MATERIAL AND EQUIPMENT STANDARD

FOR

RECIPROCATING INTERNAL COMBUSTION ENGINES

CONTENTS :

PAGE No.

APPENDICES:

1. SCOPE

1.1 This Standard specification covers the minimum requirements for reciprocating internal combustion engines for mechanical drives and electric power generator drives.

It is intended for use in oil refineries, chemical, gas and petrochemical plants and where applicable in production, exploration and new ventures.

1.2 Compliance by the engine Vendor with the, provisions of this Standard specification does not relieve him of the responsibility of furnishing properly designed equipment, mechanically and electrically suited to meet operating conditions.

1.3 The engine shall be the product of a manufacturer regularly engaged in manufacturing of engines and shall have been in regular production by the manufacturer for at least three years.

1.4 No exceptions or deviations from this Standard are permitted without prior written approval of Company.

The intended deviations or exceptions shall be listed separately along with the reasons thereof for company's consideration.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The edition of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor.

IPS (IRANIAN PETROLEUM STANDARD)

E-PM-120	"Accessibility and Safety of Machineries"
M-PM 320	"Lubrication, Shuft Sealing and Control Oil System for Special Purpose Application"

DEMA (DIESEL ENGINE MANUFACTURERS ASSOCIATION)

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

3046 PART 1&2	"Reciprocating Internal Combustion Engines: Performance"
6708	"Pipe Components-Definition of Nominal Sizes"
7268	"Pipe Components-Definition of Nominal Pressure"

NEMA (NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION)

3. CONFLICTING REQUIREMENTS

In case of conflict between documents relating to the enquiry or order, the following priority of documents (whichever more stringent realized by Company) shall apply:

- First Priority:	Purchase order and variation thereto
- Second Priority:	Data sheets and drawings
- Third Priority:	This Standard specification

All conflicting requirements shall be referred to the Purchaser in writing. The Purchaser will issue conforming documentation if needed for clarification.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. DEFINITIONS AND TERMS

5.1 Reciprocating Internal Combustion Engine

A mechanism delivering shaft power by the combustion of fuel in one or more cylinders in which working pistons reciprocate.

5.2 Compression Ignition Engine

An engine in which ignition is effected by the temperature of the cylinder contents, resulting solely from their compression.

5.3 Engine with Externally Supplied Ignition

An engine in which ignition is effected by a device in the chamber supplied with energy from a source situated outside the cylinder.

5.4 Spark Ignition Engine

An engine in which ignition is effected by means of an electric spark.

5.5 Liquid-Fuel Engine

An engine which operates on liquid fuel.

5.6 Compression Ignition Oil Engine

A compression ignition engine in which air is compressed and liquid fuel (oil) is introduced into each cylinder near the end of this compression.

Note:

This engine is generally known as a "diesel-engine".

5.7 Spark Ignition Engine with Carburetor; Carburetor Engine

A spark ignition engine in which a mixture of air and fuel is formed outside the cylinder in a device called a carburetor.

5.8 Multi-Fuel Engine

An engine so designed and equipped that without changes to the construction of the engine it can operate on liquid fuels of widely defferent ignition properties.

5.9 Gas Engine

An engine which operates basically on gaseous fuel.

5.10 Compression Ignition Gas Engine

A compression ignition engine in which a mixture of gaseous fuel and air is compressed and ignited by liquid fuel introduced into each cylinder near the end of this compression.

5.11 Spark Ignition Gas Engine

A gas engine in which ignition occurs by means of an electric spark.

5.12 Dual-Fuel Engine

A compression ignition engine which can operate either as a compression ignition gas engine or as a compression ignition oil engine, the change from one to the other is being possible while the engine is running.

5.13 Liquid-Cooled Engine

An engine in which the cylinder blocks are cooled by liquid.

Note:

The name water-cooled engine is also used when the liquid is predominantly water.

5.14 Air-Cooled Engine

An engine in which the cylinder block is cooled by air.

5.15 Four-Stroke Cycle

A working cycle such, for completion, needs four successive strokes of a working piston of a reciprocation internal combustion engine.

5.16 Four-Stroke Engine

An engine which works on the four-stroke cycle.

5.17 Two-Stroke Cycle

A working cycle which, for completion, needs two successive strokes of a working piston of a reciprocating internal combustion engine.

5.18 Two-Stroke Engine

An engine which works on the two-stroke cycle.

5.19 Turbo-Charging

Pressure-charging in which the fresh charge is pre-compressed by means of a compressor driven by a turbine fed by the exhaust gas of the engine to be charged.

5.20 Specific Air Consumption

The quantity of air entering the working cylinders per unit of power and time.

5.21 Overall Air-Fuel Ratio

The ratio of the quantity of air entering the working cylinders to the quantity of fuel supplied to the engine during the same period of time.

5.22 Delivery Ratio

The ratio of the mass of fresh charge supplied to a cylinder for one working cycle to the mass of fresh charge corresponding to the piston swept volume at the pressure and temperature conditions in the charge air manifold.

5.23 Combustion Chamber

A space in which ignition and combustion occur.

5.24 Per-Chamber

The subsidiary part of a divided combustion chamber into which fuel is injected, communicating through one or more comparatively narrow passages with the other part of the combustion chamber.

5.25 Air Chamber

The subsidiary part of a divided combustion chamber into which fuel is not injected, the communication with the other part of the combustion chamber being restricted.

5.26 Piston Chamber

The subsidiary part of a divided combustion chamber situated in the piston.

5.27 Cylinder Bore

The nominal inner diameter of the working cylinder.

5.28 Piston Area

The area of a circle of diameter equal to the cylinder bore.

Note:

For an engine in which a piston rod passes through the combustion space, this area must be reduced by the area of the cross-section of the piston rod.

5.29 Stroke

The nominal distance through which a working piston moves between two successive reversals of its direction of motion.

5.30 Dead Centre

The position of the working piston and the moving parts which are mechanically connected to it at the moment when the direction of the piston motion is reversed (at either end-point of the stroke).

5.31 Bottom Dead Centre

Dead centre when the piston is nearest to the crankshaft.

5.32 Top Dead Centre

Dead centre when the piston is farthest from the crankshaft.

Note:

In engines with only one piston in each cylinder, the expression "outer dead centre" is sometimes used instead of "top dead centre" and "inner dead centre" instead of "bottom dead centre". However,for opposed-piston engines and free-piston engines, it is common to use these expressions in the opposite sense. Only the terms defined in 5.62 and 5.63 shall be used.

5.33 Stroke Bore Ratio

The ratio of the numerical values of stroke and bore.

5.34 Engine Speed; Rotational Frequency

The number of revolutions of the crankshaft in a given period of time.

5.35 Mean Piston Speed

The time-averaged mean velocity of the piston, calculated as twice the product of the stroke and the engine speed.

5.36 Indicated Power

The total power developed in the working cylinders as a result of the pressure of the working medium acting on the pistons.

5.37 Brake Power

The power or the sum of the powers at the driving shaft or shafts.

5.38 Torque; Brake Torque

The turning moment delivered by the engine at a driving shaft.

5.39 Mechanical Efficiency

The ratio of the brake power to the indicated power.

5.40 Nominal Volume

Volume calculated from nominal dimensions.

Note:

Nominal volumes are mainly used for mechanical but not for ther-modynamic calculations.

5.41 Nominal Clearance Volume

The nominal volume of the space or the combustion side of the piston at top dead centre.

Note:

When applicable, this volume includes both parts of a divided combustion chamber.

5.42 Piston Swept Volume

The nominal volume generated by the working piston when traveling from one dead centre to the next one, calculated as the product of piston area and stroke.

5.43 Nominal Cylinder Volume

The nominal volume of the space on the combustion side of the piston at bottom dead centre.

Note:

The nominal cylinder volume is equal to the sum of the nominal clearance volume and the piston swept volume.

5.44 Engine Swept Volume

The sum of all piston swept volumes of the engine.

Note:

This volume is sometimes known as "cylinder capacity".

5.45 Engine Cylinder Volume

The sum of all nominal cylinder volumes of the engine.

5.46 Nominal Compression Ratio

The numerical value of the nominal cylinder volume divided by the numerical value of the nominal clearance volume.

5.47 Effective Volume

Volume determined for the purpose of thermodynamic or other calculations.

Note:

Effective volumes take into account the effect of events such as valve or port opening or closure. Values are normally expressed in the cold condition; if otherwise, the condition should be as stated.

5.48 Load

A general term describing the magnitude of the "power" or "torque" demanded from the engine by its driven machinery and usually expressed relative to a declared power or torque.

Note:

For quantitative purposes, the terms "power" or " torque" should be used, instead of "load", together with a statement of speed.

5.49 Maximum Cylinder Pressure

The maximum pressure of the working medium pressure in a cylinder attained during a working cycle.

Note:

The pressure level of the atmosphere in the environment of the engine installation.

5.50 Boost Pressure

The pressure of the air supplied to a working cylinder of a pressurecharged engine.

Note:

When the boost pressure is only slightly above atmospheric pressure, the term "scavenging pressure" is sometimes used.

5.51 Exhaust Back Pressure

The pressure of the exhaust gas at the point of leaving the engine.

5.52 Single-Acting Engine

An engine in which combustion takes place on only one and same side of each working piston.

5.53 Double-Acting Engine

An engine in which combustion takes place alternately on either side of each working piston.

5.54 Opposed-Piston Engine

An engine, normally two stroke, having in each cylinder two mechanically connected working pistons running in substantially opposite directions, with the working medium between them.

5.55 Unidirectional Engine

An engine in which the crankshaft rotates always in the same direction.

5.56 Direct-Reversing Engine

An engine in which the direction of rotation may be changed by the operation of a control device.

5.57 Cylinder Row

An arrangement of cylinders whose pistons are connected to the same crankpin of the crankshaft.

5.58 Cylinder Bank

An arrangement of cylinders in which the centre line of the crankshaft journals lies in or is parallel to the plane containing the centre line of the engine cylinders, all cylinders being on the same side of the crankshaft.

5.59 Vertical Engine

An engine with one or more cylinder banks each located in a vertical plane above its crankshaft.

5.60 Horizontal Engine

An engine with one or more cylinder banks each located in a horizontal plane.

5.61 Inverted Engine

An engine with one or more cylinder banks each located in a vertical plane below its crankshaft.

5.62 In-Line Engine

An engine with one cylinder bank.

5.63 Vee-Engine

An engine with tow cylinder banks inclined at an angle to each other and with one crankshaft.

5.64 Twin-Bank Engine

An engine with two parallel cylinder banks and two crankshafts.

5.65 Opposed-Cylinder Engine

An engine with two cylinder banks located in the same plane on opposite sides of the crankshaft.

5.66 Radial Engine

An engine with more than two cylinders in each row equally spaced around the crankshaft.

5.67 Broad-Arrow Engine

An engine with more than two cylinder banks inclined at an angle to each other and with one crankshaft, the inclined angle between the extreme banks being less than 180°.

Note:

The broad-arrow engine with three cylinder banks is known as the "V-engine".

5.68 Inclined Engine

An engine with one cylinder bank which is located in an inclined plane lying between the vertical and horizontal planes through the crankshaft.

5.69 X-Engine

An engine with one crankshaft having four cylinder banks arranged in two planes inclined at an angle to each other, the two banks in each plane being on opposite sides of the crankshaft.

5.70 H-Engine

An engine with two crankshafts having four cylinder banks in two parallel planes, the two banks in each plane being on opposite sides of a crankshaft.

5.71 Polygon Engine

An opposed-piston engine with three or more cylinder banks inclined at an angle to each other so that banks from the plane sides of a polygonal prism with a crankshaft at each corner of the prism.

5.72 Free-Piston Engine

A mechanism delivering power by the combustion of fuel in one or more cylinders in which working pistons reciprocate but are not mechanically constrained.

Note:

The power is thus not transmitted by a shaft.

5.73 Free-Piston Gas Generator

A free-piston engine in which the power is delivered in the form of hot gas.

5.74 Free-Piston Compressor

A free piston engine in which the power is delivered in the form of compressed air.

5.75 Free-Piston Gas Generator Set

A combination of one or more free-piston gas generators with a mechanism which converts power in the hot gas into shaft power.

5.76 Diameter Nominal

The international nomenclature-written as DN 15, 25, 32, 40, etc., has been used for pipe size in accordance with ISO 6708 (1980) and Appendix B in this Standard specification.

5.77 Pressure Nominal

The international nomenclature-pressure nominal written as PN 20, 50, 68, 100, etc., has been used for flange ratings in accordance with ANSI-ASME B 16.5 (1981), ISO 7268 (1983) and Appendix C in this Standard Specification.

6. DESIGN

6.1 General

6.1.1 Unless otherwise specified, the equipment shall be suitable for the service specified on the engine data sheet. Site data and cooling parameters will be specified by purchaser.

6.1.2 The engine noise shall be not more than 90 dB at 1 meter from the equipment surface.

6.2 Mechanical Design

6.2.1 The rated output for the engine shall meet the requirements of ISO 3046-Part 1.

6.2.2 Unless otherwise specified a speed governing system shall be provided per NEMA SM-23 and SM-24.

The following governing classes shall be provided:

For mechanical drive NEMA class C or D for electric power generator drive NEMA class D, isochronous.

When hydraulic governer is furnished, an independent hydraulic oil system from engine lubricating oil system shall be provided for governer.

6.2.3 The torsional natural frequencies of the engine and driver equipment system, including couplings and gear units, shall not be within 10% of any normal operating shaft speed range.

6.2.4 When emergency duty is specified the engine shall be designed to reach operating speed and full load capability within 10 seconds after receiving a short signal.

6.2.5 A tachometer shall be supplied and mounted on the engine. Speed range shall be 0 to 115 precent of rated speed .

6.2.6 All gears, belts, couplings, pulleys, or similars shall be adequately guarded for personnel protection in accordance with IPS-E-PM-120.

6.3 Construction

6.3.1 The cylinder block and crankcase shall be of one piece high quality casting of high quality cast iron having a minimum tensile strength of approximately 241000 Kpa, with thick top deck and heavy structural webbing between cylinders and bearing journal bridging.

6.3.2 The crankshaft shall be of a multi-plane forging of high alloy steel statically and dynamically balanced with one crank for each cylinder and each crank supported between two main bearings.

When approved by the Purchaser forged carbon steel may be considered.

The crankshaft shall be carefully designed to avoid torsional vibration within the operating speed ranges.

The crankshaft shall be hardened to a depth so that the depth of hardness allows the shaft to be reground up to minimum three times for under size bearing.

6.3.3 The connecting rod shall be strong heat treated alloy steel without excessive weight with bearing at each end to transmit the piston thrust to the crankshaft and vice versa.

For high speed or emergency cases connecting rods with excessive weight may be considered.

The big end of the connecting rod shall be split horizontally or angularly with serrated surfaces.

A two-piece-precision, babbit-lined, or tri-metal type bearings shall connect the rod to the crankshaft at big end. If purchaser approves, the tongue and-groove joint can be employed.

6.3.4 Cylinders shall be provided with sleeves. Unless otherwise specified cylinder sleeves shall be of replaceable wet sleeve design made from centrifugally high strength alloy cast iron.

6.3.5 Unless otherwise specified the piston shall be of machined heavy-duty aluminum alloy castings with a cast-in-NI resist steel insert.

The piston shall be cooled by a pressure jet of oil from the connecting-rod impinging upon the under side of the piston crown and upper ring belt region.

The wrist ring set consisting of a barrel faced, chromium carbide-molybdenum coated top compression ring and conformable hooker type oil rings is preferred.

6.3.6 The camshaft shall be of a carburized forged steel providing hard surface case and precision ground to a super finish.

6.3.7 Principle engine accessories including camshaft, magneto drive and lubricating oil pump shall be gear drived from the crankshaft .

All gears shall be high strength alloy steel forgings. The gear shall be helical tooth design with tooth engagement over-lap considering quiet operation and strength.

The teeth shall be crowned shaved for ideal tooth contact and loading.

6.3.8 Individual deep section cylinder heads shall be made from high quality alloy cast iron with an internal baffling arrangement to direct coolant flow at high velocity across the high temperature surfaces insuring good heat transfer and low thermal stresses.

The valves shall be of high quality material and poppet type with hardened stem tips and stellite facing.

6.4 Lubrication System

6.4.1 The engine shall be equipped with pressure lubrication system supplying oil to all surfaces requiring pressure lubrication. Circulation shall be by means of positive displacement engine-driven pump equipped with adjustable pressure regulator.

The lubrication system shall include a full-flow oil filter and a series connected oil cooler of sufficient size to properly cool all lubricating oil circulated.

Unless otherwise specified for babbited bearings 25 Nm or finer mesh and for aluminum and micro babbited bearings 10 Nm or finer shall be supplied. Filter cartridge materials shall be corrosion resistant.

For replaceable cartridge filter, the clean pressure drop shall not exceed 35 K pa (5 psi) at design temperature and flow. The cartridge collapse pressure shall not be less than 350 K pa (50 psi). The filter shall be equipped with vent and drain connections.

All components shall be installed and mounted on the engine or engine baseplate complete with piping and including automatic lube oil temperature control.

6.4.2 The engine shall be equipped with a hand-operated, pre-lube pump of adequate size to provide oil to all force-fed location. For engines 200 hp and higher Dc Pre-lube pumps shall be provided.

6.4.3 All components of the oil system shall be of steel construction, 18 chrome -8 Nickel stainless steel piping shall be provided downstream of the lube oil filter to the engine and drive train bearings.

6.4.4 Carbon steel lube oil piping shall be pickled. Stainless steel tubing and piping shall be cleaned with suitable solvent.

6.4.5 **a)** Oil cooler shall be provided to maintain lube oil supply temperature at or below 65°C.

b) The cooler shall be a water cooled, shell and tube-type per TEMA C with removable bundle and channel cover design, or it shall be a suitable air cooled type, as specified.

c) Tubes shall not be smaller than 16 mm OD (5/8") and the minimum tube wall thickness shall be 1/24 mm (0.044"). U-bends are not permitted.

d) Materials shall be per the manufacturers' standard, except that materials for salt or brackish water service shall be per the following.

SHELL	CHANNELS AND COVERS		TUBE SHEETS		TUBES	
	Materials	Specification	Mat.	Spec.	Mat.	Spec.
Carbon Steel	Acid resisting Bronze or Aluminum Bronze	ASTM B 584 ALLOY C 92200 ASTM B 169 ALLOY C 61400	Naval brass	ASTM B 171 ALLOY C 46400	Inhibited Admiralty	ASTM B111 ALLOY C 44300 C 44400 or C 44500

e) The Vendor shall insure that the lubricating oil pressure at the cooler outlet is greater than the cooling water pressure specified to prevent contamination of the lubricating oil in case of cooler failure.

f) Coolers shall be equipped with vent and drain connections on oil and water sides.

6.4.6 A removable steam heating element or thermostatically controlled electrical immersion heater shall be provided for heating the charge capacity of oil prior to start up in cold weather. The heating device shall have sufficient capacity to heat the oil in the reservoir from the specified minimum site ambinent temperature to the manufacturer's required temperature within 12 hours. If an electrical immersion heater is used, it shall have a maximum watt density of 2.3 watts/cm².

6.5 Cooling Water System

6.5.1 The engine shall have an engine jacket water heater with adjustable thermostat control in a water bypass line of ample capacity to maintain water temperature in engine between 38 to 50°C. Heater voltage will be specified on the gas engine data sheets.

6.5.2 The engine shall be cooled by means of a closed loop jacket water radiator with pusher type fan. The radiator shall have provisions for attachment of purchaser's discharge ducting. The cooling system shall be thermostatically controlled and capable of maintaining engine water temperatures at 74-80°C at continuous full-load operation.

6.5.3 Engine cooling other than by means of a pusher type fan and radiator will be specified on the individual gas engine data sheets.

6.5.4 Unless otherwise specified the engine shall operate completely independent of any external cooling water supply and require make-up water only.

6.5.5 Service connections and valves for draining and filling shall be easily accessible.

6.5.6 The Vendor shall provide a diagram of the cooling water systems showing all connected equipment, the water flow rate, heat pickup and volume of air required.

6.6 Inlet and Exhaust System

6.6.1 The Vendor shall provide an industrial type intake air filter with replaceable dry elements.

6.6.2 A residential type spark arrestor/silencer with flexible exhaust connection shall be furnished with engine. Silencer shall be properly sized for the engine and be completed with companion flanges and rain cap. Exhaust silencer will be connected to the exhaust system and mounted over the engine.

6.6.3 Flexible exhaust expansion joints shall be furnished for exhaust outlet.

6.6.4 If the engine is turbo-charged a water cooled exhaust manifold shall be provided.

6.6.5 Unless otherwise specified vendor shall include elbow, flanges, straight pipes, rain traps, drain plugs and rain cover to provide a complete system, stated in data sheet.

6.6.6 Vendor shall advise the exhaust gas temperature in his proposal.

6.6.7 Air intake and exhaust systems shall be supplied complete with supporting stands for outdoor installation and interconnecting pipework from engine with necessary support plates, unless otherwise specified.

6.7 Baseplate

6.7.1 The engine driven equipment unless otherwise specified and local control panel and jacketed water radiator shall be mounted on a steel baseplate of adequate size and strength to properly support and align all rotating equipment.

6.7.2 Grout holes shall be arranged so that the baseplate with driven equipment and all auxiliaries mounted in place, can be grouted without removing any components or piping. Adequate vent holes shall be provided to insure a complete distribution of grout.

6.8 Instrumentation and Controls

6.8.1 The engine shall be equipped with a tachometer, a governor and automatic speed control complete with a bumpless transfer station sensing from electrical signal.

6.8.2 Controls shall be provided to protect the engine against the followings:

a) Low lubricating oil pressure
b) High temperature cooling water leaving the engine jackets
c) Low flow or low pressure from each cooling water circulating pump
d) Low level in each cooling water surge tank
e) Overspeed
f) Excessive vibration
g) High lubricating oil temperature

6.8.3 Provision shall be made for a manual speed control in addition to the automatic speed control.

6.8.4 A vibration free instrument local panel having the following instrumentation shall be provided (all gages in SI units):

a) Mechanical Tachometer
b) Oil Pressure Gage
c) Water Temperature Gage (water out of engine)
d) Engine Manifold Vacuum Gage (for gas engines)
e) Fuel Pressure Gage (for diesel engines)
f) Fuel Reservoir Level (for diesel engines)
g) Running Time Meter, (5 digits minimum)
h) Battery Charging Ammeter
i) Start/Stop Control
j) Low Battery Voltage Indicator and Battery Voltmeter
k) Exhaust Gas Temperature
l) Cooling Water Pressure

6.8.5 Particular attention shall be focused on emission Nitrogen Oxide (Nox) and Engine Nox emission level reduction control.

6.9 Nameplates

A stainless steel nameplate must be provided for each equipment as shown below.

Manufacturers may add the data required to their standard plates provided that they are made from the above mentioned material. The data called for must be legibly stamped or preferably engraved on the plate which shall be fixed to an accessible part of the equipment.

The nameplate shall be securely fixed to the equipment, but the method of fixing shall not involve drilling into the wall of a pressure part. The name plate shall include as a minimum the following information:

Equipment Identification No. .....
Order No. .....Order Placed by .....
Manufacturer's Name .....
Type and Size .....Serial No. .....
Bore and Stroke, mm .....
Rated, KW .....R.P.M. .....
Firing Order .....
Weights-Total Net Wt. Equipment.....kg

Baseplate.....kg

Heaviest Removable Component

For Overhaul.....kg

6.10 Special Tools

6.10.1 When special tools and fixtures are required to disassemble, assemble, or maintain the unit, they shall be included in the quotation and furnished as part of the initial supply of the machine. For multiple-unit installations, the requirements for quantities of special tools and fixtures shall be mutually agreed upon by the Purchaser and the Vendor.

These or similar special tools shall be used during shop assembly and post-test disassembly of the equipment.

6.10.2 When special tools are provided, they shall be packaged in separate, rugged boxes and marked "special tools for (tag/item number)." Each tools shall be stamped or tagged to indicated its intended use.

6.11 Specific Requirements for Diesel Engines

6.11.1 Mechanical

The rated power of the engine at rated speed, with all accessories driven, shall be at least that required to produce the power specified on the diesel engine data sheets for adverse conditions.

6.11.2 Fuel system

6.11.2.1 Unless specified otherwise a day tank with a minimum 8 hours operating capacity shall be supplied with the unit. An engine-driven fuel pump shall draw fuel from this tank for operation. The day tank shall be of heavy duty welded construction type and shall be vented and drained.

A level control facility shall be provided on the day tank to prevent overfilling, and also to give alarm on high and low levels of fuel oil.

Day tank shall also be provided with a guarded sight gage glass.

6.11.2.2 If the fuel pressurized system will not be available the following sub-clauses shall be complied.

6.11.2.2.1 An electric motor-driven fuel transfer pump shall be provided by the engine Vendor to transfer fuel from main storage tank to the tank. Pump shall be designed for the horizontal run and suction lift as required or sustained normal and overload operation of the engine. Pump shall be controlled by the level control facility in the tank.

6.11.2.2.2 A hand operated fuel pump with handle length min. 25 cm shall be provided with connections to bypass the electric fuel pump and discharge into the day tank.

6.11.2.2.3 The main storage diesel fuel tank shall be quoted as separate item by the engine Vendor. It shall have a 36 hours minimum capacity and be suitable for underground installation.

Exterior of this tank shall be properly coated for direct burial. No galvanizing shall be used. Suction and return line connections, filter and breather lines, water draw-off and gagging connection as well as any other necessary lines or connections shall be furnished by the engine Vendor.

6.11.2.3 Fuel oil filter shall be provided by the engine Vendor and shall be of dual full-flow replaceable cartridge type.

6.11.3 Starting system

6.11.3.1 Unless specified otherwise an electric engine starting is required. The engine Vendor shall provide two (2) heavy duty starting batteries of the nickel-Cadmium alkaline type, not less than 200 ampere hour capacity, complete with battery cables and vibration-proof rack. Battery voltage requirements will be specified on the diesel engine data sheets.

6.11.3.2 A battery charger with a high and low rate, shall be provided, and shall have manual switch to select and adjustable trickle charge rate. The charger shall operate from normal mains supply, to maintain the battery fully charged for engine starting.

6.11.3.3 An automatic change-over switch shall be provided to change from mains to engine driven charging when the set is running.

6.11.3.4 Provision shall be made for automatic test start of the engine.

6.12 Specific Requirements for Gas Engines

6.12.1 Mechanical

6.12.1.1 Unless otherwise specified the engine shall be turbocharged four cycles. It shall be full-gas type utilizing wet cylinders.

6.12.1.2 The available engine power, when derated as per DEMA for continuous duty, altitude, temperature and other service conditions, shall be sufficient to drive the unit it is coupled with at speeds ranging from 60% to 100% of design speed with the unit operating at its design conditions.

6.12.1.3 A clutch is not required unless it is specifically called for by the Purchaser.

6.12.2 Fuel system

6.12.2.1 The engine shall be designed to operate on fuel gas of the approximate composition specified by the Purchaser .

6.12.2.2 The fuel gas system shall include all items required to accept the fuel gas specified by the Purchaser and utilize it in the engine.

This system shall include as a minimum, a pressure gage, temperature gage, relief valve, drain valve, pressure reducing valve(s), fail-safe emergency shutdown valve and a fuel gas control valve.

All valves provided shall be steel.

6.12.2.3 A fuel gas demister shall be provided where the fuel gas available is not processed plant residue gas.

6.12.3 Starting system

6.12.3.1 The starter shall be an air, electric, or gas operated cranking motor. It shall be sized with adequate capacity to rotate the engine and any unloaded unit which may be coupled with the driver.

6.12.3.2 The starter motor piping shall be supplied complete with a block valve, liquid trap, fog lubricator, strainer, control valve and regulator with a relief valve. When fuel gas pressure is adequate for use as starting gas the starter supply shall be connected to the engine fuel gas line. Adequate exhaust piping shall be supplied.

6.12.3.3 When electric engine starting is specified, the engine Vendor shall provide two (2) heavy duty starting batteries of the Nickel cadmium alkaline type, not less than 200 amper hour capacity, complete with battery cables and vibration proof rack. Battery voltage requirements will be specified on the gas engine data sheets.

6.12.3.4 A battery charger with a high and low rate, shall be provided, and shall have a manual switch, to select and adjustable trickle charge rate . The charger shall operate from normal mains supply, as specified in data sheet, to maintain the battery fully charged for engine starting.

6.12.3.5 An automatic change-over switch shall be provided to change from mains to engine driven charging when the set is running.

6.12.3.6 All mechanical electric switching and other electric devices shall conform to Class I, Division I, Group D service and to purchase order for other specific requirements.

6.12.3.7 Provision shall be made for automatic test start of the engine. The engine shall also be automatically stopped after a preset period of unloaded running.

6.12.4 Control

An automatic fuel gas shut-off and vent valve shall be provided to shut-off the fuel gas to the engine in the event of its stopping.

This type of shut-off mechanism shall be used in conjunction with grounding the magneto to automatically shutdown the engine in case of any abnormalities listed in 6.8.2 occur.

7. INSPECTION AND TESTING

7.1 General

The Vendor shall provide the Purchaser with advance notification of certain shop inspection and tests as outlined in the purchase order or other agreements.

The Purchaser's representative shall have entry after prior notification by the Purchaser to all vendor and subvendor plants where work upon or testing of the equipment is in progress.

The Purchaser or his representative shall has the right to reject any parts of equipment which do not conform to the purchase order. It shall be the responsibility of the Vendor to notify subvendors of the Purchaser's inspection requirements.

7.2 Inspection

7.2.1 Informations specified in following paragraphs shall be provided to the inspector upon request for the purchase order.

7.2.1.1 Evidence, such as purchase specification or bills of material to establish that major parts are of specified materials.

7.2.1.2 Copies of shop test data for the purchased equipment as required in the purchase order.

7.2.2 When specified the oil system furnished shall meet the cleanliness required by API Standard 614 as amended supplemented by IPS-M-PM-320.

7.3 Testing

7.3.1 General

All engine testing will be non-witnessed unless otherwise noted on the individual engine data sheets.

7.3.2 Hydrostatic test

a) Engine cylinders or liners shall be hydrostatically tested with water at ambient temperature. The minimum test pressure shall be 1- ½ times the maximum allowable casing pressure.

b) Cooling water jackets shall be hydrostatically tested at 790 kpa (G).

c) All hydrostatic tests shall be maintained for a minimum period of 30 minutes. Certification of the test results is required.

7.3.3 Mechanical running test

a) The engine shall be operated at 100% load for a period of 4 hours. When steady-state conditions have been reached and held for 15 minutes, test data shall be recorded.

Final readings shall be recorded at completion of 4 hours tests, following which, and overload test of 110% full load shall be run for 30 minutes. Overload test data shall also be recorded.

All alarm circuits must be tested under actual running conditions, (e.g. engine must be overheated, overspeed tested, lube oil pressure alarms and shutdowns checked, etc.)

b) Operation of the engine overspeed governor shall be checked at 110% normal speed following the final load testing, followings which, the engine shall be re-started and temporarily loaded to 100% full load.

c) Certified test data shall be provided by vendor from data obtained during the performance test of the purchased engine.

7.3.4 Performance test

The engine performance shall be tested in accordance with ISO Standard 3046, parts 1 and 2, to verify that engine rated power, fuel consumption and lubricating oil consumption comply the appropriate declared values.

8. PREPARATION FOR SHIPMENT

8.1 General

Preparation for shipment shall be in accordance with Vendor's standard and as noted herein. The Vendor shall be solely responsible for the adequacy of the preparation for shipment provisions employed with respect to materials and application, and to provide equipment to their destination in ex-works condition when handled by commercial carriers.

All parts shall be shipped with the equipment and separate shipment is not permitted.

8.2 Painted Surfaces

Vendor standard cleaning and painting procedures for the operating temperature and climatic condition of the equipment is acceptable.

8.3 Nonpainted Surfaces

Nonexposed finished and machined surfaces including coolers, filters and piping shall be throughly cleaned internally of metal particles, dirt and debris, and coated with a suitable rust preventive compound, easily removable by standard solvent, prior to shipment.

Exposed finished and machined surfaces, including bolting, shall be given a coating of rust inhibiting compound.

8.4 Marking and Tagging

8.4.1 Each equipment shall be identified with its Purchase Order Number, and equipment Tag Number. Tags shall be corrosion resistance metal and impression stamped:

P.O. No.————————————
P.O. ITEM No. ————————————
EQUIPMENT No. ————————————

8.4.2 Tags shall be attached to each component with stainless steel wire. This tagging is in addition to the equipment nameplate. Equipment shipped in fully enclosed containers shall also include the above information marked on the external side of the container.

8.4.3 Miscellaneous parts shall be tagged or marked with the equipment tag number for which they are intended.

9. VENDOR DATA REQUIREMENTS

9.1 General

9.1.1 All drawings and data shall be furnished in English and in accordance with the schedule established at time of Purchase Order Placement.

9.1.2 Approval of drawings shall not relieve Vendor of any responsibility in meeting the requirements of specifications nor shall such approval be considered as permitting deviations from specifications or Purchase Order requirements, unless specifically agreed to in writing.

9.2 Drawings and Data

9.2.1 The Vendor shall provide the Purchaser with the 4 sets of the following drawings and data in English with Quotation:

- Complete technical vendor's products catalogues.

- Comprehensive catalogues, technical data, dimensional outline drawings, proposed test procedure, service facilities etc. of the equipment offered and its various components.

- Preliminary connection and wiring diagrams, dimensional and cross sectional drawings, control system diagram.

- Declaration of confirmation with the set standards and/or clear indication of deviations from the standards and this specification.

- Completed purchaser data sheet.

- Vendor's design calculation, necessary documents and/or data for the calculation of the power output of the engine in respect to the site and climatic condition detailed in data sheet.

- Performance curve showing torque, fuel and oil consumption, engine speed and power output.

- Performance data.

- Reference list showing the successful continuous operation for at least two years and the location of the equipment offered, in major oil company installations.

- Recommended commissioning and 2 years running consumable and spare parts separately listed, numbered, referenced, duly priced and approximate normal delivery time and stocking points given.

- Rates for technical assistance.

- Rates for training purchaser's personnel.

- Dimension and weights of unit and its different parts.

- Shipping dimensions (length, width and height) and weight with shipping schedules.

- Tabulation of all connections to which purchaser connections, giving size, rating, facing etc.

- Scheme of fuel circuit.

- Scheme of lube oil circuit

- Scheme of starting system.

- Assembly drawing of unit electrical and control panels with size and weight (as applicable)

- Location of rates (such as flow, pressure, voltage etc.) of various connection to the outside equipment and recommended installation details.

9.2.2 The Vendor shall provide the Purchaser immediately following the placing of order (not later than 60 days) 5 sets of:

- Piping, wiring, control system diagram and dimensional outline drawings, dimensional outlines of all accessories of various connections details for purchaser's approval.

- Foundation plan/anchor bolts location weight of all components shown on drawings, weight of the heaviest piece for maintenance, unbalance forces and moments, start-up forces etc.; foundation and support drawings of intake and exhaust system.

- Instruments specifications with manufacturer, model and technical characteristic and schematic diagrams.

- Local panel dimensions and cutouts.

- Area classification and certificates for electrical instruments installed in hazardous areas.

- Single line and wiring diagram of control and electrical panels (as applicable) with indication of characteristic of control alarms and shut down devices.

- Detailed manufacturing and testing program for the equipment and its components.

9.2.3 The Vendor shall provide the Purchaser at least 90 days before delivery 12 sets of installation, operation and maintenance manuals consisting of :

- Complete Data Sheet
- Codes and Standards Compliance Certificate.
- Safety and Control Equipment/Components Calculation Sheets.
- Wiring Diagrams.
- Certificates of Material.
- Certificates and Test Curves.
- Panels Layout, Wiring, Connections and interconnections .
- Auxiliary System Schematics.
- Factory Test Certificates, including test data and calculated results (when ready).
- Illustrated and numbered parts list and three years running spare parts list final revision.
- One set of reproducibles of all civil, mechanical, control and electrical drawings with "AS BUILT"

10. GUARANTEE AND WARRANTY

10.1 Performance

10.1.1 Operating under load

Engine performance shall be guaranteed for ¼ or ½ and full load operation at the ambient temperatures and atmospheric pressure.

Engines shall be guaranteed to be capable of operation at 110% of full rated load for 2 hours per 24 hours of operation.

10.1.2 Torque and speed

Each engine shall be guaranteed to deliver the rated torque at the rated speed for the type of service and site conditions specified, with no negative tolerances allowed. The actual engine fuel heat rate may not exceed the guaranteed heat rate at full load.

10.2 Mechanical

Unless exception is recorded by the Vendor in his proposal, it shall be understood that the Vendor agrees to the following guarantees and warranties:

During a period of 12 months after the date of commissioning, the Vendor shall, with all possible speed and without cost to the Purchaser, replace or repair the goods or any part thereof found to be defective due to faulty material, workmanship or to any act or omission of the Vendor. In particular the Vendor shall reimburse any transportation and other charges incurred by the Purchaser in effecting such replacement or repair at the point of use.

APPENDICES

APPENDIX A

RECIPROCATING INTERNAL COMBUSTION ENGINES, DATA SHEET

JOB No. ..... ITEM No.....
PAGE .1 .. OF ..2.. BY.....
DATE .....REVISION....

NOTE - INFORMATION TO BE COMPLETED BY : ○ PURCHASER ☐ VENDOR

FOR ——— SITE ———
UNIT ——— SERVICE ———
ENGINE ITEM No. ——— QUANTITY ———
ENGINE SERIAL No.☐ ——— SIZE/TYPE ☐ ———
ENGINE MANUFACTURER☐ ———

○ OPERATING CONDITION

DRIVEN EQUIPMENT ———
DUTY ———
MAX. POWER REQ'D ——— KW
SPEED REQ'D (RPM) ———
ALTITUDE (m) ——— MAX. AMBIENT TEMP (°C)

TYPE OF ENGINE FUEL :
INSTALL. : ○INDOOR ○OUTDOOR
○SHELTERED ○UNSHELTERED
CP/CV AT ——— °C ——— kpa
FUEL HHV KJ/M³ LHV KJ/M³
FUEL PRESS. MAX/MIN kpa
FUEL TEMP. MAX/MIN. °C

☐ PERFORMANCE

ISO CONT. RATING :——— KW AT ——— RPM
ISO PEAK. RATING :——— KW AT ——— RPM
SITE CONT. RATING ——— KW AT ——— RPM
COMP. RATIO : ———
FUEL PRESS. REQ'D. MAX/MIN.——— kpa
FUEL GAS HEATER REQ'D FOR START UP.
☐YES ☐NO
REMARKS ———

○ EQUIPMENT & ACCESSORIES

STARTER. ○ELECTRIC ○HYDRAULIC ○PNEUMATIC
START-UP : MANUAL (LOCAL/REMOTE)
AUTO BOTH
BATTERIES : TYPE ——AMP.HR CAP.☐———
BATTERY : CHARGER ☐ ———
DRIVE TYPE: ○DIRECT, ○GEAR,○ ———
COUP(S) TYPE /MFR. ———
CLUTCH REQ'D: ○NO ○YES, TYPE, MFR. ———
GEAR REQ'D ○NO ○YES RATIO—— MFR——
GOVERNOR : TYPE/MFR. ——— , CLASS ———
PRELUBE PUMP & DRIVE REQ'D NO YES, TYPE
LUBE OIL COOLER ☐AIR BLAST.☐
SHELL & TUBE☐
LUBE OIL HEATER WITH THERMOSTAT : ———
C.W. HEATER WITH THERMOSTAT : ———
INTAKE AIR FILTER : ☐DRY, ☐WET,☐ ———
EXHAUST SYSTEM COMPLETE WITH :
○SILENCER, ○SPARK ARRESTOR, ○EXPAN JOINT
HORIZ. PIPE(mm)☐ ——VERT PIPE (mm)☐——
ELBOW(s)☐ ——— LAGGING☐ ———
DAY FUEL TANK : CAPACITY ——— LIT.———
SKID MOUNTED, ○SEPARATE,○ ———
FUEL FILTER, ○SINGLE,○DUPLEX,○ ———
SKID MOUNTING, ○SEPARATE, ○WITH DRIVEN EQUIP.
TACHOMETER: ○MECHANICAL, ○ELECTRICAL○———
COMPLETE ENGINE ENCLOSURE REQ'D○NO ○YES
DIMENSIONS(mm):LENGTH☐— WIDTH☐—
HEIGH☐—
WEIGHTS (Kg) :TOTAL☐ ———
HEAVIEST PART FOR OVERHAUL.☐ ———

☐ DESIGN AND CONSTRUCTION

NO CYLINDERS ——— NO CYCLES ———
ARRANGEMENT ———
BORE(mm) ——— STROKE(mm) ———
PISTON SPEED (MAX.) ——— m/sec.———SPM
MAX. ALLOW SHAFT SPEED ——— RPM
SHAFT ROTATION ——— VIEWED FROM CPLG END
CYLINDERS: ☐LINED, ☐UNLINED,☐WET ☐DRY
ENGINE COOLING: ☐RADIATOR, ☐AIR FIN☐———
MAIN BRGS: NO. ——, TYPE ——, SIZE ———
CRANK BRGS: NO. —, TYPE ——, SIZE ———
INTAKE VALVES NO.———, SIZE ———
SEATS: ☐INTEGRAL, ☐RENEWABLE
EXHAUST VALVE: No.———, SIZE ———
SEATS: ☐INTEGRAL, ☐RENEWABLE
LUBRICATION SYSTEM:
☐FORCED FEED, SPLASH,
OIL PUMP: ☐INTEGRAL ☐SEPARATE,☐———
OIL FILTER ☐SINGLE, ☐DUPLEX, ☐———
LUBE OIL TYPE/GRADE ———
☐TURBOCHARGED, ☐NAT. ASPIRATED,☐ ———
FUEL INJ. EQUIP. ———
REMARKS ———

☐ MATERIAL OF CONSTRUCTION

FRAME ———
CRANK SHAFT ———
CONN RODS ———
CYLINDERS ———
LINERS ———
PISTONS
CYLINDER HEADS ———
MAIN BRGS ———
CRANK BRGS ———
WRIST PINS ———
VALVES ———
INTAKE———— ,SEAT ———
EXHAUST ———— ,SEAT ———
REMARKS : ———

INSTRUMENTATION

SHUTDOWN DEVICES :
○LOW OIL PRESS. ○HIGH COOLING WATER TEMP
○HIGH OIL TEMP. ○OVER-SPEED
ENGINE INST PANEL: ○ON SKID ○OFF SKID
ANNUNCIATOR PANEL: ○ON SKID ○OFF SKID
REMARKS ———

APPENDIX A

RECIPROCATING INTERNAL COMBUSTION ENGINES, DATA SHEET

JOB No. ..... ITEM No.....
PAGE ..2.. OF ..2.. BY.....
DATE .....REVISION....

☐ TOTAL UTILITY CONSUMPTION:		☐ MAINTENANCE:
COOLING WATER	m^3/h	MAINTENANCE REQUIREMENTS (HOURS)
ELECTRICAL POWER	KW.AC	
	KW.DC	
STEAM NORMAL	Kg/s	TIME BETWEEN MAJOR OVERHAULS
MAX.	Kg/s	
FUEL NORMAL	MJ/h	
MAX.	MJ/h	
INSTRUMENT AIR	m^3/h	

A T M O S P H E R I C E M I S S I O N S

INFORMATION BY PURCHASER	INFORMATION BY VENDOR
NO_x REQUIREMENTS	GUARANTEED NO_x
NO_x REDUCTION METHOD (IF REQUIRED)	NO_x REDUCTION METHOD
○ WATER INJECTION	☐ WATER INJECTION
○ STEAM	☐ STEAM
○ OTHER	☐ OTHER
SO_2 REQUIREMENTS	SO_2 (BASED ON STATED SULFUR
SULFUR CONTENT OF FUEL	CONTENT)
% WT	
CO REQUIREMENTS	CO EMISSIONS
PARTICULATE REQUIREMENTS	PARTICULATE EMISSIONS
APPLICABLE EMISSION CODES OR REGULATION	
○ EPA – TITLE 40-CFR	
○ OTHERS	
○	

COMMENTS:

APPENDIX B
PIPE COMPONENTS NOMINAL SIZE

The purpose of this Appendix is to establish and equivalent identity for the piping components nominal sizes in Imperial System and SI System.

TABLE B1

Nominal Size		Nominal Size		Nominal Size		Nominal SIZE	
DN (1)	NPS (2)	DN	NPS	DN	NPS	DN	NPS
15	½	100	4	500	20	1000	40
20	¾	125	5	600	24	1050	42
25	1	150	6	650	26	1100	44
32	1¼	200	8	700	28	1150	46
40	1½	250	10	750	30	1200	48
50	2	300	12	800	32	1300	52
65	2½	350	14	850	34	1400	56
80	3	400	16	900	36	1500	60
90	3½	450	18	950	38	1800	72

1) Diameter nominal, mm.

2) Nominal pipe size, inch.

APPENDIX C
PIPE FLANGES PRESSURE-TEMPERATURE RATINGS

The purpose of this Appendix is to establish and equivalent identity for the pipe flange nominal pressure temperature ratings in Imperial System and SI System.

TABLE C1

Pn (1)	ANSI RATING CLASS
20	150
50	300
68	400
100	600
250	1500
420	2500

1) Pressure Nominal