design calculations shall define the basic design approach, assumptions, criteria used and the calculated stress levels in sufficient detail to demonstrate that the equipment meets the specified requirements and to provide adequate information for trouble-shooting of the equipment.

Detailed calculations for all protection settings shall be provided

2.1.10.21.11 Bills of Material

A list of equipment shall be submitted for each major assembly or sub-assembly and shall include the names of manufacturers of articles and auxiliary equipment to be incorporated in the work, together with description, part number, ratings, performance characteristics and other significant information as necessary to allow the Employer to obtain replacement parts. A separate list of equipment shall be provided for each printed circuit board and sub-assembly incorporated into the work, identifying the individual components mounted on the board. Bills of Material shall be provided listing the spare parts, special tools and maintenance equipment.

2.1.10.21.12 Cable Schedules

Tabulations showing the routing of all cable and wire used for power, control and instrumentation circuits shall be provided. Cable tabulations shall be prepared showing the type, size and number of conductors in each cable. Each cable shall be given a unique cable identifier. The cable tabulations shall list the equipment to which each cable is connected (From/To) and the cable tray in which it is routed.

2.1.10.21.13 Functional Block Diagrams

Block diagrams shall be provided that show the functional configuration of the main components of a system including the communication network and paths interconnecting them. The functional block diagram shall be presented in a manner that conveys the functionality of the system. Interfaces to main structures and equipment components in the Project shall be shown as well as interfaces with Employer's remote facilities.

2.1.10.21.14 Termination Drawings/Schedules

All terminations of power, control and instrumentation cable external to an electrical component, panel or cabinet shall be shown either on termination drawings or on schedules. Information shall include the terminal block designation, cable identifier, cable characteristics (i.e., size, number conductors/pairs/triads, shielding) conductor identification (e.g., number, color), number of spare conductors and to where the other end of the cable is routed (with references).

2.1.10.21.15 Logic Diagrams

A complete set of logic diagrams describing the software used in microprocessor-based controllers shall be provided. The logic diagrams shall be provided as follows:

- Analog Control Loops. These diagrams shall be provided in accordance with ISA standard format.
- Sequencing Controls. Controls used for sequencing logic shall be provided in Boolean or ladder-type format.

2.1.10.21.16 Instructions

2.1.10.21.16.1 General

The Contractor shall submit written detailed instructions for shop assembly and testing; handling and storage; installation, operating and maintenance and field commissioning procedures of check-out, start-up, initial operation, testing and test run for each item of equipment. The instructions shall be submitted as early as possible so that final reviewed copies can be made available to the field for use in planning their work well in advance of actual installation and operation. After review, ten (10) complete, durable bound copies of the final instructions shall be furnished.

2.1.10.21.16.2 Shop Assembly and Testing Procedure

A step-by-step procedure shall be submitted outlining the details of the checks to be made before and after shop assembly and testing of the equipment to demonstrate that the requirements of these Employer's Requirements and other parts of the Contract have been fulfilled. The shop assembly and testing procedure shall be submitted in a tabular form itemizing each test, indicating the results expected in accordance with the design and leaving space for the actual observation during assembly and testing. The test procedures shall include test values to be used, maximum/minimum acceptable test results and reference to accepted industry standards. The limitations, if any, of the shop tests shall be fully explained and shall be approved by the Project Manager.

2.1.10.21.16.3 Handling and Storage Instructions

Detailed instructions, with illustrations, diagrams and weights, for handling, storage and care of equipment at the site shall be submitted. The instructions shall include:

- Identification of parts requiring special outdoor, indoor or temperature or humidity-controlled storage for both long- and short-term storage;
- Space requirements for outdoor, indoor and temperature- or humidity-controlled storage for both long-term and short-term storage;
- The procedures to be observed in unloading, placing, stacking and blocking of equipment;
- Rigging and lifting procedures;
- Maintenance procedures for both long- and short-term storage including maximum recommended storage period for items stored outdoors;
- Periodic rotation of components, where required;
- Application of protective coatings; and
- Cleaning of protective coatings and/or corrosion prior to installation.
-

2.1.10.21.16.4 Installation Instructions

Detailed instructions for the installation of the equipment shall be submitted together with reduced-size copies of applicable Drawings showing the erection sequence. The instructions and Drawings shall include information on handling and slinging the major pieces of equipment including weights, erection tolerances and special precautions to be observed during installation.

2.1.10.21.17 Operating and Maintenance Instructions

Detailed operating and maintenance instructions, which shall include reduced-size copies of all Drawings, applicable parts lists and catalogs covering all equipment furnished and which may be needed or useful in operation, maintenance, repairs, dismantling or assembling and for repair and identification of parts for ordering replacements, shall be submitted. The operating and maintenance instructions shall include a complete set of performance curves clearly showing the operating limits over the full range of operating heads.

Operating and maintenance instruction manuals shall be written to provide a complete and clear text, which can be used directly throughout the service life of the equipment without any addition by the Employer. Terminology and designations used in the instruction manuals shall be exactly the same as used on the Contractor's Drawings.

The sequence of subjects within the instructions, the arrangement of paragraphs and the use of headings shall permit an overview of the entire subject matter as well as permit quick reference to particular subjects.

The operating and maintenance instructions shall clearly state the salient features of the equipment supplied and the operation of the electrical controls. All required liquid levels, flows, pressure settings and settings for all auxiliary protective devices shall be included. A troubleshooting chart, maintenance timetable, lubrication diagrams and disassembly, reassembly and adjustment procedures shall be provided.

2.1.10.21.18 Reports

The Contractor shall furnish six (6) bound copies of all final reports related to the equipment including testing, initial operation, load rejection and load acceptance tests and the index and capacity tests. The reports shall be bound for permanent reference use.

2.1.10.21.19 Photographs

The Contractor shall furnish progress photographs of the shop and field erection work done. Photographs shall be taken at approximately quarterly intervals. Photographs shall be approximately 200 mm by 250 mm in size including a margin on one 250 mm side for binding. Approximately twenty-five (25) views each of the turbines and generators and five (5) views each of the inlet valves, governing systems and excitation systems will be required. Each photograph shall contain upon its face the date, the name of the manufacturer and the title of the view taken.

2.1.10.21.20 Submission of Technical Documents

The contractor shall issue to the Project Manager ALL technical documents and drawings for review and approval.

2.2 Civil Specific Requirements

2.2.1 Geotechnical Investigations

Geotechnical information is limited due to site constraints and accessibility. However it is anticipated from site observations and walkover that keying in bedrock will be achievable at relatively shallow depths.

The Contractor shall allow for any additional Geotechnical Investigations it deems necessary such that the design and construction of the Facilities shall be completed in accordance with the Contract.

For the avoidance of doubt rock is defined as material which is unable to be excavated with a 15 tonne excavator with a 400mm wide bucket and requires to be broken out with a mechanical breaker or with blasting.

2.2.2 Topographic Investigations

Lidar data were surveyed in early 2015. This information was been included in Section 6 Part 4 Supplementary Information, electronic copies of the surveys have also been included.

The Contractor shall verify the adequacy of the survey information. The Contractor shall make its own interpretation of the surveys and carry out any additional investigations it deems necessary such that the design and construction of the Facilities shall be completed in accordance with the Contract.

All work, including access, spoil, trenches, Plant and Facilities shall be entirely within the easements shown on the Employers survey and site plans. Should the Contractor wish to undertake work outside these areas, or require clarification as to the easement boundaries, they must obtain the Project Managers approval.

2.2.3 Access Roads – ALL ROAD WORK WILL BE HANDLED UNDER SEPARATE CONTRACT BY EMPLOYER. IT IS NOT PART OF BIOMASS CONTRACT.

2.2.3.1 Function

The access roads shall provide safe access in all weather conditions for rubber tyred vehicles and heavy transporters from existing roads to the intake areas.

All roads shall be designed for the loads from the Contractor's Equipment and the transporters carrying the heavy mechanical and electrical plant.

2.2.3.2 Existing Access Roads

The access roads are to following the existing access roads and easement accesseswhich are in a varying state of repair from fit for purpose to either fully overgrown or have significant debris across them.

2.2.3.3 Contractor's Design

The Contractor shall design, construct and maintain all roads and related works required for access to the Site and that may be necessary for completion of the Facilities. In case that the access roads are used as construction roads, the Contractor shall repair such access roads, if necessary, and transfer the access roads to the Employer in good condition after taking-over as permanent roads specified in the Contract.

Unsealed access roads in varying states of repair are shown on the drawings.

Where the Contractor believes an existing road needs repair or upgrading to permit construction activities, the Contractor shall repair the road at their own expense. In the situation where the Contractor damages an existing road, the Contractor shall repair the road back to its original condition.

2.2.4 Powerhouse and Transformer

2.2.4.1 Function

The powerhouse houses all mechanical and electrical plant and equipment require for the generation of electrical power including the control equipment and ancillary's requirement for the operation and maintenance of the facility.

The transformer shall be pad mounted outside of the powerhouse.

2.2.4.2 Contractors Design

2.2.4.2.1 Requirement

The Contractor shall design:

- The powerhouse and the associated structures to house all mechanical and electrical plant required for generation and transmission of electricity.
- The tailrace arrangement to discharge the design discharge to the river.
- The transformer pad.
- The hardstanding area.
- All necessary services that include drainage, lighting and power supply to the area etc.
- Security fencing around the area with gated vehicle access into the hardstanding area.

2.2.4.2.2 Powerhouse

The powerhouse shall include provision for loading and unloading of equipment, materials, tools and other relevant items for the purposes associated with operation, maintenance and overhaul.

The powerhouse shall include:

- Machine bay
- Loading bay.
- Control area
- Batteries and panels area.
- Overhead travelling crane.

The above can in a single room or separate areas/ rooms.

Adequate access, laydown and withdrawal areas shall be provided to allow ready maintenance of the powerhouse equipment without unnecessary dismantling of adjacent plant to gain access.

The powerhouse shall have a minimum of two safe means of access and egress generally located opposite each other.

All access doors to the powerhouse shall be heavy metal construction security doors. Roller doors to the loading bay shall be reinforced to prevent forces entry by vehicles.

Windows for natural lighting shall be fixed glazed to minimise unwanted entry of vermin. The total area of glazing provided shall be at least 10% of the floor area distributed evenly around the room.

Staircase access and platforms shall be provided where necessary to gain access. Where access for operational inspection is required on an infrequent basis only, fixed step ladder access is acceptable, however care is to be taken to ensure that the requirement to use fall arrest devices is avoided. In all cases the creation of confined spaces due to ladder access shall be avoided. Where operational access is required on a frequent basis, or where maintenance access is required, stair access shall be provided.

All floors shall be constructed from reinforced concrete complete with an industrial floor finish suitable for its permanent use.

The Powerhouse shall be provided with forced ventilation. Ventilation shall be incorporated into the Powerhouse to simplify the layout of ducts and pipework for the distribution of supply air and collection of exhaust air throughout the station.

Handrailing shall be provided where required and removable handrailing shall be provided for use around hatches and other openings which may be left open for extended periods.

The Powerhouse will be enclosed by a steel truss roof with weatherproof protected metal roofing and internal linings and metal walls with cladding or concrete blockwork construction. Provisions for stormwater management shall be included in the arrangement. The Contractors design shall prevent condensation from developing on the roof linings and dripping into the powerhouse.

The machine bay shall house a single turbine and generator unit and the associated auxiliary equipment. Permanent station cranage shall be provided that covers the loading bay with sufficient capacity to handle all major plant components. The station crane shall be of a manually operated chain driven type.

A loading bay shall be provided in the powerhouse. It shall be arranged such that vehicles will be able to drive in to load and unload equipment using the station crane.

Cableways shall be adequately sized for the services requirements and shall be fire rated in accordance with the appropriate standards. The cables within the powerhouse shall be laid in cable trenches covered with metal floor plates.

Station drainage shall be collected in a sump pit below the lowest section of the powerhouse. The sump shall be sized and configured to accommodate the drainage and sump pumps, have sufficient volume for requirements associated with pump cycling times, oil spill capture and containment, and have adequate access for operation and maintenance.

The aim of oil containment is to minimise environmental contamination and spread of fire in the event of an oil or fuel spill and to meet requirements of environment regulations.

Oil and other industrial liquid waste shall be separated from rain, water and other drainage water and retained for recovery and deliberate disposal.

Oil containment systems shall be incorporated into the Facilities, designed to catch and contain any oil spilt from oil filled equipment. In addition, provisions shall be made to contain any spillage arising from the storage or handling of oil.

2.2.4.2.3 Transformer Compound

The transformer shall be located in a small compound adjacent to the powerhouse.

The footings for the transformer equipment shall be designed to resist the loadings applied by the installed equipment. Cable ducting shall be provided to distribute cabling from the transformer to the powerhouse and from the transformer to the 22kV overhead distribution line. Transformer shall be installed inside a concrete bund to stop spill of any oil onto the ground. Bund drain shall be fitted with a device that will drain water and contain oil spilled from the transformer.

The transformer compound shall be covered with a 150 mm layer of crushed aggregate.

The transformer compound shall be drained by a system of drains consisting of pipes, sumps and concrete trenches with gratings connected to the powerhouse drainage system.

The arrangement of the equipment shall have adequate space for access for maintenance and operation; and particularly for electrical and safety clearances.

The arrangement shall permit safe access with all equipment energised, with personnel on foot in all parts of the transformer compound and with vehicles on the road pavement.

The drainage system for the transformer compound shall be designed for a 1 in 100 year return period storm without any sumps surcharging above their gratings. Pipes and surface drains shall have a minimum grade sufficient for self cleaning.

Transformer shall be fenced off with a 2meter high chain link fence with gate. Use 1.5 inch diameter galvanized pipes for fence post with a concrete base around the fence.

2.2.4.2.4 Hardstand Area

A hardstand area shall be provided adjacent to the powerhouse. The area shall be provided with a security fence and access to the area shall be gated and via the access road for the project.

The area shall have adequate area for:

- Parking facilities for the vehicles that will be used during the operation and maintenance of the facility;
- Sufficient area for the vehicles transporting equipment to load and unload the equipment in addition to the parking facilities;
- Unrestricted access to the powerhouse and switchyard in addition to the parking facilities

2.2.4.2.5 Drainage

- The Contractor shall design a drainage system to collect and remove drainage water from the area.
- The drainage shall discharge to the tailrace or the river.

2.3 Civil General Requirements

2.3.1 Demolition and Site Clearance

2.3.1.1 Scope

This Specification covers the removal of vegetation and surface obstructions, and the demolition and removal of structures, including their foundations, if any.

2.3.1.2 Applicable Codes and Standards

a) All work, materials and practices shall comply with the requirements of current New Zealand or Australasian standards for that particular class of work. The following standards shall apply specifically:

AS 2601:2001 : Demolition of Structures
NZS 4224:1983 : Code of practice for measurement of civil engineering quantities

b) Compliance with these Codes and with this Specification shall be the minimum requirement necessary for this Contract.

c) The documents listed above and in the clauses that follow refer to their latest issue complete with amendments that are current at the date of the Tender Document and are deemed to form part of this Specification. However, this Specification takes precedence when it is at variance with the cited document.

2.3.1.3 Disposal of Materials

a) Material obtained from clearing and grubbing and from the demolition of structures shall be disposed of by dumping and burying on site at locations indicated by the Project Manager. The Contractor shall control the dumping operation to optimise utilisation of the dump area and shall shape the dump during the progress of the works to prevent erosion or the ponding of stormwater.

b) Where no such place for disposal on the site of the Facilities is indicated by the Project Manager, the Contractor shall make his own arrangements for dumping the material at an approved location outside the site of the Facilities.

c) The Contractor shall endeavour to recover old and damaged pipelines/ penstocks for reuse elsewhere in the Facilities. Should the Contractor wish to sell the pipelines/ penstocks as scrap or to other parties for reuse then these savings shall be passed on to the Employer.

d) Combustible material shall not be burned without the written permission of the Project Manager. Such permission will only be granted where burning is permitted by the local authority and where the resulting air pollution will not cause a nuisance. Plastic material shall not be burnt. It shall be the Contractor's responsibility to obtain the necessary consents for the burning of waste and to comply with the conditions of the consent. A copy of the consent shall be forwarded to the Project Manager before any burning takes place.

e) Fencing wire shall be neatly wound into rolls and, together with the fence posts and other re-usable materials, neatly stacked on the site of the Facilities.

f) Trees and material from structures shall be removed from the site of the Facilities or unless instructed otherwise by the Project Manager.

2.3.1.4 Area to be Cleared

a) All areas on which earthworks, cuttings, embankments, borrow pits or structures are to be constructed shall be cleared and grubbed.

b) In order to limit dust and erosion, clearing and grubbing shall be carried out at the latest practicable stage of the Contract.

2.3.1.5 Trees

a) When cutting or trimming trees, the Contractor shall take the necessary precautions to prevent injury to persons and animals and damage to property. Where necessary, trees shall be cut from the top downwards.

b) No tree shall be cut down until the Project Manager has given written authorisation for such work to commence.

c) Individual trees indicated and marked by the Project Manager as 'trees to be preserved' shall be left standing and uninjured.

2.3.1.6 **Clearing**

Clearing shall consist of:-

i. the removal of all trees, bushes, roots, other vegetation, rubbish, fences and all other materials that interfere with the construction of the Facilities;

ii. the disposal of all materials resulting from the clearing;

iii. iv. the removal of small boulders lying on the surface;

v. where fences have to be taken down and retained on the site of the Facilities, the sorting, coiling and stacking of the material; and

vi. the removal and stacking of other re-usable materials as specified.

2.3.1.7 **Grubbing**

a) All stumps and roots larger than 50mm in diameter shall be removed to a depth of at least 200mm below the cleared surface.

b) Except in borrow areas, cavities resulting from grubbing shall be backfilled with approved material and compacted to a density at least equal to that of the surrounding ground.

2.3.1.8 **Topsoil**

If there is good quality topsoil within the limits of the cleared area, the Contractor shall remove and stockpile the topsoil and grass, and shall conserve it for later use in the manner specified.

2.3.1.9 **Existing Road Pavements**

Existing road pavements or hardstandings that are no longer required, shall be scarified and windrowed free of soils, clay or other contaminating material. The aggregates shall then be recovered and carted to stockpile for subsequent reuse if required or disposed of in an appropriate manner.

2.3.1.10 **Reclearing of Vegetation**

If vegetation grows on any portion of the cleared areas, such areas shall be cleared again before the construction of earthworks or structures over the area.

2.3.1.11 **Demolition of Structures**

a) Structures shall be demolished in accordance with AS2601.

b) Structures that cannot be cleared by a bulldozer of mass approximately 20 tonnes and flywheel power 130kW shall only be demolished by contractors suitably qualified and skilled in such work. In such cases, the Contractor shall prepare a method and capability statement to the satisfaction of the Project Manager for the demolition of the structure.

c) Explosives and blasting for clearance of structures shall only be permitted where stated in Section 4 of this Specification.

2.3.1.12 **Environmental Considerations**

Clearing, grubbing, and permanent disposal of materials removed during clearing and grubbing operation during the period of construction shall conform to the requirements of all applicable laws, regulations and permits. The Contractor shall be responsible for obtaining and/or complying with any and all permits associated with clearing, grubbing, and permanent disposal of materials.

2.3.2 Crop Compensation

Prior to clearing the Contractors Local Liaison Officer shall consult with the local landowners to confirm crop compensation values (paid for by others) and shall advise this to the Project Manager.

2.3.3 Fills

2.3.3.1 Scope

The Contractor shall plan, design, construct, and maintain all permanent and temporary fills required for construction of the Facilities. Such work shall include, but not be limited to preparation of foundations for placement of fills, and furnishing, placing, compacting, and maintaining materials for fills required for construction of the Facilities.

All fill work shall be conducted in accordance with this Part and all other pertinent parts of the Employer's Requirements. The Contractor is solely responsible for conducting all investigations and testing necessary to determine fill properties, quantities, placement requirements, and placement techniques to achieve the requirements of the design.

2.3.3.2 Quality Control and Assurance

The Contractor's Quality Assurance Plan shall include a method statement regarding the quality assurance intended to be carried out in association with fill placement, including topographic survey profiles, foundation preparation, material sampling, in-place density testing of all constructed fills to confirm that the required compaction has been achieved, and related laboratory testing has been performed. Quality assurance related to fill work shall also include test fills required to determine the engineering properties of various fill materials in accordance with this specification, and refine fill placement techniques. In-place density testing shall be carried out using a Nuclear Density Meter for all fill materials containing coarse aggregates that are maximum 40mm in size. Site testing of fills with maximum aggregate size greater than 40mm shall be tested. Filling and compaction shall be in accordance with Clause 10 of TNZ F/1.

2.3.3.3 Submittals

The Contractor shall submit to the Project Manager gradations of all materials, laboratory and field density testing, and records of inspections and all other tests and test fills required to furnish and place fills for construction of the Facilities, as well as records of any corrective actions taken during fill placement activities.

2.3.3.4 Materials

The Contractor shall construct test fills as required to determine the engineering characteristics and suitability of materials obtained from borrow or excavation on Site as fill materials, as well as to determine the proper placement and compaction conditions and requirements to achieve the design objectives. Results of all test fill construction and testing shall be recorded and provided to the Project Manager.

Demonstration and verification of the suitability of all materials and their placement in the fills shall be the Contractor's sole responsibility.

Materials shall be reasonably well graded except where specified, and shall be free of roots and organic matter. All fills supporting, or influenced by any structure shall comprise of clean well graded gravel with a maximum size of 100mm, and shall be crushed and/or screened (i.e manufactured) material.

Adjacent fill materials of varying gradation shall be compatible with each other. Suitable geotextile filter fabric may be used to separate adjacent fill materials of varying gradations in fills other than fill dams, if necessary, as long as the geotextile filter fabric is designed, supplied and installed in accordance with all applicable standards and regulations. Where the potential for seepage through fill exists, adjacent fill zones shall be designed in accordance with standard filter criteria as specified.

2.3.3.5 Lines and Grades

The fills shall be constructed to the design lines, grades, and cross sections developed by the Contractor and shown on the Construction Drawings. Fills shall be over-built as required to account for settlement during and after construction of the Facilities. Slopes exposed to view, including rockfill slopes, shall be dressed to neatly appearing final surfaces. The thickness of various fill zones within each embankment may be increased or decreased or other such changes may be made as required for conditions encountered during construction or as a result of test fill results.

2.3.3.6 **Foundation Preparation**

All surfaces on or against which fill material is to be placed shall be treated after excavation to final grades in accordance with 'Excavation'. All foundations upon which fill will be placed shall be unwatered and free of standing or running water in accordance with 'Diversion and Care of Water'. No fill material shall be placed until the foundation has been treated and prepared for receiving fill.

Foundations in overburden, excavated overburden slopes and fill slopes upon which fill material will be placed shall be scarified and compacted prior to fill placement.

2.3.3.7 **Placement and Compaction**

All fill materials shall be placed in lifts at the proper moisture content and compacted by suitable compaction equipment to achieve the proper density, including fills placed on slopes that may require specialized equipment or compaction procedures.

Fills shall be maintained and protected in a satisfactory condition at all times until final completion and acceptance of the Facilities. As soon as practicable after the construction of the fills has commenced, the surfaces shall be sloped or crowned sufficiently to prevent the ponding of water and this crown or slope shall be maintained during construction.

Any fill material rendered unsuitable after being placed in the fills shall be removed and replaced to the satisfaction of the Project Manager.

Temporary construction slopes within the fill should not be steeper than 2.5H:1V. Materials placed against temporary slopes should be well keyed into the temporary slope.

In order to achieve a good contact against adjacent structures, and achieve good compaction, fill materials adjacent to structures and abutments should be ramped for a minimum distance of 5 meters to a height approximately 600 mm, or two layer of fill, higher than the general level of the fill during construction.

Care shall be exercised when operating compaction equipment adjacent to abutment contact areas to avoid disturbing abutment material. Disturbed material shall be removed, appropriate foundation treatment be made, and replaced with appropriate fill materials.

During severe weather conditions when fill works must be temporarily halted, the top surface of fills to receive additional fill materials shall be protected by placing a loose layer of fill or plastic sheeting over the compacted surface. Prior to resuming fill placement activities, the protective layer of loose fill or plastic sheeting shall be removed and the original surface scarified and compacted. Should the original surface be found to be frozen, disturbed, or otherwise contaminated, such zones shall be removed. Resumption of fill placement activities can occur only after inspection and acceptance by the Project Manager of the repaired surfaces.

2.3.4 **Earthworks (Pipe Trenches)**

2.3.4.1 **Scope**

This specification covers the excavation, backfilling and reinstatement of trenches for pipes and culverts, but excludes the bedding of pipes and culverts.

2.3.4.2 **Applicable Codes and Standards**

a) All work, materials and practices shall comply with the requirements of current New Zealand, Australasian or other standards for that particular class of work. The following standards shall apply specifically:

BS 1377.1-9:1990 : Methods of test for soils for civil engineering purposes

NZS 3109:1997	: Concrete construction
NZS 3111:1986	: Methods of test for water and aggregates for concrete
NZS 3116:2002	: Concrete segmental and flagstone paving
NZS 4224:1983	: Code of practice for measurement of civil engineering quantities
NZS 4402.2.1-8:1986	: Methods of testing soils for civil engineering purposes - Soil classification tests
NZTA M07:2009	: Specification for roadmarking paints
SNZ HB 2002:2003	: Code of practice for working in the road
TNZ B/02:2005	: Specification for construction of unbound granular pavement layers
TNZ F/1:1997	: Specification for earthworks construction
TNZ HM/11:2006	: Surfacings – Maintenance Specification
TNZ M/4:2006	: Specification for basecourse aggregate
TNZ M/6:2004	: Specification for sealing chip
TNZ M/10:2010	: Specification for asphaltic concrete
TNZ P/3:1995	: Specification for first coat sealing
TNZ P/9:1975	: Specification for construction of asphaltic concrete paving
TNZ P/12:2000	: Specification for pavement marking

b) Compliance with these Codes and with this Specification shall be the minimum requirement necessary for this Contract.

a) The documents listed above and in the clauses that follow refer to their latest issue complete with amendments that are current at the date of the Tender Document and are deemed to form part of this Specification. However, this Specification takes precedence when it is at variance with the cited document.

2.3.4.3 **Definitions**

Backfill	: The material used for filling the trench from the top of the bedding to the underside of the finished surface.
Bedding	: The material surrounding the pipe to a level 300mm above the crown of the pipe.
Flexible pipe	: Flexible pipes include pipes and fittings manufactured from ABS, PVC, PE, FRP, GRP, Steel, Ductile Iron and Cast Iron
Rigid pipe	: Rigid pipes include pipes and fittings manufactured from Concrete and Vitrified Clay
Surface	: The concrete, seal, paving or grassing at the top of the trench.

2.3.4.4 **Abbreviations**

CIV	: Clegg impact value
IANZ	: International Accreditation New Zealand
MDD	: Maximum dry density
NZTA	: New Zealand Transport Agency (formerly TNZ)
RCA	: Road controlling authority
STMS	: Site traffic management supervisor
TNZ	: Transit New Zealand (now NZTA)

2.3.4.5 **Materials**

2.3.4.5.1 Materials for Backfilling in Carriageways

a) On all arterial routes, principal streets and industrial streets, base course shall comply with TNZ Specification M/4 AP20. On lesser streets, base course shall comply with GAP 40 as specified below.

b) Sub base shall comply with GAP 65

c) The aggregate source used for backfilling under carriageways shall have the following properties:
   i. Sand equivalent, based on NZS 4402 of not less than 40;

ii. Clay Index, based on NZS 4402 of not greater than 3;

iii. Plasticity Index, based on NZS 4402 of less than 15%; and

iv. Crushing resistance of the parent aggregate, based on NZS 3111 of not less than 125kN.

d) Rock material shall be free from clay, organic matter and other deleterious materials.

e) The Contractor shall provide test results demonstrating this compliance.

f) Unless the Project Manager approves alternative gradings for locally available materials, GAP 20 shall meet the following grading limits:

GAP 20	Percentage Passing	
Aperture Size (mm)	Lower Limit	Upper Limit
19.0	100	100
13.2	80	95
9.5	64	76
4.75	37	48
2.36	26	36
1.18	18	28
0.6	12	22
0.3	6	14
0.15	2	7
0.075	0	3

g) Unless the Project Manager approves alternative gradings for locally available materials, GAP 40 shall meet the following grading limits:

GAP 40	Percentage Passing	
Aperture Size (mm)	Lower Limit	Upper Limit
37.5	100	100
19.0	61	80
9.5	38	57
4.75	23	43
2.36	10	33
1.18	7	25
0.6	2	19
0.3	0	14
0.15	0	10
0.075	0	7

h) Unless the Project Manager approves alternative gradings for locally available materials, GAP 65 shall meet the following grading limits:

GAP 65	Percentage Passing	
Aperture Size (mm)	Lower Limit	Upper Limit
65.0	100	100
37.5	80	90
19.0	50	70
9.5	30	55
4.75	20	40
2.36	15	30
1.18	10	22
0.6	6	18
0.3	4	14
0.15	2	10
0.075	0	7

i) Unless the Project Manager approves alternative gradings for locally available materials, GAP 100 shall meet the following grading limits:

GAP 100	Percentage Passing	
Aperture Size (mm)	Lower Limit	Upper Limit
100.0	100	100
75.0	80	92
65.0	70	85
40.0	54	75
19.0	39	60
13.2	32	52
9.5	27	46
4.75	20	34
2.36	15	25
1.18	10	18
0.6	6	13
0.3	3	10
0.15	1	7.5
0.075	0	5

j) Unless the Project Manager approves alternative gradings for locally available materials, GAP 150 shall meet the following grading limits:

GAP 150	Percentage Passing	
Aperture Size (mm)	Lower Limit	Upper Limit
150.0	100	100
100.0	79	95
75.0	64	89
65.0	58	85
40.0	41	73
19.0	28	54
9.5	21	40
4.75	15	30
2.36	9	23
1.18	6	18
0.6	4	14
0.3	3	10
0.15	1	8
0.075	0	5

2.3.4.6 **Materials for Backfilling Outside Carriageways**

a) Unless otherwise instructed by the Project Manager, material for backfilling outside carriageways shall be sound material excavated from the trench.

b) If, in the opinion of the Project Manager, the site material is unsuitable, suitable material shall be imported by the Contractor at rates to be agreed in advance.

c) Under footpaths and vehicle crossings, the material in the upper 100mm shall be GAP 65 sub-base complying with the above.

d) Under berms and outside road reserves, the material in the upper 100mm shall be topsoil selected from the trench excavation.

2.3.4.7 **Bedding of Pipes**

Bedding of pipes shall be in accordance with the relevant specification for pressure pipelines and in accordance with the manufacturers' specifications.

2.3.4.8 **Health and Safety**

All trench excavation, backfill and reinstatement shall be carried out in accordance with the New Zealand Department of Labour's Approved Code of Practice for Safety in Excavation and Shafts for Foundations (April 2000).

2.3.4.9 **Traffic Management**

Prior to any excavation commencing in the road, the site shall be prepared in accordance with a site specific traffic management plan. Safety at roadwork sites shall be maintained at all times to ensure the safe movement of all road users.

2.3.4.10 **Underground Services**

a) The Contractor shall give at least 48 hours' notice to the owners of all utilities in the vicinity of the trench and shall comply with the requirements of the owners with respect to marking and protecting their underground services.

b) The Contractor shall pothole for existing or suspected services at least 50m ahead of the laid pipe.

c) The Contractor shall physically locate all underground services before commencing with excavation. The Contractor shall expose all existing underground services, public and private as required. If failure to explore ahead necessitates altering work already done, then the cost of altering shall be borne by the Contractor.

d) Where existing services are damaged by trenching work, the Contractor shall immediately advise the Project Manager and shall arrange for the service to be repaired by the appropriate Authority. The Contractor shall be responsible for the cost of repair unless the service or services were unavoidably damaged.

e) The Contractor shall notify the Project Manager in advance of any diversion or removal of utilities, which it may require for its own convenience or because of its proposed method of working, and shall comply with any requirements of the Project Manager with respect to them.

f) The Contractor shall ensure that during the operation of its works, no part of a machine or its load should come the minimum approach distance from overhead power lines unless written permission has been obtained from the controlling electricity authority.

g) The Contractor shall record the positions, levels and particulars of all existing services which are exposed during the construction of the works.

2.3.4.11 **Access to Properties**

Unless alternative arrangements are made to the satisfaction of the Project Manager, temporary access over the trench shall be provided to all adjacent properties until permanent access has been reinstated.

2.3.4.12 **Silt Control**

a) The Contractor shall submit a programme and method of construction statement to the Project Manager both on site and at any proposed disposal site in relation to the Contractor's works.

b) The method of construction statement shall include but not be limited to the following:
   i. Extent of works at various stages during the Contract.
   ii. Length of time bare ground is to be exposed.
   iii. Length of trenches open at any one time.
   iv. Method of dealing with run-off and sediment control from the site of the Works.
   v. Method of dealing with run-off and sediment control from any landfills associated with the Facilities.

c) Silt settling areas and detention storage shall be constructed where necessary to pond run-off and precipitate silt, so as to prevent damage to adjoining property, road channels and public stormwater systems.

d) The Contractor shall provide the necessary measures to prevent silt laden water leaving the site of the Facilities.

e) Erosion control shall be maintained in good working order throughout the length of the Contract up to the end of the Defects Liability Period.

f) The Contractor shall remove any such silt retention measures and structures at the end of the Contract and reinstate the land to its original condition or better.

2.3.4.13 **Stockpiled Material**

During construction, the Contractor shall take all the necessary measures to prevent materials yet to be compacted from becoming waterlogged, to prevent erosion of fill materials, to prevent damage to or fouling of work in progress or completed and to prevent damage to any street, public or private property, road channel or public stormwater system.

2.3.4.14 **Excavation**

2.3.4.14.1 Classification of Excavation

Excavation shall be classified as per Transit NZ Specification F/1, except for the following:

i. Type R1 Materials. This group of materials shall include all rock-like materials which can only be excavated with a hydraulic excavator of not less than 22 - 24 tonnes weight as defined in the latest issue of the New Zealand Contractors Federation Guide to New Zealand Plant Hire Rates with a bucket of width not greater than one metre and fitted with ripper teeth.

ii. Type R2 Materials. This group of materials shall include all materials which cannot be removed using a hydraulic excavator as defined for Type R1 materials.

iii. Boulders. Boulders shall include loose rocks and other hard, inorganic objects which can be removed by normal trench excavation, but which are larger than 1m in their longest dimension. Boulders and objects smaller than 1m in their longest dimension shall be classified as Type F/1 material.

2.3.4.14.2 Excavation - General

a) Excavation shall not commence until sufficient supplies of all materials are available to ensure speedy and uninterrupted progress of the work.

b) When working within existing road reserves, all surplus excavated material shall be removed from the work site within 48 hours of being excavated. Where excavated material meets required specifications and is to be re-used, it may be stockpiled on site provided it is used within 48 hours. Alternatively, stockpiling arrangements may be approved by the Project Manager and shall be included in the traffic management plan.

c) All excavation shall be carried out to the grades and levels shown on the Contractors Drawings and shall be excavated by open cut unless otherwise approved by the Project Manager.

d) The maximum length of trench open prior to backfilling, or otherwise causing local disruptions to vehicles or people, shall not exceed 20 metres unless the Project Managers written agreement to a longer length has been obtained. The Project Manager may, in particular circumstances, instruct the Contractor to limit his operations to some shorter lengths of open trench.

e) Open sections of trench shall be maintained in a safe condition at all times by the use of steel cover plates, safety fencing or other appropriate measures.

f) All necessary precautions shall be taken to ensure that no spoil (either spilled from trucks or spread from truck wheels) is deposited on carriageways. Should deposition occur, the Contractor shall immediately clean and wash down the affected area.

g) It is the Contractor's responsibility to remove all surplus excavated material from site to an appropriate disposal location. The cost shall be borne by the Contractor unless otherwise stated. No material that is suitable for re-use shall be removed from a site without the permission of the Project Manager.

h) Should any over dig occur, then the void shall be filled with suitable material, as approved by the Project Manager, to the correct formation level. The cost of any over dig shall remain with the Contractor.

2.3.4.14.3 Poor Ground Conditions

a) If in the opinion of the Contractor the formation level is unsuitable, or is damaged or is allowed to deteriorate, he shall inform the Project Manager immediately.

b) Where the bearing capacity of the trench bottom is low, and the Project Manager so directs, extra depth shall be excavated in order to obtain a firm trench bottom. The portion excavated shall be refilled to the level required for the bedding of the pipe with an approved fine non-cohesive material such as sand or crushed fine rock, placed in layers of 150mm thick and compacting by approved means.

c) Where the ground at the bottom of the trench is spongy or boggy in nature, and the Project Manager so directs, clean hard rock ballast, of nominal size 150mm (85%, passing 150mm sieve and less than 20% passing 100mm sieve) shall be placed in layers and compacted by ramming into the boggy ground until an approved firm foundation is obtained at the level required for bedding of the pipe.

2.3.4.14.4 Trench Width (relating to clearance around the pipe as defined by the embedment zone).

a) Trenches shall be excavated within the tolerances specified below. Generally trenches are expected to be excavated with vertical sides within the embedment zone. Sloped trench walls within the embedment zone are only permitted with the approval of the Project Manager. Sloping trench walls for flexible pipe installations are permitted above the embedment zone.

b) Unless otherwise specified by the Project Manager, the trench width limits for flexible pipes shall be:

Pipe OD mm	Minimum clearance to trench walls from pipe OD mm	Minimum Trench Width mm	Maximum Trench Width mm
≤ 150	300	Pipe OD + 600	800
>150 and ≤ 300	300	Pipe OD + 600	900
> 300 and ≤ 450	300	Pipe OD + 600	1200
> 450 and ≤ 600	300	Pipe OD + 600	1500
> 600 and ≤ 900	300	Pipe OD + 600	Refer to section 4
> 900 and ≤ 1500	350	Pipe OD + 700	Refer to section 4

c) Unless otherwise specified by the Project Manager, the trench width limits for rigid pipes shall be:

Pipe OD mm	Minimum clearance to trench walls from pipe OD mm	Minimum Trench Width mm	Maximum Trench Width mm
≤ 600	300	Pipe OD + 600	Refer to section 4
> 600, ≤ 1200	300	Pipe OD + 600	Refer to section 4
> 1200, ≤ 1800	300	Pipe OD + 600	Refer to section 4

d) Over-excavation

i. Where the "maximum trench width"has been exceeded, either as a result of over-excavation or due to collapse of one or both walls of the trench, before or after laying the pipe, the Contractor shall remove all disturbed material from the trench.

ii. The Project Manager may then direct one or more of the following actions to be taken by the Contractor:
- Bedding and laying, as specified, using the same pipe.
- Installation of a heavier class of pipe
- Fill the space between the pipe and the undisturbed ground on both sides of the pipe and to a height of 300mm above the top of the pipe using an approved granular material complying with the relevant AS/NZS or AS Standard.
- Another course of action, as advised by the Project Manager, until the Project Manager can confirm that the Contractor has put corrective measures in place to ensure that the pipe installation is a structurally compliant design.

iii. Localised widening and deepening may be necessary to allow for jointing, e.g. welding of pipes in the trench, and the installation of valves, fittings and associated thrust or anchor pipes. The extent of permitted localised widening or deepening allowed shall be discussed and agreed with the Project Manager.

2.3.4.14.5 Temporary Support

a) Temporary support, shoring or other alternatives shall be provided where unstable ground conditions are encountered and where required by the New Zealand Department of Labour's Code of Practice for Safety in Excavation and Shafts for Foundations (April 2000). Alternatives may include battering, dewatering, ground stabilisation or sheet piling.

b) Temporary support shall also be provided where the excavation would otherwise endanger the stability of adjacent properties or structures.

c) A suitably qualified person shall design and oversee the installation of all temporary support, shoring or other alternatives. The temporary support shall be placed so that it does not prevent pipes from being bedded and laid to specification. Any damage to the surrounding area that may occur as a result of the work shall be the responsibility of the Contractor.

d) All trench support used in trenches shall be incrementally removed in short sections before backfilling so as not to compromise the safety of personnel working in the trench.

2.3.4.14.6 Excavation Across Sealed Surfaces (Sawcutting)

a) Where an excavation is required to be made through any existing concrete, asphalt or chip seal surface, the edges of the excavation or trench shall be neatly cut with a power saw in straight lines prior to commencing the excavation. Joints shall form a neat simple pattern to include trimming allowances. Generally this will mean parallel or rectangular sawcuts on the sides of the excavated area. The minimum over break length of cut shall be 5m.
Saw cutting shall comply with the relevant national code of practice. In New Zealand this is the national code of practice for Utility Operator's access to Transport Corridors, November 2011. This includes for reinstating trench over breaks.

b) The cuts shall be at least 30mm deep and shall extend through the full thickness of the surface layer. The cuts shall be made in such a way that subsequent use of excavation equipment does not lift or disturb adjacent surfaces.

c) A minimum trench trimming allowance width of 150mm applies to all trenches in the carriageway, except in concrete carriageways where a minimum trimming allowance width of 300mm is required.

d) Areas adjacent to the excavation shall not be undercut. If slumping of material from the sides of the excavation causes depressed areas adjacent to the excavation, or if the edges of the pavement are lifted during the excavation, additional saw-cutting outside of the original line and outside of the area of damage will be required before the final surface reinstatement. If overbreak occurs, a change in direction of the saw-cut shall not exceed 45^{o}.

e) Over break of the trench shall not exceed 10% per 100 metres of trench and shall not be more than three separate areas within the 100m length. Should two over breaks occur within 5 metres of each other, a straight parallel line shall be formed between the two.

f) Where the line of the trench changes direction by more than 45^{o}, the inside corner of the existing seal shall be cut back 500mm to form a 45^{o} corner.

g) If the edge of a trench is within 1m of a crack, joint, edge of an existing trench, boundary or kerbline, the existing pavement shall be replaced as part of the surface reinstatement, and saw-cut accordingly.

2.3.4.14.7 Excavation in Private Property

a) A precondition survey shall be undertaken by the Contractor and shall be provided to the Project Manager prior to works commencing. This survey shall be agreed with the landowner. The Contractor shall reinstate the property as agreed of the conditions with the landowner.

b) All topsoil and turf from lawns shall be saved and re-used when completing the backfilling. The Contractor shall be careful not to damage gardens or property unnecessarily and shall only use excavating machinery appropriate for the circumstances. Excavated material shall be stockpiled well clear of the tops of trenches and any surplus material shall be removed from site. Topsoil shall be stockpiled separately.

c) Where directed by the Project Manager, tarpaulins shall be placed under stockpiles.

2.3.4.15 **Groundwater**

Should groundwater appear in trenches, it shall at all times be kept down below the level of joints or bedding by means of side channels and pumping if necessary until backfilling. Adequate precautions shall also be taken at all times to prevent completed sections of pipeline from floating. The cost of all machinery and work in connection with the handling of subsoil water shall be included in the Contractor's price. All sumps and channels shall be backfilled upon completion in accordance with this Specification. All ground water discharges shall comply with the Silt Control Measures.

2.3.4.16 **Surface Water**

During the course of any trenching work, the Contractor shall maintain all channels, watercourses and catchpits free of debris and provide for the free flow of surface water. Where such is not practical, the Contractor shall make adequate temporary arrangements for dealing with the surface water and shall be responsible for the operating of such measures and the re-establishment of the permanent water channel on completion of the trenching work.

2.3.4.17 **Backfilling**

This covers the material zone from above the pipe embedment zone (which includes the overlay zone).

2.3.4.17.1 General

a) No backfilling shall be done until the laying and jointing of the pipe has been approved by the Project Manager. Special care shall be taken not to damage the pipes or joints during backfilling.

b) Where instructed by the Project Manager, the Contractor shall provide groundwater drainage to ensure that the groundwater is kept below 1m from the finished surface level.

c) The degree of compaction required in the embedment zone is specified on the Contractors drawings. This relates to the design selection of the pipe support type. The Contractor is responsible to ensure that material in the embedment zone is not compacted beyond the limits specified and note the following clauses in taking care not to over load the pipe.

d) Compaction of embankment material needs to be completed carefully to ensure that adverse loading is not transferred onto the pipe during compaction.

e) The use of vibratory trench rollers and other heavy compaction equipment should be avoided at least within 500mm from the top of the pipe (flexible or rigid), unless otherwise confirmed that this is acceptable by the Project Manager.

f) The Contractor shall take care during the installation of rigid pipes to ensure that material in the overlay zone is not over compacted. The overlay zone shall extent from the top of the side zone to 150mm above the pipe crown. The fill material in the overlay zone shall be *Selected* or *Ordinaryfill* consisting of material from the excavation or elsewhere. It shall not contain stones larger than 150mm, nor more than 20% with a size between 75mm and 150mm. Overlay zone material should be compacted to provide a minimum 85% dry density (R_D) or 50% density (I_D) for installations outside of a highway and 90% dry density (R_D) or 60% density (I_D) for installations within a highway.

g) Over-compaction over the top of a flexible pipe will lead to pipe deflection as the pipe sheds loading into the supporting embedment zone. If compaction occurs close to the pipe crown there will be little if any side support offered by the embedment material and the pipe will deflect, likely beyond the maximum permissible limit. Once deflection has occurred, the pipe will have lost some of its ring bending strength and be less able to shed loading to the supporting embedment zone as backfill continues. For hand held or walk-behind equipment, the minimum depth of un-compacted material over the top of the pipe should be at least 200mm, and for large 'ride-on' machines operating within the trench, the minimum depth of material should be increased to 500mm, unless otherwise confirmed by the Project Manager.

h) Where the compactive force and bearing area of the compaction/ construction equipment is known, design in accordance with AS/ NZS 2566.1 may be used to determine the minimum height of cover before that load can be applied.

2.3.4.17.2 Backfilling in Carriageways

a) Backfilling under carriageways means the basecourse layer, the sub-base layer and ordinary backfill above the pipe embedment zone.

b) Compaction of all materials shall be carried out in layers with mechanical compaction equipment appropriate to the size and location of the trench and the type of backfill used.

c) The basecourse layer thickness shall comply with the pavement design or to local / regional engineering standards, whichever is appropriate. It shall be compacted in layers no greater than 200mm thick to achieve a mean value greater or equal to 98% of the maximum dry density (MDD) as per TNZ B/02: 2005 or as otherwise specified by local/ regional engineering standards.

d) The sub-base course layer thickness shall comply with the pavement design or to local / regional engineering standards, whichever is appropriate. It shall be compacted in layers no greater than 200mm thickness, and achieve a mean value greater or equal to 95% of the maximum dry density (MDD) as per TNZ B/02: 2005 or as otherwise specified by local/ regional engineering standards.

e) The subgrade (measured as the top 1m of the construction from the underside of the sub-base course) shall be compacted with *Selected* or *Ordinary* fill in layers no greater than 150mm thick in the lower 600mm or 135mm thick in the top 400mm depth, unless field trials show, to the satisfaction of the Project Manager, that the specified compaction is obtained with thicker layers. *Ordinary* fill placed within 1.5m of the finished surface shall be a material suitable for use as a subgrade as defined by TNZ F/1: 1997.

f) Unless otherwise specified, *selected* fill shall be placed within 0.8m depth from the finished road surface and shall be GAP 65 or a suitably approved excavated material compacted to at least 95% of maximum dry density at optimum moisture content.

g) Subgrade material below 0.8m depth from the finished road surface shall be a suitable selected or ordinary fill, and shall be compacted to at least 90% of the maximum dry density at optimum moisture content.

2.3.4.17.3 Backfilling Outside Carriageways

Unless otherwise instructed by the Project Manager, material excavated from the trench shall be used for backfilling outside carriageways. Backfill shall be compacted in layers not exceeding 200mm thick to 90% of MDD or to the same density as the surrounding ground, whichever is the lesser.

2.3.4.17.4 Backfilling of Over-width Trenches

The Contractor shall keep trench widths to a minimum consistent with the above. However, if for any reason a trench is excavated to a width such that it affects the stability of buildings or any structures (e.g. fences, kerbs, other services or roads), the placing of the whole of the backfill and the standards of compaction shall be to the appropriate specification. If, in the opinion of the Project Manager, any such extra width was unnecessary and will result in more load being placed on the pipe than it can safely carry, the Contractor shall provide at own cost additional bedding, backfill or stronger pipes as appropriate.

2.3.4.18 Trench Subsidence

The Contractor shall be responsible for any trench subsidence or failure of reinstatement works occurring after the work has been completed up to the end of the defects liability period.

2.3.4.19 Testing

2.3.4.19.1 Testing – General

a) All testing shall be the responsibility of the Contractor who shall provide the Project Manager with the results of the tests within 48 hours of testing occurring or as otherwise agreed with the Project Managerto demonstrate that the backfilling has complied with the Specification.

b) The Contractor shall be responsible for carrying out laboratory tests according to NZS 4402:1986, Test 4.1.3 to determine the maximum laboratory dry density at the optimum water content (OWC) of the backfill material to be used. The Solid Density of the aggregate tested shall be determined according to NZS 4407:1991, Test 3.7. The tests shall be undertaken on material that is representative of that used in construction and a grading for the material tested shall be supplied with the results.

c) Prior to commencement of fill compaction the Contractor shall carry out a 'Trial Compaction – Plateau Test' in the presence of the Project Manager to provide confirmation that the laboratory compaction results can be achieved onsite. The methodology for this trial shall be submitted to and agreed by the Project Manager prior. This should generally is in accordance TNZ B2 Specification.

d) Compaction testing shall be carried out with a nuclear densometer or approved equivalent that can demonstrate that the required standards have been met. A Clegg hammer (4.5 kg) may be used to monitor compaction densities, providing laboratory correlation tests have been carried out to confirm that the specified density has been achieved in accordance with ASTM D5874-95. The following Clegg impact hammer values (CIVs) may be used as a guideline for estimating maximum dry density (MDD):

CIV	MDD
35	98%
32	95%
25	90%

2.3.4.19.2 Testing of Compaction in Carriageways

a) Testing of compaction shall be carried out in accordance with the above.

b) All materials used for backfilling shall have been sampled and tested by a certified testing laboratory. The Project Manager may instruct the Contractor to provide records of material test certification.

c) Density testing shall be carried out and recorded by a suitably qualified person at the following frequencies:
   i. For trenches in berms, testing is required at least one per layer of backfill per 15 m of trench, with a minimum of two tests.
   ii. For trenches in carriageways or footpath testing is required at least one per layer of backfill per 5 m of trench with a minimum of two tests.
   iii. Where the excavated area greater than 0.5 m2 and less than 5 m2 testing is required one per backfill layer.
   iv. Where the excavated area greater than 5 m2 testing is required one per 5 m2.
   v. Tests shall be carried out on every lift of each tested backfill layer to be assured of proper compaction of all of the backfill.

2.3.4.19.3 Benkelman Beam Testing in Carriageways

a) The Contractor shall undertake Benkelman Beam tests on the existing carriageway before the works are undertaken to determine a baseline for the stiffness of the existing carriageway.

b) Prior to placing the base course and the final sealing the Contractor shall undertake Benkelman beam tests at 20m intervals. No sealing shall be undertaken until the Contractor supplies the results of the beam testing demonstrating compliance with the Engineering standards.

2.3.4.19.4 Testing of Compaction Outside Carriageways

a) Testing of compaction shall be carried out in accordance with the above.

b) Density testing shall be carried out by a suitable qualified person at the following frequencies:
   i. For trench lengths of 100m or more, testing is required at a rate of at least one test per layer of backfill per 50m of trench.
   ii. For trench lengths less than 100m, a minimum of two tests per layer will be required.
   iii. Where the excavated area is greater than 0.5m^2 and less than 30m^2, one test per backfill layer will be required.

2.3.4.20 **Reinstatement**

2.3.4.20.1 Scope

Reinstatement of trenches includes:-

i. removal of surplus soil, stones and debris;
ii. trimming of the backfill to line and level;
iii. topsoiling and, where applicable, seeding;
iv. initial restoration of sealed and concreted surfaces where required;
v. temporary surfacing; and
vi. permanent reinstatement of existing surfaces.

2.3.4.20.2 Reinstatement – General

a) All materials used for reinstatement shall have been sampled and tested for compliance with this Specification by a certified testing laboratory. The Project Manager may instruct the Contractor to provide records of material test certificates.

b) The Contractor shall reinstate trenches within five working days or as soon as practicable after the backfilling has been completed in accordance with the specification. If, in the opinion of the Project Manager, reinstatement is not following up pipelaying work as soon as practicable, the Project Manager may order a stop to further trench excavation until practicable reinstatement has been achieved. The Contractor shall not be entitled to compensation for any such stoppage.

c) The finished reinstatement shall have a neat appearance with clean long straight lines parallel to the kerb or footpath.

d) Permanent reinstatement materials shall be similar in type, quality, texture, skid resistance and strength to the surrounding materials.

e) The quality of the final reinstatement shall be better than or equal to the standard prior to undertaking the works. The surface level of the trench shall match the surrounding surface level, finished flush or not more than 5mm above the existing surface. No ponding of water will be permitted. Where the transverse or longitudinal shape of the existing pavement is not a straight line the Contractor shall shape the reinstatement work accordingly.

2.3.4.20.3 Temporary Surfacing

In major roads, or where instructed by the Project Manager, backfilling in carriageways shall be topped immediately after completion with a temporary plant mix surfacing. This temporary surfacing, together with overcut material, shall be removed prior to constructing the final surfacing.

2.3.4.20.4 Reinstatement in Carriageways

2.3.4.20.4.1 Concrete Surfaces

a) All concrete shall comply with NZS 3109 and shall have a compressive strength of at least 20MPa at 28 days. The concrete shall contain a rapid hardening additive giving nominal 7 day strength in 24 hours and shall have attained at least 80% of its specified strength before being exposed to traffic.

b) The thickness of the concrete shall match the thickness of the existing concrete.

c) Cut edges shall be treated with cement grout, to which an approved bonding additive (e.g. Cemstick or Febmix) has been added prior to placing concrete.

d) Expansion and/or construction joints shall be formed to match the existing surface.

e) Concrete surfaces shall be broom finished, except where an asphalt overlay is required, in which case the concrete surface shall be roughened to facilitate bonding between the asphalt and the concrete.

f) Where the existing concrete surface contains reinforcing steel, the reinstated concrete shall be similarly reinforced.

g) In all instances D16 starter bars at 300mm centres shall be epoxied into the existing concrete with an embedment length of not less than 150mm.

2.3.4.20.4.2 Asphalt (hot mix surfaces)

a) Asphalt shall comply with TNZ Specification M/10 and shall be placed and compacted in accordance with TNZ P/9.

b) The Contractor shall demonstrate that the mix design meets the specifications and shall submit the proposed design to the Project Manager prior to commencing reinstatement.

c) The Contractor shall remove previously placed metal and/or plant mix to depth of the original paving, compact as necessary, clean free of dust and apply a tack coat to the edges and metal with rapid breaking emulsion. Asphalt Mix 10 at a temperature of 150°C - 160°C shall then be placed and rammed in layers not exceeding 50mm and the final surface finished by rolling.

d) The thickness of the asphalt layer shall be the same as existing layers or 50mm using a Mix 15 sized aggregate or 30mm using a Mix 10 sized aggregate, whichever is the greater.

e) The surface shall be smooth and even, having no ridges or depressions; shall finish flush with, but in no case more than 3mm above, the adjacent surface; and shall not cause water to pond.

f) The Project Manager may from time to time take core samples of the asphalt for testing. Should the tests show that that the depth and materials do not comply with the specification, the Contractor shall remove the sub-standard asphalt and replace it to specification.

g) Where reinstated with asphaltic concrete is specified, the Contractor shall maintain the consistency of the texture and skid resistance between running lanes and AC surfaces shall be texturised with a chip seal layer. The asphalt mix and depth shall be in accordance with the project specification.

2.3.4.20.4.3 Chip Sealed Surfaces

a) Chip sealed surfaces shall match the existing surface. Where this is not specified, the reinstated surface shall comply with TNZ Specification P/3. Chips shall be Grade 4 complying with TNZ Specification M/6.

b) In locations where the existing chip seal surface has been placed over an asphalt layer, the Contractor shall sweep the backfilled surface and apply a rapid breaking emulsion. 20mm of asphalt mix 10 shall then be placed at a temperature of 150°C - 160°C, and finished by rolling and applying chip seal to the same texture as the adjacent surfaces.

2.3.4.20.4.4 Joint Sealing of Carriageway Surfaces

Within one week of final reinstatement taking place, either side of joints in carriageways shall be sealed with hot poured rubber bitumen. The material shall be in accordance with TNZ HM/11 specification. Prior to sealing, the joints shall be water blasted to remove loose dirt and other foreign matter and dried. The sealant shall be applied and levelled with a sealing shoe in a 100mm band across the joint with an overlap of 50mm on either side of the joint.

2.3.4.20.4.5 Kerbs and Channels

a) Where a section of kerb and channel is damaged by a trench crossing, the damaged section shall be replaced to the original line, level and standard.

b) Where an excavation extends under a concrete channel or kerb and the channel has not subsided, cracked or been damaged, it may remain in place. A 200 mm deep concrete foundation shall be placed under the channel for support. The concrete shall have a minimum strength of 20MPa at 28 days.

c) All stone kerbs must be salvaged and re-used to match existing stone kerbs.

2.3.4.20.4.6 Road Marking and Signs

a) Prior to the commencement of the Facilities, the Contractor shall offset or otherwise record the location of the existing road marking and signs and shall include the information with the road opening notice.

b) Road marking and signs shall be replaced with the same type

c) All road markings and signs shall be reinstated.

2.3.4.20.4.7 Reinstatement near Joint or Edge

If the edge of the trench in a footpath or road carriageway is within 1m of a joint or existing edge of the pavement, then the existing pavement shall be replaced to that joint or edge as part of the surface reinstatement, and cut accordingly.

2.3.4.20.4.8 Reinstatement outside Carriageways

a) On completion of backfilling and compaction, the Contractor shall spread the stockpiled topsoil evenly over the area from which it was removed, relay turf and reinstate all fences and other parts of the property which may have been disturbed or damaged by the works, to the original condition or better. Grassed areas shall be reinstated at least to the original standard. The grassed or planted area shall be maintained until it has been restored to its original condition.

b) Reinstatement of footpaths, drives, paths, fences, walls and any other features shall be reinstated in the same material and to the same standard as that existing at the commencement of the works unless otherwise approved by the Project Manager.

2.3.4.21 **Damage to Adjacent Areas**

a) On any section where the sealed surface has been damaged beyond the trench line in any way as a result of the Contractor's operations, the surface is to be resealed over an area that ensures that uniformity of skid resistance of both wheel paths of any particular lane, approved by the Project Manager.

b) Details of the proposed surfacing repair method, including the first and second coat chips sizes, shall be submitted to the Project Manager for approval, not less than 5 working days prior to sealing.

c) If the pavement under the sealed surface is disturbed as a result of the Service Owner's operations it shall be repaired by digging out the full pavement depth, re-compacting the subgrade and then relaying a new pavement layer complying with this specification.

2.3.4.22 **Cleaning Up and Making Good**

As reinstatement work proceeds, the Contractor shall progressively carry out all reinstatement and tidying up work by clearing away all rubbish and surplus material, cleaning and sweeping the area and leaving it in a condition as good as or better than it was when work commenced.

2.3.5 Concrete Work

2.3.5.1 **Scope**

In accordance with the Employer's Requirements, the Contractor shall:

1. Design and detail all concrete work;
2. Prepare and submit shop drawings and all other information required by the Project Manager as specified herein;
3. Furnish all plant, Materials, Contractor's Equipment, and labour required to manufacture, transport, place, finish, protect, repair, and cure concrete;
4. Construct, erect, and dismantle forms;
5. Detail, furnish, and place steel reinforcing bars and welded wire fabric;
6. Furnish and place materials for waterstops; expansion, contraction, control, and construction joints; and beam seats;
7. Design and furnish all labour, plant, and Contractor's equipment to manufacture, cure, transport, and place prestressed or precast concrete components, where approved for use by the Project Manager;
8. Use lift numbers designated by the Contractor in all correspondence, drawings, and reports.

2.3.5.2 **Applicable Codes and Standards**

a) All work, materials and practices shall comply with the requirements of current legislation, standards and codes for that particular class of work. The following standards shall apply specifically:

AS 1478.1:2000	:	Chemical admixtures for concrete, mortar and grout – admixtures for concrete
AS 3610:1995	:	Formwork for concrete
AS 3799:1998	:	Liquid membrane forming curing compounds for concrete
BS 4486:1980	:	Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete
AS/NZS 1554.1:2011	:	Structural Steel Welding - Welding of Steel Structures
AS/NZS 1554.3:2008	:	Structural Steel Welding - Welding of Reinforcing Steel
AS/NZS 1170 Set	:	Structural Design Actions Set
AS/NZS 2980:2007	:	Qualification of welders for fusion welding of steels
AS/NZS 4671:2001	:	Steel Reinforcing Materials
AS/NZS 4672.1:2007	:	Steel prestressing materials – General requirements
ASTM C309-07	:	Standard Specification for Liquid membrane-forming compounds for curing concrete
NZS 3101:2006	:	Concrete Structures Standard
NZS 3104:2003	:	Specification for Concrete Production
NZS 3106:1986	:	Concrete Structures for the storage of Liquid
NZS 3109:1997	:	Concrete Construction
NZS 3111:1986	:	Methods of Test – water and aggregate
NZS 3112:1986	:	Method of Tests for Concrete
NZS 3114:1987	:	Specification for Concrete Surface Finishes
NZS 3121:1986	:	Specification for Water and Aggregate for Concrete
NZS 3122:2009	:	Specification for Portland and Blended Cements (General and Special Purpose)
NZS 3123:2009	:	Specification for Pozzolan for use with Portland and Blended Cement
NZS 3124:1987	:	Specification for Concrete Construction for Minor Works
NZS 3125:1991	:	Specification for Portland–Limestone filler Cement
NZS 4224: 1983	:	Code of practice for measurement of civil engineering quantities
NZS 4702:1982	:	Metal-arc welding of Grade 275 Reinforcing Bar

b) Compliance with these Codes and with this Specification shall be the minimum requirement necessary for this Contract.

c) The documents listed above and in the clauses that follow refer to the latest issue complete with amendments that are current at the date of the Tender Document and are deemed to form part of this Specification. However, this Specification takes precedence when it is at variance with the cited document.

2.3.5.3 **Other Publications**

Other publications applicable to this specification are:

i. Building Industry Authority: New Zealand Building Code Handbook and Approved Documents, 1992.

ii. Cement and Concrete Association of New Zealand, TR 3, 1991: Alkali aggregate reaction- minimizing the risk of damage to concrete.

iii. Cement and Concrete Association of New Zealand, TR 11, 2003: Properties of New Zealand Concrete Aggregates

iv. Cement and Concrete Association of New Zealand/ SANZ, New Zealand Guide to Concrete Construction

v. New Zealand Transport Agency TNZ Standards.

vi. New Zealand OSH approved Codes of Practices.

2.3.5.4 **Quality Control and Assurance**

The Contractor's Quality Assurance Plan shall include a method statement regarding the quality control and assurance intended to be carried out in association with concrete works, including reinforcing steel,

joint sealers, waterstops, etc. The method statement shall include the standards and codes that the Contractor proposes to use for his concrete works, the intended sampling frequencies, quality control testing, and methods for transportation, storage, and handling of all materials used, as well as testing of the Contractor's equipment utilized.

The Materials used in the project shall be mill or factory tested, where appropriate. Mill or factory test reports made by the manufacturer or fabricator certifying that the material is in conformance with the applicable standards shall be delivered with the shipments and shall be made available for review by the Project Manager.

Standard release forms shall be utilized for all concrete work to provide check lists for the Project Manager to verify that the work is in conformance with the latest revision of the Contractor's Quality Assurance Plan. The release form shall be completed prior to concrete placement and shall certify that the formwork, reinforcement, embedded items, waterstops, etc. are located correctly and adequately braced to prevent movement during concrete placement and that requirements of the design are met in all respects. The release form shall be signed by the Project Manager prior to concrete placement.

The Contractor's quality assurance procedures shall encompass all aspects of the concrete construction, including, but not necessarily limited to:

i. concrete mix design;
ii. evidence of compliance with requirements to prevent alkali-aggregate reaction;
iii. proposed concrete testing procedures;
iv. shop drawing submission and review;
v. pre-pour inspection procedures;
vi. reinforcing compliance records;
vii. certificates for pre-stressing and post tensioning strand;
viii. extension calculations for pre-stress strand;
ix. post tension calculations of extensions, friction losses and force profiles along the cable length;
x. concrete batch/delivery docket records;
xi. curing methodologies for the various parts of the structures; and
xii. off site precast inspection.

The Contractor shall nominate and advise the Project Manager of a suitably experienced and qualified representative to be responsible for the quality control of all precast and in-situ concrete.

The Contractor shall supply evidence of production quality standards to the Project Manager in advance of construction in accordance with NZS 3109.

2.3.5.5 **Submittals**

Should it be requested by the Project Manager, the Contractor shall provide the following information for review:

i. the ready mixed concrete supplier's mix design including evidence from the Contractor that he has provided full information to the supplier to enable him to understand the concrete design requirements and to enable him to design the concrete mix to satisfy the requirements of the Contract;
ii. curing methodology;
iii. concrete compression test results analysed in accordance with the requirements of NZS 3109;
iv. slump tests analysed in accordance with the requirements of NZS 3109;
v. shop drawings of precast concrete items;

vi. delivery dockets and pre-pour check sheets which shall be available for the Project Manager's inspection on site;

vii. extension calculations for prestressed concrete items; and

viii. extension, friction, and force calculations for post tensioning cables.

2.3.5.6 **Material Standards**

2.3.5.6.1 Cement

a) Cement shall comply with NZS 3122, and be certified as made in New Zealand unless otherwise approved in writing by the Project Manager, or specified in this Specification. Alternative cement may only be used if specifically approved in writing by the Project Manager.

Alternative cements shall comply with NZS 3123 or NZS 3125.

2.3.5.6.2 Aggregate and Water

Aggregate and water shall comply with the requirements of NZS 3122. The maximum nominal aggregate size used in the concrete mixes shall be 20mm, with the exception of mass concrete or unless otherwise specified in section 4 of this Specification or on the drawings.

2.3.5.6.3 Reinforcement

a) Reinforcing steel bars shall be hot rolled steel bars complying with AS/NZS 4671 unless otherwise approved in writing by the Project Manager.

b) Reinforcing steel shall be Class E in accordance with AS/NZS 4671. Class L and N shall not be used unless expressly noted on the drawings.

c) Grade 500 reinforcing steel shall be manufactured by micro alloy techniques. Reinforcing manufactured by quenching and tempering processes will not be permitted.

d) Reinforcing steel shall be identified along its length with:
   i. The strength grade
   ii. The ductility class
   iii. The steel producer
   iv. The method of manufacture

e) The length of laps shall be in accordance with NZS 3101.

j) Hooks and bends shall be in accordance with NZS 3101 and NZS 3109.

l) Mechanical connection of reinforcement shall not be permitted without prior written approval from the Project Manager. All mechanical connections where permitted shall be installed in accordance with the manufacturer's recommendation, and shall comply with the provisions of NZS 3101.

2.3.5.6.4 Concrete

2.3.5.6.4.1 Concrete Strengths

Concrete strength and durability shall be selected by the Contractor to meet the specific requirements at each location. Concrete strength shall be clearly marked on the Contractors drawings.

2.3.5.6.4.2 Concrete Mix Design Submission

a) Concrete mix design details shall be submitted to the Project Manager at least two weeks before concrete supply commences. Submission of these details in no way reduces the Contractor's obligation to meet the requirements of this Contract. Neither does the submission of details infer in any way that the Project Manager has approved them.

b) The following mix details shall be supplied in writing:

   i. specified strength of concrete and grade;

ii. minimum target mean strength;

iii. nominated slump;

iv. grading curve for the aggregates;

v. source and type (crushed etc) of aggregate;

vi. batch weights of cement and aggregate;

vii. total free water content;

viii. water/cement ratio by weight;

ix. fineness modulus of the sands;

x. any admixtures, name and quantity;

xi. yield;

xii. source and type of cement and aggregates including sands; and

xiii. proposals for extending the workability for time periods longer than the 90 minutes in NZS 3109 cl 7.4.1, if required.

c) Concrete mixes shall be capable of being readily placed and compacted in normal placing situations without segregation. They shall result in homogeneous, dense concrete with low shrinkage characteristics, and capable of achieving the specified surface finish. The Contractor shall show by previous records or trial mixes that these requirements can be met with concrete achieving the specified strength.

d) No change shall be made to the submitted mix details without approval of theProject Manager.

e) All concrete mixes shall be produced strictly in accordance with submissions accepted in writing by the Project Manager.

2.3.5.6.4.3 Concrete Supply

a) Concrete used in the construction shall be either made on the site, supplied ready mixed, or supplied in the form of precast products. Site mixed concrete shall comply with NZS 3104 or NZS 3124 as appropriate.

b) The concrete plant must have a current Certificate of Audit in terms of NZS 3104 or approved equivalent. The concrete supplier shall submit to the Project Manager the current Certificate of Audit and the name and contact details of the assigned plant engineer.

c) Delivery dockets shall be supplied by the producer for each load. Dockets shall contain the following minimum information for each load:-

i. name of concrete supplier;

ii. specified grade of concrete (strength);

iii. cement content;

iv. maximum aggregate size;

v. slump;

vi. date and time of mixing;

vii. quantity delivered;

viii. identifying number of truck; and

ix. additives used.

2.3.5.6.4.4 Concrete Additives

a) Unless otherwise specified, no concrete additive shall be included in the concrete mixes without the written approval of the Project Manager. Chemical admixtures, where approved by the Project Manager for use in concrete, shall comply with AS 1478, and shall be used in accordance with NZS 3109.

b) No calcium chloride or chloride containing admixture shall be added to any mix.

c) An approved air entraining agent shall be added to all concrete mixes sufficient to provide an air content of 4.5% ± 1½%.

b) An approved water reducing agent may be included in the mix designs.

2.3.5.7 **Storage of Reinforcement**

Upon delivery to the site, the reinforcement shall immediately be stacked in racks located in a clean dry area removed from construction traffic.

2.3.5.8 **Defective Concrete**

a) Acceptance of concrete in the works will be primarily based on the results of slump and compression testing in accordance with the acceptance criteria in table 9.3 of NZS 3109 and tolerances for slump in table 9.1 of NZS 3109.

b) Where concrete is liable for rejection, the location and extent of the concrete so represented shall be assessed and identified. No further concrete shall be placed where it would prejudice the subsequent removal of the concrete in question. If the Contractor disputes the results and elects to have confirmatory testing of hardened cores undertaken, all coring and testing shall be at the Contractor's expense and shall be undertaken by a testing authority approved by the Project Manager.

2.3.5.9 **Quality Assurance**

It shall be the Contractor's responsibility to ensure that the materials comply in all respects with the Contractors Drawings and Specifications.

2.3.5.10 **Inspection and Testing**

2.3.5.10.1 Inspection

a) The Project Manager may inspect construction in accordance with NZS 3109, clause 1.3. Before pouring commences, the Project Manager or his representative shall be given 24 hours notice to enable inspection of formwork, reinforcement and construction joints. No concrete shall be placed until the Project Manager is satisfied that all provisions of the specifications and drawings have been complied with.

b) Where necessary, the Project Manager's instructions shall be carried out before concrete placing commences.

c) The Contractor shall submit in writing to the Project Manager for approval a method statement for handling, placing, finishing, curing and protecting fresh concrete giving the precautions that will be taken to prevent the influences of the weather causing premature cracking of the concrete element. The sequence of placing of concrete and method shall not be varied without further approval.

2.3.5.10.1.1 Concrete Assessment

a) The concrete manufacturing process shall follow the sampling, testing and control requirements of NZS 3104.

b) Assessment of special concrete mixes and other concrete for this Contract shall be as specified in Section 4 of this Specification.

2.3.5.11 **Durability**

a) To provide durable concrete structures, the Contractor shall provide, in place, a dense low permeability concrete with low chloride ion content, sound aggregates free from alkali aggregate reaction, and a concrete which will provide adequate protection to the prestressing and reinforcing steel.

b) The Contractor shall ensure that the handling and placing of all concrete shall be in accordance with section 7 of NZS 3109.

c) The personnel placing concrete shall be experienced in the handling and placing of concrete.

d) Compliance with this specification shall be the minimum requirement necessary to meet the objectives in a) above.

2.3.5.12 **Compaction**

a) All concrete shall be vibrated in accordance with section 7.6 of NZS 3109. Complete compaction of the concrete will be required to ensure that the concrete in place has the durability necessary for its long term environment. Refer also to the Cement and Concrete Association guide "Placing and Compacting Concrete".

b) Control of compaction shall at all times be under the control of experienced operators and supervised by staff of at least foreman level.

2.3.5.13 **Finishing**

The surface finish of unformed concrete shall comply the requirements of NZS 3109 clause 7.7 and with the provisions of NZS 3114.

2.3.5.14 **Formwork**

2.3.5.14.1 General

a) All formwork shall be designed by the Contractor to meet the requirements of Section 5 of NZS 3109 and AS 3610.

b) Formwork may be re-used provided forms are adequately cleaned to maintain the standard of finish and the tolerances specified.

c) Unless specified otherwise, forms shall be radiused or chamfered at all sharp edges with a dimension of 20mm across the diagonal face. The surface finish of the fillets shall match that of the forms. All fillets shall be well greased to avoid tearing of edges during form stripping.

2.3.5.14.2 Tolerances

Dimensional tolerances shall be in accordance with Table 4 of NZS 3109, except where modified in Section 4 of this Specification.

It is recommended that at key structural positions the tolerance for both fabrication and erection be checked and where necessary revise the default tolerances of NZS 3109 clause 5.3.

2.3.5.14.3 Ties

a) Where ties pass through joints, the ties shall be removed after concreting so that no part remaining in the concrete shall be nearer the surface than 40mm.

b) Ties left in the walls of hydraulic structures shall have a rubber ring waterbar attached. Ties which leave a penetration through the wall are not permitted.

c) Holes left after removal of the tie cones shall be filled with an epoxy mortar or hard pack cement grout such that leakage or damp patches are prevented in the completed hydraulic structure. The Contractor shall obtain the approval of the Project Manager for the mortar or grout prior to filling the holes.

2.3.5.14.4 Surface Finishes

a) Surface finishes shall be finished to the most appropriate standard detailed in NZS 3114 Table 1 (formed finishes) and Table 2 (unformed finishes).

c) Defects such as honeycombing, voids around reinforcement etc shall not be repaired without the knowledge and approval of the Project Manager. The Contractor shall provide a methodology of repair to the Project Manager prior to execution of the work. Superficial defects shall be repaired by grinding and "bagging in" with mortar.

2.3.5.14.5 Stripping

Removal of formwork shall be removed without shock or vibration and in such a manner to permit the concrete to take the imposed stresses gradually. Stripping times shall be in accordance with Clause 5.4 of NZS 3109. Due regard shall be taken of the special characteristics of concrete containing Duracem cement, such as a longer cure time, for example.

2.3.5.15 **Falsework**

a) The Contractor shall be responsible for the engineering design, erection, maintenance, safety, and staged removal of all falsework, including staging, walkways, forms, ladders etc.

b) All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads. Falsework for the support of a superstructure shall be designed to support the loads that would be imposed if the entire superstructure were placed at one time.

c) Falsework shall be placed on solid footings, safe against undermining, and protected from softening.

d) Where falsework is supported on any portion of the structure which is already constructed, the load imposed by the falsework shall be spread, distributed and braced in such a way as to avoid any possibility of damage to the structure.

2.3.5.16 **Construction Joints**

a) Concrete placed monolithically shall be of such size, geometry, and sequence that shrinkage cracking is minimised. Where any shrinkage crack exceeds 0.1mm in width and where required by the Project Manager, remedial work shall be carried out. The Contractor shall obtain the approval of the Project Manager for all materials and methods before undertaking the repairs.

b) Construction joints shall be either
   i. as shown on the drawings, or
   ii. "type B" in accordance with NZS 3109, located as shown on the drawings, or where the locations are not defined, at positions of low shear stresses as approved by the Project Manager.

2.3.5.17 **Curing**

a) Curing shall be carried out in accordance with NZS 3109. This standard shall be the absolute minimum for any structure on this Contract.

b) From immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures and mechanical injuries. The concrete shall be maintained with minimum moisture loss for the period necessary for hydration of cement and hardening of the concrete as defined in clause 7.8 of NZS 3109.

c) For non-hydraulic structures, concrete shall be cured for a minimum of 7 days. Curing compounds may be used on these structures.

d) For hydraulic structures, membrane curing compounds shall not be used. Concrete shall be cured for a minimum of 14 days as follows:

Either	first 7 days	all concrete and its formwork and other surfaces shall be kept continuously wet by ponding where possible, and protected from sun and drying winds
	8 – 14 days	all concrete surfaces shall be protected from sun and drying winds, and shall be kept damp by occasional hosing
or,	where approved in writing by the Project Manager, a curing compound complying with ASTM C309 or AS 3799 may be used.	

2.3.5.18 **Reinforcement**

2.3.5.18.1 Cover to Reinforcement

a) The minimum cover shall not be less than 50mm on surfaces exposed to liquids or soil unless approved protective coatings are used, or 40mm elsewhere. Concrete cast against ground shall have a 75mm minimum cover.

b) Cover is measured from the concrete surface to the nearest layer of reinforcement.

c) If the concrete surface contains rebates or architectural features which in places reduce the cover, then the cover is measured from the deepest surface rebate to the nearest layer of reinforcement.

2.3.5.18.2 Workmanship and Care of Reinforcement

a) Prior to bending, bars shall be cleaned of all loose rust, mill scale, dirt, oil, paint etc. The use of flame for cleaning and straightening is not permitted.

b) Badly twisted bars shall be rejected and removed from the site. Bars shall not be bent or straightened after placing unless approved in writing by the Project Manager, for each specific case.

c) At the time of concreting, the bars shall be free of any foreign coatings, form oil or dried accumulation of mortar, which reduce the effective bond between concrete and steel.

2.3.5.18.3 Additional Reinforcement Requirements to NZS 3109

a) In all hydraulic structures and in concrete cladding panels, all tie wire shall be galvanised. Ends of tie wire shall be bent back away from the cover concrete.

b) Spacer blocks shall be plastic or 40MPa concrete. Concrete masonry spacers, or spacers made on site shall not be used.

c) Reinforcing shall not be tack welded.

d) Welding of reinforcing is not permitted without the Project Manager's approval. If approval is given, welding shall be in accordance with NZS 4702.

e) If approved, welding shall be carried out by qualified welders and shall be in accordance with NZS 4702, to achieve at least Class S welds. Welding shall not be carried out under damp conditions or at temperatures of below 10ºC. Welders shall be adequately supervised so as to ensure use of proper electrodes, suitable amperages and sufficient time for each weld to avoid sudden quenching. For 500E strength grade, welded using 'Manual Metal Arc Welding process', without preheating, low hydrogen electrodes are the only electrode that shall be used. Reduction in tie (bar cross section) area or faulty welding will be cause for rejection or repair of welds.

f) For concrete cast against ground, particular care shall be taken to ensure that
   i. no damage occurs to any waterproofing membrane or damp proof course; and
   ii. reinforcement is not displaced by foot traffic to reduce its cover.

2.3.5.19 **Embedded Items**

2.3.5.19.1 Minor Embedded Items, Holes, Chases, Rebates

a) The Contractor shall provide and adequately support prior to concreting, all sleeves, inserts, anchors, holding down bolts, conduits, pipes and other embedded items. Voids in sleeves, inserts and anchor slots shall be plugged, taped or filled temporarily with readily removable material to prevent entry of concrete into the voids.

b) The Contractor shall accurately form and position all chases, fillets, holes, upstands and nibs as shown on the drawings, prior to concreting.

2.3.5.19.2 Embedded Pipework

a) All pipes and fittings cast into concrete shall be provided with puddle flanges or other approved systems of ensuring water tightness.

b) Pipes passing through post-tensioned concrete shall be connected after completion of the post-tensioning in one of two ways. Either blockouts to accommodate such pipes shall be formed in the appropriate place, or spool pieces shall be cast into the concrete prior to tensioning.

2.3.5.20 **Casting New Concrete Against Old**

a) Where concrete is to be cast against old concrete (any concrete which is older than 60 days of age), the surface of the old concrete shall be thoroughly cleaned and roughened by water blasting or abrasive blasting (exposing aggregate).

b) The joint surface shall be coated with an epoxy based bonding agent unless indicated otherwise by the Project Manager.

2.3.5.21 **Sealants and Waterstops**

2.3.5.21.1 General

a) All joint sealants shall be mixed and applied strictly in accordance with the manufacturer's specification and applied by skilled applicators.

b) Concrete surfaces shall be prepared in accordance with the sealant manufacturer's specification. All surfaces in contact with sealant shall be clean and dry prior to the application of joint sealants. Sealing shall not be carried out while surfaces show any sign of dampness.

c) Joint cross section dimensions are shown on the Contractors drawings. The Contractor shall examine all joint details to confirm that the sealant may be formed in a satisfactory manner to provide a completely watertight joint.

d) All joint surfaces shall be primed prior to the application of joint sealant material. Primers, bond-breaking tape and filler rods shall be as specified by the sealant manufacturer, and shall be applied and allowed to cure before sealant application in accordance with the manufacturer's specification.

e) Surfaces adjoining the joints shall be masked to prevent contamination by sealant or primer materials. Masking shall be removed on completion of sealant application.

f) The Contractor shall take care to prevent damage due to any action, including mechanical or chemical attack, after the application of sealant material.

g) A detailed record shall be kept of when sealants were placed so that curing times can be monitored. No sealant shall be relied upon to fulfil its purpose until fully cured.

2.3.5.21.2 PVC Waterbars and Waterstops

All waterbars and waterstops shall be joined, spliced and installed in accordance with the manufacturer's specifications. The Contractor shall allow for all necessary additional reinforcing, ties, supports, etc. to ensure that the waterstop is restrained in its correct position during concreting.

2.3.5.21.3 Hydrophilic Waterstops

a) Hydrophilic waterstops shall be butted and glued together in accordance with the manufacturer's instructions to give a water-tight junction.

b) Hydrophilic waterstops shall be installed with a minimum of 100mm cover.

2.3.5.22 **Dry Pack Mortar**

a) Dry pack mortar shall be a sand cement mortar in the proportions of one part cement to three parts sand by weight.

b) Additives to reduce water content or to enhance adhesion shall not be used without the written approval of the Project Manager.

c) Water and additives shall be added to the sand cement to produce a mortar that has a dry consistency. When squeezed in the hand to a ball, the mortar shall retain its shape, but shall not be so dry that it shows cracking on its outer surface.

d) The water/cement ratio shall not exceed 0.40 by weight.

e) Mortar shall be placed in layers, packed hard with a wooden caulking tool and hammered tight. Adequate rigid formwork shall be used where required to confine the mortar during the packing operation.

2.3.5.23 **Waterproofing Form-Tie Holes**

2.3.5.23.1 Preparation

Plastic cones, snap-ties and tapered rods shall be removed from the concrete to expose tie holes. Tie holes shall then be cleaned with a wire brush to remove loose debris and other contaminants. Tie holes shall then be flushed with clean water. If necessary, form oil is to be removed.

2.3.5.23.2 Application

a) Tie holes and surrounding areas shall be pre-soaked with clean water to a saturated, surface-dry condition (SSD).

b) The application shall be protected for a minimum of 48 hours from:
   i. rapidly drying out due to heat;
   ii. damage from rain;
   iii. excessive wind;

2.3.6 **Steel Work and Metal Work**

2.3.6.1 **Scope**

The Contractor shall design, detail, fabricate, furnish, install, and paint or galvanize all steelwork and metalwork.

2.3.6.2 **Applicable Codes and Standards**

a) All work, materials and practices shall comply with the requirements of current New Zealand or Australasian standards for that particular class of work. The following standards shall apply specifically:

AS 1101.3:2005	: Graphical Symbols for general engineering – Welding and non-destructive examination
AS 1111.1:2000	: ISO metric hexagon bolts and screws – Product Grade C - Bolts
AS 1111.2:2000	: ISO metric hexagon bolts and screws – Product Grade C - Screws
AS 1112.1:2000	: ISO metric hexagon nuts - Style 1 - Product grades A and B
AS 1112.2:2000	: ISO metric hexagon nuts - Style 2 - Product grades A and B
AS 1112.3:2000	: ISO metric hexagon nuts - Product grade C

AS 1112.4:2000	: ISO metric hexagon nuts - Chamfered thin nuts - Product grades A and B
AS 1214:1983	: Hot-dip galvanised coatings on threaded fasteners (ISO metric coarse thread fasteners)
AS 1237.1:2002	: Plain washers for metric bolts, screws and nuts for general purposes - General plan
AS 1237.2:2002	: Plain washers for metric bolts, screws and nuts for general purposes - Tolerances
AS 1397:2001	: Steel sheet and strip – hot-dipped, zinc-coated or aluminium / zinc-coated
AS 1674.1:1997	: Safety in welding and allied processes – fire precautions
AS 1897:1976	: Electroplated coatings on threaded components (metric coarse series)
AS 3828:1998	: Guidelines for the erection of building steelwork
AS 4100:1998	: Steel structures.
AS/NZS 1163:2009	: Cold-formed structural steel hollow sections
AS/NZS 1252:1996	: High strength steel bolts with associated nuts and washers for structural engineering
AS/NZS 1554.1:2011	: Structural steel welding Part 1: welding of steel structures
AS/NZS 1554.2:2003	: Structural steel welding Part 2: stud welding (steel studs to steel)
AS/NZS 1554.5:2011	: Structural steel welding Part 5: welding of steel structures subject to high levels of fatigue loading
AS/NZS 2980:2007	: Qualification of welders for fusion welding of steels
AS/NZS 4680:2006	: Hot dipped galvanised (zinc) coatings on ferrous articles
AS/NZS 4855:2007	: Welding Consumables – Covered electrodes for manual metal arc welding of non-alloy and fine grain steels - Classification
AS/NZS ISO 9000.2:1998	: Quality management and quality assurance standards - Quality management and quality assurance standards - Generic guidelines for the application of ISO 9001, ISO 9002 and ISO 9003
AS/NZS ISO 9001:2008	: Quality Management Systems - Requirements
ASTM A106/A106M-08	: Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
BS 466:1984	: Specification for power driven overhead travelling cranes, semi-goliath and goliath cranes for general use
BS EN 10025:2004	: Hot rolled products of structural steels
BS EN 10029:2010	: Specification for tolerances on dimensions, shape, and mass for hot rolled steel plates 3mm thick or above
BS EN 60974	: Arc welding equipment
BS EN ISO 2560:2009	: Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels. Classification
HERA: June 1998	: Design and Construction Bulletin (HERA *DCB No.44*)
HERA	: Structural Steel Design Guide, Volumes 1 and 2
NZS 3404.1 & 2:1997	: Steel structures standard and Commentary
NZS 3910:2003	: Conditions of contract for building and civil engineering construction
NZS 4224:1983	: Code of practice for measurement of civil engineering quantities
NZS 4781:1973	: Code of Practice for safety in welding and cutting
WTIA	: Flame cutting of steels, WTIA Technical Note No. 5
WTIA	: Health and safety in welding, WTIA Technical Note No.7

b) Compliance with these Codes and with this Specification shall be the minimum requirement necessary for this Contract.

c) The documents listed above and in the clauses that follow refer to their latest issue complete with amendments that are current at the date of the Tender Document and are deemed to form part of this Specification. However, this Specification takes precedence when it is at variance with the cited document.

2.3.6.3 **Definitions**

Specification	: The Technical Specification covering the stated discipline
Construction Reviewer	: A person who, on the basis of qualifications or experience, is competent to undertake the review. See Clause 1.6.3.1 of NZS 3404
Welding Supervisor	: A person engaged by the Contractor who shall ensure that all welding is carried out in accordance with the plans, specifications, any other documents, and the requirements of AS/NZS 1554.1. His qualifications shall comply with AS/NZS 1554.1 Section 4.12.1.
Welding Inspector	: A person who has qualifications complying with AS/NZS 1554.1 Section 7. The Welding Inspector shall normally be an independent party contracted directly to the Contractor.
Part turn	: Method of tensioning bolts. See NZS 3404 15.2.5.2

2.3.6.4 **Abbreviations**

NZS	: New Zealand Standard
AS	: Australian Standard
HERA	: Heavy Engineering Research Association
BS	: British Standard
ISO	: International Standards Organisation
ASTM	: American Society for Testing and Materials
UB	: Universal beam
UC	: Universal column
PFC	: Parallel Flange Channel
TFC	: Taper Flange Channel
EA	: Equal Angle
RHS	: Rectangular Hollow Section
CHS	: Circular Hollow Section
HDG	: Hot Dipped Galvanised
NDT	: Non Destructive Testing
GP	: General Purpose (welds)
SP	: Special Purpose (welds)
WITA	: Welding Technology Institute of Australia

2.3.6.5 **Storage**

a) Storage shall comply with the relevant sections of NZS 3404.

b) Steel shall be stored in such a manner that is not damaged. Steel shall be stacked in a clean dry area on the site at least 300mm clear of the ground. Sufficient timber packing shall be provided to prevent distortion.

c) Steel decking shall be stored in accordance with the written requirements of the decking manufacturer. In all instances, decking shall be stored clear of the ground and protected from the weather.

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2.3.6.6 **Material Standards**

2.3.6.6.1 Structural Steel

Structural steel shall comply with NZS 3404 and the steel Grade shall be as listed below.

i. Universal Beams, Universal Columns, Parallel Flange Channels, Equal Angles, Unequal Angles, Taper Flange Channels, Taper Flange Beams.
Grade 300 or
BHP-300PLUS

ii. Hot-rolled plate, flat, packing or filler plates
Grade 250

iii. Welded Beams and Welded Columns
Grade 300 MOD (BHP New Zealand Steel)

iv. Rectangular Hollow Sections (RHS) and Square Hollow Sections (SHS)
Grade C350

v. Circular Hollow Sections
Grade C350 to AS1163 or
Grade B to ASTM A106, or
API Spec. 5L

2.3.6.6.2 Welding consumables

Welding consumables shall comply with AS/NZS 1554.1 and NZS 3404.

2.3.6.6.3 Bolts, Nuts and Washers

a) Bolts, nuts and washers shall comply with the standards listed in NZS 3404.

b) All bolts, nuts and washers shall be hot-dip galvanised by the manufacturer and comply with AS 1214. Custom galvanising of high strength bolts is not permitted.

2.3.6.6.4 Cold Formed Sections

a) These shall be Steel & Tube HST profiles to finish and grade as follows:
i. Grade 450 for metal thickness > 1.5mm
ii. Grade 500 for metal thickness < 1.5mm
iii. Hot-dip galvanised Z275 finish

b) Cold formed members forming a part of a roof or a wall are to be provided with galvanised sag and brace members in accordance with the manufacturers recommendations.

2.3.6.6.5 Steel Shear Studs

Steel shear studs shall comply with AS 1554.2.

2.3.6.6.6 Steel Decking Systems

a) Steel tray decking systems shall be manufactured from G550 galvanised steel coil, to AS 1397, with a Z200 zinc layer.

b) The Contractor shall be responsible for supply of all end caps, closure strips, edge forms and hanger tabs required to complete the decking.

2.3.6.6.7 Crane Rails

Lengths of individual crane rails shall not be less than 3m.

2.3.6.7 **Grating and Grating Treads**

Grating shall be per NAAMM MBG 531 for standard grating and per NAAMM MBG 532 for heavy duty grating. Depth of the bearing bars shall be based on the loading and span requirements. Gratings shall have an anti-slip system. Welding should be per NAAMM MBG 533.

Grating stair treads shall be sized for the required design load and span and shall meet the requirements of NAAMM.

2.3.6.8 **Handrails**

Handrails shall be designed, fabricated and installed per AS1657 "Fixed Platforms, Walkways, Stairways & Ladders – Design, construction and installation". Handrails should consist of hollow steel pipe of nominal size not less than 25 mm and thickness not less than 3mm. Posts, rail and corners maybe joined by either flush-type rail fittings, mitering and welding, or bending with suitable jigs so as to not

crush the pipe. Removable sections should be provided where appropriate around access openings. Handrailing shall be attached to walls and floors by suitable connections and face plates.

All pipe handrail systems shall be hot dipped galvanised, and site welding and repair is to be minimised.

2.3.6.9 **Fixed Ladders**

Comply with the requirements and recommendations of AS1657 "Fixed Platforms, Walkways, Stairways & Ladders – Design, construction and installation". The ladders and the stays shall be thickly galvanised after complete manufacture.

2.3.6.10 **Staircases**

Comply with the requirements and recommendations of AS1657 "Fixed Platforms, Walkways, Stairways & Ladders – Design, construction and installation". Staircases shall be suitable for the design loads acting on the plan area of the stair. The grating treads should be as described above. Stair and landings shall be guarded on each side with a continuous guard/handrail as appropriate. Staircases should have a maximum angle to the ground of 50º, while above 65º ladders should be boarded between 50º & 65º.

2.3.6.11 **Access Covers**

Access covers and frames shall be fabricated from standard steel sections and checker plate. They shall be weatherproof (prevent the ingress of water) when closed, and shall in all respects be strong and durable.

The minimum thickness of all materials shall be 3 mm. The covers shall be lockable. The covers and frames shall be galvanised.

2.3.6.12 **Chain-Link Fence and Gates**

Chain-link fence shall be per the Chain-Link Fence Manufacturer's Institute Product Manual. Fence posts, gates, and accessories shall be of the design that is standard with the manufacturer. Post tops, extension arms, gate hinges, stretcher bars, top-fitting rails, stretcher-bar bands, bolts and nuts, clips, and fabric bands shall be steel, wrought iron, or malleable iron.

Barbed wire shall be zinc coated after fabrication. Extension arms shall be cast steel galvanised to accommodate the provided number of strands of barbed wire and sloped to 45 degrees.

Gates should be of the swing type, hinged to swing through 90 degrees from closed to open, and shall be complete with latches, stops, keepers, hinges, fabric, braces, and padlocks. Gate frames and fabric shall match the fence. Provisions shall be made for the padlocks to be attached and operated from either side of the installed gate. Gate posts and gate end members shall extend above the top of fabric to support three strands of barbed wire.

With the exception of the chain link fabric, all ferrous metal used in the construction of the fence shall be hot-dipped zinc-coated after fabrication.

2.3.6.13 **Guard Rail**

Guard rail shall consist of a galvanised steel beam mounted on galvanised steel posts. Bolts, washers, and nuts used in connection with the guard rails shall be galvanised.

2.3.6.14 **Fabrication and Erection**

2.3.6.14.1 Connections

In general, shop connections shall be welded and field connections shall be bolted. All bolted connections for structural framing shall be made using ASTM A325/A490 high-strength bolts. Welded connections shall be completed in accordance with AWS D1.1.

2.3.6.14.2 Fabrication

Fabrication and assembly shall be performed in the shop to the greatest extent possible. All work shall be performed to the best modern practice in the manufacture and fabrication of materials of the type covered by the Employer's Requirements.

The Contractor shall fabricate all metal work in accordance with the accepted shop drawings and all requirements of AISC "Manual of Steel Construction." All work shall be square, true, straight, and

accurate to the required size, with joints closely fitted and properly secured. All shearing, planning and machine flame-cutting shall be done neatly and accurately. All joints that depend on bearing contact for transfer of load shall have the bearing surfaces machined to a common plane. Self-tapping shake-proof screws shall be used on items requiring assembly by screws or as required. Exposed welds shall be continuous for the length of each joint. Exposed welds shall be filed or ground smooth and flush.

2.3.6.14.3 Corrosion Protection, Painting, and Galvanizing

The Contractor shall adequately protect all parts of the Facilities against corrosion under service conditions and during transport, storage, and erection. The surface treatment shall in general be carried out at the manufacturer's facilities. Prior to shipment, the work shall be cleaned and primed or galvanised as required.

Items in contact with concrete, friction connection surfaces, machined surfaces, surfaces to be field welded and galvanised items shall not be primed. One shop coat of red oxide primer should be applied to all nongalvanised steelwork items. Minimum film thickness should be 50 mm. After grinding of rough welds and sharp edges, surfaces to be painted should be blast cleaned to Commercial SSPC SP6.

Heavy deposits of grease shall be removed by solvent prior to blast cleaning. Any rust formed on cleaned surfaces prior to painting shall be removed and the affected surfaces cleaned again. All damaged surfaces and surfaces without shop coat with primer shall be touched up, except as specified otherwise.

Material, including structural shapes, plates, bolts, expansion anchors, nuts, lock nuts, handrails, railings, railing posts, gratings and grating frames shall be hot-dip galvanised. Material shall not be galvanised until all shop operations upon it have been completed, except that nuts may be threaded after galvanizing.

Aluminium surfaces should be treated as follows:

a) Clean all surfaces and degrease with white spirit.
b) Apply etching primer to a total dry film thickness of not less than 2.5 mils.
c) Apply to two finishing coatings with paint of a single pack alkyd finish.
d) The final total dry film thickness should not be less than 12.0 mils. The coats of paint shall have different colours.
e)

2.3.6.15 **Erection of Structural Steel**

2.3.6.15.1 General

Erection of structural steel shall be in accordance with the applicable provisions of the AISC Specification, unless otherwise indicated.

2.3.6.15.2 Connections

Anchor bolts and other connections between the structural steel and the concrete structure shall be provided and shall be properly located and embedded.

2.3.6.15.3 Field-Welded Connections

Field-welded structural connections shall be completed in accordance with AWS D1.1.

2.3.6.15.4 Correction of Errors

Minor misfits may be corrected by moderate amounts of reaming, chipping, or cutting, and the drawing of elements into line through the use of drift pins. The Contractor shall clean with mechanical brushes and touch up shop primer to bolts, rivets, welds and burned or scratched surfaces at completion of erection.

2.3.6.16 **Installation of Miscellaneous Metals**

Installation of miscellaneous metals shall be in accordance with applicable provisions of the relevant specifications.

Grating shall be installed in accordance with manufacturer's standards. Fasteners shall be mechanical and detailed so that grating can be easily removed. All fasteners and hardware shall be galvanised or of corrosion resistant materials.

All anchors shall be chemical epoxy type and installed in accordance with manufacturer's instructions. Expansion type anchors are not permitted.

Exposed fastening devices shall match finish and be compatible with material through which they pass. Contractor shall touch-up rivets, field welds, bolts and burnt or scratched surfaces after completion of erection with primer. Contractor shall touch-up galvanised surfaces with zinc rich primer where burned by field welding.

2.3.7 Concrete (Block Masonry)

2.3.7.1 Scope

This Specification covers the requirements for the supply and laying of all concrete masonry work including filling with grout.

2.3.7.2 Applicable Codes and Standards

a) All work, materials and practices shall comply with the requirements of current New Zealand or Australasian standards for that particular class of work. The following standards shall apply specifically:

AS/NZS 1170.0:2002	: Structural design actions - general principles
AS/NZS 1170.1:2002	: Structural design actions - permanent, imposed and other actions
AS/NZS 1170.2:2011	: Structural design actions - wind actions
AS/NZS 1170.3:2003	: Structural design actions - snow and ice actions
AS/NZS 1170.5:2004	: Structural design actions - earthquake actions - New Zealand
AS/NZS 2699.1:2000	: Built-in components for masonry construction - wall ties
AS/NZS 2699.2:2000	: Built-in components for masonry construction - connectors and accessories
AS/NZS 4455.1:2008	: Masonry units, pavers, flags and segmental retaining wall units - Masonry units
AS/NZS 4455.3:2008	: Masonry units, pavers, flags and segmental retaining wall units - Segmental retaining wall units
AS/NZS 4671:2001	: Steel reinforcing materials
NZS 3101.1 & 2:2006	: Concrete structures standard
NZS 3103:1991	: Sands for mortars and plasters
NZS 3104:2003	: Specification for concrete production
NZS 3109:1997	: Concrete construction
NZS 3112.1:1986	: Methods of test for concrete - tests relating to fresh concrete
NZS 3604:1999	: Timber framed buildings
NZS 4202:1995	: Standard method of measurement of building works
NZS 4210:2001	: Masonry construction: materials and workmanship
NZS 4224:1983	: Code of practice for measurement of civil engineering quantities
NZS 4229:1999	: Concrete masonry buildings not requiring specific engineering design
NZS 4230:2004	: Design of reinforced concrete masonry structures

b) Compliance with these Codes and with this Specification shall be the minimum requirement necessary for this contract.

c) The documents listed above and in the clauses that follow refer to their latest issue complete with amendments that are current at the date of the Tender Document and are deemed to form part of this Specification. However, this Specification takes precedence when it is at variance with the cited document.

2.3.7.3 Materials

2.3.7.3.1 Quality Assurance

a) It shall be the Contractor's responsibility to ensure that the materials comply in all respects with the Drawings and Specification.

2.3.7.3.2 Material Standards

2.3.7.3.2.1 Masonry

a) All concrete masonry shall be in accordance with AS/NZS 4455. All to have true and unblemished surfaces and arises and be from a single manufacturer. Excessively damaged or otherwise irregular blocks will not be accepted.

b) Where block types are not shown on the Drawings, the blocks used shall be such as to achieve the joint patterns shown on the drawings, and be capable of being placed to reinforcing steelwork already in place. Knock-in bond beam blocks shall not be used instead of plain end blocks.

c) For intermittently filled construction, where vertical reinforcement is placed prior to laying of blocks, "Standard" blocks shall be used except at vertical reinforcement where "Open End" blocks shall be used. At horizontal reinforcement "Channel Bond Beam" blocks shall be used together with "Open End Channel Bond Beam" blocks at vertical reinforcement.

d) For "all Cells Filled" construction, "Open End Bond Beam" blocks shall be used throughout with "Knock-In Bond Beam Corner" blocks to be used at ends.

e) Blocks shall be cut, as necessary, to fit dimensions or to suit reinforcing. Cutting shall be done by means of a special hydraulic block cutting machine or carborundum saw and exposed edges shall be clean, square and even.

2.3.7.3.2.2 Mortar

All mortar shall have a compressive strength of 12.5MPa and shall generally be in accordance with NZS 4210, Section 2.2. Approved workability additives may be used.

2.3.7.3.2.3 Reinforcement

a) Reinforcement is as per this Specification and shall conform to Clause 2.6 of NZS 4210.

b) In general, reinforcement shall comply with AS/NZS 4671 and shall be deformed steel, except for ties, which are plain round mild steel.

2.3.7.3.2.4 Grout

a) Grout shall have properties specified in NZS 4210 clause 2.3.2 for the particular durability zone.

2.3.7.4 **Alternative Materials**

Should the Contractor propose to use materials other than those in this Specification, he shall submit to the Project Manager for approval detailed specifications of the materials he proposes to use. The Contractor shall not use any such materials until he has obtained written approval for their use from the Project Manager.

2.3.7.5 **Storage of Materials**

a) Materials shall be stored on site in accordance with the manufacturer's specification and shall be adequately protected against mechanical damage and prolonged exposure to ultraviolet radiation.

b) Upon delivery to site, the reinforcement shall immediately be stacked in racks located in a clean dry area removed from construction traffic. Before use, blocks shall be kept dry, free from contact with ground and completely covered from the weather.

2.3.7.6 **Defective Materials**

Defective materials shall not be used for the construction of the Facilities and shall be removed from Site and replaced with sound materials at the Contractor's expense.

2.3.7.7 **Execution**

2.3.7.7.1 Laying & Cleaning Down

a) Blockwork shall be carried out by blocklayers employed by a Contractor specialising in the laying of concrete blocks. All work shall be carried out in a tradesman-like manner. A foreman Blocklayer who is a Registered Mason shall be on site at all times blocks are being laid.

b) The surface on which the first course is laid shall be scabbled to form a good construction joint.

c) To facilitate cleaning out of mortar droppings and other debris, the first course of each lift shall be laid using inverted knock-in bond beam blocks. The surface on which the first course has been laid shall be sprinkled with sand to facilitate easy removal of the mortar.

d) All walls shall have clean out ports at the bottom of each lift, in accordance with NZS 4210 clause 2.7.8.2, and shall be formed by leaving half of full-face shells off. Where clean out ports will not be visible on completion of the work, the block side may be made good with the infill concrete. Where clean out ports will be exposed in the finished work face shells are to be mortared in and pointed to match the surrounding blockwork. The face shells shall be braced prior to grouting, but only after cleaning out and inspection by the Project Manager. Alternatively, retain the block fill with a recessed form, later to be plastered to a finish to match the balance of the masonry.

e) Masonry shall, in general, maintain stretcher bond, except where otherwise specified or shown on the drawings. Laying shall conform to NZS 4210 clause 2.7. Masonry shall be carefully laid out to avoid the use of cut blocks where possible. The Contractor shall advise the Project Manager when the first course has been laid.

f) Build Masonry to vertical reinforcing with open ended type blocks and end closers. Provide bond beam and open ended bond beam type blocks and end closers for horizontal reinforcement. Use special blocks or cut blocks as required.

g) Where Masonry is not course bonded at wall junctions, cut blocks to allow bond beam reinforcing to pass through.

h) Starter positions: Check the location of starter reinforcement before block laying commences, or by a dry trial lay up of the first course. Do not attempt to correct misplacement by cranking bars. Where misplacement exceeds the location tolerance, obtain written directions before proceeding further.

i) Moisture content: Ensure that blocks are air-dry prior to laying. Blocks shall not be laid during weather sufficiently inclement to affect the quality of the finished work. If necessary to reduce excess absorption of water from the mortar, some dampening of the surface is permissible but no surface water may be present at the time of placing mortar.

2.3.7.7.2 Joints

a) Joints, both horizontal and vertical, shall be level and plumb and of uniform thickness throughout, nominally 10mm and perpends on alternate courses shall be in a vertical line.

b) Remove excess mortar and droppings as the laying proceeds and in particular, keep spaces to be filled with concrete clear and clean. Mortar fins protruding more than 10mm from joints shall be removed before pouring core-filling concrete.

2.3.7.7.3 Construction Joints

a) Ensure the structural integration of all masonry with adjacent concrete work by providing well-roughened retarded construction joints at all junctions.

b) All construction joints between grout and concrete and between grout and grout shall be similar to Type B as described in NZS 3109, clause 5.6.3, prepared using an approved retarder, except that the roughness at fine grout surfaces may be ±1.5 mm above and below the average level. Use a "double strength" retarder if necessary to suit the high cement content of the grout.

c) Vertical joints between masonry and concrete shall achieve full structural integration across the joints. Allow to construct concrete work first with prepared vertical construction joints at block junctions the same as for horizontal construction joints. Lay masonry so that all courses have open ends abutting the existing concrete work.

2.3.7.7.4 Control Joints

a) Build control joints into walls where detailed on drawings, or, at no greater spacing that the maximum given in NZS 4210 clause 2.10.

b) Control joints shall be continuous vertical perpends. Reinforcement shall be discontinuous through the joint as detailed in Figure 2 of NZS 4210. Grouting of bond beams at control joint locations to be discontinuous unless specifically noted otherwise.

c) Rake back the vertical joints where accessible, to a depth of 10mm on each face at the block joint. At least four weeks after adjacent masonry has been grouted neatly point interior control joints with mortar to match all normal joints.

d) Joints required to be weatherproof shall be sealedwith an approved sealant on approved bond breaking tape. Prime the masonry before application. Use in complete accordance with the manufacturer's written instructions.

2.3.7.7.5 Pointing and Cleaning Down

a) Walls to be exposed in the finished work shall be neatly and expertly pointed with ruled concave joints of mortar, as previously specified, as the work proceeds.

b) Walls to be covered in the finished work shall have joints compacted by tooling and left flush. Add additional mortar to joints to ensure that they are completely full before tooling.

c) On completion of walls exposed in the finished work, clean down and remove all mortar projections and irregularities. Peach and make good around all pipes, conduits, etc., that penetrate concrete blockwalls. Make good any faults in the pointing.

2.3.7.7.6 Reinforcement

a) Ensure correct location of Masonry starters, paying regard to block layout, etc. Co-operation with other trades will be necessary in the set out of starters.

b) In general, vertical reinforcing will be positioned in advance of laying, but horizontal reinforcing will be positioned when the appropriate course is laid. Lapping bars shall be tied to each other.

c) Reinforcement shall be adequately held in position to achieve the cover specified.

d) Reinforcing details shall conform with Clause 2.6 of NZS 4210.

2.3.7.7.7 Rebates, Reveals, etc

Ensure all blocks around openings, etc. are correctly laid with sills, reveals and rebates as necessary.

2.3.7.7.8 Building In

As the work proceeds, build into masonry all necessary bolts, steelwork and metalwork items and other fittings and fixings as shown on the drawings or otherwise required for the work. The Blocklayer is to ascertain these particulars and make the necessary provisions beforehand.

2.3.7.7.9 Filling

a) Grouting shall be by the high lift grouting method described in NZS 4210. Note that a sequence of compacting, waiting and recompaction is to be followed.

b) All grout shall be vibrated using suitable equipment and shall intimately and completely surround the reinforcement and fill the voids. Finish to a level surface at the top of each pour and ensure good construction joints between pours. Do not grout until spaces to be filled are checked for restriction or debris.

c) Prevent any movement of reinforcement during grouting and setting. Ensure all face shells, supports, forms, etc. are adequately supported to prevent bursting of the wall during filling.

d) No cell filling shall take place above a bondbeam until that bondbeam and all cells below it have been properly filled.

2.3.7.7.10 Tolerances

Construct within the tolerances set out in NZS 4210, clauses 2.6.5 and 2.7.1.4. Lay blocks with jointing of consistent thickness throughout.

2.3.7.7.11 Weather Precautions

When extreme temperatures prevail, make adjustments to construction as listed in NZS 4210, sections 2.18 and 2.19.

2.3.7.7.12 Bracing

a) Provide temporary lateral bracing where necessary to ensure stability and until final supporting construction is in place.

b) The Contractor's attention is drawn to the fact that reinforced walls will not be stable under all conditions until the infill concrete in them has reached its design strength, and that he should therefore allow to strut walls until this strength has been achieved.

2.3.7.7.13 Inspection and Testing

a) Blockwork will be subject to observation by the Project Manager to ensure the standard of blockwork construction satisfies this Specification.

b) The Project Manager requires the Contractor to notify him, at least one full working day in advance, when any cell filling will be done, so that he may have the opportunity of observing prior to its beginning, and of being in attendance. Such notification, observation or attendance shall in no way relieve the Contractor of any of his responsibilities under the contract.

c) Specific testing requirements shall be as specified in Section 4 of this Specification. All costs of testing shall be borne by the Contractor, who is required to maintain on site the necessary equipment for taking and preparing samples for test. All test results shall be supplied to the Project Manager.

2.3.7.7.14 Completion

Protect angles and corners against impact and other damage. On completion, clean down walls and remove all mortar projections and irregularities and all surplus mortar from beneath the overhanging edges of bottom courses. Make good around all penetrations. Make good any damaged corners, arrises, or surfaces. Remove from Site any debris pertaining to this trade. Remove all efflorescence at the end of the defects liability period.

2.3.8 **Retaining Systems (Gabions)**

2.3.8.1 **Scope**

This specification covers the construction of coated rock-filled wire mesh basket gabions in accordance with New Zealand and international standards and industry practice.

2.3.8.2 **Applicable Codes and Standards**

a) All work, materials and practices shall comply with the requirements of current New Zealand statutes, regulations, codes and standards for that particular class of work. Where a relevant NZ document does not exist, Australian or other recognised international standards may be accepted, subject to the Project Manager's approval.

b) Compliance with the standards referred to herein shall be the minimum requirement necessary for this contract.

c) The documents listed in this specification refer to their latest issue complete with amendments current at the date for return of tenders and are deemed to form part of this specification. However, this specification takes precedence when it is at variance with a cited document.

AS 2758.4:2000	:	Aggregates and rock for engineering purposes – Aggregate for gabion baskets and wire mattresses
AS 4678:2002	:	Earth-retaining structures
AS/NZS 4534:2006	:	Zinc and zinc/aluminium-alloy coatings on steel wire
AS/NZS 4680:2006	:	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
ASTM A313 – 10e1	:	Standard Specification for Stainless Steel Spring Wire
ASTM A856 - 03	:	Standard Specification for Zinc-5% Aluminum-Mischmetal Alloy-Coated Carbon Steel Wire
ASTM A975 - 97	:	Specification for Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire with Poly Vinyl Chloride (PVC) Coating)
ASTM B750 - 09	:	Standard Specification for GALFAN (Zinc 5%-Aluminum-Mischmetal) Alloy in Ingot Form for Hot-Dip Coatings
NZS 4402:1986	:	Methods of testing soils for civil engineering purposes – Soil Tests
NZS 4407.3.10:1991	:	Methods of sampling and testing road aggregates - Laboratory tests - Test 3.10 - The crushing resistance of coarse aggregate under a specific load

2.3.8.3 **Definitions**

Diaphragm	Transverse mesh panel which divides the gabion into cells
Galfan	95%-Zinc, 5%-Aluminium-Mischmetal (Zn-5Al-MM) alloy used in the production of hot-dip coatings on steel (see ASTM B750 and ASTM A856)
Galmac	Maccaferri trade name for its version of Galfan
Mischmetal	Alloy of rare-earth metals containing about 50% cerium and 50% lanthanum, neodymium, and similar elements
Selvedge	Reinforced wire edge of a basket, wound so that the gabion will not fray or unravel

2.3.8.4 **Materials**

2.3.8.4.1 Baskets

2.3.8.4.1.1 Mesh

a) Mesh wire shall have a tensile strength between 372 – 470 MPa and be manufactured with wire coating in accordance with the coating types and standards specified.

b) The mesh shall be hexagonal and formed of double twisted wire. It shall have sufficient deformability to permit minimum mesh elongation equivalent to 10% of the un-stretched length of a mesh test section without reducing the gauge or tensile strength of individual wire strands to less than that for similar wire, one gauge smaller in diameter.

c) The mesh shall be fabricated so as not to unravel. It shall resist pulling apart at any twist or connection forming the mesh when a single wire strand in a section of mesh is cut or broken.

2.3.8.4.1.2 Fabrication

a) Gabions shall be fabricated so that the sides, ends, lid and diaphragms can be assembled at Site into baskets of the size specified and shown in the Drawings. The gabion base, lid, ends, and sides shall be woven into a single unit.

b) All edges shall be selvaged using wire of diameter not less than 25% greater than that of the gabion. Alternatively, stainless steel ring fasteners of diameter ≥ 3.0 mm and tensile strength between 1530 - 1745 MPa (to ASTM A313) may be used in lieu of lacing wire.

c) Where the length of the gabion exceeds 1.5 times its horizontal width, the gabion shall be divided into cells by diaphragms of the same mesh and gauge as the gabion body. Individual cell length shall not exceed the cell width + 100 mm. The gabion shall be furnished with the necessary diaphragms secured in the proper position on the base in such a way that no additional diaphragm tying is required at Site.

2.3.8.4.1.3 Form for Delivery

Gabions shall be delivered to site in collapsed form, folded and in compressed strapped bundles. Lacing wire shall be delivered in coils. Ring fasteners shall be delivered in boxes. Preformed bracing wires shall be delivered in bundles.

2.3.8.4.2 Gabion Fill Material

a) Gabion fill shall be durable dense rock compliant with AS 2758.4 and be weather resistant, non-friable, insoluble and sufficiently hard for its duty.

b) The rock shall be between 1.5 and 3 times the diameter of the dimension of the mesh, in the range 100 – 200 mm. A variation of 5% oversize and/or 5% undersize rock may be permitted, provided it is not placed on the gabion's exposed surface. On no account shall oversized rock exceed 210 mm or undersized rock be smaller than 90 mm. Rock that can pass through the mesh shall not be used.

c) Rock shall have a minimum crushing resistance of 130 kN when tested in accordance with the NZS 4407:1991 Test 3.10 "The Crushing Resistance Test".

d) Every effort shall be made to ensure that the stone fill material used in constructing the gabion structure matches the stone fill on which the designs were based.

2.3.8.4.3 Granular Backfill

Granular backfill shall consist of a durable, free draining, and crushed granular material. The backfill shall be graded and conform to the grading specification as determined by NZS 4402-1986.

2.3.8.4.4 Geotextile Filter Fabric

Filter fabric shall be non-woven needle punched geotextile or approved equivalent.

2.3.8.5 **Execution**

2.3.8.5.1 Excavation

a) Excavation for the gabion baskets shall be kept to the minimum necessary to provide suitable foundations. The base of the finished foundation, ready for the placement of gabion baskets, shall be dished to provide a positive outlet such that water does not pond beneath the baskets.

b) The Project Manager shall verify on-site the suitability of foundations. The Contractor shall give the Project Manager at least one working day's notice of when the excavation to foundation level will be ready for inspection. Inspection must be conducted prior to installation of the gabion baskets.

c) Installation of gabion baskets shall proceed as quickly as practicable after excavation and inspection so as to minimise the effect upon adjacent areas.

2.3.8.5.2 Lining

Unless shown otherwise on the drawings, geotextile filter fabric shall be placed immediately beneath and behind the gabion walls.

2.3.8.5.3 Gabion Assembly

a) Gabion size, construction and selvaging shall be according to the manufacturer's specification and as shown on the Drawings. All gabion dimensions shall be within ±5 % of the manufacturer's stated dimensions.

b) Each gabion unit shall be assembled by tying or fastening all connecting seams using selvage wire of the diameter specified. The binding wire shall be tightly looped around every other mesh opening along the seams in such a way that single and double loops alternate.

c) Ring fasteners, if used, shall be applied at not more than 200 mm intervals on all vertical and horizontal seams. No fewer than 2 fasteners shall be used per 300 mm on any seam. The ring ends shall have a nominal overlap of 25 mm after closure.

2.3.8.5.4 Gabion Placing

a) All work shall be installed in accordance with the manufacturer's recommendations. A line of empty gabions shall be placed into correct position, alignment and angle according to the Drawings. Binding wire or alternative wire fasteners shall be used to secure each unit to the adjoining one along the vertical reinforced edges and the top selvedges.

b) Baskets shall be correctly tensioned. A manufacturer approved corner closure tool shall be used to join adjacent gabions to ensure a tight, neat seam at front and back and minimise additional wire or fasteners.

c) The end from which work is to proceed shall be secured either to completed work or by steel stakes driven into the ground. The stakes must be secure and reach at least to the top of the gabion box.

d) Placement of adjacent gabion units in any one layer shall be front to front and back to back so that pairs of facing lids can be wired down in one process.

e) When more than one layer of gabions is to be assembled, in order to provide a unified structure, the next layer of gabions must be secured to the layer underneath after the lower layer has been securely closed. This securing shall be to the same centres and methods specified for selvedges.

f) To achieve optimum alignment and finish for retaining walls, stretching if the gabion boxes shall be carried out using a pull lift of at least 1 tonne capacity, which is firmly secured to the free end of the assembled gabion boxes. Tension shall only be released when the gabions are fully laced and sufficiently filled with rock to prevent the mesh from slackening.

2.3.8.5.5 Gabion Filling

a) Rock filling shall be performed manually to minimise voids. Care shall be taken to avoid damage to the wire coating. Rocks shall not be dropped from more than 600 mm vertically above the gabion basket. Exposed faces shall be carefully hand placed to give a neat, flat and compact appearance. Fill shall be fully compacted and the completed gabion shall be without deformation.

b) The cells shall be filled in stages to avoid local deformation. No cell shall be filled to a depth exceeding 300 mm higher than an adjoining cell.

c) To prevent distortion of the gabion units during filling and in the completed structure, pre-formed bracing wires shall be inserted into the cells during the filling operation according to

the manufacturer's instructions and at least every 300 mm vertical fill of the gabion unit. A minimum of two ties must be used per 300 mm lift. The bracing wires shall be wrapped around two of the mesh wires and extend from front to back.

d) The rock fill shall be levelled off 20 - 30 mm above the top of the mesh to allow for settlement. The top edge of diaphragms must remain exposed.

2.3.8.5.6 Gabion Closing

a) The lids of filled gabion units shall be folded down and pulled where necessary using a crowbar to close any gaps between the edge of the lid and the edges of the basket before lacing down. Excessive deformation of the lid or basket shall be avoided by redistribution of fill if necessary.

b) The closed lids shall be tightly laced along all edges, ends and diaphragms in the same manner used for assembling the gabions. Adjacent lids may be securely attached simultaneously. All end wires shall be turned in.

2.3.8.5.7 Granular Backfill

a) The backfill shall extend behind the gabion walls for at least 300 mm and shall be spread evenly in horizontal layers not exceeding 200 mm loose depth. Unless specified otherwise on the drawings, the granular backfill shall be capped with a layer of geotextile filter fabric and a 200 mm thick layer of clay to prevent the entry of surface runoff.

b) Where more than one lift of gabions is constructed, granular backfill should proceed with the construction of the baskets, such that no more than one basket-height of fill remains at any time.

2.4 Pipework General Requirements

2.4.1 Pipework (Pressure Pipelines)

2.4.1.1 Applicable Codes and Standards

a) All work, materials and practices shall comply with the requirements of current New Zealand standards for that particular class of work. The following New Zealand standards shall apply specifically:

ANSI/ASME B36.19M: Stainless Steel Pipe
ANSI/ASME B16.9 : Factory-Made Wrought Buttwelding Fittings
AS 1111.(1-2):2000: ISO metric hexagon bolts and screws
AS 1281:2001 : Cement mortar lining of steel pipes and fittings
AS 1554.1:2004 : Structural steel welding - Welding of steel structures
AS 1579:2001 : Arc- welded steel pipes and fittings for water and wastewater
AS 2239:2003 : Galvanic (sacrificial) anodes for cathodic protection
AS 2638.1:2002 : Gate valves for waterworks purposes – Metal seated
AS 2638.2:2006 : Gate valves for waterworks purposes – Resilient seated
AS 2832.1:2004 : Cathodic protection of metals – pipes and cables
AS 3571.1:2001 : Plastics piping systems - Glass-reinforced thermoplastics (GRP) systems based on unsaturated polyester (UP) resin - Pressure and non-pressure drainage and sewerage (ISO 10467:2004, MOD)
AS 3571.2:2001 : Plastics piping systems - Glass-reinforced thermoplastics (GRP) systems based on unsaturated polyester (UP) resin - Pressure and non-pressure water supply (ISO 10639:2004, MOD)
AS 3680:2008 : Polyethylene sleeving for ductile iron piping
AS 3681:2008 : Application of polyethylene sleeving for ductile iron piping
AS 3690:2009 : Installation of ABS pipe systems
AS 3996:2006 : Access covers and grates
AS 4037:1999 : Pressure equipment – Examination and testing
AS 4041:2006 : Pressure Piping
AS 4087:2011 : Metallic flanges for waterworks purposes
AS 4321:2001 : Fusion-bonded medium-density polyethylene coating and lining for pipes and fittings
AS/NZS 1200:2000 : Pressure Equipment
AS/NZS 1516:1994 : The cement mortar lining of pipelines in situ
AS/NZS 1518:2002 : External extruded high-density-polyethylene coating system for pipes
AS/NZS 2033:2008 : Installation of polyethylene pipe systems
AS/NZS 2280:2004 : Ductile iron pipes and fittings
AS/NZS 2312:2002 : Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
AS/NZS 2566.1:1998 : Buried flexible pipelines – Structural Design
AS/NZS 2566.2:2002 : Buried flexible pipelines - Installation
AS/NZS 2980:2007 : Qualification of welders for fusion welding of steels
AS/NZS 3518:2004 : Acrilonitrile butadiene styrene (ABS) compounds, pipes and fittings for pressure applications
AS/NZS 3725:2007 : Design for installation of buried concrete pipes
AS/NZS 3750:various : Paints for steel structures
AS/NZS 3862:2002 : External fusion-bonded epoxy coating for steel pipes
AS/NZS 3992:1998 : Pressure equipment - Welding and brazing qualification
AS/NZS 4020:2005 : Testing of products for use in contact with drinking water
AS/NZS 4058:2007 : Precast concrete pipes (pressure and non-pressure)
AS/NZS 4130:2009 : Polyethylene (PE) pipes for pressure applications
AS/NZS 4158:2003 : Thermal-bonded polymeric coatings on valves and fittings for water industry purposes
AS/NZS 4331.1:1995 : Metallic flanges – Part 1: Steel flanges
AS/NZS 4331.2:1995 : Metallic flanges – Part 2: Cast iron flanges

BS/EN 545:2006 : Ductile pipes, fittings, accessories and their joints for water pipelines – requirements and test methods
BS/EN 598:2007 : Ductile pipes, fittings, accessories and their joints for sewerage applications – requirements and test methods
BS/EN 1092-1:2007 : Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges
BS/EN 1092.2:1997 : Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges
ERMA Code
HSNOCOP 22-1:2007 : Code of Practice for Pipework Under Pressure
NZS 3109:1997 : Concrete construction
NZS 3501 : Specification for copper tubes for water, gas, and sanitation
NZS 4104:1994 : Seismic restraint of building contents
NZS 4224:1983 : Code of practice for measurement of civil engineering quantities
NZS 4442:1988 : Welded steel pipes and fittings for water, sewage and medium pressure gas
NZS 5807:1980 : Code of practice for industrial identification by colour, wording or other coding

b) Compliance with these Codes and with this Specification shall be the minimum requirement necessary for this Contract.

c) The documents listed above and in the clauses that follow refer to their latest issue complete with amendments that are current at the date of the Tender Document and are deemed to form part of this Specification. However, this Specification takes precedence when it is at variance with the cited document.

2.4.1.2 **Definitions**

Expansion joint: A pipe joint that allows relative longitudinal movement between adjacent pipes without the occurrence of fracture or leakage
Flexible joint: A pipe joint that allows relative angular (radial) and longitudinal movements between adjacent pipes without the occurrence of fracture or leakage
Specification: The Technical Specification covering the stated discipline
Rigid joint: A pipe joint that allows no relative movement between adjacent pipes without the occurrence of fracture or leakage
Specifications: The Employer's Requirements as defined in the Conditions of Contract

2.4.1.3 **Abbreviations**

CI: Cast iron
DI: Ductile iron
GRP: Glass filament reinforced thermosetting plastic
HDPE: High density polyethylene
MDPE: Medium density polyethylene
PE: Polyethylene

2.4.1.4 **Materials**

2.4.1.4.1 Material Standards

2.4.1.4.1.1 Polyethylene (PE) Pipes

PE pipes shall comply with AS/NZS 4130.

2.4.1.4.1.2 Ductile Iron Pipes

Ductile Iron Pipes shall comply with AS/NZS 2280, cement mortar lined in accordance with AS 1281 or AS/NZS 3862 as applicable and externally painted with a bituminous protective coating in accordance with AS/NZS 3750.4 or equivalent. When laid underground, the pipe shall have a loose polyethylene protective sleeve to AS 3680 and applied in accordance with AS 3681.

2.4.1.4.1.3 GRP Pipes

GRP pipes shall be SN5000 and shall comply with AS 3571.

2.4.1.4.1.4 Steel Pipes

a) Steel pipes shall comply with NZS 4442 and shall be cement mortar lined in accordance with AS 1281 or AS/NZS 1516 as applicable. Unless otherwise specified, steel pipes shall be externally protected with one of the following :

i. for buried pipes, a high density polyethylene sleeve, "black jacket" complying with AS 1518.
ii. for pipe bridges and pipes above ground, a zinc metal spray sealed with vinyl or epoxy coating complying with AS/NZS 2312 or a fusion bonded epoxy coating complying with AS/NZS 3862.

b) Steel pipes shall be fitted with cathodic protection complying with AS 2239 and AS 2832.1.

2.4.1.4.1.5 Fittings, Joints and Couplings

a) Except as set out in (b) below, tees, hydrant tees, crosses, tapers, blank caps, bends and gibaults shall be ductile iron complying with AS/NZS 2280.

b) All fittingsshall be protected with a thermal bonded coating complying with AS/NZS 4158, or be externally bitumen coated and internally concrete lined to comply with AS/NZS 2280.

c) Bolts, washers and nuts in joints shall be 316 stainless steel or hot dipped galvanised mild steel with a thermal bonded coating complying with AS/NZS 4158. A nickel or molybdenum based anti-galling lubricant (e.g. molybond) shall be used when installing stainless steel nuts and bolts.

d) Spigot and socket rubber ring joints shall ductile iron to AS/NZS 2280.

e) Flanged joints shall comply with AS 4087. Buried joints shall be protected in accordance with the manufacturer's recommendations.

f) Welded joints shall either be butt welded or spigot and socket welded as appropriate. The welded joints of steel pipe shall be protected in accordance with the manufacturer's recommendations.

g) Gibault joints shall be fitted with grade 316 stainless steel bolts or galvanised mild steel bolts, provided that if galvanised bolts are used, the whole Gibault shall be protected by plastic sleeve, taped in place. Buried joints shall be protected in accordance with the manufacturer's recommendations. Gibaults shall not be used in direct contact with concrete lined steel pipe.

h) MDPE joints shall be welded.

2.4.1.4.1.6 Pressure Classes

Pipes and fittings shall be designed and manufactured for the design pressure including transient allowances.

2.4.1.4.1.7 Bedding Material

Material used for bedding, pipe surround and haunching shall be selected granular, non-cohesive, free draining material selected in accordance with the pipe manufacturers recommendations.

2.4.1.4.2 Storage of Materials

a) Pipes shall be unloaded and handled in accordance with the manufacturer's recommendations.

b) Pipes shall be stored on level ground.

c) Pipes shall be protected from direct sunlight if stored for more than one month after delivery from the supplier.

d) PE pipes that have scoring or damage to a depth greater than 10% of the wall thickness or have been distorted because of improper handling and/or storage shall not be used in the Facilities.

e) Steel and ductile iron pipes shall be stored in such a way that liners and coatings are not chipped or damaged or become debonded from the pipe.

2.4.1.4.3 Defective Materials

Any pipes or other materials that do not comply with this Specification or that have been damaged during handling and storage shall be removed from site and replaced or repaired by the manufacturer.

2.4.1.5 **Execution**

2.4.1.5.1 Trench Excavation, Backfilling and Reinstatement

Trench excavation, backfilling and reinstatement shall be in accordance with the Specification.

2.4.1.5.2 Handling and Placing

The plant and rigging equipment used by the Contractor for the handling and placing of pipes shall be of the type recommended by the pipe manufacturer and such that at no time during handling and placing is any pipe overstressed or damaged.

2.4.1.5.3 Bedding, Laying and Jointing

2.4.1.5.3.1 Bedding

All principal and rider mains shall be thoroughly bedded, haunched and surrounded by a granular bedding at least 100mm thick below the soffit of the pipe and at least 300mm thick above the crown of the pipe. The material shall be well rammed and compacted so as to hold the pipe firmly in position and prevent future settlement. Care shall be taken during compaction to avoid displacing or damaging the pipe.

2.4.1.5.3.2 Laying and Installation of Pipes

a) Where socketed pipes are required to be laid on a granular or sand bed, joint spaces shall be formed in the bedding material to ensure that each pipe is uniformly supported throughout the length of its barrel and to enable the joint to be made.

b) No protective cap, disc or other appliance on the end of a pipe or fitting shall be removed permanently until the pipe or fitting which it protects is about to be jointed. Pipes and fittings, including any lining or sheathing, shall be examined for damage and the joint surfaces and components shall be cleaned immediately before laying.

c) Suitable measures shall be taken to prevent soil or other material from entering pipes, and to anchor each pipe to prevent flotation or other movement until the works are complete.

d) Where a metallic detection strip is specified, it shall be laid between 100mm and 300mm above the pipe and shall be continuous and adequately secured to valves and fittings.

e) In all cases, the manufacturer's recommendations for pipe storage, handling, protection and laying techniques shall be followed.

f) All pipe joints, fittings and anchors shall be left exposed for inspection during the course of the acceptance test unless otherwise agreed by the Project Manager.

g) Pipes shall be installed so they are centred in the trench and on the alignment as shown in the Drawings.

2.4.1.5.3.3 Cutting of Pipes

a) Pipes shall be cut by a method which provides a clean square profile, without splitting or fracturing the pipe wall, and which causes minimal damage to any protective coating. Where necessary, the cut ends of pipes shall be formed to the tapers and chamfers suitable for the type of joint to be used. Any protective coatings shall be made good.

b) Where pipes are to be cut to form non-standard lengths, the Contractor shall comply with the manufacturer's recommendations in respect of end preparation for further jointing.

c) Pipe jointing surfaces and components shall be kept clean and free from extraneous matter until the joints have been made or assembled.

2.4.1.5.3.4 Jointing of PE Pipes

a) PE pipes shall be butt-welded or electrofusion welded in accordance with the manufacturer's specifications.

b) All welding, both butt and electrofusion, shall be carried out by welders who are certified by an accredited PE welding technical institute.

c) The Contractor shall keep weld records of all welds and shall forward them to the Project Manager immediately after welding. The weld records shall clearly demonstrate that the procedure specified by the manufacturer and that the weld parameters have been achieved.

d) All butt-welding of PE pipes shall be undertaken within a welding tent that completely surrounds the pipe and welding equipment. The open ends of the pipes shall be sealed during installation to prevent contamination of the ends prior to welding and to prevent circulation of air within the pipe. Welding of pipes during inclement weather periods shall not be undertaken.

e) All welds shall be stamped with a weld number and the welder's identification number. The stamp shall be made in the bead at the beginning of the cooling process, while the material is still soft.

f) Each welded joint shall have a record, correlated with the weld number.

g) The internal weld bead shall be removed to provide a smooth bore.

h) Flanges on PE pipes shall be stub flanges with loose metal backing rings or full face up to 100 mm pipe diameter. On ABS and PE pipes of 100 mm diameter and larger, stub flanges with metal backing rings shall be used. Backing rings shall be manufactured from 316 or 316L stainless steel.

2.4.1.5.3.5 Jointing of GRP Pipes

GRP pipes shall have spigot and socket joints with rubber rings or shall be jointed with GRP pressure couplings in accordance with the manufacturer's recommendations.

2.4.1.5.3.6 Jointing of Ductile Iron Pipes

Ductile iron pipes shall have spigot and socket joints with rubber rings.

2.4.1.5.3.7 Jointing of Steel Pipes

a) Steel pipes shall have spigot and socket joints with rubber rings or shall be plain ended and butt welded as appropriate.

b) Pipes for welding shall be jointed by an arc welding process capable of consistently producing welds complying with the requirements of NZS 4442.

c) Full details of the welding procedure and of the edge preparation proposed to be used shall be supplied to the Project Manager prior to welding.

d) Any faulty welds shall be cut out and rewelded. On no account shall leaks be sealed by caulking.

e) On completion and acceptance of the welding by the Project Manager, the external corrosion protection shall be repaired.

2.4.1.5.3.8 Jointing of Curved Pipelines

Where steel and ductile iron pipes with flexible joints are required to be laid to curves, the maximum deflection at any joint shall be 2.5 degrees, which is equivalent to a 250mm offset for a 6 metre length pipe.

2.4.1.5.3.9 Thrust Blocks and Anchorage

a) Cast in situ concrete thrust blocks shall be provided at all points where the pressure pipeline changes direction, and where other unbalanced thrust occurs, with the exception ofwhere alternative provision is made and thrust blocks are specifically omitted.

b) Normal maximum concrete encasement shall be 180 degrees. All thrust blocks shall be designed according to the soil bearing capacity and shall be installed so as not to impair access to bolts or fittings.

c) Where concrete is poured against PE pipe or fittings, a protective membrane shall be placed to separate the concrete from the pipe or fitting.

d) All fittings and anchors shall be left exposed for inspection until after the acceptance test unless previously inspected by prior arrangement with the Project Manager.

2.4.1.5.3.10 Pipes Connected to Structures

Where a pipe is built into an underground structure, a flexible joint shall be provided as close as possible to the outside face of the structure. A short length of rocker pipe shall be connected to the flexible joint. The length of the rocker pipe shall not exceed 8 diameters or 3m, whichever is the shorter.

2.4.1.6 **Tolerances**

a) No deviation will be permitted from the minimum cover shown on the Drawings.

b) The centreline of the pipeline and designated changes in gradient shall be regarded as control points and shall be located with a permissible vertical deviation of ±100mm on the centreline. The same deviation will be permissible laterally, except where the Contractor is required to lay the pipeline at a designated distance from a fence line, kerb line or boundary, in which case the permissible deviation shall be ±20mm.

c) The permissible deviation in alignment between control points from a straight line joining the control points shall be ±100mm or ±20% of the nominal diameter of the pipe, whichever is the larger, and the permissible deviation per pipe length shall be ±20mm.

d) The permissible deviation from the designated level at any point on the pipeline shall be ±50mm or ±10% of the nominal diameter of the pipe, whichever is the larger.

2.4.1.7 **Inspection and Testing**

2.4.1.7.1.1 Pressure Testing of Pipelines

a) All new pipes shall be subjected to a pressure test after laying and jointing.

b) All necessary apparatus for testing shall be supplied by the Contractor. The section to be tested shall be capped or flanged off at either end, and at branches intended to be tested separately. The blanked off ends and branches shall be securely propped or otherwise prevented from movement, before applying any pressure.

c) Pipelines shall withstand a hydrostatic pressure of 1.5 times the maximum working pressure for 15 minutes measured at the lowest point of the section under test without any drop in pressure.

d) For PE pipes, the test procedure shall be identical to that for all other pipe types, except that, if the test pressure cannot be maintained for 15 minutes, the pressure shall be rapidly lowered to 300kPa on the test gauge by opening a release valve at the extremity of the section under test. When 300kPa is reached, the valve shall be shut, and in order for the pipe to pass the test, the pressure on the test gauge shall rise to 450kPa within 10 minutes.

e) The Contractor shall successfully pre-test the line before requesting an acceptance test.

f) Any faulty pipes, joints or fittings shall be replaced by the Contractor and the line retested.

2.4.1.7.1.2 Joint Inspection and Testing (PE Pipes)

a) All joints installed by open trench methods shall be left uncovered until the Project Manager completes the visual inspection.

b) Each butt welded joint will be visually inspected by the Project Manager to check that:

i. Both fusion beads are of the same size and shape and project evenly above the outside diameter of the pipe.
ii. The bead width is within the parameters shown in the table below.
iii. The fusion bead does not have a highly polished appearance (indicating too high a temperature).
iv. There are no cracks in the beads.
v. There are no obvious inclusions or other faults present.

Bead Width	
Minimum Wall Thickness (mm)	Width of Bead (mm)
3	4-6
4	4-7
5	5-8
6	6-9
8	7-10
9	8-11
11	9-12

Bead Width (continued)	
Minimum Wall Thickness (mm)	Width of Bead (mm)
13	10-14
16	11-15
18	12-16
19	12-18
22	13-18
24	14-19

c) Each electrofusion joint will be visually inspected by the Project Manager to check that:

i. The pipes and fitting have been aligned correctly.
ii. The pipe ends have been positioned centrally to the coupling. Measurement marks on the pipes shall be visible to show this.
iii. The pipe ends have been cleaned by scraping. The scrape marks shall extend at least 20mm from the edge of coupling.
iv. There are no cracks or inclusions in the interface between the fitting and the pipe.
v. There is no evidence of under- or over-melt (observe the extent rise of melt in the fusion indicator holes).
vi. There is no evidence of melt leak from the interface between the pipe and coupling.
vii. There is no evidence of the electrofusion wires exposed in the joint.

d) The Contractor shall obtain the approval of the Project Manager for each joint prior to installation or backfilling.

2.4.2 Valves and Gates

2.4.2.1 General

a) Valves and penstocks shall comply with NZS/AS specifications and the relevant provisions of the Standards and the following clauses.

b) Valve extension spindles shall be solid stainless steel 316, fabricated in single lengths. Any lengths stated or shown are approximate only and the Contractor shall be responsible for obtaining the exact length. The maximum length between guides shall be 2m.

c) Operating handwheels shall have the direction of open/close operation cast, stamped, or otherwise permanently marked upon the handwheel rim.

d) All valves shall be supplied with handwheels.

e) Handwheels shall be sized to enable the valve to be operated against the maximum operational differential pressure or a minimum of one bar; whichever is the greater, with an operating effort at the rim (push/pull) not exceeding 250N.

f) Where situated remote from the valve, operating handwheels shall be positioned at a nominal height of 1m above operating floor level. Extension spindles shall be supported by means of guide brackets/floor pedestals.

g) Lever-operated valves shall require a force not exceeding 250N, applied at the lever, to open or close the valve. In the open position the lever shall be parallel to the direction of flow. In the closed position the lever shall be at right angles to the direction of flow.

h) Remote mounted actuators shall each be mounted on a floor pedestal and shall be provided with drive shafts between valve and actuator units complete with all necessary universal joints and shaft support bearing brackets.

i) Provision shall be made for the necessary lubrication of all universal joints/bearing points in an extended valve drive shaft assembly. Lubrication facilities shall be in the form of grease nipples or grease filled protective gaiters as appropriate.

j) Guards shall be designed such that universal joints and other serviceable areas are readily accessible without dismantling the headstock or valve unit. Guards may be split along the longitudinal axis or be of telescopic design. Guards shall be designed to comply with "Guidelines for Guarding Principles" published by NZ Department of Labour.

k) Valves shall normally be designed for clockwise closing.

l) Valves shall be capable of being locked in their operating and isolation position to prevent unauthorised use of the valves. Valves fitted with a handwheel shall incorporate a locking bracket for use with a padlock or padlock and chain. Valves fitted with valve caps shall be provided with a lockable cap. All devices shall be easily removed when unlocked and captive to prevent loss of the device.

2.4.2.2 **Gate Valves**

a) All gate valves shall be resilient seated constructed to AS/NZS 2638.2.

b) Each valve shall present a virtually full bore opening to the flow when fully open, free from obstruction and from a seat pocket where solids can accumulate and give rise to solids compaction when the valve is being closed.

c) The body/gate seal shall be located outside the fluid flow so as to be protected from erosive/abrasive solids in the flow and shall provide a bubble tight shut-off.

2.4.2.3 **Air Release and Vacuum Relief Valves**

Combination air release and vacuum relief valves shall be Stainless Steel. All air valves shall be rated to PN10. An isolation valve shall be fitted immediately upstream of the air valve.

2.4.2.4 **Flap Gates**

All new flap gates shall be rectangular type with neck and plain flap for anchor bolting, manufactured from 316L stainless steel, chloroprene seal.

2.4.2.5 **Slide Gates**

a) Slide gates shall consist of a sliding door controlled by a mechanically operated spindle moving vertically over an aperture in the frame.

b) Each gate shall have a rising spindle.

c) The gate supplier shall provide a seating detail for each gate.

d) Each gate shall be engineered to ensure it is suitable for the loading and duty required. Seat materials and design will take into consideration the service duty and service life.

e) The design, selection of materials, manufacture, testing/inspection, definitions and provision of information shall comply with the requirements of BS 7775.

f) The gate size and aperture size shall be selected from Tables 9, 10 or 11 of BS 7775. The permitted tolerance on the aperture shall not exceed that stated in BS 7775, Table 12.

g) The permitted gate leakage rate between the door and the frame shall not exceed that stated in BS 7775, Table 13. The joint between the gate frame and the supporting structure shall be sealed drop tight. No leakage shall occur.

h) Provision shall be made for taking up wear. Any wedges or adjusting bolts shall be accessible.

i) The information listed in Annexe 'A' of BS 7775 shall be provided.

j) The gate door and mountings shall be designed to withstand a combined load, without permanent deformation, equivalent to:

- The maximum differential operating head, and
- Simultaneously an impact load to the gate that will induce a stress equivalent to 50% of the stress resulting from the maximum operating head.

They shall be designed to:

- prevent cavitation and deposition of particles from the working liquid,
- prevent turbulence and erosion,
- prevent noise generation due to movement.

k) Gates shall be lockable in both open and closed positions.

l) Handwheel diameters shall not exceed 450mm and shall be clearly marked with the open and close operating directions. The required force to operate a hand wheel shall not exceed 0.25kN.

m) Rising spindles shall be protected with graduated transparent plastic covers. Non rising spindles shall have "slot and pointer" type indication within a pillar.

n) Spindles more than 2m long shall be provided with intermediate supports.

o) Gate materials shall be suitable for the duty and the installed environment, designed and sized to minimise turbulence and erosion.

p) Materials shall be selected from Tables 1 to 8 of BS 7775. Materials shall be selected to avoid galvanic corrosion. Insulating sleeves and washers shall be provided where necessary.

Stainless steel components shall be to BS 970 grade 316. Any welded components shall be grade 316L.

q) All spindles, pins, screws and couplings shall be stainless steel to BS 970 Grade 316, except for those used to secure gunmetal seals, which shall be non-ferrous. Any welded components shall be grade 316L.

r) Gate spindle nuts shall be manufactured from materials to BS EN 1982:1999 Grade AB2.

s) Gates shall be suitable for manual or automatic operation as specified. They shall be suitable for intermittent operation with periods of idleness of up to six months.

t) The service life shall not be less than 20 years.

u) Details of slide-gates shall be submitted for the Project Manager's approval a minimum of five (5) days prior to scheduled procurement. Procurement shall only be initiated after written approval of the proposed items is provided by the Project Manager.

2.4.2.5.1 Installation

Gates shall be installed by an experienced person/supplier. The Contractor shall ensure that the pipework, fittings and valves can be assembled as shown on the Contractors Drawings.

2.4.3 Fixtures and Fittings

2.4.3.1 Fasteners

a) Bolts and screws shall be in accordance with AS 1111. Washers shall be in accordance with AS1237. Nuts shall be in accordance with AS 1112.

b) Extensive use of stainless steel, especially for nuts, bolts and screws shall be adopted for components coming in contact with moisture or in a corrosive environment.

c) All bolts and studs for gland joints, couplings joints and flanges shall be stainless steel grade 316 unless specified otherwise. Associated nuts and washers shall be stainless steel grade 316. Where high strength is required and approval is given, high tensile bolts, nuts and washers may be used.

d) All threads of stainless fasteners shall be coated with an approved nickel based anti-seize compound prior to assembly.

e) All fasteners, including chemical set, anchor bolts, threaded rods, nuts and washers that are embedded into concrete shall be manufactured in stainless steel grade 316. Zinc plated or black bolts and screws shall not be used.

f) On structural components, such as walkways and handrails, fasteners shall be stainless steel grade 316 excepting when structural components are hot-dipped galvanised, hot-dip galvanised fasteners shall be used.

g) The anchor bolts, nuts, and washers shall be sized for the duty required. Chemical set or cast-in fasteners are permitted. Wherever possible, chemical set fasteners shall be used. Chemical anchors, when used, shall be installed in accordance with the manufacturer's directions.

h) Abandoned drill holes shall be thoroughly cleaned and filled with epoxy grout.

i) Where the relocation of masonry anchors necessitates alteration to steelwork base plates, the installer shall determine all additional stiffening or strengthening of the base plate and adjacent steelwork required.

2.4.3.2 Sockets

a) All socketed pipes shall be rubber ring jointed. Rubber rings shall comply with AS 1646.

b) In connecting pipes with rubber rings, the pipes shall be cleaned prior to connecting and care shall be taken to ensure that the rubber ring is maintained in a plane at right angles to the axis of the pipe. Each pipe shall be installed and connected as recommended by the manufacturer and each joint checked with a feeler gauge to ensure that the ring is in place. For pipes with skid type rubber ring joints, only the lubricant specified in writing by the manufacturer shall be applied in making that joint. The installer shall make the joint such that the witness mark, at no point, shall be more than one (1) mm from the end of the socket.

2.4.3.3 **Gaskets**

a) Flange gaskets shall be in accordance with AS/NZS 4087.

b) Gaskets shall be manufactured from an elastomer (neoprene/fabric) complying with AS 1646 and may contain a reinforcement material. The minimum working pressure for gaskets shall be 1600 kPa at 3.0mm thick.

c) The gasket material shall be suitable for contact with the fluid being conveyed, the operating conditions and environment.

d) Pipes and fittings shall be in their correct position, alignment and grade before the joints are made and no springing of joints shall be permitted.

e) Pipe anchorages shall be provided to absorb static and dynamic thrusts from pipe fittings and valves.

2.4.3.4 **Flanges**

a) Flanges shall be in accordance with AS/NZS 4087.

b) Raised face flanges shall be mated with raised face flanges. Flat faced flanges shall be mated with flat face flanges.

c) Flanges on all steel, ductile iron, PVC, and GRP pipes shall be fully fixed flanges. Flanges on ABS and PE pipes may be stub flanges with loose metal backing rings or full face up to 100 mm pipe diameter. On ABS and PE pipes of 100 mm diameter and larger, stub flanges with metal backing rings shall be used. Backing rings shall be manufactured from 316 or 316L stainless steel.

2.5 M&E Specific Requirements

2.5.1 Afolau

2.5.1.1 Generator Parameters

The Employers minimum expected generator rating is 938kVA.

The preferred generator speed is 600 rpm.

2.5.1.1 Station Transformer Parameters

The Employers minimum expected station transformer rating is 1,000kVA.

The Station Transformer shall be installed on a ground mounted concrete pad with bund wall to contain full volume of transformeroil in case the transformer oil leaks so that environment will not be contaminated.

2.5.1.2 Protection Requirements

The electrical protection system shall be designed to ensure that the generator cannot operate into an islanded or faulted 22kV network. The protection shall incorporate rate of change of frequency and neutral voltage displacement elements.

2.5.1.3 24V DC System Parameters

The 24V DC system shall be sized to supply the Plant 24V DC requirements for a duration not less than 24 hours, with both chargers inoperative.

2.5.1.4 22kV Grid Connection

An approximately 500m long over head 22kV line shall be constructed between the powerhouse and the existing EPC 22kV transmission network.

The line shall be terminated at a pole structure adjacent to the station transformer. The termination pole shall include surge arrestors and a 22kV isolator.

A short length of 22kV cable shall be provided between the 22kV isolator and the station transformer HV terminals.

The line shall be connected into the EPC 22kV transmission network on the Main South Coast Road.

2.6 M&E General Requirements

2.6.1 Contract Wide Requirements

2.6.1.1 Design Responsibility

The Contractor shall assume full responsibility for a coordinated and adequate design of all equipment specified and shall ensure that such equipment conforms to the best engineering practice for the operating conditions specified. When requested by the Project Manager, the Contractor shall furnish complete information as to the maximum stresses and other criteria used in the design. All equipment shall be proportioned and arranged to fit with proper clearances into the powerhouses.

2.6.1.2 Units of Measurement

The units of measurement to be used throughout this Contract shall be metric in accordance with ISO 1000:1992 "SI units, etc." On drawings or printed pamphlets where other units have been used, the equivalent metric measures shall also be shown.

2.6.1.3 **Site Conditions**

2.6.1.3.1 General Conditions

The equipment shall be suitable for operation at, and ratings shall be based on, the following conditions:

- Maximum outdoor ambient temperature for design purposes 45°C
- Minimum average over 24 hours 23°C
- Maximum average over 24 hours 40°C
- Design river water temperature 25°C
- Relative Humidity 80 - 97%
- Average annual rainfall 3500 mm
- Thunder storm days per year (estimate) 50

2.6.1.3.2 Transport Limitations

The contractor shall be free to select the route for delivery of plant to site and shall be responsible for determining any limitations on route selections imposed by weight and/or size limits on roads, bridges, etc.

2.6.1.3.3 Water Conditions and Corrosion

The Contractor shall perform his own analyses and evaluation of the water in determining that suitable materials are used for the equipment.

The Contractor shall design the equipment and provide materials that will give satisfactory service based upon his evaluation of the water characteristics.

Corrosion resisting steel or bronze shall be used for bolts and nuts when either or both are subject to contact with river water and/or frequent adjustment or frequent removal, such as adjusting bolts for packing glands on removable screens or strainers, on adjustable bearings, etc.

2.6.1.4 **Labels and Plates**

The Contractor shall supply all name plates, caution plates and labels for the safe and efficient operation of the plant.

Each item of plant shall have permanently attached to it in a conspicuous position a nameplate or label of approved size and pattern. Before the manufacture of any nameplates or labels, the Contractor shall submit to the Project Manager a copy of the nameplate and label design standard for approval. All data, name plates and instruction plates on plant and cubicles shall be in the English language. Any other language labels may be provided for construction and commissioning purposes but shall be temporary and removed prior to completion.

2.6.1.5 **Standards and Workmanship**

All materials shall be new, of a first-class nature. All materials shall comply with the latest relevant authorised standards for testing materials unless otherwise specified or permitted by the Project Manager.

All workmanship shall be of highest class throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not render them liable to distortion, undue wear, or damage under the most severe conditions encountered in service.

All parts shall conform to the dimensions shown, and shall be built in accordance with, the approved drawings. All joints, datum surfaces and mating components shall be machined and all castings shall be spot faced for bolts and/or nuts. All machined finishes shall be shown on the approved drawings.
All screws, bolts, studs and nuts and threads for pipe shall conform to the latest standards of the International Organization for Standardization (ISO) covering these components and shall all conform to the standards for metric sizes.

The Contractor shall use exclusively the standard and size system presented in his Tender and accepted and incorporated in this Contract.

2.6.2 Generators

2.6.2.1 Type and Description

Generator shall be totally enclosed, three phase, rotary field, horizontal shaft (IM B3), salient pole type synchronous machines. Cooling shall be open circuit air through the generator with rotor mounted fans (IC01). The heat shall be ducted from the generator to the powerhouse exterior; the ductwork will be as specified in Section 6 Part 2.6.12~~2.7.14~~. The generator enclosure shall be IP 23 of IEC60034-5.

The rated continuous output of the generator shall be matched to the associated turbine.

The terminal voltage shall be 415V phase to phase.

The maximum continuous output of the generators shall be possible at any voltage between 95 and 105% of rated voltage and at any frequency between 49 and 51 Hz from 0.8 lagging to 0.95 leading power factor. The generators shall be suitable for operation in parallel with the other generators in the existing power system.

2.6.2.2 Speed

The generator speed shall be as required by the turbine manufacturer.

The generator shall be capable of withstanding the maximum runaway speed of the turbine continuously without damage.

2.6.2.3 Efficiency

The generator average efficiency shall be greater than 95% over the range 15% to 100% of Rated Output and at 0.8 power factor. The Contractor shall provide a minimum average generator efficiency over the range 15% to 100% of Rated Output.

Theminimum acceptable generator efficiency at rated output, and at unity power factor, is 95%.

The Contractor shall provide an efficiency curve for each generator with their offer. This curve shall show the generator efficiencies at 25%, 50%, 75% and 100% of rated output for 0.8 power factor.

2.6.2.4 Voltage Regulation

The inherent voltage regulation (without AVR) of the generator at 0.8 lagging power factor shall not be greater than ± 30 percent. Guaranteed values at 0.8 lagging power factors shall be given in the Tender.

2.6.2.5 Insulation and Temperature Rise

Insulation of the generator windings shall be classified as Class F. With the turbine at the rated design output as defined in IEC 60085 and the generator at 0.8 lagging power factor, the temperature rise shall not exceed the limit for Class B insulation as defined in IEC 60085.

2.6.2.6 Unbalanced Load

The generator shall be capable of a negative sequence I_2^2t value of 20 for transient operation under system fault conditions and continuous operation of 10% negative phase sequence current.

2.6.2.7 Generator Connections

The generator shall be star connected with three (3) terminals brought out at the neutral side and three (3) terminals at line side of the stator winding. Both the line and neutral terminals shall be insulated for full line voltage.

2.6.2.8 **Temperature Detectors and Thermometers**

The generator shall be provided with RTD temperature detectors. At least three (3) for the stator winding and one (1) for each bearing. These shall be located where it is anticipated the maximum temperatures will occur. The RTDs shall be 3 wire or 4 wire Pt 100 type and wired to the Generator Terminal Box.

2.6.2.9 **Structural Design**

a) Stator

The stator frame shall be made of welded steel plate with sufficient reinforced ribs. The stator cores shall be built up with high-permeability and low specific loss silicon steel lamination. Preferably, the stator core shall be adequately keyed or detailed to the stator frame. Any deviation from this shall be specifically noted with the Tender offer. The stator frame shall be provided with lifting lugs suitable for applying slings for lifting the stator or generator assembly by crane or lifting gear.

Within the generator housing, the stator terminals shall be copper, and shall be of the bolt-clamped type for connection to the power cable terminals.

The stator coil conductor shall be electrolytic copper with a conductivity not less than the value for annealed copper specified in the approved standard. The coil insulation shall be properly vacuum and pressure impregnated with high-grade insulating varnish or thermos-setting epoxy resin to eliminate voids.

b) Rotor

The entire rotor shall be designed to safely withstand all mechanical stresses. Special case shall be taken to prevent the end turns from deforming or slipping due to the centrifugal stresses on the interconnections. The poles shall be provided with copper damper-bars and a complete damper winding. The rotor leads shall be connected to the brushless exciter mounted on the generator shaft.

c) Shaft

The generator shaft shall be forged carbon or alloy steel properly heat-treated. The shaft shall be of ample size to operate safely at any speed up to the maximum runaway speed of the unit without detrimental vibration or distortion.

The exterior cylindrical surface of the shaft and couplings shall be accurately and smoothly machined all over and polished at bearing surfaces. The end of the shaft shall be arranged for suitable coupling to the turbine.

The entire turbine generator set shaft line shall be designed to ensure that the first critical speed is at least 25% greater than the runaway speed.

d) Bearings

The generator shall be provided with self-aligning roller bearings, journal bearings will not be accepted.

The bearings shall be grease lubricated and shall be fitted with an automatic greasing system sized such that refilling the grease reservoirs is required no more than once per month.

Bearing seals shall be provided to prevent grease leakage, as well as to prevent the entrance of foreign materials into the bearing housing.

The bearings shall be designed to withstand safely and without damage the natural retardation of the turbine-generator unit from the maximum runaway speed to rest.

Each bearing shall be fitted with a Pt100 temperature sensor for bearing temperature monitoring and protection.

Each bearing shall be fittd with a two axis vibration detector with switch output to signal high vibration levels.

e) Generator Housing

A steel plate housing shall be furnished for the generator and shall be sufficiently rigid to prevent objectionable vibrations.

The generator housing shall be arranged to permit easy removal for the purpose of inspection and maintenance.

f) Generator Heaters

The Generator shall be provided with suitable type space haters of adequate capacity to prevent moisture condensation while the generator is shutdown. The space heaters shall be arranged to be energised automatically when the generator is not running. Power supply to the heaters shall be three-phase 415 volt or single-phase 240/250 volt AC.

g) Bedplate

Preferably, the generator components shall be mounted on soleplates to facilitate site alignment. The generator shall be fully assembled at the Contractor's shop.

2.6.2.10 **Generator Neutral Earthing**

The generator neutral shall be solidly earthed.

2.6.2.11 **Terminal Boxes**

The main and neutral terminals shall be brought out to terminal boxes on the side of the generator that shall also house the voltage and current transformers. The main and neutral cable connections shall be made at these terminal boxes. All other electrical interfaces to the generator including CT and VT secondaries, instrumentation, protection and controls shall be made at the Generator Terminal Box, mounted on the generator.

The terminal boxes shall be totally enclosed and provided with removable front panels for Plant inspection and termination.

2.6.2.12 **Specified Spare Parts**

The Contractor shall furnish spare parts for the generators as listed below. A set is defined as the total number of each component required for one generating system. One set of spare parts shall be provided. Where listed components differ between generators supplied, one set shall be provided for each design of generator.

- One set of bearings
- Other items recommended by the Contractor.

2.6.3 Excitation Systems

2.6.3.1 Type and Description

The capacity of the excitation system shall be more than 110% of capacity required for the generator. The ceiling voltage of the excitation system shall be not less than 175% of the rated field voltage under the field winding temperature at 75°C. The response ratio of the system shall be to less than 2.0.

The excitation system and voltage regulating shall be able to operate safely at any speed put the frequency corresponding to the maximum momentary speed rise when full load is rejected.

2.6.3.2 Power Supply

The excitation system shall be powered either from a permanent magnet generator (PMG) mounted on the generator shaft, or by means of the AREP principal whereby auxiliary series and shunt windings are installed in the generator.

The existing AC exciter on the generator shaft shall be re-used.

2.6.3.3 Rotating Rectifier

Rotating rectifiers shall be:-

- of three-phase full bridge silicon diode type connected to the AC exciter.
- provided with protection devices to suppress overvoltage and transient voltage in the rectifier circuit. The rectifier diodes and protection devices shall be mounted rigidly on the holder ring so as to withstand centrifugal force of the maximum runaway speed, and shall withstand all site ambient temperatures.
- designed that when one diode is faulted, the generator shall be able to keep running safely until the next scheduled servicing shutdown. A diode failure detector shall be provided to given protection and alarm for the excitation system.

2.6.3.4 Voltage Regulator

The voltage regulator shall consist of an automatic voltage regulator (AVR). The automatic voltage regulator shall be of high speed, quick response static transistor amplifier type and shall include a power system stabiliser. The AVR is to be housed in the generator junction box. The AVR shall preferably be able to be interfaced to an external device by a digital communications link. This link shall be a standard protocol such as Profibus, Modbus or DeviceNet.

The AVR shall operate in one of two modes. When operating isolated from the power system, the AVR shall operate in voltage setpoint mode. The voltage setpoint shall be adjusted from "Raise" and "Lower" inputs from the Employer control system. An adjustable droop shall be present which allows the machines within the scheme to operate in parallel. When operating in parallel with the power system, the AVR shall be able to control the power factor of the output. The power factor setpoint shall be set by the Employer Control System. The AVR shall adjust the relevant parameter linearly over the range. The selection between the two operating modes shall be made by an input driven by the Employer Control System. The outputs must be limited so that machine capability is neither exceeded nor artificially limited.

The automatic voltage regulator shall continuously respond with high speed to correct any change in generator voltage and maintain the generator terminal voltage under steady state conditions within plus or minus 2.5 percent (± 2.5 %) without hunting for any excitation value within the normal operating range.

The AVR shall include a Volt/Hertz limiting function. Provision shall be made to de-energise the field quickly if a fault is identified in the generator.

All adjustments shall provide a wide range of settings to allow the full use of the generator capability.

2.6.3.5 Protection and Alarm for Excitation System

The protection for the excitation system shall be classified into two groups by the nature and extent of faults. If a serious fault is detected the excitation system shall be tripped and the generating unit will be

shut down. When a fault is not so serious, the faulted device shall be isolated from the system without interruption of the generator excitation and an alarm shall be raised.

The protection and alarm system for the excitation system shall be designed to be compatible with the protection and alarm system for the generating Plant. The protection and alarms shall be provided for, but not limited to, the followings:-

a. Protection (Trip)

- AVR power source, failure
- Two (2) diodes on one phase of rotating rectifier, fault
- AVR, fault
- Field overvoltage

b. Alarm

- One (1) diode on one phase of rotating rectifier, fault
- Field circuit, ground

2.6.3.6 **Specified Spare Parts**

The Contractor shall furnish spare parts for the excitation systems as listed below. A set is defined as the total number of each component required for one excitation system. One set of spare parts shall be provided. Where listed components differ between excitation systems supplied, one set shall be provided for each design of excitation.

- One set of all plug-in type electronic components and printed circuits cards.
- Other items recommended by the Contractor.

2.6.4 Electrical Configuration

Power station shall be connected to the EPC 22kV distribution system as shown on Figure 2below. The following sections detail the technical requirements for each component.

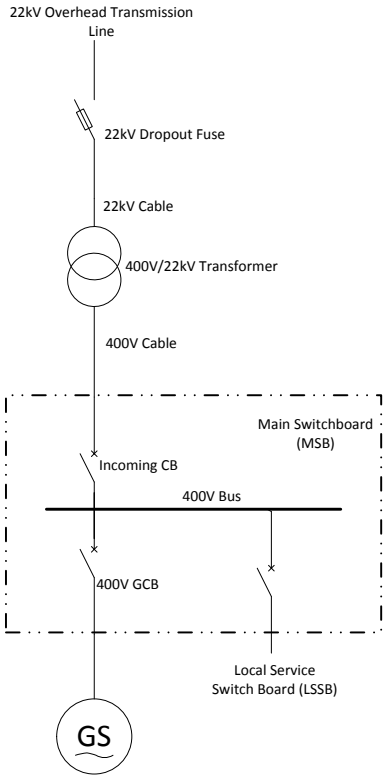

Figure 2 – Single Line Diagram

Comment [TL1]: Must be 415 volts AC

2.6.5 22kV Connection and Anciliary Items

The contractor shall construct the 22kV connection from the power station transformer HV terminals to the designated interface point on the EPC system.

The 22kV connection shall consist of:-

- 22kV pole mounted air-break isolator mounted on the existing EPC pole at the Interface Point.
- Overhead 22kV pole mounted distribution line from the air-break isolator to the powerstation.
- Pole mounted drop out fuses and surge arrestor at the terminal pole adjacent to the powerhouse.
- 22kV underground cable from the terminal pole to the station transformer.

The overhead 22kV conductor shall be "Wasp"(7/4.39) All Aluminium Conductor (AAC) to AS/NZS1531.

All insulators shall be polymeric type rated for 33kV and with 95kV/130kV wet/dry power frequency flashover voltage.

Poles shall be softwood utility poles to AS3818.11 "Utility Poles" and shall be treated to grade H5 in accordance with AS1604.1 "Timber – preservative treated".

The overhead distribution line shall be designed in accordance with AS/NZS7000:2010 for cyclonic conditions. The following minimum clearances, with a conductor temperature of 75C, shall be achieved :-

- Minimum phase to ground over, or adjacent to, roadways 6.7m
- Minimum phase to ground, other areas 5.5m
- Minimum clearance to any structure 4.5m

The conductors shall be arranged in a horizontal configuration.

2.6.6 Station Transformers

2.6.6.1 Type and Description

Each station step-up transformer shall be an outdoor, oil-immersed three phase, double-wound type unit based in a single tank.

The transformer shall conform to the requirements of IEC 60076 and be suitable for operation under IEC 60354. The transformers shall each meet continuous rated power with ONAN cooling.

Number of phases	3
Cooling	ONAN
Frequency, Hz	50
Number of windings	2
Primary winding, rated V	22,000
Secondary winding, rated V	415
Primary connection	Wye
Secondary connection	Delta
Winding Vector Group	DYN11
Minimum impedance from high voltage to low-voltage winding, based on rated kVA (%)	5.0%
Primary winding taps for rated kVA on-load taps; low rated voltage	+5.0% to -5% in 2.5% steps
Average sound pressure level, dBA	65
Winding temperature rise, above a 24-hr average 36°C ambient, with a maximum ambient of 45°C	80°C
Power Frequency Withstand Primary/Secondary windings	50kV/2.5kV
Basic Insulation Level Primary Windings	125kV

2.6.6.2 General Design Requirements

Each transformer shall be of the hermetically sealed type with radiators supported from the transformer tank. Designs requiring a conservator tank will not be accepted.

Each transformer shall be mounted on a concrete pad.

2.6.6.3 Losses

The Contractor shall provide guaranteed no-load and load losses for the transformer.

2.6.6.4 Core

The core shall be constructed of the highest quality steel especially suitable for the purpose. The steel shall be in thin laminations, annealed after cutting, and rolled to ensure a smooth surface at the edges. Both sides of each sheet shall be insulated with a durable, heat-resistant, baked enamel or varnish. The cores shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength to support the windings.

2.6.6.5 Windings

Both primary and secondary windings shall be vacuum pressure impregnated. Each coil shall be cast under vacuum to ensure complete and void-free resin impregnation throughout the entire insulation system.

Transformer windings shall be copper.

2.6.6.6 **Enclosures**

The transformer shall be provided with an oil-tight galvanized steel case. The joints between the case and cover shall be such that the cover and top section of the case are integral. Gasket or shield material, which will not deteriorate under service conditions, shall be provided between the top cover and case. The top cover shall be bolted to the case.

The transformer shall be provided with eyebolts and/or lugs for lifting the essential parts and for lifting the completely assembled transformer filled with oil. Guides shall be provided inside the case for guiding the cores and windings as they are being removed from or lowered into the case.

The transformer case shall be provided with a pressure relief diaphragm or valve of adequate size to protect the case against a primary explosion due to arcing below the surface of the oil. The relief diaphragm shall be designed so as to minimize discharge of oil and to exclude air and water after it opens. It shall be equipped with a visual alarm indicator and with alarm contacts.

The transformer case shall be capable of withstanding without leakage or distortion a full vacuum and an internal gas pressure 25% greater than the maximum operating pressure resulting from the system of oil preservation used. All valves, fittings, and piping affected by this requirement shall be of correct design and construction for full vacuum filling.

The transformer shall be provided with approved valves as required for:

- Draining the case (flanged-gate valve).
- Sampling oil from the extreme bottom of the case.
- Sampling oil from the top of the case.
- Filling the case and radiators.

Oil valves shall be specially designed for use with insulating oil and shall hold hot oil without leaking. An air vent shall be provided on the transformer at the top of the case and piped to a valve within reach from the floor for releasing air when the case is being filled with oil and/or nitrogen gas.

Two transformer tank grounding pads shall be furnished on opposite sides of the tank near the transformer base.

2.6.6.7 **Tap Changer**

The transformer shall be equipped with an externally, manually-operated no load tap changer rated for the maximum rating of the transformer and suitable for changing connections to the taps in the windings. Taps shall be changed only when the transformer is de-energized. The operating hand wheel shall be mounted on the side of the case at a convenient height for operating from the floor on which the apparatus is mounted and shall include an indicating pointer and dial and means for locking the tap changer in any desired position.

2.6.6.8 **Insulating Oil**

Insulating oil used for oil impregnation and testing at the Contractor's works shall be PCB free, uninhibited and free of all additives.

Oil used for filling on site will be supplied under this Contract and will be inhibited oil to Class 1A of BS 148.

2.6.6.9 **Cooling System**

Cooling shall be ONAN.

Where external radiators are required, they shall be of the panel type and shall have the following features:-

- Externally galvanised
- Two lifting lugs per radiator
- Isolating valves to permit uncoupling from the radiator bank without draining the bank. These valves shall withstand full vacuum.
- No crevices where moisture may be trapped and thereby cause corrosion

Radiators shall be tested for leaks by the same methods as used for the transformer tank, and shall withstand full vacuum.

Any radiator shall be able to be removed from a bank without first removing any other items.

2.6.6.10 **Bushings & Terminals**

The HV and LV winding connections of each transformer shall be brought out through the transformer tank wall by means of outdoor bushings in a cable box.

Cable boxes shall be air insulated and located with the bottom of the box located at a sufficient level above the bottom of the transformer tank to permit power cable access.

Each cable box shall be provided with two earth terminals per phase for the following purposes:-

- The separate earthing of the copper wire screen of each cable.
- The temporary earthing of the cable terminal.
- The temporary earthing of the bushing terminal.

Each cable box shall have a removable gland plate made of non-magnetic metal.
Where proprietary plug and socket arrangements are used for HV terminations, the cable termination kit shall be supplied.

2.6.6.11 **Earthing Terminals**

Earthing terminals complying with this specification shall be provided. Two shall be located on the transformer tank, one on either side and near to ground level. The earthing terminals shall be sized for connecting 150 mm2 cable clamps

2.6.6.12 **Control, Instrumentation & Protection**

The following control, instrumentation and protection features shall be provided:-

2.6.6.12.1 Winding Temperature Indicator

The transformer shall be provided with winding temperature indicator consisting of a current transformer, thermal replica device, winding temperature indicator and relay contacts.

Each winding temperature relay shall have two or more independent contacts, which shall be separately adjustable trip/alarm contacts with a range of at least 60°C to 150°C.

The winding temperature indicators shall have a range of at least 20°C to 150°C over a scale length of 110 mm.

2.6.6.12.2 Oil Level Indicators

An oil level indicator shall be supplied for the transformer tank. This indicator shall have contacts for high and low level. The contacts shall be wired to the Unit PLC.

2.6.6.12.3 Pressure Release Device

The transformer shall be fitted with a pressure release device, the device shall be fitted with visual indication and contacts wired to the Unit PLC.

2.6.7 **415V Main Switchboard (MSB)**

2.6.7.1 **General Requirements**

Each MSB shall have a voltage rating of 415V, with incoming line circuit breaker, generator circuit breaker and local service switchboard (LSSB) feeder. The MSBs shall be composed of factory assembled metal clad cubicles. The equipment shall be of type tested design and shall be completely factory assembled and tested prior to shipment.

MSBs shall be designed and supplied as per below specification:

- Nominal system voltage (r.m.s. value, phase to phase voltage): Un = 0.415 kV
- Highest value of system operating voltage (r.m.s. phase to phase voltage): Um = 0.46 kV
- Rated insulation voltage: Ui = 1.0kV
- Rated impulse voltage: Uimp = 8.0kV
- Standard Rated Frequency: 50Hz
- System configuration: 3 ph, effective earthed.
- Design fault level 16kA (3s).
- Form of Construction: Form 3b.

The LSSB, Unit Control Panel and Unit Protection panel may be incorporated into the MSBpanel suite at the Contractors discretion.

2.6.7.2 **Busbars**

The switchgear shall have a 3-phase, 4-conductor bus with a continuous current-carrying capacity of at least 630 A with a hottest-spot temperature rise not greater than 65°C above the ambient temperature outside the switchgear.

The neutral bus shall be of the same rating as the phase bus.

Buses and connections shall be fully insulated with flame-retardant sleeve-type or moulded insulating material.

An earth bus shall extend through the entire length of the switchgear. The switchgear frame and all internal equipment bases and mountings shall be connected to the earth bus.

2.6.7.3 **Circuit Breakers**

Circuit breakers shall comply with IEC 60947-2.

The incoming and generator circuit breakers shall both be either moulded case circuit breakers (MCCBs) or air circuit breakers (ACBs) and shall be specifically designed for generator applications.

The circuit breakers shall be suitable for at least two (2) daily open-close operations over the 40 year design life of the plant.

Circuit breakers shall have a minimum short circuit rating of 16kA (3s).

Circuit breakers shall be of utilisation category B and suitable for isolation to overvoltage category IV as defined by IEC60947.

The operating mechanism shall be of the quick make quick break type, with the speed of operation independent of the operator, and shall be trip free.

The generator circuit breaker shall be withdrawable to permit isolation of the generator during maintenance.

The breakers shall be operated by a toggle, which shall clearly indicate the three fundamental positions ON, and OFF and TRIPPED. It shall not be possible to close the generator circuit breaker using the front toggle.

The breakers shall provide double insulation from the front face allowing field installable auxiliaries to be fitted without isolating the unit.

Each Circuit Breaker shall be provided with an integral trip unit suitable for interfacing with the plant 24V DC protection system.

Each circuit breaker shall be provided with a spring charged, motor wound, closing mechanism suitable for interfacing with the automatic synchroniser system.

Auxiliary contacts shall be provided for the remote indication of the following conditions "CB Closed"; "CB Open"; "CB Tripped" to the control systems~~ystem~~.

2.6.7.4 **Instrument Transformers**

2.6.7.4.1 General

The instrument transformers shall be indoor type designed and rated in accordance with IEC60185 or 60186.

2.6.7.4.2 Voltage Transformers

Voltage transformers shall be manufactured to IEC60186.

The IEC relaying accuracy class at 50-Hz shall be at least 3P for protective circuits and class 1.0 for measuring or metering circuits.

2.6.7.4.3 Current Transformers

Current transformers shall be manufactured to IEC60185 and shall use standard IEC winding ratio's. Protection and instrumentation current transformers shall use 1 A secondary and metering transformers 5A secondary.

The IEC relaying accuracy class at 50-Hz shall be at least 5P20 for protective circuits and class 0.5 for measuring or metering circuits.

Standard application data shall be furnished in accordance with IEC 60185. Curves and data to be furnished for the transformers shall include, but not be limited to the following:

- Ratio and phase-angle correction curves.
- Short-time thermal and dynamic stability current ratings.
- Excitation current curves showing "knee" point voltage for each type and rating.

Current transformers shall be provided on the circuit breakers as listed herein.

Incoming Circuit Breaker

- Ratio — Circuit Breaker Rating/5A
- Number of three phase sets required — One
- Accuracy Class — 0.5

Generator Circuit Breaker

- Ratio — Circuit Breaker Ratings/1A
- Number of three phase sets required — Two
- Accuracy Class — 5P20 (CT1)
0.5 (CT2)

2.6.7.5 **Surge Protection Equipment**

Surge protection shall be provided on each incoming circuit breaker. Each set of surge protection equipment shall consist of 3 surge arresters mounted in a separate compartment of the switchgear assembly.

2.6.7.6 **Cable Terminators**

Cable entry shall be from the top or bottom via removable gland plates. The gland plates shall be made of non-magnetic metal. The gland plates shall completely seal off the bottom of the cable termination panel and shall be bonded to the associated cubicle to provide earth continuity.

Control and instrumentation cable and AC / DC power cables shall be wired between panels and marshalled at a single termination point at the switchboard. The boxes shall be suitable for termination of a single or a number of multicore control and or power low voltage cables.

Each cable box shall be provided with two earth terminals per phase for the following purposes:-

- The separate earthing of the copper wire screen of each cable.
- The temporary earthing of the cable terminal.
- The temporary earthing of the bushing terminal.

2.6.7.7 **Control Switches**

Control switch for each circuit breaker control shall be 3-position, momentary-contact type, with spring return to the neutral position, and shall have a pistol-grip handle. A pull-to-lock feature shall be provided.

Selector switch for local/remote control shall be 2-position, maintained contact type and shall have a round notched handle.

2.6.7.8 **Protective Relaying**

All protection required for the units shall be mounted on the Unit Control, and protection panels. Refer Section **Error! Reference source not found.**~~2.7.10~~ Protective Relays.

2.6.7.9 **Multifunction Metering Modules**

A multifunction metering module shall be provided on the control cubicle for each incoming and generator circuit breaker. The multifunction meter modules shall be a digital instrumentation package consisting of the following:

- Field selectable displays for unit and feeder volts, amperes, kVA, kW, kVAR, demand amperes, demand power factor, frequency, kWh, and kVARh.
- Serial communications port for transmitting data to the PLC control system.

Multifunction meter modules shall be suitable for accurately measuring 3-phase, 50-Hz quantities. The maximum allowable error shall not exceed ±0.25% of full scale at 25°C. The modules shall have electrical isolation between input, output, power supply, and the case ground connection. The module shall have a minimum dielectric test voltage rating of 1500-V AC rms for 1 minute.

2.6.7.10 **Revenue Metering**

The MSBs shall include revenue meters onto each incoming circuit breaker. This shall include:-

- A four quadrant Class 0.5 revenue meter complying with IEC 62053.
- DNP3 communications to the station control system.
- Sealable terminals for the connection of the meters to CT and VT secondary circuits.

2.6.8 Control and Instrumentation Systems

2.6.8.1 Type and Description

A control and instrumentation system shall be provided to control and monitor the generating unit and all the power plant apparatus.

The control system shall be designed to allow the scheme to operate in a fully automatic manner with limited Operator involvement. The powerhouse will normally be monitored and controlled from the Employers National Control Centre (NCC) located at Fuluasou Substation. The power scheme controls and protection systems must be designed to:-

a) Ensure the safety of the Facilities, EPC staff and the general public during normal and abnormal event.
b) Maximise the efficient utilization of available biomass of the controlled scheme.
c) Minimise the lost generation following plant trips and other disturbances.
d) Alert the EPC Operator to any abnormal condition that may exist with the Facilities and of any maintenance that may be required.

The scope of supply, work and services shall be complete in every respect for the purpose it is intended, even if it is not explicitly stated in these technical Employer's Requirements.

The Plant and Facilities will be monitored and controlled locally via the operator's stations and HMI's and remotely at the Employer's NCC.

2.6.8.2 Controlled Equipment

For Generator and transformer Unit:

a) Gas Engine
b) Generator and excitation system.
c) Unit Transformer.
d) 400V Switchgear
e) All unit auxiliary systems and equipment.

General services of the powerstation:

a) Station service AC and DC systems.
b) Powerhouse drainage systems
c) Powerhouse ventilation

2.6.8.3 Control System Operation

2.6.8.3.1 General Requirements

The control system shall provide centralized control and monitoring of the power plant from an operator station located in the control room of the powerhouse or from the Employers NCC.

The control system shall be configured to provide the following functions:

a) Manual and automatic starting and stopping of the generating unit.
b) Control of MW and MVAr output of the generating units.
c) Monitor and log the status of generating units.
d) Monitor and control the station services, generating unit auxiliaries, intake water levels, and other powerhouse systems hereinafter specified.

Features of the control system shall include:

a) Alarm annunciation and management
b) Data acquisition and control.
c) Human Machine Interface (HMI)
d) Historical data management
e) Integration with the EPC NCC

The control system shall be programmable logic controller ('PLC' – as per IEC 61131) based with PC based HMI workstations, providing a completely integrated state-of-the-art system. The system shall have an "open architecture" which shall permit reconfiguration, expansion, and future upgrade.

The control system at each powerhouse shall include as a minimum the following equipment:

a) One HMI Operator's Station located in the powerhouse control room.
b) One "Unit" PLC per turbine generator used for control and monitoring of the associated turbine generator.
c) For stations with more than one turbine generator; one "Station" PLC for control and monitoring of the power station, remote Penstock Valve and headpond level. For stations with only one turbine generator, the Unit PLC shall be used for the "Station" control functions.
d) One fault-tolerant, redundant, fibre optic based 100MBPs Ethernet LAN serving all of the equipment listed above.
e) Other hardware and software required to fulfil the requirements of these Employer's Requirements.

2.6.8.3.2 Design and Performance Criteria

The control system shall be designed to minimize the duration of failures by the ability to diagnose and resolve problems quickly and to replace any failed part easily.

The Average System Availability over a one year period shall be 99.8% or better. The Contractor shall provide a guarantee for the Average System Availability with his Tender.

The hardware and software elements of the Control system shall be easy to maintain using the maintenance facilities, hardware and software tools, and recommended spare parts provided by the Contractor.

All tuning parameters and set points shall be accessible by the Employer, via password protected engineering screens on the HMI system.

The PLC code shall be provided to the Employer, along with a licensed copy of the programming software installed onto a Notebook computer. The PLC code must be fully open to the Employer with no 'locked' elements.

2.6.8.3.3 Expandability

The Control system shall be capable of being expanded over and above the specified system by adding more stations, PLCs, functions, input-output modules, or metering modules. This expansion shall not degrade the performance of the existing system. Twenty (20) percent spare capacity is to be provided. For ease and flexibility in expanding the Control system, the Contractor shall conform to the open architecture concept as described herein.

2.6.8.3.4 Product Quality and Advanced Technology

The Employer requires hardware and software products of high quality in design, fabrication, and performance.

The standard hardware equipment (such as printers, etc) and devices of the control system shall be brand-new and shall be as close as possible to being of the latest design technology. In order to meet this requirement, the Contractor shall defer the procurement of all standard hardware as late as possible in the project schedule until just prior to system integration. Similarly, for the standard software, the latest versions available at time of Factory Acceptance Test (FAT) shall be delivered.

The Contractor shall use and provide the latest versions of all the standard software, e.g., the operating system, utilities, language compilers, graphics software, picture editor, networking software, database management system, which are available at the time of system integration, as long as there is full upward compatibility with the control system software. PLC programming must comply with IEC 61131-3.
All software shall be standard. Therefore, any Contractor's code modification on standard software packages shall not be permitted.

All software shall use the Microsoft Windows 7 Operating System. All software shall be in the English language.

The control system PLC hardware and software must be from a recognised global supplier of such equipment. Spare parts and engineering support for the PLC hardware and software must be available

to the Employer from licensed representative companies located either in Samoa, or in countries with regular (at least bi-weekly) direct flights to Apia.

2.6.8.4 **Unit Controllers**

2.6.8.4.1 General Requirements

a) Unit Controllers (Unit PLC) shall be PLC based, and shall include main and auxiliary memory, HMI with keyboard/pad and optical mouse, interfaces with intelligent devices and Process LAN interface. One Unit PLC shall be provided for each turbine generator.
b) The Unit PLC shall be a standalone system, designed to operate totally independent from other devices in the Control system. Therefore, all functions shall be available in the Unit PLC at all times, regardless of whether the Process LAN is in service or not.
c) The Unit PLC shall be located in a Unit control panel near the generator on the generator floor.
d) The Unit PLC shall communicate with multifunction meter modules, and protection relays using Modbus or DNP3 communication protocols.
e) The Unit PLC shall communicate with other drops in the system over the Process LAN, using industry-standard communication protocol based on TCP/IP.
f) The Unit PLC functions shall be programmed in an IEC61131-3 compliant language.

2.6.8.4.2 Control Functions

The Unit PLCs shall have the necessary processing power, memory, software, and peripheral facilities to perform the following functions:

- Control of unit start up.
- Control of unit shut down.
- Engine speed and load governing.
- Monitoring of generator unit pressures, levels, vibrations, flows, temperatures etc and providing protection system "trips".
- Monitoring of hardwired trips from protective relaying system and providing backup 'trips'.
- Syngas Temperature
- Individual control of generating Unit MW and MVArsetpoints.
- Control of auxiliary equipment including pumps.
- Control of unit 415V circuit breaker (synchronised closing will be via synchroniser).
- Unit alarms.
- Local Service AC System control and monitoring.
- DC Systems monitoring
- Powerhouse sump pumps control and monitoring
- Powerhouse dewatering pumps control and monitoring.
- Fire alarms monitoring.
- Security Systems monitoring.
- Interfacing with Employers SCADA

Note that the Unit designs shall be based on the premise that the Unit PLC must be in service for the generating unit to operate.

2.6.8.4.3 Individual Control of MW Generation

The Unit PLC shall have the software for executing MW setpoint controls entered manually by the operator at any of the operator stations or HMIs. The setpoint control software shall be a closed loop, proportional-integral controller of the generator MW output. When in MW control mode, the unit shall be loaded to the lower of the MW setpoint, or the intake level control algorithm.

2.6.8.4.4 Individual Control of MVAR Generation

The Unit PLCs shall have the software for executing MVAR setpoint manually entered by the operator at any of the operator stations or HMIs. The setpoint control software shall be a closed loop, proportional-integral controller of the generator MVAR output.

The setpoint control algorithm shall respect the maximum and minimum reactive power limits of the generating unit that shall be calculated dynamically in the Unit PLC. Reactive power limits shall be calculated using the generator capability curves. These limits shall be modifiable by the Operator on the HMI.

2.6.8.4.5 Automatic Start Sequence Control

The generating unit automatic start sequence shall be initiated by an operator's request at the HMI or from the headwater level control.

A sequential control algorithm resident in the Unit PLC shall execute the automatic start sequence. The Contractor shall define the exact sequence, pre-start conditions, and timers.

The automatic starting sequence program shall control the turbine-generator unit through a series of steps from one steady state to another, starting with the unit at dead stop and ending with the unit synchronized to the power system and with load.

The Unit PLC shall perform as a minimum the following sequence within a predetermined time schedule:

a) Pre-start conditions and permissives satisfied.
b) Penstock at pressure.
c) Unit Auxiliaries start.
d) Governor start.
e) Unit spinning up.
f) Excitation on at 95% speed.
g) Unit auto synchronizer activated at greater or equal to 95% speed.
h) Unit synchronized on-line.
i) Unit loaded to minimum load.

The Unit PLC shall notify the operator of any discrepancy of unit status with the expected normal operation at all stages of the starting sequence. Failure to complete the sequence will result in the unit being automatically shut down.

The operator shall have the option of interrupting the starting sequence at any steady state. After the operator interrupts the automatic sequence, the Unit PLC control logic shall be designed to return to the last steady state.

2.6.8.4.6 Automatic Stop Sequence Control

The generating unit automatic stop sequence shall be initiated by an operator's request at the HMIor from the headwater level control..

A sequential control algorithm resident in the Unit PLC shall execute the automatic stop sequence. The Contractor shall define the exact sequences, pre-stop conditions, and timers.

The automatic stopping sequence program shall control the turbine-generator unit through a series of steps from one steady state to another, starting with the unit loaded and ending at dead stop.

The Unit PLC shall perform as a minimum the following sequence within a predetermined time schedule:

a) Pre-stop conditions.
b) Load condition reduced to minimum operational load.
c) Unit circuit breaker trips.
d) Excitation off.
e) Spear valve closed.
f) Speed reduction.
g) Zero speed.
h) Inlet valve closed
i) Dead stop condition.

The Unit PLC shall notify the operator of any discrepancy of unit status with the expected normal operation at any stage of the unit stopping sequence. Failure to meet the stop sequence will result in a unit trip being initiated.

The operator shall have the option of interrupting the stopping sequence at any steady state. After the operator interrupts the automatic sequence, the Unit PLC control logic shall be designed to return to the last steady state. A Unit restart shall be possible from any of the steady states.

2.6.8.4.7 Synchronising

The Unit Control Panel shall include an automatic synchroniser configured to operate into the generator circuit breaker. Provision for manual synchronising shall also be provided at the Unit Control Panel.

2.6.8.4.8 Employers SCADA Interface

The Unit PLC shall be used as a data concentrator for interfacing the Plant control and instrumentation system, including the protection relays, with the Employers NCC SCADA system.

The Unit PLC shall be interfaced to the SCADA by means of a DNP3.0 communications port from the Unit PLC to the SCADA

2.6.8.5 PLC Technical Requirements

2.6.8.5.1 General

Each PLC shall be provided with a system of input-output modules (local or remote), instrumentation bus, and power supplies.

The input-output modules and power supplies shall meet the Surge Withstand Capability standards as defined by IEC or ANSI/IEEE.

2.6.8.5.2 Processors

Processors shall support standard IEC 61131-3 languages. As a minimum these are to include the following:

- Ladder Logic.
- Sequential Function chart.
- Function Block Diagram.
- Structured Text.

The processors shall have sufficient internal memory to run the PLC program without the need for external memory cards. Processors shall be supplied with enough surplus memory to allow future modifications to the program.

All processors shall have either non volatile memory or be supplied with internal batteries to prevent loss of volatile memory.

The processors must have facility for online changes to be made to the program code.

2.6.8.5.3 Digital Input Modules

Digital input modules shall accept normally open or normally closed dry contacts for status and sequence-of-events inputs. All digital inputs shall include optical isolators and filtering to eliminate contact bounce.

The digital input module shall accept bistable and momentary-change inputs. Circuit breaker status and switch positions are bistable inputs. Equipment alarms and protective relay operations are momentary-change inputs.

Protective relay operations, including electrical and mechanical protective devices, shall be processed as Sequence-of-Event (SOE) inputs. SOE inputs are momentary-change inputs that shall be detected within the resolution window specified for SOE recording.

Digital input modules shall use 24V-DC as the signal voltage.

No more than 16 IO points are permitted on any single digital input Module. The maximum number of IO points with common 0V rail shall be 8.

2.6.8.5.4 Analogue Input Modules

The analogue input modules shall accept and process transducer voltage signals in the range of ± 10-V DC or current signals in the range of ±20 mA DC. All inputs shall be optically isolated.

The analogue input processing shall include filtering, scaling, and A/D conversion with a 12-bit 2's complement resolution.

Accuracy shall be at least ±0.05% and linearity ±2 LSB over the full input range and temperature range.

2.6.8.5.5 Resistance Temperature Detector (RTD) Input Modules

The RTD input modules shall have the capability of interfacing with Platinum RTDs.

All RTD inputs shall be wired to RTD input modules on the PLCs. Multiplexing of RTD signals is not permitted.

The RTD input module shall have a resolution of 0.1°C, accuracy of 0.8°C for RTD Type 100-Ohm Platinum.

2.6.8.5.6 Control Output Modules

The control outputs shall be of the "clean contact", individually isolated type, with each output individually configurable as normally open or normally closed.

Control Output modules shall use 24V-DC as the signal voltage.

No more than 16 IO points are permitted on any single control output module.

2.6.8.5.7 Analogue Output Modules

The analogue output modules shall transmit process control signals in the range of ± 10-V DC or current signals in the range of ±20 mA DC. All outputs shall be optically isolated. Outputs shall revert to 0V DC or 0mA DC in the event of a module failure.

The analogue output processing shall include filtering, scaling, and A/D conversion with a 12-bit 2's complement resolution.

Accuracy shall be at least ±0.05% and linearity ±2 LSB over the full input range and temperature range.

2.6.8.5.8 Communications Media

The communications media for external (outside PLC cabinet) communication links shall be fibre optics.

The communications media for internal (inside PLC cabinet) communication links and short links between adjacent cabinets may be copper but shall be to the Project Manager's approval.

2.6.8.5.9 Physical Requirements

The PLCs shall be housed in a standard electronic equipment cabinet with a window door.

2.6.8.5.10 Power Requirements

The PLCs shall be suitable for operation from 24V-DC. All control and indication wiring to and from the PLC panels shall be 24V-DC and 240V-AC wiring is strictly prohibited.

2.6.8.5.11 Configuration System

The PLCs shall be provided with a Windows-based configuration system, which shall include all the necessary software to configure and program any function in the PLC.

The configuration system shall be installed on the portable maintenance PC.

The configuration system shall allow downloading and uploading of configuration data files.

The configuration system shall program, download, debug and store programmable algorithms.

The Contractor shall ensure that **all** OEM licenses for the configuration system are valid throughout the warranty period. The configuration software must have an international license and there shall be no requirement for hardware 'dongle' type security devices.

The Operating system shall be Microsoft Windows 7.

2.6.8.5.12 Programming Language

The programming package shall be an industry standard package IEC 61131-3 compliant and shall be totally integrated with the PLC software. No special database shall be required for the implementation of control programs. The control programs shall use ladder diagrams; function block diagrams, sequential function charts, structured text, instruction lists, and C++ based routines. Programs shall be fully annotated with tags and comments on a per line basis to fully document the code functionality. The programming package shall support on-line and off-line development, off-line simulation, documentation and reporting capabilities.

2.6.8.6 Human Machine Interface

2.6.8.6.1 General

The Human Machine Interfaces (HMIs) shall consist of an integrated SCADA/HMI PC-based graphic display system to support an interactive dialogue between the operator and the power plant equipment. The HMI shall be based on an industrial touch screen, panel mounted computer, which shall be mounted on the Station Services PLC panel or, in the case of single unit stations, on the Unit Control Panel.

The HMI computer shall incorporate a solid state hard drive, and shall be designed for operation from a 24V DC power supply.

The HMI package shall include alarming, reporting, event logging and trending capabilities.
The HMI package shall include an interactive display editor.

All displays (formats and design) shall be subject to review by Project Manager.

The Contractor shall be responsible for integrating as a minimum the following displays:

a) Alarm Lists. Display of alarms. The entries in the alarm lists shall be arranged in chronological order.
b) System events summary. A chronological listing of all system events, i.e., alarms and operator-initiated actions.
c) Sequence of events list (one list).
d) Unit generation displays.
e) Station service displays.
f) Control system configuration display.
g) Generator and turbine capability curves with operating point shown.
h) Single line diagrams.
i) Sequence Monitor. The sequence monitor function shall monitor the sequential operation of the unit by checking the processing time for each step of the normal start and stop sequences. In the event of trouble in any sequential step, the step and equipment/devices shall be indicated on the sequence monitor to be mounted on the operator console.
j) Temperature Monitor. The winding temperatures of the generator, and generator step-up transformer winding temperatures shall be monitored with reference to the load and shall be continuously compared with the design characteristics. When an abnormal temperature trend is detected the related temperature-monitoring image shall be displayed. Display shall include a unit vertical section graphic indicating the location of the temperature sensors of the machine.
k) Daily, monthly and annual reports.
l) Help screens.
m) Additional displays shall be as required by other functions included in this Contract.

2.6.8.6.2 Software Requirements

The operating system for the PC-based stations shall be Microsoft Windows 7 compatible.

The HMI software must have an international license and there shall be no requirement for hardware 'dongle' type security devices.

The database shall be designed to support the following input types:

a) Analogue Inputs - Read an analogue value either directly from a PLC or from a register within a protection relay device, and automatically convert the raw count to engineering units.
b) Analogue Alarms - Alarm capabilities for alarm suspension and remote acknowledge.
c) Calculations - Perform arithmetic calculations based on other database inputs.

d) Digital Inputs - Sense logical state of a switch or relay directly from the PLC input module or from a bit in memory of a protection relay.
e) Digital Alarm - Alarm capabilities for alarm suspension and remote acknowledge.
f) Digital Output - Set a logical on/off state in an output relay either directly in the PLC output module or in a bit within the memory of a protection relay.
g) Each database point shall include an instrument tag name, hardware device name, address, specific parameters, signal conditioning requirements and point description. The database shall be shared with the PLC database so as to ensure commonality of tag names throughout all devices.
h) The database shall be stored as a standard Windows file.
i) The database maintenance facilities shall be totally integrated with the graphic display system.
j) The database shall use a high-level data manipulation language such as Structured Query Language (SQL).

2.6.8.6.3 Security Management

The HMI software shall provide a user-based security system. If enabled, the security system shall allow for the creation of users with certain rights and/or privileges. These rights must include the ability to run any combination or all of the applications in the data acquisition system.

The ability to allow or disallow users' access to change values, such as setpoints and machine-setups, on an individual tag basis shall be supported.

2.6.8.6.4 Historical Data Management

Historical Data shall be collected at periodic intervals and stored in historical files, classified by type. The periodicity of data collection and storage shall be different for each data type and shall be changeable for a specified period at the Operator's option.

The storage of collected real-time data in the historical files shall be in the same format as in the HMI database.

It shall be possible for the user to retrieve sets of data belonging to the same time sample or different time samples through a sort operation or through relational constructs and displays them in tabular form.

It shall be possible to archive historical files on optical disk for storage in a disk library.

2.6.8.7 **System Performance and Testing**

2.6.8.7.1 General Requirements

The Contractor shall meet the system functional and performance requirements given in these Employer's Requirements. The verification of compliance with the requirements shall be done through a series of tests focused primarily on functionality and system availability.

The testing sequence of the complete system shall consist of the following:
a) Pre-Factory Acceptance Test (PreFAT).
b) Factory Acceptance Test (FAT).
c) Site Acceptance Test (SAT).

All system testing shall be made with the ultimate number of PLC and Operator stations and the ultimate number of points being simulated.

2.6.8.7.2 Acceptance Tests

The Contractors shall prepare a Factory Acceptance Test (FAT) Plan and shall submit it to the Project Manager for review and approval at least four (4) months before the scheduled start of system FAT.

The FAT Plan shall consist of the following:

1. FAT Overview
   This shall describe the test configuration, the hardware and software simulators used, the measurement tools, the complete test schedule, the forms for recording test results, the classification of discrepancies, and the processing of test reports.

2. Test Procedures
This shall describe the test preconditions and assumptions, the detailed steps to be taken for each test and the verification of results of each step.
    a) The Test Procedures shall include both hardware and software tests.
    b) The Test Procedures shall have a separate section for the acceptance test procedures for the Plant Control System.
    c) A Pre-Factory Acceptance Test (Pre-FAT) shall be performed by the Contractor to verify that the system as fully integrated complies with all of the required functional details and that the system satisfies the response and resource utilization requirements.
    d) The Pre-FAT shall follow completely the test procedures of the FAT Plan reviewed by the Project Manager.
    e) The Project Manager may choose to witness the pre-FAT.
    f) The Contractor must correct all discrepancies found in the pre-FAT before the Factory Acceptance Test can be started.
    g) Project Manager or representative will witness the FAT upon notification by the Contractor that the system is ready for the FAT.
    h) The FAT shall verify that the system as fully integrated complies with all of the required functional details and that the system satisfies the response and resource utilization requirements.
    i) All discrepancies found in the FAT shall be corrected prior to shipment of the system.
    j) After the system has been installed and checked out completely on site to the satisfaction of the Project Manager, Contractor shall perform the Site Acceptance Test (SAT). As part of the check-out, the SAT shall be preceded by a system generation of the clean software free of any remaining errors found in the FAT.
    k) Essentially the SAT procedures shall be a repeat of the FAT test procedures under actual field conditions. Some of the FAT procedures shall be modified by the Contractor to reflect the field conditions.
    l) At the end of the SAT the software shall be free of any 'forces' or other temporary bypasses.

2.6.8.8 **Specified Spare Parts**

The Contractor shall furnish spare parts for the control systems as listed below. A set is defined as the total number of each component required for one control system. One set of spare parts shall be provided. Where listed components differ between control systems supplied, one set shall be provided for each design of c.

- One PLC power supply
- One PLC processor.
- One of each type of IO module.
- Other items recommended by the Contractor.

2.6.9 Communication Systems

2.6.9.1 Type and Description

The Contractor is to design and install the following communication systems:

- Control system fibre optic LAN at the powerhouse.
- A fibre optic communications cable linking the powerhouse controls to the intake level transmitter.
- SCADA system DNP3 communications linking intelligent electronic devices (IED's) at the powerhouse to the Employers SCADA at the NCC.
- Extension of the Employers VHF radio network for voice communications between the powerhouse and NCC.

The Employer will provide a single mode fibre optic cable to the power station building for the SCADA communications. The Contractor shall provide a fibre optic termination frame and terminate the single mode fibre cable. All fibre optic cable, transceivers, convertors etc required to interface the power station controls and protection scheme to the Employer provided cable shall be provided by the Contractor.

2.6.9.2 Fibre Optic Network Features

2.6.9.2.1 Fibre Patch Panels

Fibre patch panels shall be provided at:-

- The Powerhouse

Each individual fibre core of all cables shall be terminated into SC type receptacles in the patch panels. All fibres are to be terminated with type 'SC' connectors. Preformed fiber patch cables shall be provided. These shall be colour coded in accordance with the service they are associated with. The coding shall be:-

- Blue for control system LAN.
- Green for SCADA DNP3 network.
- Red for protection signalling.

No patch cords in excess of 15m long are permitted.

All fibres are to be fully tested 'point-to-point' i.e. from the source device to the destination device with all interconnecting 'patch' cables installed. The attenuation over the entire length of each fibre is to be measured and recorded and each length measured using an OTDR to check for any significant step changes in attenuation. Any loss greater than that expected and commonly recognised as being 'typical' is to be thoroughly investigated and the suspect/faulty component replaced and the complete length retested. A record of the measured loss and OTDR profile for each fibre is to be submitted for the Project Managers approval and once approved, included with the 'as-built' documentation.

2.6.9.2.2 Power Station Control System LAN

Power station control LAN's shall be 'fault-tolerant', fibre optic based 100 MBPs 'Ethernet' network. All network links between steel enclosures shall be fibre optic. Network connections within steel enclosures or between adjacent steel enclosures shall be implemented using either fibre or CAT 6 cabling.

The LAN shall link the following devices on the Plant control system:

- The Unit PLCs, located in the Unit control panels.
- HMI workstations, located in the power station control room.
- One monochromatic printer, located at the power station control room.

Network switches, hubs and routers shall be provided as necessary. These devices shall be located in the same enclosure as the PLC / HMI operator interface or in a wall or desk mounted enclosure for the HMI workstations. All switches, hubs or routers shall be provided with power supplies taken off the powerhouse 24V DC system.

The station control system LAN cabling shall be run in stainless steel conduit over all sections external to steel panels.

2.6.9.2.3 SCADA Network

The Contractor is to design and implement a transport network for a Level 2 DNP3 communication between IED's and a SCADA master located at the Employers NCC.

The Employers NCC uses ClearSCADA manufactured by Schneider Electric Ltd.

As a minimum the DNP3 network shall link the following IED's to the SCADA RTU:

- The generator protection relays.
- The revenue meters.
- The Unit PLC

Failure of any single device shall not affect the integrity of the overall DNP3 network.
Network switches, hubs and routers shall be provided as necessary. These devices shall be located in the same enclosure as the IED. All switches, hubs or routers shall be provided with 24V DC power supplies.

2.6.10 DC Systems

2.6.10.1 General

The Contractor shall furnish all labour, materials, and equipment required to design, supply, install, field test, and pre-commission battery backed up DC system for the powerhouse control, protection, SCADA, communications and emergency lighting systems.

The system shall normally supply 24 V DC to the powerhouse systems by utilizing the DC output from the battery charger to feed the 24 V DC switchboard. When the 415/240 V AC power supply to the battery charger fails, the battery set shall provide 24 V DC to the 24 V DC switchboard.

24 VDC power supplies shall consist of:

- One Battery bank rated for 100% of station 24VDC load.
- Two Battery chargers each for 100% of station DC load plus the capacity to recharge one battery bank in 8 hours
- One DC distribution board including paralleling diodes.
- DC distribution.
- 24V DC shall be used for all protection and control functions.

The Contractor shall provide all necessary associated equipment, special tools, controls and detailed information for the installation, testing, pre-commissioning and operation of the equipment supplied.

2.6.10.2 Battery Sets

The batteries shall be valve regulated lead acid (VRLA) type complying with IEC 60896-21 and 60896-22.

The batteries shall be designed for a minimum service life of twelve years to 80% remaining capacity. The battery rating shall be increased to allow for an 80% end-of-life capacity (i.e. battery increased by 1.25).

Each battery set shall have the capability of being completely discharged to the 1.8 V per cell rating over a 4-hr period a minimum of 50 times over the 12-year life period.

The plates shall be assembled in plastic jars of heat-resisting and shock-absorbing material which will not warp, bulge, or lose its shape. The jars shall provide a permanent seal at the joint of the jar and cover and shall be easily cleaned. Plastic cell jars shall be clear with no colouring.

Cell covers shall have flame arrester type vent caps.

The cables from the batteries to the DC charger/distribution panels shall be electrically protected by fuses located as close as practical to the battery terminals. DC positive and negative cables shall not run in close proximity until after the fuse protection.

2.6.10.3 **Battery Rack**

The battery cells shall be located on a battery rack at a convenient height and shall be easily replaceable. The rack shall be of the stepped type with a maximum of 2 steps and made of galvanized steel. It shall permit easy maintenance and cleaning of the battery set and the battery room floor. It shall allow a compact assembly of the cells to assure maximum voltage across the battery. The rack shall be painted with 2 coats of acid resisting paint.

Note: the battery voltage test point on the battery terminals shall not be higher than 1800mm above floor level.

2.6.10.4 **Battery Chargers**

Battery chargers shall:

- be housed in a heavy gauge sheet metal cabinet. The cabinet shall be free standing, floor or wall mounted. Access shall be from the front through a hinged door
- be regulated, thyristor controlled with fully automatic controls.
- Be designed for use with VRLA batteries.
- be self-ventilated for operation in an ambient temperature not to exceed 40°C or below 0°C
- be capable of float charging the battery set and simultaneously supplying other loads to its full ampere capacity.
- be provided with an adjustable current limiting feature that will limit the output current to the maximum recharge current recommended by the VRLA battery manufacturer.
- Be provided with temperature compensation to prevent over charging or thermal runaway of the batteries. A remote temperature sensor shall be provided for each battery cell.
- have a voltage regulation of ±1.0% from no load to full load with a ±10% supply voltage variation
- operate properly over a ±5% supply voltage frequency variation.
- be capable of picking up a fully discharged battery without tripping.
- be designed for parallel operation with a second battery charger.
- have a two or more winding transformer to isolate the AC supply from the DC output
- have reverse-current protection to prevent draining the battery in the event of rectifier failure or short circuit

The A-weighted sound level shall not exceed 60 dB when measured at a distance of one meter from the charger enclosure. The sound level shall be measured while the charger is operating at rated voltage and frequency and at maximum rated output current.

The chargers shall have surge suppressors and filters to prevent voltage spikes or other distortion from being fed back into the AC power supply or from affecting the DC output. The filters shall limit the voltage transients to not more than 5% of the fundamental. Output ripple content shall be limited to less than 2% rms.

Thermal magnetic circuit breakers of suitable current carrying and interrupting capacity shall be used in the following applications:

a) Alternating Current Input
   All chargers shall have a thermal magnetic circuit breaker.
b) Direct Current Output
   All chargers shall have a 2-pole thermal magnetic circuit breaker.

Each battery charger shall also be equipped with the following:

a) Output DC voltmeter.
b) Output DC ammeter.
c) AC power failure relay, with one normally open and one normally closed contact and a local pilot light.
d) DC low and high voltage alarm relays, each furnished with one normally open and one normally closed contact. A local pilot light shall be furnished for each relay.
e) DC ground detection relay for remote alarm with local pilot light.
f) AC power "ON" pilot light.

Each battery charger nameplate shall contain:

a) Manufacturer's name.
b) Model, type, and serial number.

c) AC voltage and frequency.
d) Number of phases.
e) AC ampere rating.
f) DC voltage rating.
g) DC ampere rating.

2.6.10.5 **DC Main Distribution Boards**

DC distribution boards shall be designed and constructed in accordance with AS/NZS 3439.1 and AS 2672.2, as applicable. Where compliance is not relevant the board shall be designed for the fault rating expected using industry standard components.

All circuit breakers shall be at least two-pole, breaking both the negative and the positive lines. All MCCBs shall be fitted with panel-front mounted rotary handles.

2.6.11 Powerhouse Lighting and General Power

2.6.11.1 General Requirements

Where specified in Section 6 Part 2.52.6 the Contractor shall provide powerhouse lighting and general power equipment as specified below:-

- Provision of cables from the Main Switch board (MSB) to the Local Services Switch Board (LSSB).
- Provision of LSSB.
- Interior LED lighting.
- Exterior LED floodlighting.
- Emergency evacuation LED lighting.
- Power outlets.
- Power supplies to generator ancillary equipment.

2.6.11.2 Local Service Switch Board

Provide a Local Service Switch Boardfor each powerhouse. The LSSB shall comprise:-

- A main incoming switch.
- Busbars rated for the incoming main switch capacity and prospective fault level.
- Outgoing feeder circuit breakers for the turbine generator ancillary services requirements, battery chargers, lighting and general power outlets. 25% spare capacity is to be provided.

The switchboard shall be wall mounted and located in an area where best protected from flood events.

The LSSB may be incorporated into the Main Switch Board.

2.6.11.3 Lighting

Provide luminaires complete with control gear and lamps. All luminaires shall be adequately mounted and supported in accordance with the manufacturer's recommendations and when installed shall operate at a lagging power factor of not less than 0.95.

Sufficient luminaires shall be provided to ensure a minimum illumination level of 300lux, as measured 1000mm above the powerhouse floor.

The placement of the fittings shall in no way affect the operation of other services.

All wiring to light fittings and switches shall be run in suitable surface mounted conduit and the size shall be as indicated in the load schedules.

2.6.11.4 Indoor Luminaires

All indoor luminaires shall be light emitting diode (LED) type with built in driver and control gear.
The luminaires in areas with a ceiling height less than 3500mm shall consist of linear type T8 tube fittings. Luminaires in areas with higher ceiling height may either use linear fittings, or industrial high bay fittings.

All fittings shall have fibreglass reinforced polyester or aluminium housing with polycarbonate prismatic clear diffusers and shall have a protection rating of at least IP66 and minimum impact protection rating of IK08.

Lamps shall have a correlated colour temperature of 4000 K.

Fittings and lamps shall have a rated life of not less than 50,000 hours with ambient temperature in the range +20 to +40 °C.

2.6.11.5 Emergency Evacuation Lighting

Two automatic emergency lighting luminaires shall be provided in each powerhouse to allow safe egress from the machine floor areas when the main lighting has failed. The emergency lighting luminaires shall be robust weatherproof battens complete with led lamps. Each luminaire shall consist of a moulded GRP

body and moulded polycarbonate diffuser and shall have a protection rating of at least IP65. The emergency evacuation lights shall be powered from the 24V DC system.

2.6.11.6 **Auxiliary Emergency Lighting**

Provide a battery backed emergency luminaire to provide limited manual lighting in the powerhouse entrance area when the emergency evacuation lighting batteries have fully discharged following an extended power outage. The unit shall be installed to operate independently from the normal emergency lighting system with the charger permanently connected to a power supply and the lighting circuit switched off via a suitable switch. This light shall only run when the manual switch is operated.

2.6.11.7 **Outdoor Floodlights**

Provide outdoor LED floodlights to illuminate the powerhouse entrance, transformer and tailrace areas. The outdoor floodlights shall be robust high performance fittings complete with energy efficient LED lamps and electronic control gear. Each luminaire shall consist of a white moulded GRP body with asymmetrical reflector and toughened glass lens in a GRP frame and shall have a protection rating of at least IP65. The floodlights shall be supplied with proprietary mounting stirrups for surface mounting and the final aiming angles shall be determined on site to achieve optimal area lighting.

The outdoor LED floodlights shall be provided with automatic night-time/movement detection for switching the lights on & off. A manual switch shall be provided within the powerhouse to select the light control "On, Auto, Off".

2.6.11.8 **Lighting Control and Switching**

All light switches shall be mounted at a height of 1.30m above floor level and within 0.20m of any doorframe on the handle side.

The light switches shall be robust and have surface mounting enclosures made from high-impact strength polycarbonate (or equivalent) with a protection rating of IP66. They shall be fitted with integral red neon indicators that illuminate when each switch is in the "ON" position.

2.6.11.9 **Power Outlets**

Provide new power outlets on the machine floor, switchgear area and controls annex. One single phase and one three phase outlet shall be located on the powerhouse wall close to each turbine generator.

Four single phase outlets shall be provided in control rooms and two single phase outlets in the switchgear area. Two single phase and one three phase outlet shall be located in the unloading bay area.

All outlets shall be adequately mounted in accordance with the manufacturer's recommendations.
All wiring to power outlets shall be run in suitable surface mounted steel conduit and the sized to suit the loads.

All single phase 10A socket outlets shall have a flat pin configuration complying with AS/NZS 3112 and the three phase 32A socket outlets shall have a round pin configuration complying with AS/NZS 3123.

All socket outlets shall be protected by the use of suitable RCD units mounted on the distribution boards with each RCD suitably labelled identifying the protected sockets.

2.6.12 **Ventilation Systems**

2.6.12.1 **Scope**

Where specified the Contractor shall provide ductwork and louvres to vent hot air from the generators outside the powerhouse. In addition, louvres shall be fitted at a high level on the powerhouse wall to provide a return air flow.

2.6.12.2 **Ductwork**

Unless otherwise stated all ductwork shall be constructed from galvanised mild steel. Internal roughness and unspecified obstructions to air flow will not be accepted in ductwork. Where practicable, sharp edges or corners on the outside of ductwork, fittings and supports shall be avoided. Remove all sharp corners including from angle at flange corners. Paint all cut edges, all lock seams, and any place where the galvanising is broken, with zinc rich paint.

Duct penetrations through roofs or external walls shall be weather-proofed with a weather cravat or other purpose made arrangement. Flashings and making good shall be done by this Contractor.
The casings of all ventilation equipment shall be rigidly constructed and stiffened where necessary to prevent drumming and vibration. Locking devices shall be used with all fastenings subject to vibration.

Flexible joints shall be heavy-weight, white vinyl covered glass fibre cloth.

2.6.12.3 **Louvres**

Weather Louvres shall be drainable blade louvres with blades which drain through vertical down pipes to discharge water at the bottom of the louvre. Drainable louvres blades shall be 102mm louvred blades set at 76mm centres and constructed in a 107mm flanged (F) or channel (C) frame to suit the installation profile. Drainable blade weather louvres shall be of extruded aluminium construction and finished in natural anodised, powdercoat and fitted with accessories and dampers. Louvres shall be fitted with insect and bird proof mesh.

2.6.13 General Mechanical Requirements

2.6.13.1 Materials

Materials shall be new and of first-class quality, suitable for the purpose, free from defects and imperfections, and of the classifications and grades listed herein or their equivalents. Materials not listed herein may be used subject to the Project Manager's review of their acceptability, application, and the maximum allowable design stresses established by the Contractor. Material specifications, including grade or class, shall be shown on the appropriate detail Drawings submitted to the Project Manager.

Material	Specification
Carbon Steel Castings	ASTM-A27, "Specification for Mild to Medium-Strength Carbon-Steel Castings for General Application," Grade 65-35, Grade 70-36, and Grade 70-40.
Low-Alloy Steel Castings	ASTM-A148, "Specification for High-Strength Steel Castings for Structural Purposes," Grade 80-50.
Corrosion-Resistant Steel Castings	ASTM-A743/A 743M, "Specification for Casting, Iron-Chromium, Iron-Chromium-Nickel, and Nickel Base (Corrosion-Resistant) Alloy Castings for General Application," Grade CA-15, Grade CF-8 and Grade CA-6NM. ASTM-A487/A487M, "Specification for Steel Castings Suitable for Pressure Service," Grade CA-15, and Grade CA-6NM.
Corrosion-Resistant Steel Plate	ASTM-A167, "Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip." ASTM-A176, "Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip." ASTM-A240, "Specification for Stainless and Heat-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels," Type 405 and Type 410.
Corrosion-Resistant Steel Bars	ASTM-A582, ""Specification for Free-Machining Stainless and Heat-Resisting Steel Bars, Hot-Rolled or Cold-Finished,"" Type 303 and Type 416.
Carbon and Alloy Steel Forgings	ASTM-A668, ""Specification for Steel Forgings, Carbon and Alloy for General Industrial Use,"" Class D.
Carbon Steel Forgings (for pipe flanges, fittings, etc.)	ASTM-A181, ""Specification for Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service,"" Grade I and Grade II.
Carbon Steel Plates (for low-stressed parts)	ASTM-A283, "Specification for Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality (Plates 50 mm and Under in Thickness)," Grade A and Grade B. ASTM-A36, "Specification for Structural Steel." AS/NZS 3678:2011 "Structural Steel – Hot-rolled Plates, Floor Plates and Slabs"
Carbon Steel Plates (for important stress-carrying parts) Intermediate Strength Steel Plates (for important stress-carrying parts)	ASTM-A285, ""Specification for Low and Intermediate Tensile Strength Carbon Steel Plates for Pressure Vessels (Plates 50 mm and Under in thickness),"" Grade B and Grade C. ASTM-A516, ""Specification for Carbon Steel Plates for Pressure Vessels for Moderate and Lower Temperature Service,"" Grade 60 or better, except that all plates thicker than 25 mm (one inch) shall be normalized to produce grain refinement. AS 1548:2008 "Fine Grained, Weldable Steel Plates for Pressure Equipment"
High Strength Steel Plates (for highly stressed parts) Carbon Steel Plates (for important stress-carrying parts)	ASTM-A517, ""Specification for High Strength Alloy Steel Plates, Quenched and Tempered, for Pressure Vessels AS 1548:2008 "Fine Grained, Weldable Steel Plates for Pressure Equipment"

Material	Specification
Bronze Castings, Bronze (for bearings, wearing plates, etc.)	ASTM B584, "Specification for Copper Alloy Sand Castings for General Applications", UNS Alloy Nos. C90300 and C92300.
Bronze (for bolting) High Strength Steel Plates (for highly stressed parts)	ASTM-B21, ""Specification for Naval Brass Rod, Bar, and Shapes,"" Alloy No. 464.ASTM-A517, "Specification for High Strength Alloy Steel Plates, Quenched and Tempered, for Pressure Vessels."
Copper Tubing	ASTM-B88, ""Specification for Seamless Copper Water Tube,"" Type K.
Copper Pipe	ASTM-B42, "Specification for Seamless Copper Pipe, Standard Sizes." ASTM B88/B88M, "Specification for Seamless Copper Water Tube", Type K.
Steel Pipe	ASTM-A53, "Specification for Welded and Seamless Steel Pipe." ASTM A106, "Specification for Seamless Carbon Steel Pipe for High - Temperature Service". ASTM A120, "Specification for Pipe, Steel, Black and Hot – Dipped Zinc - Coated (Galvanized) Welded and Seamless, for Ordinary Uses" NZS 4442:1988 "Welded Steel Pipes and Fittings for Water, Sewage and Medium Pressure Gas" AS 1579:2001 "Arc-welded Steel Pipes and Fittings for Water and Wastewater"
Stainless Steel Pipe	ASTM A312, Type 316L "Specification for Seamless and Welded Austenitic Stainless Steel Pipe. **Type 304 or 304L is not acceptable.** ANSI B36.19M "Stainless Steel Pipe", seamless, Grade TP316N. ASTM 376, TP316 "Seamless Austenitic Steel Pipe for High-Temperature Central-Station Service
Stainless Steel Pipe Fittings	ASTM A282, Type 361L "Forged Stainless Steel Fittings, Socket-Welding and Threaded." **Type 304 or 304L is not acceptable.** ASTM A403, Type 316L "Specification for Wrought Austenitic Stainless Steel Pipe Fittings."
Stainless Steel Tubing	ASTM A269 or ASTM A213, Grade TP316 "Specification for Soft Annealed Stainless Steel Tubing."
Stainless Steel Tube Fittings	Compression type stainless steel flareless tube fittings, suitable for 1200 psi working pressure.
Steel Pipe Flanges and Flanged Fittings	ANSI-B16.5, ""Steel Pipe Flanges and Flanged Fittings." AS/NZS 4087:2011 "Metallic Flanges for Waterworks Purposes" AS/NZS 4331.1:1995 "Metallic Flanges – Part 1: Steel Flanges"
Brazing Filler Metal	ANSI/AWS A 5.8, "Specification for Brazing Filler Metals". AS/NZS 1167.1:2005 "Welding and Brazing – Filler Metals – Filler Metal for Brazing and Braze Welding"

Material	Specification
Welding Electrodes	AWS A 5.1, "Specification for Carbon Steel Covered Arc-Welding Electrodes". AS/NZS 4855:2007 "Welding Consumables – Covered Electrodes for Manual Metal Arc Welding of Non-alloy and Fine Grain Steels – Classification"

2.6.13.2 **Test of Materials**

2.6.13.2.1 General

All materials or parts used in the equipment shall be new and shall be tested, in conformity with applicable methods prescribed by the relevant Australian, New Zealand or such other equivalent standards.

All steel used in pressure vessel applications, including turbine distributors, shall be factory acceptance tested to the requirements of the applicable pressure vessel design standard.

Materials for all principal parts shall be tested for impact resistance and using the Charpy "V" notch method. Bend tests shall be performed on specimens of all major steel castings and forgings, in accordance with the applicable Standard.

2.6.13.2.2 Test Certificates

Certified material test reports shall be submitted as soon as possible after the tests are made. The test certificates shall identify the component for which the material is to be used and shall contain all information necessary to verify compliance with the design Standard.

2.6.13.3 **Safety Factors and Design Stresses**

The design, dimensions and materials of all parts shall be such that they will not cause damage or corrosion under the most adverse conditions and not result in deflections or vibrations which will adversely affect the operation of the Plant.

The Contractor shall be responsible for an adequate design based on factors proven safe in practice and shall use lower working stresses wherever it deems this necessary or desirable or where it deems deflection to be the controlling design criterion.

Generous factors of safety shall be used throughout the design, particularly of components (parts) subject to alternating stresses, fatigue, vibration, impact, or shock.

The adopted design stress levels shall be based on an internationally recognised standard or code, applicable to hydro-electric power generating equipment. The Contractor shall provide details of the proposed standard/code for the Project Managers approval. Where the equipment provided is manufactured as part of the suppliers standard range, then the manufacturers standard design methods may be acceptable provided proof of satisfactory long term, in-service , performance is provided.

The selection of materials and design of all components shall include proper consideration to ensure against fatigue damage and excessive material and structural deflections, vibration, dynamic loading, wear, and other factors which may affect the functioning and durability of these components. A 40 year minimum life is required for the components.

The following conditions shall be considered as a minimum for the cyclic loads and the fatigue of the components in the design of the turbine and generator components:

Minimum Service Life:	40 years
Controlled starts and stops:	3 times per day per unit
Full or part load trips	Ten trips per annum
Daily Operation: Full Load 50% Load	 24 hours per day per unit 8 hours per day per unit
Load changes between 50% and 100% load in generating mode:	12 times per day per unit

2.6.13.4 **Tolerances**

Machining tolerances for all mating fits shall be suitable for the intended service and shall be in accordance with ISO Standards.

2.6.13.5 **Welding**

2.6.13.5.1 General

All welding shall be performed by the electric-arc method, by a process that excludes the atmosphere from the molten metal, and, where practicable, by automatic machines. After being deposited, all welds shall be cleaned of slag by shot blasting, unless otherwise approved, and shall be uniform, smooth, showing good fusion with the base metal, and free of voids, crack, and clinkers. Machined surfaces of parts affected by welding shall be machined to final dimensions after welding. Machined surfaces of parts requiring stress relief shall be machined to final dimensions after the parts have been stress relieved. Localized stress relieving will not be permitted for shop welded parts. All principal load carrying welds shall be full penetration type welds. Strength of welded joints shall be based upon the allowable stress of the parent materials.

2.6.13.5.2 Edge Preparation

Members to be joined by welding may be cut to shape and size by mechanical means such as shearing, machining, grinding, or by gas or arc cutting, to suit the conditions. Design of welded joints and selection of weld filler metal shall allow thorough penetration and good fusion of the weld with the base metal. The edges of surfaces to be welded shall be sound metal free of visible defects, such as laminations or defects caused by cutting operations, and free from rust, oil, grease and other foreign matter.

2.6.13.5.3 Welding Qualifications

The qualification of welding procedures, welders, and welding operators for all welding of pressure-containing components, including weld repairs and other high stressed components, shall conform to standards at least equal to Section IX of the ASME "Boiler and Pressure Vessel Code". Certificates of welders' qualifications shall be furnished when requested. The procedure for qualification testing of the field welders shall be prepared by the Contractor, and the qualification tests shall be witnessed and accepted by the Contractor. Contractor shall replace any welder or welding operator deemed unacceptable by the Project Manager.

2.6.13.5.4 Documentation

The Contractor shall maintain a strict quality control program for the welding work performed in the shop. Weld procedure specifications (WPS) shall be submitted for review prior to starting the fabrication work. All welds shall be identified on the Contractor's Drawings by numbers. All welding work shall be performed by qualified welders and welding operators and shall be properly documented.

2.6.13.6 **Non-destructive Testing**

2.6.13.6.1 General

The Contractor shall propose the Standards for the non-destructive inspections. Such proposal shall include documentation that clearly demonstrates in the judgment of theProject Manager that the inspection and acceptance criteria are appropriate for the Plant supplied.

2.6.13.6.2 Examination of Welds

All welds on weld-fabricated parts, except minor parts or low stressed parts, shall be given complete non-destructive examination. Weld examination shall be by ultrasonic, dye penetrant and magnetic particle methods, supplemented by radiographic examination where required by the shape and nature of a component.

Supplemental radiographic examination shall include examination of critical high-stressed areas where interpretations of other methods are unclear, or where the integrity of the weld is doubtful. All butt welded joints exposed to significant stress levels shall be given a 100% radiographic or ultrasonic inspection accompanied by a 100% magnetic particle or liquid penetrant inspection.

The Project Manager shall have the right to request random spot-check examination of welds, including radiographic examination, as part of his inspection of the equipment. The Project Manager shall also have the right to review films of previously performed radiographic examinations. The non-destructive

examination scope, procedures and acceptance standards of welds shall be clearly indicted on the Drawings.

2.6.13.6.3 Examination of Castings

Major castings incorporated in the equipment or their components that are castings, shall be given complete non-destructive examination by ultrasonic, dye penetrant, and magnetic particle methods supplemented by radiographic examination. Supplemental radiographic examination shall include examination of critical high-stressed areas where interpretation of other methods is unclear or where the integrity of the casting is doubtful. Non-destructive examination of other castings shall be in accordance with accepted good practice to assure sound castings and shall be indicated on the Drawings.

2.6.13.6.4 Examination of Forgings

Forgings for the shafts, needles (if made of forgings), and shaft coupling bolts shall be given complete ultrasonic examination with liberal overlap and other approved non-destructive tests, to determine that they are sound. Non-destructive examination of other forgings shall be in accordance with accepted good practice to assure their soundness and shall be indicated on the Drawings. The structure of forgings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a forging will be cause for its rejection.

2.6.13.7 Castings

All castings shall be dense, sound and true to pattern, of workmanlike finish and of uniform quality and condition, free from blowholes, porosity, hard spots, shrinkage defects, cracks or other injurious defects, and shall be satisfactorily cleaned for their intended purposes. All castings shall be checked for defects before final machining.

Castings shall not be repaired, plugged, or welded without with Project Managers permission. Such permission will be given only when the defects are shallow and do not adversely affect the strength, use, or machineability of castings. Excessive segregation of impurities or alloys at critical points in a casting will be cause for its rejection. The largest fillets compatible with the design shall be incorporated where a change in section occurs.

Surfaces which do not undergo machining and are exposed in the final installation shall be dressed to provide a satisfactory appearance so that they will not require surface smoothing at the Site prior to painting.

2.6.13.8 Forgings

The ingots from which the forgings are made shall be cast in metal moulds. The workmanship shall be first class in every respect and the forgings shall be free from all defects affecting their strength and durability, including seams, pipe flaws, cracks, scales, fins, porosity, hard spots, excessive non-metallic inclusions and segregations.

The largest fillets compatible with the design shall be incorporated wherever a change in section occurs. All finished surfaces of forgings shall be smooth and free from tool marks.
The forging shall be stamped with the heat number in such location as to be readily observed when the forging is assembled in a completed unit.

2.6.13.9 Surface Finish of Equipment Parts and Welds

All surfaces of turbine water passages from the penstock adjacent to the powerhouse to the end of the draft tube liner shall provide a smooth-contoured hydraulic surface. Upstream/downstream inlet valve extensions, turbine casing, draft tube liner plate sections shall neither be offset, bent, buckled, nor depart significantly from the water passage outline.

Finished surfaces shall be indicated on the Contractor's drawings and shall be in accordance with International Industrial Standards or equivalent. Compliance with specified surface will be determined by visual inspection of the work compared to standard roughness specimens, in accordance with the provisions of the above stated standards.

Welds shall in general be treated so that they will display good appearance and a surface suitable for painting. Structural welds shall be ground and blended, to avoid stress raisers. All welds which require

radiographic or other non-destructive examination shall be dressed by chipping and grinding as required for good interpretation of radiographic film or interpretation by other weld examination methods.

Welds exposed in water passages shall be ground to provide smooth-contoured hydraulic surfaces. The welded joints of the air receivers and oil pressure tanks shall not be ground to the extent that the tank is weakened structurally. Details of weld dressing and finishing and non-destructive testing (NDT) shall be shown on the Drawings submitted for approval.

2.6.13.10 Hydraulic Packing

Packing for seals shall be a high-grade commercial product acceptable to the Project Manager and where feasible, with polytetrafluorethylene (PTFE) content suitable for the application and for long seal life. Packing grooves that are exposed to water shall be protected from corrosion by the use of corrosion-resistant materials. Contractor shall select materials suitable for the water chemistry and temperatures expected in service. Materials containing asbestos will not be accepted.

2.6.13.11 Piping

2.6.13.11.1 General

The arrangement of piping and locations of valves and joints shall be such that there will be minimum disturbance of the piping and interference with other equipment and systems when the gas engine, generator, or other equipment is dismantled or parts are removed for inspection or repairs. Bolted flange connections or unions shall be provided at points where a piping system must be disconnected for dismantling.

2.6.13.12 Water Piping

Water piping shall be of welded 316L stainless steel pipe. Piping connection shall be of welded joints for embedded water piping and welded joints and flanged fittings for exposed water piping. Valves 75 mm and smaller shall be of stainless steel; valves 100 mm and larger shall be cast steel flanged valves with stainless steel trim, epoxy-coated inside.

2.6.13.13 Oil Piping

Pressure piping for servomotors shall be 316L stainless steel, of appropriate strength, with stainless steel compression type fittings and steel bodied valves. Lubricating oil piping shall be seamless drawn copper or red brass with brass or bronze fittings and valves.

2.6.13.14 InstrumentPiping

Piping exposed to river water shall be 316L stainless steel tubing with stainless steel compression type fittings and shut-off valves. Shut-off valves shall be provided at pressure gauges and at points where the gauge piping connects to the main equipment, together with suitable blow-off valves and drain connections. Flexible tubing for the dial thermometers shall be armoured.

2.6.13.15 Pipe Supports and Piping Materials

Adequate pipe supports shall be provided for all piping included in the supply. Supports, pipe hangers, wall brackets, pipe clamps, fastening devices and all necessary studs, bolts, nuts, washers, oil-resistant gaskets, packing, etc., required for the piping systems shall be furnished. These items shall be supplied as finished products requiring no field fabrication such as welding, cutting and drilling.

2.6.13.16 Piping Connections

On connections for all equipment, pipes may be threaded or flanged with the flanges faced and drilled in accordance with standards selected by the Contractor. All flanged external connections shall be provided with bolts, nuts and gaskets for connection to piping furnished by others. All governor and inlet valve oil piping, generator oil lubricating piping, etc. shall be furnished as a part of a complete system.

2.6.13.17 Pumps

2.6.13.17.1 General

Pumps shall be installed strictly according to the pump manufacturer's requirements. Every effort shall be made to ensure that the minimum number of pump vendors are used as suppliers, and that pumps with identical duties are interchangeable in every respect.

The pump and motor combination shall be selected so that non-overloading operation is ensured under all flow conditions.

2.6.13.17.2General Requirements for Pumps

Pumps shall be of a design and capacity capable of maintaining the fluid flow rate at the actual system resistance. The material and construction of the pump shall be suitable for the type, temperature and pressure of the fluid to be handled.

All moving parts of the pump shall be statically and dynamically balanced.

All pumps shall either be fitted with mechanical seals or be of canned construction so there is no liquid path past a moving surface. Mechanical seals shall be used wherever possible. The preferred sealing face combination is carbon on silicon carbide. Seals shall be water flushed wherever practicable.

2.6.13.17.3Centrifugal Type Pumps for General Use

Pump installations shall consist of pump casing, impeller, suction and discharge connections, driven shaft, couplings and motor as stated. Pumps shall be complete with all necessary water seals. Pump installations shall comprise suction and discharge pipe reducers and expansion pieces directly connected to the pump connections, vibration isolation equipment, and motor terminal box suitable for connection to a flexible conduit system.

Generally, pump base plates shall be constructed from cast iron, however unit constructed close coupled pumps may be mounted on mild steel rails or a fabricated mild steel flat bed plate if full corrosion resistant surface treatment is provided.

Pump flanges shall be tapped and plugged to receive gauge connections.
Volute casings shall be drilled, tapped and plugged at the bottom to enable complete drainage to be carried out.

Spherical roller bearings, or in light load applications deep groove ball bearings, are required on all pumps using rolling element bearings and shall be arranged to operate either within an oil reservoir or with grease lubrication. Parallel roller bearings are not permitted. Bearing lubricators shall be fitted with drain plugs and oil content indication.

Impellers and couplings shall be keyed to the drive shaft, the impeller being retained by a hexagonal nut. Shafts shall be fitted with water deflectors.

Unless specifically indicated elsewhere in this document, motor enclosures shall be totally enclosed fan cooled.

Belt driven pumps shall not be permitted, except in the case of gear pumps.

Unit-constructed close coupled pumps shall be of the back pull-out type, enabling the motor, drive and impeller to be withdrawn from service without disturbing the volute casing connections, piping, etc. Where pumps are to be coupled to their prime mover on site, the motor and pump shall be carefully levelled on shims and packing to achieve a close order of alignment. Dial gauges shall be used to achieve this end and the maximum permitted eccentricity shall be 0.05 mm.

Care shall be taken that the connecting pipe is so arranged as to ensure that no stresses are transmitted through the connections to the pump casing.

2.6.13.17.4Performance

The Contractor shall provide pump characteristics, power and efficiency curves certified by an internationally recognised authority to the Project Manager for approval.
All pumps shall operate with no cavitation and soft starting for power saving. In the case of pumps operating at elevated temperatures, the Contractor shall demonstrate to the Project Managers satisfaction, the no cavitation will occur under all normal operation conditions. Detailed NPSH calculations shall be submitted for approval by the Project Manager.

2.6.13.18 **Fasteners and Anchor Bolts**

2.6.13.18.1General.

Bolts, studs, nuts and screws shall conform to ISO standard thread forms and dimensions and be of high quality material. All bolts, studs, nuts and screws (including their washers) shall be well protected against corrosion according to the Site of their installation or made of corrosion resistant material. Fastener materials shall be as close together as possible in the galvanic series to minimize electrical potential differences. Fitted bolts shall be a driving fit in reamed holes they occupy, shall have the screwed portion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at Site.

Washers, locking devices and anti-vibration arrangements shall be provided and shall be subject to the approval of the Project Manager. Taper washers shall be fitted where necessary.
Nuts, bolts and screws that might become loose during operation shall be locked in fastened position by means approved by the Project Manager.

All torque values shall be stated on the drawings or torque value listing.

2.6.13.18.2Corrosion Resisting Bolts and Nuts.

Corrosion resisting steel shall be used for bolts and nuts when either or both are subject to contact with water and/or frequent adjustment or frequent removal, such as adjusting bolts for packing glands on removable screens or strainers, on adjustable bearings, etc.

2.6.13.18.3Anchor Bolts – General Requirements.

Anchor bolts shall be supplied and installed in accordance with the anchor manufacturer's recommendations, details shown on the plans and with the requirements of these Specifications unless otherwise directed.

Anchoring to concrete of components such as gas engine and generators and other heavy equipment including transformers shall be provided with sleeved or hook type anchors installed in the concrete foundations. Chemical, adhesive bonded anchors shall not be used for heavy load applications. Anchors that are subject to immersion in water or anchors, which penetrate and are welded to stainless steel liners, shall be of stainless steel.
Anchors for lighter static loads shall be of the drilled epoxy adhesive bonded anchors of 316 stainless steel.

After anchor bolts have been embedded, Contractor shall protect threads by applying grease and by having the nuts screwed on until the time of installation of the equipment or metalwork.

Minimum depth of embedment of drilled mechanical anchors shall be as recommended by the manufacturer, but not less than six and one-half bolt diameters.

2.6.13.19 **Protection, Cleaning and Painting**

2.6.13.20 **General**

All parts which will ultimately be embedded in concrete shall be cleaned and protected by a cement wash or other approved method before forwarding from the Contractor's shop. Before being installed, they shall be thoroughly de-scaled and cleaned of all rust and adherent matter. Such cleaning must not affect the strength or final operation or function of the Plant.

All machined parts or bearing surfaces shall be cleaned and protected from corrosion by the application of an approved rust preventive lacquer or a peelable plastic film before forwarding from the Contractor's shop. Where the latter is impractical, such parts shall be heavily covered with high melting point grease. After erection, such parts shall be cleaned with solvent and wiped or polished bright.

All parts, other than machined parts that will be exposed after erection, shall be thoroughly cleaned and given two coats of best quality approved primer and one coat of best quality approved finish paint before being forwarded from the Contractor's shop. One further coat of paint of an approved quality and colour shall be applied after erection and touching up on the Site (except such apparatus as panels and instruments which shall be finish painted in the factory). Paint colours shall be submitted to the Project Manager for approval by presentation of RAL 'Classic' or equivalent colour samples or colour chips.

Primer shall be applied to surfaces prepared in accordance with the paint Contractor's instructions. The surface shall be wiped clean immediately prior to applying the paint. The primer and finish coats of paint shall be applied using the methods and plant recommended by the manufacturer.

The internal surface of all pipelines shall be cleaned out by approved methods before installation and again prior to commissioning, to ensure freedom from dirt, rust, scale, welding slag, etc. All exposed pipes shall be coloured for identification after erection is completed. The colour for each classified pipeline shall be approved by the Project Manager.

The final colour of the Facilities shall be approved by the Project Manager. The Contractor shall comply with this colour scheme for the Facilities.

All Facilities shall be painted as specified herein. The painting shall include the preparation of the metal surfaces, paint application, protection and drying of the paint coatings, as well as the supplying of all tools, labour and materials necessary for the entire painting work.

Paint shall be the product of reputable manufacturers and its selection shall be approved by the Project Manager. Sufficient paint shall be provided for site painting.

2.6.13.21 **Employers Colour Scheme**

The Employers Colour Scheme for the powerhouse and appurtenant facilities is as follows:-

Item	**Colour**	**Code**	
Building Cladding	Pale Eucalypt	RAL6011	
Building Masonry Walls - Exterior	Pastel Green	RAL6019	
Building Masonry Walls - Interior	Pure White	RAL9010	
Building Roof	Olive Green	RAL 6003	
Steel Frame (Internal)	Moss Green	RAL 6005	
Handrails	Signal Yellow	RAL1003	
Stairway Bearers	Signal Yellow	RAL1003	
Ladders	Signal Yellow	RAL1003	
Powerhouse floor	Signal Grey	RAL7004	
Powerhouse floor "walkway markings"	Signal Yellow	RAL1003	
Control Room Interior Walls and Ceiling	Pure White	RAL9010	
Control Panels	Grey	RAL7032	
11kV Switchgear	Grey	RAL7032	
Distribution Boards	Grey	RAL7032	

Item	Colour	Code	
Gas engine	Light Blue	RAL5012	
Generator	Melon Yellow	RAL1028	
Air Ventilation Louvres	Olive Green	RAL 6003	
Lube Oil	Cream	RAL6001	
Transformers	Green Grey	RAL7009	
Crane and rails	Signal Yellow	RAL1003	
Generator Cooling Water pumps and piping	Light Blue	RAL5012	

2.6.13.22 **Surface Preparation**

All oil, paraffin, grease and dirt shall be removed from the surfaces to be painted using solvents. All weld spatters, slags, burrs, loose rusted mill scale and other foreign substances shall be removed by shot or sandblasting to *"white"* metal. The interior surface of the steel pipe shall be mechanically cleaned or sandblasted to a commercial standard.

Special attention shall be given to cleaning of corners and converging angles. If rust forms or the surfaces become contaminated in the interval between cleaning and painting, re-cleaning to the same degree appropriate is required. Effective means shall be provided for removing all free oil and moisture from the air supply lines of blasting plant. All surface preparations shall be subject to the approval of the Project Manager before any paint is applied.

2.6.13.23 **Application Procedure**

All paint, when applied, shall provide a satisfactory film and a smooth, even surface. Paint shall be thoroughly stirred, stained, and kept at the uniform consistency during application. Paint shall not be applied when the temperature of the metal or of the surrounding air is below 10°C. Surfaces that will be coated shall be performed by brushing or spraying. Each coat shall be allowed to dry or harden thoroughly before the succeeding coat is applied.

2.6.13.24 **Surfaces Not to be Painted**

Bronze, brass, surfaces of gear teeth, finished ferrous surfaces, surfaces in rolling or sliding contact after field assembly, stainless steel and wire ropes shall not be painted.

All corrosion resisting steel surfaces for bearings and machinery parts shall not be painted.
On completion of cleaning, such surfaces shall be coated with an adhesive plastic film to protect the surfaces from minor mechanical damage and corrosion during shipment and storage at the site. The film shall be stripped off immediately prior to field erection of the Plant.

2.6.13.25 **Galvanising**

Unless specifically mentioned to the contrary, iron and steel shall be effectively galvanised after all fabrication is completed.

The zinc coating shall be uniform, clean, smooth and as free from spangle as possible. Galvanising shall be applied by the hot dip process for all parts other than steel wires. All steel wires shall be galvanised by an approved method before stranding.

The minimum quantities of zinc coating shall be 350 g/m² for bolts and nuts and 550 g/m² for all other parts except steel wires. The uniformity of zinc coating, tested by dipping the sample into the solution of sulphate of copper, shall be such that no surface of iron or steel shall expose until four times of dipping for bolts and nuts and six times for all other parts.

The preparation for galvanising and the galvanising itself shall not distort or adversely affect the mechanical properties of the materials. After galvanising, holes shall be free from nodules of splatter. Galvanised parts are subject to the formation of white rust during shipment or storage on the Site, and special treatment shall be made during the galvanising process to prevent the formation of white rust.

2.6.13.26 **Paint Schedule**

All finished surfaces of ferrous metals including screw threads that will be exposed during transportation or while awaiting installation shall be cleaned and given a heavy uniform coating of gasoline soluble, rust preventive compound.

For painting steel, follow the requirements and recommendations of the combined Australian and New Zealand Standard AS/NZS 2312 "*Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings*". This standard has paint systems suitable for inland conditions in the Pacific islands.

The painting shall be performed as follows:-

Painting Systems Table 1 of 4

Base Material	Material Detail	Exposure	Environmental Conditions	Paint System	Comments
Mild Steel	General	Indoor	Dry	S1 or S3	
			Water Immersed	S2 or P1	
			Diesel Immersed	S5	
			Hydraulic Oil Immersed	S6	Dependent on oil type
		Outdoor	Exposed	S3 or P3	
			Water Immersed	S2	
		Buried	Soil	S11 or P2	Or coating manufacturers recommendations
	Pre-Galvanised	Indoor	General	HDG600P3	
		Outdoor	General	HDG600P3+	
	Penstock	Inner wall of penstock	Water Immersed	P1	
		Outer wall of embedded pipe	Soil	P2	
		Outer wall of open / outdoor pipe	Exposed	P3	
	Gates	All surfaces	Flowing water	G1	
Concrete	Walls and Ceilings	Indoor	Dry	C1	
			Water Immersed	C3	
		Outdoor	Exposed	C1	
			Oil / Water Immersed	C3	Oil Interceptor, Transformer area
			Water Immersed	C4	
			Buried Soil	--	Coating manufacturers recommendations
	Floors	Indoor	Light Foot Traffic	C2	
			Heavy Foot Traffic	C2	
			Water Immersed	C3	
Plastics and Fibreglass	All	Indoor	General	F1	
		Outdoor	General	F1	
Wood	--	--	--	--	No wood in this project
Aluminium	Window Frames	Indoor and Outdoor	Exposed	S7 or S8	
	Louvres	Indoor and Outdoor	Exposed	S7 or S8	
Electrical panels		Indoor	Dry	S9 or S10	

Painting Systems Table 2 of 4

System	S1	S2	S3	S4	S5	S6	S7	S8
Description	Medium build epoxy with acrylic top coat	High build MIO epoxy	Polyurethane - higher build	High build epoxy - water immersion	Epoxy - diesel immersion	Epoxy - hydraulic oil immersion	Powder coated	Anodised
Substrate	Steel	Steel	Steel	Steel	Steel	Steel	Steel or aluminium	Aluminium
Typical Application	Indoor and Outdoor. Not immersed in water	Water Immersed (a more general version of system G1)	Indoor and Outdoor. Not immersed in water	Indoor and Outdoor. Potable Water	Indoor. Immersed in diesel	Indoor. Immersed in hydraulic oil	Indoor and outdoor. Ventilation louvres and windows.	Indoor and outdoor. Ventilation louvres and windows.

Reference Standard	AS/NZS2312 ACC5	AS/NZS2312 EHB6 with thicker coats	AS/NZS2312 PUR5	AS/NZS2312 EHB8				AS 1231
Surface Preparation	SA 2 ½	SA 2 ½	SA 2 ½	SA 2 ½ (profile 50-75 µm)	SA 2 ½			
Coat 1	Zinc rich primer	Zinc rich primer	Zinc rich primer	Epoxy primer	Epoxy with amine adduct or as recommended by paint manufacturer	Dependent on oil type	As recommended by coating manufacturer	As recommended by coating manufacturer
DFT (µm)	75	100	75	250				
Coat 2	High build epoxy	Epoxy MIO	High build epoxy	High build epoxy	Epoxy with amine adduct		PVDF powder coating	Anodising thickness AA10
DFT (µm)	125	150	200	250	250			10
Coat 3	Acrylic 2-pack	Epoxy MIO	Polyurethane gloss	--	--		--	--
DFT (µm)	50	150	50					
Total DFT (µm)	250	400	325	500	250			10

Painting Systems Table 3 of 4

System	S9	S10	S11	HDG600	HDG600P3	HDG600P3+	C1	C2
Description	Epoxy powder finish	Polyester powder finish	Ultra high build epoxy	Hot dip galvanising	Epoxy painted hot dip galvanised (interior)	Epoxy painted hot dip galvanised (exterior)	Architectural paint for concrete	
Substrate	Steel	Steel	Steel	Steel	Hot dip galvanised steel	Hot dip galvanised steel	Concrete	Concrete
Typical Application	Indoor. Electrical Panels	Indoor. Electrical Panels	Soil		Interior	Exterior	Internal and external walls and ceilings	Internal concrete floors heavy traffic
Reference Standard			AS/NZS2312 EUH1	AS/NZS4680 HDG600	AS/NZS2312 HDG600P3	AS/NZS2312 HDG600P3 with polyurethane top coat		
Surface Preparation	SA 3	SA 3	SA 2 ½ (profile 75-100 µm)	Hot dip galvanised 600g/m² to AS/NZS4680	Hot dip galvanised 600g/m² to AS/NZS4680	Hot dip galvanised 600g/m² to AS/NZS4680	May need a lime stain inhibitor coating to stop lime staining	
Coat 1	As recommended by paint manufacturer	As recommended by paint manufacturer	Ultra high build epoxy		High build epoxy	High build epoxy	Penetrating epoxy primer	Epoxy enamel (solvent based) with slip resistant additive
DFT (µm)			1000	85	150	150	10	125
Coat 2	Epoxy powder finish	Polyester powder finish	Ultra high build two-pack epoxy	--	--	Polyurethane gloss	High build epoxy	Epoxy enamel (solvent based)
DFT (µm)	50	50	1000			50	200	50
Coat 3	--	--	--	--	--	--	Polyurethane gloss	--
DFT (µm)							50	
Total DFT (µm)	50	50	2000	85	HDG+150	HDG+200	260	175

Painting Systems Table 4 of 4

System	C3	C4	F1	P1	P2	P3	G1
Description	Water tanks	Water tanks	Fibreglass and plastic	Penstock - inside	Penstock - embedded	Penstock – exposed / outdoor	Gates
Substrate	Concrete	Concrete	Fibreglass or plastic	Steel	Steel	Steel	Steel
Typical Application	Water tank internals	Water tank external	Roof fans	Penstock - inside	Penstock - embedded	Penstock outside	Gates
Reference Standard			Must be compatible with the substrate				
Surface Preparation			As required by paint manufacturer	SA 2 ½	SA 2 ½	SA 2 ½	SA 2 ½
Coat 1	Epoxy filler / sealer	Epoxy filler / sealer	Epoxy primer	SA 2 ½	Denso Primer D	Denso ST epoxy (grey)	Epoxy Zinc Rich Paint (TH-4A)
DFT (µm)	As required	As required	50	250	100	250	100
Coat 2	High build epoxy	High build epoxy	Polyurethane gloss	Denso ST epoxy (grey)	Densopol 80 HT anti-corrosion tape	Denso ST epoxy (white)	Epoxy MIO Paint (TH-10A)
DFT (µm)	500	2x 500 = 1000	50	250	--	250	150
Coat 3	High build epoxy	Polyurethane gloss	--	--	--	Weatherseal acrylic (Denso recommendation)	Epoxy Abrasion Resistant Paint (TH-9A)
DFT (µm)	500	50				40	150
Total DFT (µm)	1000	1050	100	500	--	540	400

2.6.13.27 **Lubricants and Hydraulic Fluid**

Oil for the hydraulic power units shall preferably be of the same type used for the thrust and guide bearings. Grease, lubricating oil and hydraulic fluid required for initial filling of all of the equipment plus 10% shall be furnished. Upon completion of the design, a tabulation confirming the quantities of lubricating oil, grease, and hydraulic fluid required for initial application for each item of equipment shall be furnished. Final selection of the grease, lubricating oil, and hydraulic fluid shall be coordinated with the Project Manager to rationalize the oil inventory and to ensure that the selected brands are available locally.

2.6.14 General Electrical Requirements

2.6.14.1 General

Unless otherwise specified, auxiliary electrical equipment shall conform to all applicable standards of the authorities as specified in Section 6 Part 2.1.6.2~~2.1.5.3~~ Standards. Note that in the Samoa the requirements of the Australian wiring regulations AS/NZ3000:2007 and referenced standards are the paramount requirements.

The Samoa electricity system uses a Multiple Earthed Neutral (MEN) system which is described as a TN-C-S under IEC60364.

2.6.14.2 Phase Rotation

Generator and motor phase rotation will be designated as R for the 1st phase (U-X), S the 2nd phase (V-Y), and T for the 3rd phase (W-Z). Power phase rotation will be designed as R-S-T. R-S-T type bus arrangements, left-to-right, top-to-bottom and front-to-rear, will be used throughout to assure convenient and safe testing and maintenance.

2.6.14.3 Control Equipment Electrical Ratings

2.6.14.3.1 Voltage Ratings

Control equipment shall be designed for operation at the following voltages:

- Nominal rating 110-V DC with an operating range of ±20%, ungrounded from the station battery.
- Nominal rating single-phase 240-V AC, 50-Hz, grounded, with an operating range of ±10%.

2.6.14.3.2 Electrical Contact Ratings

- Contacts shall be suitable for the application and have current and voltage ratings that will not be exceeded when applied in the control circuits.
- Contacts intended for use in the control circuits shall be electrically-independent, ungrounded, dry contacts, field changeable from "normally-open" to "normally-closed" and have the following ratings:
- Maximum Design Voltage. 415/240-V AC and 110-V DC.
- Continuous Current. 5-A AC or DC.
- Maximum Interrupting Current. Inductive (when L/R≥5000), 1.5-A at 240-V AC and 1.1-A at 110-V DC.
- Maximum Making Current. Inductive (when L/R≥5000), 15-A at 240-V AC and 1.1-A at 110-V DC.

2.6.14.4 Motors

2.6.14.4.1 Standards

Motors shall comply with IEC 60034 as regards performance and testing.

2.6.14.4.2 Ratings and Characteristics

- Frequency (AC motors): 50-Hz.
- Voltage (AC motors): 0.75-kW and above, 3-phase, 415-V; less than 0.75 kW, 1-phase, 240-V
- Insulation: Class B, nonhygroscopic.
- Enclosure: totally-enclosed, fan-cooled, (TEFC) unless otherwise specified.
- Accessories. The following accessories shall be provided:
- Non-ferrous, metal guard screens on all ventilating openings.
- Lifting eyes (eye bolts) on all motors weighing more than 50 kg.
- Space heaters for motors above 50 kW shall be factory mounted in an accessible location under the stator frames and rated to maintain internal temperature approximately 10°C above ambient temperature specified. Heater leads shall be wired to a separate terminal box mounted on the motor. Heaters shall be low watt-density and connected to the motor starter control circuit. Heaters shall be automatically energized when the motor is shut down.
- Ground pads with tapped bolt holes on 2-hole standard centres for motors rated 15 kW and above. Pad locations shall be near the base and shall be shown on manufacturer's motor or assembly outline Drawings.
- Soleplates and hold down bolts, where required.
- Gasketed motor terminal boxes, sized to accommodate external cable and lugs, and suitable for conduit connections. They shall be suitable for rotating in 90º steps.

2.6.14.4.3 Service Factor

All motors shall be sized to permit the driven equipment to develop its specified capacity continuously without exceeding the rated temperature and using no more than 85% of rated motor kW capacity (1.15 Service Factor). The intent of this requirement is that the motor kW capacity be sized above the maximum continuous duty required by the driven equipment.

2.6.14.4.4 Bearings

- Bearings shall be liberal in size, suitable for continuous service under the conditions specified, sealed against the entrance of dirt and the escapement of the lubricant.
- Fitted openings shall be provided on the bearing housing for applying and draining the lubricant. Filler and drain extensions shall be furnished where necessary to give ready accessibility.
- Wherever necessary, the bearings shall be insulated to prevent the passage of shaft currents through the bearings.
- The thrust bearing for vertical motors shall be of the antifriction type, capable of supporting the weight of the motor and driven equipment rotating parts plus hydraulic thrust due to load. Bearings shall be grease lubricated with provisions for greasing. Provisions shall be made to prevent over-greasing where excess lubrication may cause damage.

2.6.14.4.5 Starting

- Except where specifically indicated otherwise, motors shall be suitable for full-voltage, across-the-line starting.
- Motors shall accelerate the driven equipment to rated speed with 80% of the motor nameplate voltage applied at the terminals. Unless otherwise approved, the maximum starting current shall not exceed 6 times the rated full-load current.
- Motors shall withstand without adverse effects, a full voltage, dead-bus transfer from one source to another. The minimum "dead time" for this transfer shall be considered to be 1 second.
- Where repetitive starting is necessary, the permissible number of starts shall be clearly indicated on the nameplate.

2.6.14.4.6 Finish

Motors for use indoors shall have the manufacturer's standard finish unless otherwise specified. Motors for outdoor use shall have corrosion-resisting hardware and corrosion-resisting finish on the rotor and shaft.

2.6.14.5 Cabling Installation Practice

2.6.14.5.1 General

All cables shall be run parallel to walls and either truly vertical or horizontal as appropriate. Agree all exposed cable routes with the Project Manager prior to commencing work. All holes through structural members shall be approved by the Project Manager before drilling commences.

Ensure that all cables are supported to avoid undue strain on cables or on terminations. All cabling shall be neatly dressed, run in single layers and identified as to function at terminating points. All cabling shall be installed in a manner which permits its convenient withdrawal and replacement. No cable shall be cast directly into concrete.

Sharp edges to steel or sheet metal shall be removed and such work shall be arranged to avoid accidental injury to personnel, or damage to insulation. Provide insulated bushes at all points where cables enter metal enclosures.

2.6.14.5.2 Cable Identification

Each cable shall be labelled with a permanent identification number as indicated on the Contractors cable schedules. All cable cores shall be numbered.

2.6.14.5.3 Underground Cables

All underground cables are to be buried in a trench at a minimum depth of 600mm, bedded on not less than 100mm of fine washed sand and covered by a further 100mm of sand. The cables are to be laid free of kinks and twists and laid in flat formation without interlacing.

The trench shall be backfilled with 150mm of soil, consolidated and a protective layer of 150 x 25 RS ground retention tanalith treated timber, or approved proprietary cable protection covering is to be placed over the full length of the trench.

Cabling is to be completed covered by timber or equal protection.

Lay on Orange PVC signal strip 100mm wide with "Electric cable below" or equal labelling, above cables over fully length of route, at a depth of 250mm. Locations of underground cables are to be accurately marked on the Contract drawings. Where underground cables enter building a warning sign indicating "danger buried cable" is to be fastened to the building 200mm above ground level.

2.6.14.5.4 Cable Ladder

Provide all necessary cable ladder to support cables. All cable ladder width shall be sufficient for the work plus 30% spare capacity.

Cable ladder shall be manufactured from aluminium and shall be of NEMA 12A type.

Cable ladder shall be stood off the wall on galvanised spacers or brackets or suspended from the ceiling using a proprietary cable ladder hanger system. Maximum spacing of supports, brackets and hangers shall be 2 meter. Cable ladder shall be capable of supporting 12.5 kg/m per 100mm, i.e. a 600mm wide cable ladder must be capable of supporting 75 kg/m.

All runs of ladders shall be continuously bonded and earthed.

For all HV cabling, proprietary cable clamps must be used.

Ladders shall not be mounted directly onto flat surfaces. Install on suitable brackets clear of the surface to allow for cleaning and sufficient space for air circulation around and through the ladders.

2.6.14.5.5 Cable Installation Practice (HV Cables)

Single core cables shall be laid in trefoil formation using approved trefoil clamps at intervals of no more than 1m. All cables shall be pulled, supported and terminated in accordance with manufacturer's instructions.

All copper wire screens and steel wire armour shall be bonded and earthed at both ends.

Joints in cable runs shall not be permitted.

All exposed cables shall be run parallel to walls and either truly vertical or horizontal as appropriate.

Cables to transformers may be supported as necessary using galvanised saddles fixed to the equipment frame but on no account shall penetrations be made in tanks containing oil.

At termination boxes cables shall be glanded. All terminations shall use compression terminals.

The Contractor shall ensure that:

a. All cables shall be glanded using stainless steel glands incorporating a waterproofing seal. All terminations shall use pressure crimp lugs, compressed using the correct tool.

b. Glanding and termination of cable is carried out strictly in accordance with manufacturer's instructions.

c. All bolts used in termination shall be stainless steel fitted with plain washer and two nuts. The torque of all bolted connections for cables over 70mm2 shall be recorded.

d. PVC shrouds are fitted to outdoor cables and/or that any future creepage will not leave armouring exposed.

e. Two locknuts are fitted to each gland and that each gland is fitted to a gland plate or bracket.

f. Bushes are fitted on each gland.

g. Cable glands and cable sheaths are effectively connected to the earthing system. Earth connections must have a cross section not less than 50% of the cross section of a core of the associated cable.

h. Under no circumstances shall copper and aluminium conductors be directly connected.

2.6.14.5.6 Cabling Installation Practice (LV Cables)

All exposed cables shall be run parallel to walls and either truly vertical or horizontal as appropriate. Cables shall be run on either cable ladder or floor ducts as appropriate.

Cables shall be sized to achieve a voltage drop of less than 2.5% of the nominal voltage between the distribution board and fitting. The maximum voltage drop from the station services transformers to the final sub circuit shall be no more than 5%.

Ensure that all cables are supported to avoid undue strain on cables or on terminations. All cabling shall be neatly dressed, run in single layers and identified as to function at terminating points. All cabling shall be installed in a manner which permits its convenient withdrawal and replacement. No cable shall be cast directly into concrete. In such areas install cables in conduit or ducting. Draw wires shall be installed in conduits or pipes where necessary for later cable installation.

Sharp edges to steel or sheet metal shall be removed and such work shall be arranged to avoid accidental injury to personnel, or damage to insulation. Provide insulated bushes at all points where cables enter metal enclosures.

After installation but before connection, all power cables shall be tested for insulation resistance.
Cabling shall be cleated at centres not exceeding:-

: 450 mm horizontally
: 900 mm vertically

On no account shall plastic sheathed cables be run in any situation where timbers have been treated or likely to be treated with tar-oil, creosote or allied products.

No ordinary grade PVC insulated cables shall be run in any location where the temperature is likely to exceed 45^{o}C. No high temperature grade PVC shall be run in locations where the temperature is likely to exceed 75^{o}C. Mineral insulated cable shall be used where the temperature may exceed 75°C.

Wiring which supplies equipment liable to overheat and cause rapid deterioration of the wiring, shall have the tails made off with heat resisting sleeves to protect the permanent wiring in a conduit box. The conduit box shall be fitted with terminals and mounted adjacent to the fitting or equipment with a run of heat resistant cabling from the box.

2.6.14.5.7 Cable Installation Practice (Instrumentation Cables)

The following installation practice shall be used:

- Cable shields shall be electrically continuous. When two lengths of shielded cable are connected together at a terminal block, an insulated point on the terminal block shall be used for connecting the shields.
- Shields shall be isolated and insulated except at their selected grounding point to prevent stray and multiple grounds to the shield.
- At the point of termination, the shield shall not be stripped back any further than necessary from the terminal block.
- For signal circuits, the shield must not be part of the signal circuit.
- Signal circuits shall be grounded at only one point.
- Digital signal circuits shall be grounded only at the power supply.
- Analogue signal circuits shall be grounded only at the control panel and on a clean earth.
- Analogue signal cables shall be physically segregated from all power and control cables and from unshielded cables carrying digital or pulse type signals.

- All signal circuits to outdoor equipment shall be fitted with transient filters for protection against lightning.

2.6.14.6 **Cabling**

2.6.14.6.1 240/415VCables

Cables shall be a minimum of 600/1,000 volt rating for 415 volt line voltage use.
All low voltage power cables are to have copper conductors and are to be run in accordance with NZS 3000 : 2007. Cables shall comply with the following standards:-

PVC insulated	:	NZS 6401
	:	AS/NZS 4961
	:	AS/NZS 5000.1
XLPE insulated	:	AS/NZS 5000.1
	:	AS/NZS 4026
	:	AS/NZS 4961
Neutral Screened	:	AS/NZS 3155

All cables shall be installed in accordance with AS/NZS 3000 and shall be rated in accordance with AS/NZS 3008.1.2.

All power cables shall have stranded copper conductors.

2.6.14.6.2 Instrumentation Cabling

Type.	Twisted pairs or triads (RTD's) with an overall shield.
Conductor	Stranded, tinned copper, 0.5 mm2 or larger.
Insulation Type	PVC
Rated Voltage (not less than)	150-V DC
Continuous operating temperature	105°C (dry)

The insulated conductors shall have an overall aluminium foil shield bonded to a mylar or polyester film with a stranded, tinned copper, continuous drain wire outside of the shield.
Each pair/triple shall be marked with indelible numbering.
Analogue signals shall be run in separate cables from digital signals.

2.6.14.6.3 Control Cabling

Type	Unarmoured, circular, multicore with an integral earth conductor.
Conductor	Stranded, copper, 1.5 mm2 or larger.
Insulation Type	PVC
Rated Voltage (not less than)	1000-V AC
Continuous operating temperature	90°C

Each core shall be marked with indelible numbering.

All cores in one cable shall operate at the same voltage.

2.6.14.7 **Earthing and Equipotential Bonding**

Effective protective earthing and equipotential bonding shall be provided, in accordance with AS/NZS 3000, for all electrical equipment installed under this contract. The Contractor must ensure all metal work encasing electrical work is bonded to earth. This shall include bonding all trays, ladders, trunking and electrical equipment.

2.6.14.8 **Panel and Switchboard Construction**

2.6.14.8.1 General

Panels and switchboards shall comply with AS/NZS 3439.1:2002: Low-voltage switchgear and controlgear assemblies - Type-tested and partially type-tested assemblies.

2.6.14.8.2 Metalwork

All enclosures used to house electrical equipment shall be gasketed, vermin proof and protected to the class specified in accordance with IEC 60947-1. If not stated, the minimum class shall be IP42. The maximum height above floor level of all instruments, control switches and relays shall allow for easy operation of the Plant and shall not exceed 1.80 m.

Enclosures shall consist of rigid, self-supporting, steel panels with a minimum thickness of 1.5 mm steel that have full-length, hinged and gasketed doors, located to provide easy access to the equipment. A tamper-proof lock shall be provided on each door of the enclosure. Interior panels shall be provided inside the enclosures for mounting items of electrical equipment.

All panels shall be located on a 75mm high plinth made of steel or concrete, as applicable to the general construction.

Mild steel panels are not permitted. All panels shall with use grade 316 stainless steel or galvanized steel construction. Steel shall be passivated, powder coated finished with baked enamel paint. Any outdoor panels, or panels in a damp area shall be grade 316 stainless steel.

Full height doors shall be provided with door stays to prevent swinging when open. All panel doors shall be hinged and shall be provided with T'bar locks. At least one T'bar on each compartment shall be key lockable. The same key pattern shall be used for every lock on the whole assembly and a set of keys (minimum of 10) shall be provided with the assembly.

All fastenings shall be integral with the panel or door and provision made for locking. Doors shall be rigid and fitted with weatherproof sealing material suitable for the climatic conditions specified. No door shall be wider than 1200mm without the permission of the Project Manager. Panel positions in general and door sizes and positions when open, shall not impinge on the safety and operability requirements of these clauses.
Outdoor panels shall be well ventilated through vermin-proof louvres comprising a filter screen attached to a frame and secured to the inside of the panel. Divisions between compartments within the panel shall be perforated to assist air circulation. If required, ventilation fans shall be used.

2.6.14.8.3 Terminals

All terminals shall be mounted in accessible positions. Adjacent terminals shall be adequately spaced to each other and to the incoming cable gland plate. Separate terminations shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores.

All terminals having a circuit voltage of 240V or higher shall be separated from lower voltages by a space created with partitions or end plates combined with end brackets and shall be shielded with an insulated cover marked with a warning notice "Danger ..... Volts". Where necessary, the different 240V / 415V phases shall be shielded from each other with partitions (i.e. where the in-service or under-maintenance breaking of a phase-wire can result in a phase to phase short circuit due to the type of terminal used). Terminal blocks shall not be located less than 200mm from cable gland plates.

Only one conductor shall be terminated in each side of the terminal block.

Shorting straps shall be used between terminal blocks to bridge identical conductor terminals.
Cubicles shall have at least 10% spare terminals and enough extra space on mounting bars for another 20% terminals.

2.6.14.8.4 Neutral & Earth Bars

These shall be a generous size to enable convenient termination of all neutral and earth conductors. Neutral and earth bars shall be provided with purpose made terminations sufficient for all connections with 25% spare. The bars shall be brass, tunnel type with slotted grub screw termination fixing and shall be rated at not less than the full current carrying capacity of the main supply. Terminations are to be provided for incoming neutral and earth cables of sizes shown on the drawings or as required by AS/NZS 3000.

Busbars and connected circuits shall be capable of carrying continuously a total load equal to the rated capacity of the incoming switch isolator without the temperature rise of any component mounted with or on a board exceeding 20°C.

The earth and neutral bar shall be located well clear of incoming cables and other connections.

2.6.14.8.5 Busbars& Connections

Busbars and connections thereto shall be fully insulated and shall comply with AS/NZS 3439.2. Busbars shall be capable of carrying the continuous rated current with a maximum temperature rise of 30°C above an ambient temperature of 40°C.

Clearances are to be maintained when a current equal to the specified short circuit rating is flowing in the busbars and connections and shall be capable of withstanding the specified test voltages. Busbars shall be rated at not less than the maximum current rating as indicated on the drawings and braced to withstand fault levels, which can be safely cleared by the section isolators.

2.6.14.8.6 Moulded Case Circuit Breakers (MCCBs)

Moulded case circuit breakers shall comply with IEC 60947-2.

The service breaking capacity (Ics) shall be 100% of the ultimate breaking capacity (Icu). The rated ultimate breaking capacity (Icu) of each moulded-case circuit breaker shall be equal to at least the value of the short-circuit current (Isc) at the point of installation on the electric circuit, unless the upstream circuit breaker makes it possible to ensure coordination as defined in Appendix A of IEC 60947-2.

MCCBs shall be of circuit breaker disconnector type and shall have a rated operational voltage of 690V AC (50/60Hz).

The rated insulation voltage of the circuit breakers shall be 750V AC (50/60Hz).
The MCCBs shall provide class II insulation (to IEC 664) between the front and internal power circuits.

The operating mechanism shall be of the quick make quick break type, with the speed of operation independent of the operator, and shall be trip free.

The breakers shall be operated by a toggle or a handle as specified which shall clearly indicate the three fundamental positions ON, and OFF and TRIPPED. If required, rotary handles shall be fitted to the breaker.

The operating mechanism shall be designed in such a way that the position of the operating handle of the circuit breaker indicates the real position of the main contacts (i.e. positive contact indication), even if the circuit breaker is equipped with a rotary handle.

Isolation shall be provided by a double break on the main circuit.

It shall be possible to lock the circuit breaker in the isolated position only with the use of a locking device and padlocks.

MCCBs shall have clearly accessible from the front face:

- Markings of rating
- Marked as suitable for isolation
- Push-to-trip test button to test operation of poles
- Contact position indicator

The MCCB shall provide double insulation of the front face to allow on-site installation of auxiliaries without de-energising the installation or circuit. All electrical auxiliaries and accessories including voltage releases (shunt or under-voltage) and auxiliary contacts shall be designed for easy on-site installation. All electrical auxiliaries shall be equipped with terminal blocks and shall be of the snap-in type. All electrical auxiliaries shall be separated from power circuits and their addition shall not increase the MCCB volume.

2.6.14.8.7 Fuses

Fuses shall be high rupturing capacity and type gG as defined in IEC 60269-1, IEC 60269-2-1 and have minimum breaking capacities equal to 80kA or greater. Fuses to be used for motor protection may be type aM.

In any case fuses shall have a minimum interrupting volt-ampere capacity at least equal to the fault rating at the switchboard specified herein.
Fuse ratings and the phase to which they are connected are to be legibly marked on holder and base.
Provide (6) spare fuse links of each size and type used on the switchboard and locate in a purpose made compartment. Provide all spare fuse bases as indicated.

2.6.14.8.8 Miniature Circuit Breakers (MCBs)

Miniature circuit breakers (MCBs) shall comply fully with AS/NZS 60898.1. They shall be removable from the in-service position without removing adjacent circuit breakers and shall be of the trip-free type. The range available shall include breakers with B, C, D and MA tripping curves and shall be available in 6kA, 10kA and 15kA fault ratings. The breaker combinations of MCCB followed by MCB and further downstream MCBs shall provide full discrimination right through the circuit breaker installation.
MCBs shall have a fault rating of not less than the fault level of the distribution system at the point of connection in the switchboard but not less than 10KA. The use of cascading is permitted to provide an increase in a breaker's fault rating.

MCBs shall be capable of being padlocked open using suitable attachments.
A minimum of 25% spare ways shall be provided to allow for the future MCBs.

2.6.14.8.9 Discrimination Function

Discrimination shall be provided to comply with IEC 60947-2 and shall be total discrimination. This means that for faults from overloads up to the full prospective short circuit level of the system, only the circuit breaker immediately upstream of the fault shall operate to clear the fault and all other circuit breakers shall remain closed.

The Contractor shall provide computer-generated calculations in the form of an easily read report that proves discrimination. In the short circuit region, the results shall be based on tests that the protective device manufacturer has carried out that have been incorporated into computer model.

2.6.14.8.10 Motor Starters

Low voltage motor starters shall be of the combination type as defined in IEC 60947 - Part 4 and shall comprise:

- Fused combination unit (disconnector and fuse switch) or moulded case circuit breaker (AC23 minimum utilisation category).
- AC contactor (AC3 minimum utilisation category).

All motor starters associated with a gas engine generator 'unit' shall be located in a single Motor Control Centre dedicated to that unit. The Motor Control Centre may be a separate cubicle within the Unit PLC panel.

The operating mechanism of the isolating device shall be mounted on the front of the cubicle, operated by a pistol grip type handle. The mechanism shall be interlocked with the door to prevent opening when in the on position. The mechanism shall be padlockable in the off position.

The rated operational current of the starter (Ie) shall be not less than the full-load current of the motor. The starter shall be rated for uninterruptible duty.

Thermal overload relays shall be Type 3c as defined in Clause 5.7.2 of IEC 60947-4-1. Time/current characteristics shall be supplied, by the manufacturer, on 28mm x 56mm logarithmic decades. These curves shall have a tolerance not exceeding + 10%.

Co-ordination of short circuit and overload protective devices shall be type 2 fully co-ordinated as defined in Clause 7.2.5 of IEC 60947-4-1 for a prospective short-circuit current not less than the value determined by the electrical system design. For this purpose the short circuit protection device shall be fitted with the maximum rating of motor circuit fuse.

Motor starters shall be suitable for both automatic and non-automatic methods of control.

Unless otherwise specified, motor starter control circuits shall be operated from a 230V AC supply, taken from the incoming supply to each motor starter cell, via a suitably rated MCB. All control and indication

circuits between the motor starter cell and remote equipment (eg Unit PLC panels etc), must use 24V DC and suitably rated interposing relays to interface with the starter 230V AC controls shall be provided in the motor starter cell.

Power factor correction capacitors shall be provided in motor starters to correct the motor power factor to a minimum of 0.93. Separate contactors shall be used to switch the motor circuit and power factor correction equipment.

Where assisted start motor starters are required in order to reduce motor starting currents, electronic soft start units shall be used. Electronic soft start units shall be provided complete with bypass contactor. Assisted start operation shall be automatic changeover with adjustable time delays to suit the motor conditions.

Contactors shall be provided with auxiliary contacts to provide all required control and signalling functions and shall be provided with two additional spare normally open and two spare normally closed contacts. Each starter shall be provided with the following local controls and indications as a minimum:-

- Supply Isolator.
- Running lamp.
- Stopped lamp.
- Fault lamp.
- Run/off/auto selector switch,

Each starter shall have the following interfaces with the Plant control system
- Motor Run - DI.
- Motor Auto - DI.
- Motor Fault - DI.
- Motor Start – DO
- Motor Stop DO

2.6.14.8.11Relays

All relays are to be of best quality with contacts rated for a continuous duty of not less than 10A at 24V DC. They shall be encased in hermetically sealed enclosures and shall be free from discernible noise when energised. Auxiliary contacts are to be self-cleaning.

2.6.14.8.12Isolators

All electrical panels, including motor control centers and distribution boards, must have an isolation switch on the incoming supply to comply with the AS/NZS3000 isolation requirements.

Any panel that is supplied from more than one 240/415V source must have a danger label affixed to the front warning that the panel is supplied from X sources and identifying the location of each of the sources.

All live side terminals of these isolators shall be shrouded to prevent accidental contact.

Isolators shall be rated for the continuous load current and for the maximum fault duty, which may be reached. Isolators shall not be smaller than sizes shown on the drawings.

Isolators shall be capable of being locked in the open or closed position. Isolators shall comply with IEC 60947-3 for AC 23 duty.

2.6.14.8.13Pushbuttons and Pushbutton Switches

Pushbuttons and pushbutton switches shall be heavy-duty, oil-tight, complete with engraved legend plates, operators, and contact blocks. Legend plate engravings shall be selected by the Contractor and will be subject to the Project Manager's approval.

Contact Ratings

- Maximum Design Voltage. 500/300-V AC and 110-V DC.
- Continuous Current. 10-A AC or DC.

- Maximum Interrupting Current, Inductive. 3-A at 240-V AC and 2.2-A at 110-V DC.
- Maximum Making Current, Inductive. 30-A at 240-V AC and 2.2-A at 110-V DC.

2.6.14.8.14 Control and Selector Switches

Control and selector switches shall be heavy-duty, rotary type complying with the requirements of IEC 60947-5-1 for AC 11 duty.

Ratings

Maximum Design Voltage.	500/300-V AC and 240-V DC.
Continuous Current.	10-A AC or DC.
Maximum Interrupting Current, Inductive.	3-A at 240-V AC and 2.2-A at 110-V DC.
Maximum Making Current, Inductive.	30-A at 240-V AC and 2.2-A at 110-V DC.

Each switch shall be provided with an escutcheon plate clearly marked to show each operating position. Escutcheon plate markings shall be selected by the Contractor and will be subject to the Project Manager's approval.

The type and colour of the switch handle shall be selected by the Contractor and will be subject to the Project Manager's approval.

2.6.14.8.15 Test Blocks

Plug type test blocks shall be provided on all protection circuits for testing CT, CT and trip circuits.

2.6.14.8.16 Electrical Digital and Analogue Indicating Instruments

Instruments shall be of the flush mounting type with non-reflecting glass. They shall be calibrated and suitable for the application. Electrical measuring instruments generally shall be 96 x 96 mm but may be 72 x 72 mm if approved by the Project Manager. Analogue instruments shall be of the 270° full-scale deflection type.
Digital instruments shall have the following features:

- Bright orange LED display.
- Minimum 4-digit, 12 mm-high, readout.
- Black bezel with hardware and accessories for front-of-panel mounting.
- 1% accuracy

Indicating instruments shall conform to IEC 60051, class index 1.5.
Scale markings shall be selected by the Contractor and will be subject to the Project Manager's approval. Where instruments are connected to instrument transformer secondaries, the scale markings shall be selected to read the electrical quantities on the transformer primary.

2.6.14.8.17 Transducers and Transmitters

Transducers and transmitters shall be suitable for accurately measuring the specified quantities. Outputs shall be a dc current signal ranging from 4 to 20-mA full scale, suitable for termination in a load resistance up to 750Ω.

Unless specified otherwise, the maximum allowable error shall not exceed ±0.25% of full scale at 25°C, and the error resulting from a temperature variation between -20°C and 60°C shall not exceed ±0.5% of full scale. AC output ripple shall not exceed 1%. The units shall be provided with a 10% full scale calibration adjustment, and the response time shall be 400 ms or better from 0 to 99%. There shall be electrical isolation between input, output, external power supply if used, and the case ground connection. All transducers and transmitters shall have a dielectric test voltage rating conforming to IEC SWC test requirements.

2.6.14.8.18 Indicating Lamps

Lamps shall be light emitting diode (led) type, 22.5mm diameter with press to test facility.
The indicating lamps and resistors shall be rated to operate at 240-V AC or 24-V DC.

2.6.14.8.19 Heaters

Enclosures containing electrical control and switching equipment shall be equipped with electric space heaters for moisture control. The construction of the enclosures and the placement of the heaters shall assure effective circulation of air and prevent damage to equipment by overheating. Heaters shall be

rated 240-V AC, single-phase. They shall be provided with thermostatically operated controls with "on-off" switches mounted inside the enclosure.

2.6.14.8.20 Lighting and Receptacles

Enclosures larger than 1.0 m^2 (vertical, front-of-panel surface area) shall be provided with a light and receptacle inside the enclosure to facilitate operation and maintenance. The light shall be incandescent type, with wire-guard and "on-off" switch. The receptacle shall be a duplex type, 2-pole, 3-wire. Power supply to the light and receptacle will be from a single-phase, 240-V AC, circuit.

2.6.14.8.21 Panel Wiring

All panel wiring shall be carried out in a neat and systematic manner with cable supported clear of the panels and other surfaces at all points to obtain free circulation of air.

All PVC insulated panel wiring shall comply with the requirements of BS 6231 Type BK. Conductors shall generally have a minimum cross section equivalent to 3/0.77mm (1.5mm²), 7/0.67mm (2.5mm²) but single stranded conductors should only be employed for rigid connections which are not subject to movement or vibration during shipment, operation or maintenance.

The Contractor shall propose a panel wire colour system to be used and shall submit to the Project Manager for approval. The colour system adopted must clearly:-

- Use different colours for 230/400V AC phase and neutral conductor.
- Differentiate 24V DC positive and negative conductors.
- Clearly identify RTD and analogue signal conductors.
- Green and Green/Yellow insulation may only be used for earthing conductors.

Wiring to doors shall be anchored at the panel side and sufficient length shall be provided to enable the door to swing fully open without strain on cabling.

All panel wiring shall be number ferruled using slide on cable markers with indelible markings. Wiring systems that rely on terminal number identification only are prohibited.

All outgoing control / controlled field wiring shall be brought out to terminals to facilitate ease of termination. Termination of all wiring at these terminals shall be effected using pre-insulated crimped ferrules or lugs of the correct size to suit cable and terminal capacity. Segregation shall be provided between 400/230V AC, 24V DC signal, 24V control and RTD/analogue terminals.
No wires may be teed or jointed between terminal points.

Bus wiring between adjacent panels, cubicles, etc, shall be terminated in each panel, with cables used for the interconnection. The use of panel wiring between adjacent cubicles not permitted

2.6.14.8.22 Panel Earthing

All metallic cases of instruments, control switches, relays, etc, mounted in panels, steel or otherwise, shall be connected by means of green with yellow stripes PVC insulated copper conductors of not less than 2.5mm² cross section to the nearest earth bar.
All metalwork shall be bonded to the main earth bar. All hinged panels shall be bonded with flexible copper.
All cable sheaths and earthing conductors shall be bonded to the earth bar. Use compression type conductor lugs for all earth connections with bolted joints. Ensure that all connections are tightened. Earth continuity shall not depend upon metal joints. For panel earthing use starred washers between screw and panel.

2.6.14.8.23 Panel Labelling

All panels shall be fitted with an identification/rating plate displaying the following information: site name; rated voltage, phasing, frequency, current, etc; panel/equipment manufacturer; and contract number.

Labels shall consist of white lettering engraved on black traffolyte. Lettering shall be 12 mm high for main panel labels and 5 mm high for circuit descriptive labels. All labels shall be fixed with chromium plated or stainless steel screws.

The requirement for labels includes, but is not limited to, the following:

- All switchboards, panels, boxes, cabinets, cubicles or enclosures.
- Equipment mounted in or on the above items including relays, contactors, starters, sounders, motors, switches, sockets, controllers and luminaires.
-

2.6.14.9 **Quality Control Requirements**

2.6.14.9.1 Factory Tests

Each item of equipment and all similar equipment supplied as spare parts shall be given the manufacturer's routine factory tests to ensure successful operation of all parts of the assemblies. Factory tests shall include all routine tests required by the relevant IEC Standard. Test equipment and test methods (including equipment calibration and certification) shall conform to the applicable requirements of the test standard.

Operational tests shall be performed on all of the equipment or devices insofar as practicable to demonstrate that they function properly. Adjustable devices shall be checked for range of adjustment and given final adjustment, insofar as possible, in the shop.
Insulation resistance and voltage withstand tests in accordance with applicable provisions of the IEC standards shall be undertaken on all electrical circuits including control, instrument and protection circuits.

2.6.14.9.2 Field Tests

The equipment shall be installed, field tested and placed in operation by the Contractor as directed by the manufacturer's supervising erectors and test engineers. All necessary assistance, tools, and facilities required for the supervising erectors and test engineers shall be provided.

Field tests shall include all routine field tests required by the relevant Australian/New Zealand and/or IEC Standards.

Prior to watering the turbines, operational tests shall be performed on all of the equipment or devices insofar as practicable to demonstrate that they function properly. Adjustable devices shall be checked for range of adjustment and final settings applied.

Supplementary Information

- Afolau Gasification Plant Site Layout Plan
- Feedstock Ultimate Analysis

3 Bank Guarantees and Certificates

3.1 Form of Performance Security

..... Bank's Name, and Address of Issuing Branch or Office .....

Beneficiary: *..... Name and Address of Employer .....*

Date: .....

Performance Guarantee No.: .....

We have been informed that . . . . . ***name of the Contractor***. . . . .(hereinafter called "the Contractor") hasentered into Contract No. . . . . ***reference number of the Contract***. . . . .dated . . . . . .with you, for the execution of . . . . . ***name of contract and brief description of Works***. . . . .(hereinafter called "the Contract").

Furthermore, we understand that, according to the conditions of the Contract, a performance guarantee is required.

At the request of the Contractor, we . . . . . name of the Bank. . . . .hereby irrevocably undertake to pay you any sum or sums not exceeding in total an amount of . . . . . name of the currency and amount in figures*. . . . . (. . . . . amount in words. . . . .) such sum being payable in the types and proportions of currencies in which the Contract Price is payable, upon receipt by us of your first demand in writing accompanied by a written statement stating that the Contractor is in breach of its obligation(s) under the Contract, without your needing to prove or to show grounds for your demand or the sum specified therein.

This guarantee shall expire no later than the earlier of:

(a) eighteen months after our receipt of:

(i) a copy ofthe Completion Certificate; or

(ii) a registered letter from the Contractor, attaching a copy of the notice to the project manager that the Facilities are ready for commissioning, and stating that 14 days have elapsed from receipt of such notice (or 7 days have elapsed if the notice was a repeated notice) and the project manager has failed to issue a Completion Certificate or inform the Contractor in writing of any defects or deficiencies; or

(iii) a registered letter from the Contractor stating that no Completion Certificate has been issued but the Employer is making use of the Facilities; or

(b) the ____ day of _____, 2___.

Consequently, any demand for payment under this guarantee must be received by us at this office on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees, ICC Publication No. 458, except that subparagraph (ii) of Sub-article 20(a) is hereby excluded.

. . . . . .

Seal of Bank and Signature(s)

3.2 Form of Advance Payment Security

..... Bank's Name, and Address of Issuing Branch or Office .....

Beneficiary: *..... Name and Address of Employer .....*

Date:.....

Advance Payment Guarantee No.:.....

We have been informed that . . . . . ***name of the Contractor***. . . . .(hereinafter called "the Contractor") hasentered into Contract No. . . . . ***reference number of the Contract***. . . . .dated . . . . . .with you, for the execution of . . . . . ***name of contract and brief description of Works***. . . . .(hereinafter called "the Contract").

Furthermore, we understand that, according to the Conditions of the Contract, an advance payment in the sum. . . . . (***the Guarantor shall insert an amount representing the amount of the advance payment denominated either in the currency(ies) of the advance payment as specified in the Contract, or in a freely convertible currency acceptable to the Employer.)***. . . . . (. . . . . ***amount in words***. . . . .) is to be made against an advance payment guarantee.

At the request of the Contractor, we . . . . . ***name of the Bank***. . . . .hereby irrevocably undertake to pay you any sum or sums not exceeding in total an amount of . . . . . ***name of the currency and amount in figures****. . . . . (. . . . . ***amount in words***. . . . .) upon receipt by us of your first demand in writing accompanied by a written statement stating that the Contractor is in breach of its obligation under the Contract because the Contractor used the advance payment for purposes other than the costs of mobilization in respect of the Works.

It is a condition for any claim and payment under this guarantee to be made that the advance payment referred to above must have been received by the Contractor on its account number . . . . . ***Contractor's account number***. . . . . at . . . . . ***name and address of the Bank***. . . . ..

The maximum amount of this guarantee shall be progressively reduced by the amount of the advance payment repaid by the Contractor as indicated in copies of interim statements or payment certificates which shall be presented to us.This guarantee shall expire, at the latest, upon our receipt of a copy of the interim payment certificate indicating that 80%percent of the Contract Price has been certified for payment, or on the . . . day of . . . . . ***(insert the expected expiration date of the Time for Completion.The Employer should note that in the event of an extension of the time for completion of the Contract, the Employer would need to request an extension of this guarantee from the Guarantor.Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Employer might consider adding the following text to the form, at the end of the penultimate paragraph:"The Guarantor agrees to a one-time extension of this guarantee for a period not to exceed [six months][one year], in response to the Employer's written request for such extension, such request to be presented to the Guarantor before the expiry of the guarantee")***. , ..., whichever is earlier.Consequently, any demand for payment under this guarantee must be received by us at this office on or before that date..

This guarantee is subject to the Uniform Rules for Demand Guarantees, ICC Publication No. 458.

. . . . . .

Seal of Bank and Signature(s)

3.3 **Form of Completion Certificate**

Contract: [. . . . .***insert name of contract and contract identification details***.. . . .]

Date: .....

Certificate No.: .....

To:[. . . . .***insert name and address of Contractor***.. . . .]

Dear Ladies and/or Gentlemen,

Pursuant to GC Clause 24 (Completion of the Facilities) of the General Conditions of the Contract entered into between yourselves and the Employer dated [. . . . .***insertdate***. . . . .], relating to the [. . . .***brief description of the Facilities*** . . . .], we hereby notify you that the following part(s) of the Facilities was (were) complete on the date specified below, and that, in accordance with the terms of the Contract, the Employer hereby takes over the said part(s) of the Facilities, together with the responsibility for care and custody and the risk of loss thereof on the date mentioned below.

1. Description of the Facilities or part thereof:[. . . .***description*** . . . .]

2. Date of Completion:[. . . .***date*** . . . .]

However, you are required to complete the outstanding items listed in the attachment hereto as soon as practicable.

This letter does not relieve you of your obligation to complete the execution of the Facilities in accordance with the Contract nor of your obligations during the Defect Liability Period.

Very truly yours,

[. . . .***Signature*** . . . .]

Project Manager

3.4 Form of Operational Acceptance Certificate

Contract: [. . . . .***insert name of contract and contract identification details***. . . .]

Date: .....

Certificate No.: .....

To:[. . . . .***insert name and address of Contractor***. . . .]

Pursuant to GC Sub-Clause 25.3 (Operational Acceptance) of the General Conditions of the Contract entered into between yourselves and the Employer dated [***date***], relating to the [***brief description of the Facilities***], we hereby notify you that the Functional Guarantees of the following part(s) of the Facilities were satisfactorily attained on the date specified below.

1. Description of the Facilities or part thereof:[***description***]

2. Date of Operational Acceptance:[***date***]

This letter does not relieve you of your obligation to complete the execution of the Facilities in accordance with the Contract nor of your obligations during the Defect Liability Period.

Very truly yours,

[. . . .***Signature*** . . . .]

Project Manager

4 Change Orders

4.1 Change Order Procedure

4.1.1 General

This section provides samples of procedures and forms for implementing changes in the Facilities during the performance of the Contract in accordance with GC Clause 39 (Change in the Facilities) of the General Conditions.

4.1.2 Change Order Log

The Contractor shall keep an up-to-date Change Order Log to show the current status of Requests for Change and Changes authorized or pending, as Annex 8. Entries of the Changes in the Change Order Log shall be made to ensure that the log is up-to-date.The Contractor shall attach a copy of the current Change Order Log in the monthly progress report to be submitted to the Employer.

4.1.3 References for Changes

(1) Request for Change as referred to in GC Clause 39 shall be serially numbered CR-X-nnn.

(2) Estimate for Change Proposal as referred to in GC Clause 39 shall be serially numbered CN-X-nnn.

(3) Acceptance of Estimate as referred to in GC Clause 39 shall be serially numbered CA-X-nnn.

(4) Change Proposal as referred to in GC Clause 39 shall be serially numbered CP-X-nnn.

(5) Change Order as referred to in GC Clause 39 shall be serially numbered CO-X-nnn.

Note:

(a) Requests for Change issued from the Employer's Home Office and the Site representatives of the Employer shall have the following respective references:

Home Office	CR-H-nnn
Site	CR-S-nnn

(b) The above number "nnn" is the same for Request for Change, Estimate for Change Proposal, Acceptance of Estimate, Change Proposal and Change Order.

4.2 Change Order Forms

4.2.1 Request for Change Proposal Form

[*Employer's Letterhead*]

To:[*Contractor's name and address*] Date:

Attention:[*Name and title*]

Contract Name:[*Contract name*]
Contract Number:[*Contract number*]

Dear Ladies and/or Gentlemen:

With reference to the captioned Contract, you are requested to prepare and submit a Change Proposal for the Change noted below in accordance with the following instructions within [*number*] days of the date of this letter[or on or before (*date*)].

1. Title of Change:[*Title*]
2. Change Request No./Rev.:[*Number*]
3. Originator of Change:
   Employer:[Name]
   Contractor (by Application for Change Proposal No. [Number Refer to Annex 6.2.7]
4. Brief Description of Change:[*Description*]
5. Facilities and/or Item No. of equipment related to the requested Change:[*Description*]
6. Reference drawings and/or technical documents for the request of Change:
   Drawing No./Document No. Description
7. Detailed conditions or special requirements on the requested Change:[*Description*]
8. General Terms and Conditions:
   (a) Please submit your estimate to us showing what effect the requested Change will have on the Contract Price.
   (b) Your estimate shall include your claim for the additional time, if any, for completion of the requested Change.
   (c) If you have any critical opinion regarding the adoption of the requested Change in connection with the conformability to the other provisions of the Contract or the safety of the F or Facilities, please inform us of your opinion in your proposal of revised provisions.
   (d) Any increase or decrease in the work of the Contractor relating to the services of its personnel shall be calculated.
   (e) You shall not proceed with the execution of the work for the requested Change until we have accepted and confirmed the amount and nature in writing.

[*Employer's Name*]
[*Signature*]
[*Name of signatory*]
[*Title of signatory*]

4.2.2 **Estimate for Change Proposal Form**

[*Contractor's Letterhead*]

To:[*Employer'sname and address*] Date:

Attention:[*Name and title*]

Contract Name:[*Contract name*]
Contract Number:[*Contract number*]

Dear Ladies and/or Gentlemen:

With reference to your Request for Change Proposal, we are pleased to notify you of the approximate cost of preparing the below-referenced Change Proposal in accordance with GC Sub-Clause 39.2.1 of the General Conditions.We acknowledge that your agreement to the cost of preparing the Change Proposal, in accordance with GC Sub-Clause 39.2.2, is required before estimating the cost for change work.

1. Title of Change:[*Title*]
2. Change Request No./Rev.:[*Number*]
3. Brief Description of Change:[*Description*]
4. Scheduled Impact of Change:[*Description*]
5. Cost for Preparation of Change Proposal:[*insert costs which shall be in the currencies of the Contract*]

(a)	Engineering		(Amount)
(i)	Engineer	_____hrs x _____ rate/hr =	_____
(ii)	Draftsperson	_____hrs x _____ rate/hr =	_____
	Sub-total	_____hrs	_____
	Total Engineering Cost		_____
(b)	Other Cost		_____
Total Cost (a) + (b)			_____

[*Contractor's Name*]
[*Signature*]
[*Name of signatory*]
[*Title of signatory*]

4.2.3 **Acceptance of Estimate Form**

[***Employer's Letterhead***]

To:[***Contractor's name and address***] Date:

Attention:***[Name and title]***

Contract Name:***[Contract name]***
Contract Number:***[Contract number]***

Dear Ladies and/or Gentlemen:

We hereby accept your Estimate for Change Proposal and agree that you should proceed with the preparation of the Change Proposal.

1. Title of Change:[***Title***]
2. Change Request No./Rev.:[***Request number/revision***]
3. Estimate for Change Proposal No./Rev.:[***Proposal number/revision***]
4. Acceptance of Estimate No./Rev.:[***Estimate number/revision***]
5. Brief Description of Change:[***Description***]
6. Other Terms and Conditions:In the event that we decide not to order the Change accepted, you shall be entitled to compensation for the cost of preparation of Change Proposal described in your Estimate for Change Proposal mentioned in para. 3 above in accordance with GC Clause 39 of the General Conditions.

[***Employer's Name***]
[***Signature***]
[***Name of signatory***]
[***Title of signatory***]

4.2.4 **Change Proposal Form**

[***Contractor's Letterhead***]

To:[***Employer'sname and address***] Date:

Attention:[***Name and title***]

Contract Name:[***Contract name***]
Contract Number:[***Contract number***]

Dear Ladies and/or Gentlemen:

In response to your Request for Change Proposal No. [Number], we hereby submit our proposal as follows:

1. Title of Change:[***Name***]
2. Change Proposal No./Rev.:[***Proposal number/revision***]
3. Originator of Change: Employer:[***Name***] / Contractor:[***Name***]
4. Brief Description of Change:[***Description***]
5. Reasons for Change:[***Reason***]
6. Facilities and/or Item No. of Equipment related to the requested Change:[***Facilities***]
7. Reference drawings and/or technical documents for the requested Change: [***Drawing/Document No./Description***]
8. Estimate of increase/decrease to the Contract Price resulting from Change Proposal:

	Amount [***insertamounts in the currencies of the Contrac***t]
(a) Direct material	_____
(b) Major construction equipment	_____
(c) Direct field labor (Total hrs)	_____
(d) Subcontracts	_____
(e) Indirect material and labor	_____
(f) Site supervision	_____
(g) Head office technical staff salaries	
Process engineer _____hrs @ _____ rate/hr	_____
Project engineer _____hrs @_____ rate/hr	_____
Equipment engineer _____hrs @ _____ rate/hr	_____
Procurement _____hrs @ _____rate/hr	_____
Draftsperson _____hrs @ _____rate/hr	_____
Total _____hrs	
(h) Extraordinary costs (computer, travel, etc.)	_____
(i) Fee for general administration, % of Items	_____

(j) Taxes and customs duties _____

Total lump sum cost of Change Proposal [***Sum of items (a) to (j)***]

Cost to prepare Estimate for Change Proposal [***Amount payable if Change is not accepted***]

9. Additional time for Completion required due to Change Proposal
10. Effect on the Functional Guarantees
11. Effect on the other terms and conditions of the Contract
12. Validity of this Proposal:within [Number] days after receipt of this Proposal by the Employer
13. Other terms and conditions of this Change Proposal:

(a) You are requested to notify us of your acceptance, comments or rejection of this detailed Change Proposal within [Number] days from your receipt of this Proposal.

(b) The amount of any increase and/or decrease shall be taken into account in the adjustment of the Contract Price.

(c) Contractor's cost for preparation of this Change Proposal:[. . . .***insert amount. This cost shall be reimbursed by the Employer in case of Employer's withdrawal or rejection of this Change Proposal without default of the Contractor in accordance with GC Clause 39 of the General Conditions*** . . . .]

[***Contractor's Name***]
[***Signature***]
[***Name of signatory***]
[***Title of signatory***]

4.2.5 **Change Order Form**

[*Employer's Letterhead*]

To:*[Contractor's name and address]* Date:

Attention:*[Name and title]*

Contract Name:*[Contract name]*
Contract Number:*[Contract number]*

Dear Ladies and/or Gentlemen:

We approve the Change Order for the work specified in the Change Proposal (No. [*number*]), and agree to adjust the Contract Price, Time for Completion and/or other conditions of the Contract in accordance with GC Clause 39 of the General Conditions.

1. Title of Change:[*Name*]
2. Change Request No./Rev.:[*Request number/revision*]
3. Change Order No./Rev.:[*Order number/revision*]
4. Originator of Change: Employer:[*Name*] / Contractor:[*Name*]
5. Authorized Price:
   Ref. No.:[*Number*] Date:[*Date*]
   Foreign currency portion [*Amount*]plus Local currency portion [*Amount*]
6. Adjustment of Time for Completion
   None Increase [*Number*] days Decrease [*Number*] days
7. Other effects, if any

Authorized by:_____ Date:_____
Employer

Accepted by:_____ Date:_____
Contractor

4.2.6 **Pending Agreement Change Order Form**

[*Employer's Letterhead*]

To:*[Contractor's name and address]* Date:

Attention:*[Name and title]*

Contract Name:*[Contract name]*
Contract Number:*[Contract number]*

Dear Ladies and/or Gentlemen:

We instruct you to carry out the work in the Change Order detailed below in accordance with GC Clause 39 of the General Conditions.

1. Title of Change:[*Name*]
2. Employer's Request for Change Proposal No./Rev.:[*number/revision*] dated:[*date*]
3. Contractor's Change Proposal No./Rev.:[*number/revision*] dated:[*date*]
4. Brief Description of Change:[*Description*]
5. Facilities and/or Item No. of equipment related to the requested Change:[*Facilities*]
6. Reference Drawings and/or technical documents for the requested Change:
   [*Drawing/Document No. / Description*]
7. Adjustment of Time for Completion:
8. Other change in the Contract terms:
9. Other terms and conditions:

[*Employer's Name*]
[*Signature*]
[*Name of signatory*]
[*Title of signatory*]

4.2.7 **Application for Change Proposal Form**

[***Contractor's Letterhead***]

To:[***Employer'sname and address***] Date:

Attention:[***Name and title***]

Contract Name:[***Contract name***]
Contract Number:[***Contract number***]

Dear Ladies and/or Gentlemen:

We hereby propose that the below-mentioned work be treated as a Change in the Facilities.

1. Title of Change:[***Name***]
2. Application for Change Proposal No./Rev.:[***Number/revision***] dated:[***Date***]
3. Brief Description of Change:[***Description***]
4. Reasons for Change:
5. Order of Magnitude Estimation (amount in the currencies of the Contract):[***Amount***]
6. Scheduled Impact of Change:
7. Effect on Functional Guarantees, if any:
8. Appendix:

[***Contractor's Name***]
[***Signature***]
[***Name of signatory***]
[***Title of signatory***]