

**OMAN WASTEWATER
SERVICES COMPANY S.A.O.C**



**الشركة العمانية
لخدمات الصرف الصحي ش.م.ع.م**

OMAN WASTEWATER SERVICE COMPANY

ELECTRICAL STANDARD SPECIFICATION


SECTION 10

STANDBY GENERATOR

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1-0 SCOPE


This specification covers basic requirements for design, application and testing of a Diesel Driven Emergency Generator Set, including all equipment necessary for an independent self contained source of electrical power for maintaining essential systems in the event of loss of main electrical power supply.

This specification defines the minimum technical requirements for AC Generators to be installed within Oman Wastewater Services Company PROJECTS.

The Supplier will supply the Diesel Driven Emergency Generator as a totally enclosed package unit.

The Scope shall include but not necessarily be limited to the following:

- Skid mounted Diesel Driven Emergency Generator set comprising diesel engine, AC generator, voltage regulator and all necessary auxiliaries
 - Closed Circuit cooling system complete with air/water exchanger(s) and pumps.
 - 24h-Diesel Fuel Storage Drum, level switch, valves and fittings.
 - Lube oil system complete with oil cooler(s), filter(s), and pump(s).
 - Engine Air Intake System, including air filter dry type cartridge not allowing any dust particle > 10 μ and air intake silencer.
 - Engine Exhaust System, including ducting, flexible bellows and silencer, as necessary.
 - Base frame, tank supports and access ladders (if required).
 - Weather-proof/ acoustic enclosure complete with supply ventilation system, Automatic Louvers and Dampers etc., as necessary.
 - Lifting features and spreader beams.
 - Electrical control and synchronization systems with associated equipment.
 - Instrumentation and redundant communication system required for the safe and efficient operation and control of the equipment.
 - Air starting equipment including air pressure bottles, electrical and gas oil compressors.
 - Local control panel.
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- Instrument and electrical cabling within the package complete with support trays and junction boxes.
 - Earthing system within package including external IP23 neutral earthing resistor

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- Electric heaters for winterisation of equipment, and to prevent condensation.
- Surface preparation and painting.
- Tools required for erection, commissioning, operation and maintenance.
- Start-up and commissioning assistance at Site.

1-1 General

The Diesel Driven Emergency Generator Set supplied under this specification shall be designed for a plant life of 30 years minimum.

The Diesel Driven Emergency Generator Set shall be rated for emergency operation and shall be suitable for the specified operating and environmental conditions stated in the Electrical specification – Section 01- Electrical Design Criteria.

The set shall normally be on standby and therefore shall be capable of standing idle for long periods without suffering deterioration or damage. Any periodic running and testing requirements to ensure reliability must be stated by the Supplier.


The Supplier shall provide calculations to prove the voltage depression is within the 10% limit and state any engine/generator overload experienced during the start-up sequence.

The Diesel Driven Emergency Generator package equipment shall be totally enclosed and contained in a weatherproof/ acoustic enclosure rated to IP54 except for air inlet and outlet which shall be IP42.

The enclosure shall be provided with all necessary air intake louvers/dampers and ancillaries.

The enclosure shall conform to Supplier's recommended standard specification suitable for the noise level requirements (95 dBA at 1m and 0 dB tolerance).

The Diesel Driven Emergency Generator set shall be furnished completely assembled on a common skid. The equipment shall be positively located on this skid with the provision of Anti-Vibration mountings between the skid and foundations. These Anti Vibration mountings shall be suitable to fulfil the seismic condition specified by Purchaser.

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The equipment shall be laid out to allow convenient access for operation and normal maintenance.

The package shall be designed for a four (4) point lift. Fully tested and certified lifting lugs shall be attached to the package skid for loading/ offloading and site installation.

1-2 Package Responsibility :

The Supplier shall be responsible for ensuring that the engine and generator and all auxiliaries are correctly aligned prior to delivery.


Supplier shall ensure that the arrangement for connections between the diesel engine, generator and all auxiliaries is satisfactory and shall ensure that there are no adverse torsional oscillations under all operating conditions.

2-0 DIESEL ENGINE

The engine shall be capable to reach the rated speed within 10 seconds after cranking has been initiated.

The diesel engine shall be pressure lubricated and supplied with a lube oil filtration system.

A closed water cooling system complete with water circulating pump, water/air heat exchanger, and thermostatic control shall be provided. The engine jacket water circulation pump shall be driven by the diesel engine.

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All moving parts shall be guarded in accordance with BS 5304 or equivalent international / national standard. The guards shall be generally steel and sufficiently robust to avoid distortion in normal industrial use.

An insulated exhaust silencer shall be supplied with the engine complete with spark arrestor and weather hood together with all necessary supports.

The engine shall be fitted with a governor which shall be electronic and suitable for control response compatible with the requirements of the automatic voltage regulator.

The engine shall be provided with a duplex type fuel filter and air cleaner. A high differential pressure signal alarm from the fuel filter shall be provided. Supplier shall consider the necessity for suitable automatic fuel filter change over facilities.

Fuel oil storage drum suitable for 24 hours supply for rated normal operation plus all necessary, valves, level switch, and in compliance with Omani industrial safety requirements, shall be provided.

The fuel oil storage drum shall be complete with level gauge, high/low level alarms, vent and drains.


The start sequence shall be six cranking periods and five rest periods each of about 15 seconds. If any start sequence is unsuccessful a visible and audible alarm on the controller shall operate, and the start sequence on that generator shall be stopped.

If considered necessary for the minimum site conditions, Supplier shall provide automatically controlled electric heaters to maintain the required fluidity of the diesel oil in the tank and fuel lines. A high temperature alarm shall be considered by Supplier in his design.

3-0 GENERATOR

3-1 Performance:

Unless specified otherwise, the engine shall have a continuous rated output, which after allowing for alternator losses, shall be sufficient to run all Site loads. The engine shall be capable of running at 10% overload for a period of 1 hour in any 12 hours.

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3-2 Baseframe:

The concrete floor slab surrounding the base frame shall be bunded to a height of 150mm to form a secondary containment system to protect against pollution caused by loss of coolant, loss of lubricating oil, or the rupture of a fuel hose. The capacity of the bund shall be the larger of:

- Coolant capacity of the engine and radiator
- Oil capacity of the engine

In order to provide sufficient storage capacity, it may be necessary to provide a trough with open mesh flooring, around the engine.

A detector shall be provided in the bund, when activated it will cause the Fuel Shut Off valve to close. Alarm contacts shall be wired to the Engine Control Panel for output to telemetry.

Wherever possible, bunds around the base plate, lubrication system and fuel system shall be combined.

3-3 Engine Speed:

Diesel engine shall be fitted with an electronic governor.

3-4 Engine Lubrication System


Bulk lubrication oil tanks shall be provided where diesel generator sets run for long periods.

3-5 Engine Cooling System

Low Coolant Level and High Coolant Temperature trips shall instigate engine shutdown, with alarm contacts wired to the Engine Control Panel for output to telemetry.

3-6 Fuel Storage Systems

All tank(s) shall be located within a secondary containment system (bunded). A double skinned tank, on its own, will not be accepted as being a secondary containment system. Outdoor installations shall be suitably skirted to prevent ingress of rainwater. A level switch shall be installed in the bund and be wired to a spillage alarm in the Engine Control Panel. Additional contacts shall be wired to terminals in the Engine Control Panel for output to telemetry.

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3-7 Bulk Storage Tank

Bulk Fuel Tank(s) shall have a capacity sufficient to supply the entire desired generator load for 3 continuous days. These shall, where possible, be located above ground (in buildings, or under cover).

Bulk tank(s) shall be located at a lower level than the Service (Day) tank in order to permit overflows from the Service tank to gravitate back to the Bulk Tank.

Full consideration shall be given to access for fuel delivery vehicles.

3-8 Fuel Transfer Pumps

Fuel transfer pumps shall be fitted with lockable suction and delivery valves and accessible for repair or replacement without removing other plant. Motors shall be 3 phase induction motors.

3-9 Fuel Transfer Pipework

All fuel pipework shall be manufactured from mild steel.


Pipe runs shall have a continual fall to allow any leaks to run back to a secondary containment system. All joints, in both the inner and outer pipework, shall be welded. Where pipework is located within the secondary containment system, screwed connections may be used. All pipework shall be treated, externally, to resist corrosion.

3-10 Fuel Transfer Fire Valve

Two volt free contacts, which close when the fire valve is activated, shall be wired to the Engine Control Panel. One output to telemetry, and the other for output to the works fire alarm system.

3-11 Service/Day Tank

The Service Tank shall have sufficient capacity to run the diesel-generator set continuously, on full load, for 8 hours. The maximum capacity of a combined Service/Bulk tank, when specified in the Particular Specification, shall be no greater than 2000 litres. Where a tank in excess of 2000 litres is required then separate Bulk and Service tanks shall be provided.

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3-12 Air Supply

Where the generator set is rated at/above 250kW then:

- The air inlet to the Engine Room shall be through an attenuated motorised louvre in the external wall. Opening and closing of the louvre shall be fully automatic. The louvre shall open when the engine is called to start, and shall close when the engine stops.
- The air outlet shall be through a gravity operated attenuated louvre. A flexible canvas bellows shall connect the radiator to the outlet louvre.

3-13 Exhaust System

Care shall be taken to prevent the exhaust gases from staining the walls of buildings.

Exhaust lagging or heat shields shall not contain any form of asbestos product.

3-14 Starting System

A battery monitoring system shall be provided to give early indication of a pending failure of the battery system.


Within rooms containing battery systems, adequate ventilation shall be provided to prevent build up of explosive gases

The AC Generator shall be of the salient pole, rotating field, self exciting, self regulating brushless type designed in accordance with IEC standard 60034.1. or equivalent.

The generator shall be suitable for:

- Power factor 0.8 lagging to unity,
- Voltage fluctuation $\pm 2.5\%$ from no load to full load,
- Frequency fluctuation $\pm 1\%$,
- Low resistance earth.

The AC Generator shall be star connected and all six terminals shall be brought out to terminal boxes. It shall be suitable for the specified cable size and type. Terminal boxes shall be sized to accommodate the CT's necessary for differential and other kind of Generator protections.

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The insulation class for rotor, stator and exciter shall be checked to ensure compatibility with the equipment maximum temperature rise and the ambient conditions.

The terminal box shall be sized to accommodate current transformers for differential protection.

4-0 VOLTAGE REGULATOR

The automatic voltage regulating equipment shall provide continuous and practically instantaneous response to correct any change in generator voltage and shall maintain it to within $\pm 1.5\%$ of rated voltage from no load to full load at any power factor between unity and 0.8 lagging.

For any sudden changes in load between no load and rated load, the regulator shall re-establish stable generator conditions within 2 seconds.

At the same time the automatic voltage regulating equipment shall operate under the master synchronization control system.

5-0 CONTROLS, INSTRUMENTATION AND ELECTRICAL SYSTEM


5-1 General

A control system shall be provided for orderly start-up, stable operation and warning of abnormal conditions, Facilities for remote alarm, and indication state.

The local control panel shall be supplied with the package completely wired and tested ready for operation at Site. The control panel shall include as a minimum the following instruments and controls:

Operator Controls:

- § Electronic Voltage Regulator (this may be mounted within an enclosure local to the alternator)
- § Hand/Off/Auto selection switch
- § Local STOP/START push buttons
- § Emergency Stop pushbutton
- § Engine heater switch
- § Voltmeter
- § Ammeter

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Monitoring Instruments:

- § Frequency Meter
- § Generator Voltmeter and selector switch
- § Generator Ammeter and selector switch
- § Engine Hours Run Meter


Remote Monitoring:

The following Remote Monitoring (Telemetry) shall be provided which shall be signalled out individually, or grouped, as detailed below:

- Generator Set on Load
- Output Circuit Breaker Open/Closed
- Mains Circuit Breaker Open/Closed
- Fire Shut Off Valve operated
- Service Tank Bund Filling
- Engine Bund Filling
- Diesel-Generator Fault
- Diesel-Generator Available in Auto
- Service Tank Low level
- Service Tank High level
- Fuel Transfer Pump Fault
- Battery Charger Failed
- Battery Voltage Low
- High Coolant Temperature
- High Coolant Level

Where the generator is to be used as an Embedded Generator then a Generator Reverse Power relay (to prevent motoring) and an analogue Forward and Reverse kW meter shall also be provided.

Where the Bulk Tank(s) are below ground or where indication local to the tank is not possible, then unless specified otherwise, a Bulk Tank Contents Indicator shall be provided on the Engine Control Panel.

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Automatic Mains Failure/Generator Set Changeover Panel:

Changeover Panels shall be housed within an LV Switchboard or within a separate changeover panel which shall not be located within the Engine Room.

5-2 Alarm System

An integrated sensing, alarm, and shutdown system shall be provided for conditions which could result in damage to or shorten the life of the package.

The following Alarms and Indicators shall be provided:

- Low oil pressure shutdown, and indicator
- High Coolant temperature shutdown and indicator
- Low Coolant level shutdown and indicator
- Engine fail to start indicator (3 attempts then lockout)
- Charger Fail/Low Battery Volts indicator
- Under speed shutdown and indicator
- Over speed shutdown and indicator
- Generator under volts shutdown and indicator
- Generator over volts shutdown and indicator
- Set Isolated indicator
- Fire valve operated indicator
- Service Tank Low/Low Fuel level
- Service Tank High/High Fuel level
- Emergency stop operated indicator

- Engine heater indicator
- Fuel Line Failure alarm
- Service Tank, Bulk Tank and Engine bund filling alarms
- Battery charging indicator
- High gas oil level alarm
- Low gas oil level alarm
- Alternator overload alarm.

Where the generator is to be used as an Embedded Generator then a generator under frequency shutdown and indicator and Generator over frequency shutdown and indicator shall also be provided.

Auto/Manual Synchronization panel shall be provided with:

- Synchroscope
- Auto/Manual selector switch
- Synchronization selector switch (A-B-C)
- Synchronization relay
- PLC to control the load demand and synchronization features
- Voltmeter and frequency meter for bus bar and genset
- Synchronizing lamps

5-3 Gauges

Temperature and pressure gauges to monitor important conditions shall be provided within the unit. Engine oil pressure gauge, water temperature gauge and battery charging ammeter shall be included as a minimum.

6-0 STARTING AND OPERATING PHILOSOPHY

A remote switchboard located in purchaser's substation shall receive power supply from the generator and from a separate normal supply source. Condition of normal power supply failure or abnormal voltage drop on the emergency panel will be transmitted to the generator control panel by means of under voltage relays.

The remote switchboard shall be provided with Undervoltage detection relays on its normal incoming supply. In addition, it will have time delay relays which allow an interval to establish a true Undervoltage condition exists before sending the start signal to the emergency generator control panel.

The Engine Control panel shall include all controls for starting/stopping and protection of the diesel-generator set. A selector switch shall be provided to enable the set to be started either manually or automatically.


Upon receipt of the start signal the generator(s) shall automatically start (be synchronized) and ready to accept starting loads within one minute. The start signal will be in the form of normally open volt free contacts which will operate when the generators are required to start.

Starting equipment shall be interlocked to prevent rotation of the unit until conditions are safe for starting.

In addition to the automatic starting, provision shall be made on the generator for manual starting and testing. An automatic/manual test switch shall be provided for this function.

Following items shall be controlled, monitored and/or supervised from the Operator panel:

- **START SEQUENCE**
Setting of sequence for load depend start/stop of generating set
- **START/STOP SETTING**
Setting of set point for start and parallel the next genset, and set point for remove and shut down the last genset.
- **LOAD SHEDDING**
Setting of sequence for load shedding of outgoing feeders.
- **ALARM SUPERVISION**
Each of the alarms is programmable due to requirements for subsequent functions:
 - § Alarm only
 - § Alarm and trip function

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b) Return to normal operation

-Upon return to normal network supply, power gensets will run in parallel with the network for a preset time until stability of the system is reached. Afterwards the power generated by the gensets will be ramped down for a preset time interval ordering to open their circuit breakers.

6-1 Control Philosophy, Additional Information:

1) Generator Set Control Panel (GCP)

In automatic, the diesel-generator shall start, if the mains voltage in any phase falls below an adjustable set value for more than an adjustable set time. Tripping of the Mains, and closing of the Generator ACB's shall be automatic. On restoration of the mains, the diesel-generator shall continue to run and supply the works for an adjustable set time to ensure reliability of the mains. The engine shall then continue to run, unloaded, for an adjustable set time before shutting down.

The engine starting circuit shall be designed for three starting attempts each comprising 10 second cranking followed by a 10 second rest period.

In manual, the starting and stopping of the diesel-generator, the tripping of the Mains and closing of the Generator ACB's shall be carried out manually.

2) Changeover Panel

The Mains Monitoring Relay and Generator Minimum Run Timers shall be located in the LV Switchboard, Change-over panel, or MCC. A Test switch shall be provided to break the signal from the Mains Monitoring relay to simulate Mains Failure.


Change-over from mains supply to generator supply shall be by means of a purpose designed change-over system which shall fully comply with all requirements of the Power Supply Company.

3) Additional Requirements for Embedded Generation

Power Supply Company must be advised that an embedded generator is to be installed, and all relevant details of the proposed generator must be submitted.

Embedded generators shall be designed to operate in parallel with the mains for short periods (typically 5 minutes).

Where generators are specified to run in parallel with the mains for testing purposes only, such tests shall be limited to 5 minutes per month, and shall be provided with protection as agreed with the Power Supply Company's.

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A timer shall be provided to prevent running in parallel with the mains for longer than 5 minutes.

All Embedded Generators must be provided with protection to prevent back feeding of faults on the supply system. The protection provided, must fully comply with the Network Operating Company's requirements. Inter-tripping shall be provided when requested by the Power Supply Company's.


Generator sets shall start up, synchronise with the mains, and run on load, when a signal is received from either a PLC or from telemetry. The load on the generator shall be progressively increased. When the load on the mains falls to a suitable value, the Main ACB shall open and the generator shall operate independently of the mains. At the end of the running period the generator shall re-synchronise with the mains, and the generator load progressively reduced. When the load on the generator falls to a suitable value, the Generator ACB shall open. The generator shall shutdown after a time delay. A "Test" switch shall be provided on the LV Switchboard or the Change-over panel. This switch shall be connected in parallel with the signal from the PLC or telemetry. When the switch is closed the generator set shall start up and run independently of the mains, as detailed above. When this switch is opened the load shall be returned to the mains and the generator set shall shutdown, unless the PLC or telemetry has called the set to run in the meantime.

When "Parallel" running is permitted by the Power Supply Company, the generator-set shall (provided that the PLC, telemetry or Test switch initiate running) synchronise with the mains, progressively take up load and operate in parallel with the mains taking a percentage of the Site load, typically 90%. A load sharing controller operating in conjunction with the engine governor shall adjust the engine output to ensure that the set percentage of load is maintained, and that Site loads in excess of the capacity of the engine are taken by the mains. The load sharing controller shall prevent the generator exporting power into the mains when large Site loads are switched off.

Synchronisation shall be fully automatic.

Sets intended for operating in parallel with the Mains shall comply with the Power Supply Company's requirements.

Unless specified otherwise, Reverse Power protection shall be provided. Reverse Mains Power Protection shall be provided to prevent returning power into the mains. The Reverse Power Relay shall trip the generator ACB, provided that the Mains ACB is closed, and shall be compatible with and shall discriminate with the protection fitted. Generator Reverse

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Power Protection shall be provided to prevent the generator from motoring. The mains Reverse Power relay shall trip the generator ACB, provided that the Mains ACB is closed.

Where the generator has sufficient capacity to supply the full Site under normal operating conditions, the Under and Over Voltage, Under and Over Frequency, and Rate of Change of Frequency (or inter-tripping,) protection shall trip the Mains ACB provided that the Generator ACB is closed. Where the generator has insufficient capacity to supply the full Site under normal operating conditions, the above protection shall trip the Generator ACB provided that the Mains ACB is closed.

Where embedded generators are expected to run for long periods in order to reduce energy costs, this shall, wherever possible, be achieved via Island Mode (i.e. Stand Alone) operation of the generator/site.

7-0 NOISE

Supplier shall comply with the maximum permissible noise levels specified in the Specification (95 dBA).


8-0 PAINING

Diesel Driven Emergency Generator shall be delivered after surface preparation, priming and painting at the Supplier's works in accordance with manufacturer standards, while Enclosure and accessories in accordance with Project Paint Specification.

9-0 INSPECTION AND TESTING

The Supplier shall have an established routine quality control program which shall be available for Purchaser review if required.

The equipment, sub items and systems shall be inspected and tested by the Supplier prior to delivery in accordance with the applicable specifications, standards and codes.

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Works Tests:

The Supplier shall perform as a minimum, the following workshop tests prior to delivery:

- Performance testing of the diesel engine to BS 5514 Part 2 or to approved diesel engine Supplier Standard.

Tests shall comprise, but not be limited to, the following:

- Cold start tests
- Load tests carried out at full load for a period of 1 hour for Gensets up to 100 kW, 2 hours for Gensets above 100 kW but not exceeding 750 kW, and 4 hours for Gensets above 750 kW
- Overload tests at 110 % full load immediately following the full load test
- Specific fuel consumption tests at full load and at 110 % full load
- Voltage and speed/frequency regulation tests
- 4 hour performance and functional string test(s) of emergency generator package complete with contract control panel.


The following data shall be recorded during the works tests:

- Load (kW)
- Voltage
- Current
- Power Factor
- Frequency
- Lubricating Oil Pressure
- Lubricating Oil Temperature
- Cooling Water Temperature
- Ambient Temperature
- Alternator Air inlet and outlet temperature

Site Tests

Tests shall be carried out on Site to prove that the set can perform, under Site conditions, in accordance with the specification.

- Full load tests shall be carried out with a load bank.
- Additional load tests shall be carried out with the specified loads connected.

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- Tests shall be carried out to prove the load acceptance of the set, and to prove its ability to start the specified motors, with the set pre-loaded.
- Tests shall be carried out to prove the protection, and to prove discrimination with the protection fitted to the Power Supply Company switchgear.

10-0 ASSEMBLY AND INSTALLATION ON SITE

The Supplier shall provide all materials needed for site installation and any special tools or equipment needed for assembly, operation and for normal maintenance.

11-0 GUARANTEES

The Supplier shall guarantee that each equipment item supplied shall achieve its individual performance criteria as specified in this specification.


12-0 RATING PLATE

12-1 In addition to the requirements stated in the standards specification, the following shall be given on the rating plate

- § Purchase order number,
- § Equipment number,
- § Connection diagram with terminal markings.

12-2 Terminal Markings:

Permanent terminal markings are to be mounted on Engine and Generator.

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13-0 FINISH

- 8.1 The Vendor shall submit his proposed painting specification for review and approval.
- 8.2 The paint specification shall be suitable for the environment in which Genstes are to be located. The finish colour shall be the manufacturer's standard.
- 8.3 The finish shall be suitable for the service conditions stated in section 3.0.

14-0 SPECIAL TOOLS

A complete set of any special tools required for operation, commissioning and maintenance.

15-0 SPARES


The Vendor shall provide a list of recommended commissioning and operating spares.

16-0 SHIPPING, HANDLING AND STORAGE

Preparation for shipment shall protect the Gensets and auxiliary devices, against corrosion, high humidity, dampness, breakage or vibration injury during transportation and handling.

17-0 DRAWINGS AND DATA

The Vendor shall provide drawings and data in accordance with international standards.

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18-0 DEVIATIONS

Deviations from this specification are only acceptable where the vendor has listed in his quotation the requirements he cannot or does not wish to comply with and the purchaser has accepted, in writing.

In the absence of a list of deviations it will be assumed by the purchaser that the vendor complies fully with this specification.

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