TECHNICAL SPECIFICATION

DIESEL FUELLED COMPRESSION IGNITION ENGINES

DEP 31.29.80.30-Gen.

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DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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Shell International Oil Products B.V. (SIOP)
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Shell International Exploration and Production B.V. (SIEP)
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The Hague, The Netherlands,

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They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This new DEP gives the minimum requirements for stationary diesel (compression ignition) engines used as prime movers. It is intended to cover the basic engine and its essential auxiliaries produced as a proprietary item by an engine Manufacturer. This DEP does not include packaging of the driven equipment.

The scope of this DEP is for engines above 250 kW rated power. Special circumstances may dictate its application to smaller engines, such as for use in vital service.

Information regarding the specific engine will be given in the requisition.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F" as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, gas handling installations, chemical plants, oil and gas production facilities (both on- and offshore) and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, installation, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

The terminology used in this DEP is in accordance with ISO 2710.

All statements regarding engine power in this DEP are in accordance with ISO 3046-1.

The following are specifically defined:

Auxiliaries — That equipment necessary for the operation of the engine but not an intrinsic part of the engine. Auxiliaries are usually manufactured by a different Supplier.

Hazardous area 423-03-01, IEC 50 — An area in which an explosive gas mixture is or may be expected to be present in a quantity such as to require special precautions for the construction, installation and use of electrical apparatus.

ISO Power — The continuous power output of the engine at rated speed at the standard ambient conditions given in ISO 3046-1.

Package — This refers to the complete assembly of the engine, its auxiliaries, the driven machine and controls with or without a baseplate, which fulfils the Principal's desire for generation of electricity or the movement of gas or liquid. The package may include any associated process equipment relating to the driven machine.

Packager — The packager is the party responsible for the design, fabrication, assembly and testing of a package.

Requisition — Information exchanged prior to order placement, using data/requisition sheets DEP 31.29.80.93-Gen.

Service Power — The power output of the engine at the most severe ambient conditions given in the requisition. Refer also to (2.3).

Vital Service — A service in which, if equipment fails in operation or fails when called upon to operate, an unsafe condition on the installation or jeopardy to life or major damage to the installation can be caused. The requisition will identify if the service is vital.

1.4 ABBREVIATIONS

BICERI : British Internal Combustion Research Institute. (111/112 Buckingham Avenue, Slough SL1 4PH, England).

ESD : Emergency shutdown.

IEC : International Electrotechnical Commission.

ISO : International Organisation for Standardization.

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (12).

1.6 ACTION ITEMS

A list of action items which need to be resolved when using this DEP are given in (11). The action items are cross-referenced to the appropriate section of this DEP by the letter 'A' and a number which appears in the left-hand margin of the page concerned.

1.7 ORDER OF PRECEDENCE

Unless otherwise agreed the following precedence of standards shall apply:

1. National or legal codes or regulations
2. The Requisition
3. This DEP
5. Other Shell and external standards referenced herein.

Any conflict of requirements which cannot be resolved by the above order of precedence shall be referred to the Principal for resolution.

2. BASIC REQUIREMENTS

2.1 APPLICABLE STANDARD

It is intended that engines shall be designed and supplied generally in accordance with ISO 3046 parts 1 to 7. This DEP provides specific requirements amplifying the requirements of the International Standard.

2.2 RANGE OF APPLICATION

The driven machines will include alternators, pumps (including firewater pumps) and compressors in a variety of duties. The engine will in general be supplied to a packager who will undertake the packaging of the engine into a complete unit to fulfil the Principal's requirement for electric power or fluid movement.

The engines will be in continuous or intermittent use in vital or non-vital service as described in the requisition. The engine shall be suitable for continuous unattended baseload operation for 24 hours per day at the extremes of ambient conditions given in the requisition.

(A1) Engines in vital service shall be guaranteed by the Manufacturer to be able to accept full load within 10 seconds of receiving the starting signal. Any shorter period required on a specific project will be given in the requisition.

The fuel specification will be given in the requisition; the Manufacturer shall guarantee that the fuel is suitable for the engine at the service power. See also (3.4.1).

If the Manufacturer proposes a turbocharged version of an engine originally developed for natural aspiration, the suitability of the engine to meet the operating requirements shall be demonstrated by means of design calculations and service references.

2.3 POWER OUTPUT, FUEL AND LUBRICANT CONSUMPTION

The service power of the engine in accordance with ISO 3046-1 shall be the continuous power available at the drive coupling of the engine after deduction of all engine driven auxiliaries. The Manufacturer shall state the auxiliaries driven by the engine and their power absorbed in computing the rated power.

Engine driven fuel and lubricating oil pumps and separate lubricators for valve gear or cylinders are regarded as engine components and not auxiliaries within the context of the declaration of power per ISO 3046-1.

The ISO power is to be derated to the service power at the most severe ambient conditions under which the engine will operate.

The service power of the engine as defined in ISO 3046-1 shall be not less than 110% of the maximum power required by the driven equipment under extremes of driven equipment operating conditions.

The fuel and lubricant consumption at the above declared powers shall be declared by the Manufacturer.

2.4 TECHNICAL AUDIT

The Principal reserves the right to review and check any part of the design of the equipment to be supplied, using his own expert or a consultant employed for the purpose. The Manufacturer shall make available to such an expert or consultant all the necessary drawings or other information to enable him to make any check calculations or analyses as he may consider necessary. The expert or consultant will, if so required by the Manufacturer, give a written undertaking not to divulge such information or drawings to any other party except as is necessary to satisfactorily complete his review or check.

In the event of a conflict between any calculations, analyses or recommendations made by the expert or consultant and the corresponding calculations, analyses, etc., made by the Manufacturer, every effort shall be made to resolve such conflicts and arrive at a mutually

acceptable solution.

In the extreme, if mutual agreement cannot be reached, the Principal shall have the right to insist that any modifications, additional calculations or additional tests recommended by the expert or consultant be made. If the Principal does overrule the Manufacturer in this way, it is clearly accepted that the Manufacturer's responsibilities, both contractually and in relation to the costs of any modifications, additional tests, etc., shall be limited to the extent indicated by the Manufacturer's calculations or design, unless it can be shown either at the time or subsequently by, for example, the analysis of test results that the Manufacturer's calculations or designs were in error.

2.5 BOUGHT-OUT ITEMS AND SUB-SUPPLIERS

The Principal shall be advised if:

- the Manufacturer proposes to purchase any item from sub-suppliers (except standard fasteners and other small items covered by internationally recognised standards), and
- there is any intent to employ sub-suppliers to partly or wholly manufacture any part of the equipment or its auxiliaries.

Any purchase from or manufacture by sub-suppliers shall be disclosed to the Principal as soon as possible, in any case before the orders for such items are placed. The Principal shall have the right to request that a nominated sub-supplier and/or type of equipment be substituted for the Manufacturer's initial selection for any reason including rationalisation, past experience in similar service or technical superiority. If such requests are made before or at the time of placing the order, they shall be considered mandatory. Requests for substitutions made after the order is placed shall not be refused by the Manufacturer without good reason.

Alternatively, the Principal may, at the outset, nominate suppliers from whom certain items (e.g. instruments) shall be obtained.

2.6 MATERIAL IDENTIFICATION AND TRACEABILITY

The Manufacturer shall operate and maintain an effective material control system. The Manufacturer shall submit, via the packager if applicable, a description of the quality assurance procedures in place at the engine production facility.

The Manufacturer shall have an acceptable system of numbering all replaceable parts. The part number shall completely define the part, including the materials from which it is made. For example, two items which are dimensionally identical but are made from different material shall have different part numbers.

The Principal shall have the right to review, inspect and monitor the operation of the Manufacturer's materials control systems.

2.7 UNCONVENTIONAL MANUFACTURING METHODS

The Manufacturer shall declare to the Principal his intention to use any unconventional methods to manufacture any item or component.

NOTE: An unconventional method is a method of manufacture which the particular Manufacturer has not used for closely similar items for a sufficient period for the items to have been proved satisfactory in service. For example, fabrication by welding of components which hitherto have been cast or otherwise made from one solid piece.

2.8 RESPONSIBILITY

Engines will be purchased generally as an integral part of a driven equipment package. It is intended that this DEP be used by the Contractor or packager with whom the purchase order is placed and, if they are not one and the same, by the Manufacturer with whom the Contractor or packager places a sub-order for supply of the engine.

Overall responsibility for the package lies with the packager, who shall ensure that the engine complies with the requirements of the overall package specification as well as this

DEP.

2.9 OFFSHORE INSTALLATION

2.9.1 Certifying authority

(A2) If an engine is specified to be installed on an offshore installation, the design of the engine and its auxiliaries shall comply with the requirements of the appropriate Certifying Authority. Certifying Authorities are Det Norske Veritas, Lloyd's Register of Shipping, or the appropriate authority in the area of operation.

2.9.2 Weight control

The Manufacturer shall provide as part of the proposal the estimated total installed and operating weight of each item of equipment to be supplied. This includes all auxiliaries regardless of whether they are supplied loose or not. The estimate shall not be exceeded by more than 10%.

Within a period as specified in the requisition, after receipt of an order the Manufacturer shall supply the weight and position of the centre of gravity of each piece of equipment as follows:

- as intended to be shipped including packing, temporary shipping constraints, lifting equipment, etc.
- as installed including all auxiliaries, etc.
- in operation, including the normal contents of process fluids, lubricants, etc.
- any auxiliary or component to be shipped separately
- any component or item greater than 200 kg or 25% of the total weight of the engine, whichever is the lesser (defined as a major component).

The above information shall be provided on a Weight/Centre-of-Mass data sheet DEP 30.10.01.92-Gen.

The Manufacturer shall operate a weight control programme and shall notify the Principal if at any time information becomes available indicating that the weight of the equipment or any major component differs from the data provided by more than 5% of the total weight. The Manufacturer shall weigh all components or auxiliaries as they are completed in their own workshops or received from sub-suppliers.

On completion of the engine and its auxiliaries the Manufacturer shall weigh the complete package and revise the initial estimates if necessary. The Weight/Centre of gravity data sheet shall then be issued as certified final.

2.10 EMISSION CONTROLS

(A3) The requisition will state the requirements for emission control on the engine to meet the legislation applicable to the installation.

Emission control equipment shall be an integral part of the engine package. Control of nitrogen and carbon oxides and unburnt hydrocarbons in the engine exhaust should be achieved by the design of the engine combustion system. Catalytic converters in the engine exhaust should be regarded only as a last resort to meet the emission requirements and shall be installed only with the agreement of the Principal.

All other fugitive emissions such as from crankcase breathers shall be suitably controlled as part of the engine design. Disposal of such vents into the engine air intake upstream of any filter is not permitted.

The Manufacturer shall provide a statement of the emissions from his engine and the method of achieving them. Any maintenance requirements to maintain emission levels shall be clearly documented in the operating manual.

If there are limits on emissions of sulphur oxides, the Principal will supply fuel to the engine treated to residual levels of sulphur compounds which will not infringe the local regulations.

2.11 TROPICALISATION

If an engine is to be installed in a hot and humid (tropical) climate, the engine and its electrical and instrumentation equipment shall be suitably designed and preserved to ensure reliable operation in the specified climate.

2.12 NOISE CONTROL

(A4) The Contractor or packager shall be responsible for meeting any noise limitations set by the Principal. The Manufacturer shall co-operate by providing noise spectra of the engine and auxiliaries and by providing attachments, supports, etc. for installation of any noise control equipment that may be necessary to meet the project noise specification. Any noise limitation for the package shall be given in the requisition.

2.13 ELECTRIC MOTORS

Alternating current electric motors shall comply with DEP 33.66.05.31-Gen.

2.14 HEATERS

Heaters may be specified for maintenance of satisfactory temperatures on idle engines in cold climates (3.6.5) (3.7.2). All heaters shall be fitted with integral thermostats to cut off the power when the fluid reaches the specified temperature. Power circuits supplying the heater shall be protected by miniature circuit breakers incorporating overload, short circuit and earth leakage protection, in accordance with IEC 947 or IEC 898. Heat dissipation from the heating element shall not exceed 2.3 W/cm^2 on heaters in hydrocarbon heating duty.

2.15 FIRE PUMPS

(A5) On certain installations the application of ANSI/NFPA 20, or other National Standard agreed with the Principal, may apply to engines driving fire pumps. This requirement will be stated in the requisition.

3. ENGINE AND AUXILIARIES DESIGN

3.1 GENERAL

3.1.1 Proven design

Equipment shall be selected from the Manufacturer's standard range of products. Prototype equipment will not be considered. Only equipment which is of a size, type, rating and method of manufacture with which satisfactory experience can be demonstrated, shall be supplied. Details of such equipment in service shall be provided by the Manufacturer.

3.1.2 Periodic inspection and overhaul

The time between major overhauls shall be at least 25 000 running hours for engines in continuous duty. The effect of frequent starting and of periods of idleness shall be taken into account when determining the time between major overhauls of engines in intermittent duty.

Unless otherwise agreed, minor overhauls should be limited to the following:

- cleaning or changing air, fuel and lube oil filters
- checking lube oil condition and magnetic chip collectors
- changing lube oil
- external lubrication as appropriate (e.g. governor linkage)
- checking fuel injection system
- checking cooling system
- checking valve clearances
- checking injection timing
- checking condition and tension of driving belts
- checking of emission control equipment
- external inspection for general condition, leaks, loose components.

The Manufacturer shall provide the following information:

- recommended periods between inspections, minor and major overhauls
- inspection, minor overhaul and major overhaul activities, together with the man-hours required for each
- weight of the heaviest component normally removed during major overhaul
- recommended oil and oil filter change frequency
- engine availability based on scheduled downtime
- spare parts and special tools required for major and minor overhauls.

3.1.3 Maintenance

The engine and its auxiliary equipment shall be designed and configured to optimise inspection/maintenance and overhaul activities. Components with a mass greater than 15 kg shall be provided with lifting lugs for mechanical handling during installation and maintenance.

The Manufacturer shall provide the following information:

- recommended space required around the engine for maintenance and overhaul, including any access platforms
- withdrawal distances of components
- maximum maintenance masses and lifting arrangements for them.

The Manufacturer shall provide barring gear for turning the engine during maintenance. The barring gear shall be pneumatic, unless the engine can be easily turned by hand. The barring gear shall allow engine rotation in either direction. The engine barring gear shall be interlocked with the engine starting system to ensure safety during maintenance.

To prevent the engine turning over inadvertently during maintenance, means shall be provided to lock the crankshaft in any position.

The cylinder firing order and the valve clearances shall be marked prominently on the engine block.

3.1.4 Direction of rotation arrow

The direction of rotation shall be permanently marked on the engine in a prominent position.

3.1.5 Hot surfaces

If, in the course of undertaking normal operational duties on a running engine, personnel need to take specific action to avoid contact with exposed hot surfaces, such surfaces shall be screened. Screening shall be provided, however, only if the exposed surface attains a temperature in excess of 70 °C under normal operational conditions. Hot surfaces shall not be insulated for personnel protection. See (5) for installations in hazardous areas.

Screening shall also be installed to ensure that the discharge from a crankcase breather and any leaks from the lubrication or fuel systems cannot reach any surfaces with a temperature greater than the autoignition temperature of lubricating oil or fuel. In general, surfaces with a temperature greater than 250 °C should be screened.

NOTE: The above clause also applies to external piping and connections thereon for supplying lubricating oil to the turbocharger.

3.1.6 Water Deluge

(A6) Engines will not normally be installed in compartments where there is a firewater deluge system. If there is a likelihood of the engine being subjected to deluge, it will be stated in the requisition. The engine and its electrical equipment shall then be protected to IEC 529 IP 55. Particular attention is required for protection of cable entries and junction boxes.

3.2 COMBUSTION AIR INTAKE SYSTEM

3.2.1 Air filter

The engine air filter shall comprise a minimum of two stages, an inertial stage followed by a replaceable dry media stage for all installations except where specified otherwise in the requisition.

The air filter shall remove 98% of all particles greater than 10 micrometres in SAE fine test dust when tested in accordance with the ASHRAE 52.

NOTE: In areas where there is a high loading of wind-blown sand or snow, consideration should be given to placing the air filter intakes at two metres or greater height above ground to reduce the loading on the air filter.

All air filters shall be sheltered from rain ingress.

The filter shall have means of removing debris arrested in the inertial stage.

The filter shall be fitted with a differential pressure indicator to show when the filter requires attention.

For marine and offshore installations, all components of the air filter shall be made from non-corroding materials. Stainless steel is preferred. Aluminium alloys shall not contain more than 3% magnesium. Paint or similar coatings shall not be applied to the internal surfaces of combustion air ducting downstream of the air filter.

3.2.2 Intake location and piping

If the air filter is to be installed remotely from the engine, the Manufacturer shall supply the filter loose. The pipework between the filter and the engine shall be either type 316L stainless steel or marine grade aluminium with less than 3% magnesium.

The Manufacturer shall recommend the size of the intake pipe between the filter and the engine, and shall review the Contractor's design to ensure that the pipework does not impose unacceptable strains on the engine. The Manufacturer shall supply a flexible joint between the intake pipe and the engine.

All external connections from the engine shall terminate in flanges to ANSI/ASME B16.5.

3.2.3 Blow-in doors

A blow-in door bypassing the intake filter is prohibited.

3.2.4 Water removal

A connection shall be provided downstream of any turbocharger aftercooler for removal of water condensed from the intake air.

3.2.5 Air Intake silencer

(A4) An air intake silencer shall be provided if the air intake noise level exceeds that permitted in the requisition.

3.2.6 Hazardous areas

See (5) for engines installed in a hazardous area.

3.3 EXHAUST SYSTEM

3.3.1 Silencer

(A4) The exhaust silencer shall be supplied by the Manufacturer, and shall attenuate the engine exhaust to 85 dB(A) at one metre unless otherwise specified in the requisition. The exhaust silencer shall have an integral spark arrester in accordance with EEMUA 107 if the exhaust discharges to a Zone 2 area. See (5).

3.3.2 Exhaust duct

The routing of the exhaust ducting from the engine termination to the discharge to atmosphere shall be agreed between the Principal and the Manufacturer. The Manufacturer shall advise the size of the exhaust pipe for remote discharge.

The design of the exhaust ducting shall be agreed between the Contractor or packager and the Manufacturer to ensure that excessive forces are not transmitted to the engine termination. The design of spring or flexible supports shall be reviewed by the Manufacturer. The Manufacturer shall provide an expansion bellows at the engine termination.

All external connections from the engine shall terminate in flanges to ANSI/ASME B16.5.

3.3.3 Corrosion protection

All carbon steel piping, silencers, etc. subjected to exhaust temperatures and exposed to the atmosphere shall be blast cleaned and flame sprayed aluminium coated for corrosion protection. Alternatively, type 316L stainless steel may be used.

3.3.4 Surface temperature

The Manufacturer's standard treatment for limitation of surface temperature of hot exhaust components for protection or for energy conservation will be acceptable. See also (3.1.5).

If dry insulation applied to hot surfaces is oil or water absorbent it shall be clad and sealed to prevent ingress of oil and water.

See (5) for engines installed in a hazardous area.

3.3.5 Exhaust heat recovery

The Manufacturer shall advise the maximum allowable back pressure on the exhaust of engines to be fitted with exhaust heat recovery systems. A graph of exhaust temperature and mass flow vs. engine power output shall be made available by the Manufacturer for engines being considered for this type of duty.

3.4 FUEL SYSTEM

3.4.1 Fuel quality

(A7) If the fuel is not specified, the engine shall be capable of operation on BS 2869 Classes Al or A2 diesel fuel. The Manufacturer shall advise the maximum allowable quantity and size of solids and water in the fuel oil upstream of the engine mounted filters.

3.4.2 Fuel supply pumps and filtration

The fuel supply and filtration system shall include at least the following:

- water and sediment trap/prefilter
- engine driven fuel supply pump
- fuel filter
- manual fuel priming pump(s).

Duplex fuel filters with a changeover valve shall be supplied unless specified otherwise in the Requisition. The filters shall be of the replaceable element type and readily accessible for maintenance. The elements shall be capable of removal with the engine running without breaking any fuel connections or disturbing the fuel pumps or other engine parts.

Fuel filters shall be equipped with a differential pressure indicator. Fuel filters and prefilters shall be fitted with sediment drain valves and vent valves for purging any air trapped in the filter.

The injector fuel spill shall be routed to the fuel day tank. This requirement does not apply if the Manufacturer has a standard system which returns the spill-back to the suction of the fuel injection pump.

3.4.3 Isolation valve

The Manufacturer shall provide a manually operated quick-acting fuel isolation valve for installation in the fuel supply line to the engine. This valve shall be additional to any automatic cutoff valves specified in any certifying authority rules.

3.4.4 Fuel system installation

The fuel system components in (3.4.2) and (3.4.3) shall be mounted either on the engine or supplied loose to the packager for mounting on the baseplate.

3.4.5 Day tank

(A8) A fuel oil day tank shall be supplied by the Manufacturer if specified in the requisition. The tank shall be manufactured from type 316L stainless steel. The tank shall be arranged to supply the engine by gravity via the prefilter and the fuel supply pumps.

The tank capacity shall be sufficient for not less than six hours continuous operation at full load, or other capacity or operating period that may be specified in the requisition.

The day tank shall be fitted with level gauge(s) and high and low level alarm switches. The low level alarm shall be set for half the running time design capacity of the tank, or as otherwise specified in the requisition. The inlet shall be fitted with a level control float valve if specified in the requisition, otherwise it shall be fitted with a snap-opening cap for manual filling.

The following connections are required on the tank: inlet, outlet, injector spill-back (if required), drain (with self-closing valve), overflow, vent line (with flame trap), manhole and nozzles for instrumentation. The nozzles welded to the tank shall be DN 50 minimum, concentrically reduced to the required flange size where necessary. The fuel outlet to the engine shall be not less than 50 mm above the bottom of the tank.

If the site ambient temperature given in the data sheets is below the cloud point of the specified fuel, the day tank shall be fitted with an electric heater. The heater shall comply with (2.15), and shall maintain the fuel at a temperature 20 °C above the fuel cloud point.

If practicable, the day tank shall be part of the engine installation. If its size dictates otherwise, it shall be supplied loose for installation on the package by the packager or into the Principal's structure.

3.5 FUEL INJECTION

The Manufacturer's standard selection of fuel injection pumps, fuel injectors and spill back arrangements will be acceptable.

3.6 LUBRICATION SYSTEM

3.6.1 Standard system

The Manufacturer's standard system of lubrication of on-engine moving parts will be acceptable unless otherwise specified in the requisition.

3.6.2 Filters

Full flow oil filters should be fitted as standard. Duplex filters with changeover valves will not be required provided that the maintenance schedule specifies a filter change no more frequently than with each lubricating oil change. Duplex full flow filters with manual changeover valves shall be fitted to engines in continuous vital service. In this case, the lubricating oil filters shall be fitted with indicators to show when the filters require changing.

Separate free-standing lubricating oil filters shall have a manual drain valve and a manual vent returning to the oil sump with a sight glass for removal of trapped air during filter changes.

3.6.3 Oil cooling

The lubricating oil cooler may be either included in the engine coolant circuit or separately cooled in an air cooled radiator or by an external water circuit. Selection of the cooling system shall be agreed between the Manufacturer and the Principal.

All lubricating oil piping and connections to a remotely mounted oil cooler shall be AISI Type 316L stainless steel.

The oil cooler shall be designed for 110% of the heat rejection at the engine Service Power at site conditions with the absolute maximum ambient temperature given in the Requisition.

NOTE: Any reduced design ambient temperature allowed for engine rating when installed in hot climates shall be ignored for radiator design.

Oil coolers cooled by separate water circulation systems shall be used only with the Principal's approval. The lubricating oil pressure shall at all times be greater than the coolant pressure. For seawater cooling the materials in contact with the seawater shall be of a corrosion resistant material approved by the Principal.

Air cooled oil coolers (radiators) should be included as a separate section of the engine coolant radiator.

3.6.4 Prelubrication

The Manufacturer shall advise if a prelubrication pump is required for rapid starting of the engine. The prelubrication pump shall be supplied by the Manufacturer. Either a manual, pneumatic or electric prelubrication pump will be specified in the requisition.

If the engine is to be installed in a vital service requiring rapid starting, starting shall not be delayed by a prelubrication period. If the engine design requires prelubrication prior to starting, the Manufacturer shall include a prelubrication pump control which runs the prelubrication pump for five minutes in each hour that the engine is on standby. The Manufacturer shall confirm the suitability of this prelube for engines in vital service.

If a turbocharged engine is fitted with a prelubrication pump, it shall run for not less than 10 minutes after engine shutdown to supply lubricating oil to the turbocharger during cool down. The Manufacturer shall apply other arrangements to prevent heat soak into the turbocharger bearings upon engine shutdown on engines without prelubrication pumps.

3.6.5 Cold climates

Multigrade lubricating oils should be used for achieving satisfactory lubrication during rapid starting in cold climates. The Principal's approval shall be obtained for lubricating oil heating. Heaters shall comply with (2.14).

3.6.6 Condition monitoring

The lubricating oil circuit shall be fitted with a $^{1}/_{2}$ inch NPT plugged connection as defined in ANSI/ASME B1.20.1 between the oil pump and the oil filters for the Principal to install magnetic chip detectors and an oil sampling cock.

3.6.7 Fire prevention

Any external lubricating oil piping shall be designed such that a fracture of the piping or leakage from any joint will not cause lubricating oil to spray onto any surface at a temperature exceeding 250 °C.

3.6.8 Automatic oil makeup

If specified in the requisition, the oil sump shall be fitted with an adjustable oil level controller and slow-flow meter.

3.7 ENGINE COOLING

3.7.1 Coolant

The engine shall be cooled by water with added scale and corrosion inhibitors. The Manufacturer shall advise the method of coolant temperature control, which will be acceptable unless otherwise specified.

Glycol will be added to the water if ambient temperatures stated in the requisition are below +5 °C. The cooling system shall in this instance be suitable for a mixture of up to 50% ethylene glycol in water. The Manufacturer shall advise on acceptable scale and corrosion inhibitors. The selection shall take account of any light alloy and elastomer materials in the cooling system.

The cooling system shall be provided with an expansion tank, level indicators, pressure relief valve and filling connections. The expansion tank shall have sufficient volume to allow for the thermal expansion of the water or water/glycol mixture. The expansion tank may be either separate from or integral with the radiator according to the Manufacturer's standard design.

All low and high points in the coolant circuit shall be fitted with drain or vent cocks.

3.7.2 Cold climates

(A9) If the minimum ambient temperature specified in the Requisition is less than +5 °C the engine jacket cooling system shall be fitted with an electric heater. The heater shall be rated to achieve a minimum temperature of 45 °C in the engine block during the lowest specified ambient temperature. The heater shall be in accordance with (2.14) and the integral thermostat shall cut off the heater when the coolant temperature reaches 75 °C.

All engines driving fire pumps in accordance with ANSI/NFPA 20 shall be fitted with jacket coolant heaters. The Manufacturer shall advise the minimum temperature of the jacket coolant for rapid starting.

3.7.3 Radiator

The coolant shall be cooled in an air cooled radiator supplied by the Manufacturer, unless otherwise specified in the requisition. The radiator will be attached to the engine, free-standing for separate installation or included in associated package process equipment, as stated in the requisition. The radiator shall be designed for 110% of the engine heat rejection at the engine service power at site conditions with the absolute maximum ambient temperature given in the requisition.

NOTE: Any reduced design ambient temperature allowed for engine rating when installed in hot climates shall be ignored for radiator design.

The air flow through the radiator shall be away from the engine or towards the outside of the enclosure or vertically upwards as appropriate for the location of the radiator.

The blades of forced draft fans shall be of either aluminium alloy or anti-static reinforced plastic. The fan blades shall be designed to withstand an operating temperature of 120 °C. The fan ring for aluminium alloy blades shall be of a spark reducing material such as reinforced plastic or of brass.

NOTE: On engines packaged with the Manufacturer's standard integral radiators, the Manufacturer's standard engine driven steel bladed fans will be acceptable. See (5.) for installations in hazardous areas.

3.7.4 Fan drives

The radiator fans shall be either directly driven from the engine or by electric motors as specified in the requisition. If electric drive fans are specified in vital service, then they should be powered from the engine.

If the radiator is not mounted at the engine but the fan is supported on the engine, the arrangement of the radiator and fan drive shall be agreed between the Principal, the Contractor, the packager and the Manufacturer.

For fans with a diameter of 1.5 metres or greater that are directly driven from the engine, and for fans or if there are two or more fans on the same drive, a freewheeling clutch or passive hydraulic coupling shall be fitted to allow the fans to freewheel to rest upon shutdown of the engine. A single freewheel coupling on the engine power takeoff will be permitted for this purpose.

Flexible couplings in the fan drives shall be of the dry type.

3.7.5 Belt drives

Either toothed belts or V-belts are preferred for fan drives. All belt drives shall be in accordance with ISO standards 155, 254, 4183, 4184 or 5292. Driving belts shall be anti-static in accordance with ISO 1813.

3.7.6 Circulating water cooling

Engine cooling by separate water circulation systems shall be used only with the Principal's approval. The jacket coolant pressure shall at all times be greater than the circulating water pressure. For seawater cooling the materials in contact with the seawater shall be of a corrosion resistant material approved by the Principal.

3.8 STARTING SYSTEMS

3.8.1 General

(A10) The type of starting system for the engine will be given in the requisition. One or more systems may be specified according to the duty of the engine.

Within the context of this DEP, a start is defined as a minimum of seven complete crankshaft revolutions at the engine firing speed. See (4.2.1) for automatic starting control.

3.8.2 Electric battery starting

The starting system shall be supplied complete with batteries, starter control, starter contactor and starter overspeed limiting switch. A timer shall limit the duration of each start attempt to approximately 12 revolutions at firing speed. Starting control may be integrated with the package control system (4.1).

A single set of starting batteries shall be provided (see below for fire pump engines). Batteries shall be of the nickel-cadmium or lead-acid recombination type and rated for twelve sequential starts. The batteries shall be supplied empty of electrolyte unless of the lifetime sealed type. Electrolyte shall be supplied separately in sealed, unbreakable containers for addition to the batteries during commissioning on the installation site.

Batteries shall be provided with a ventilated, steel-reinforced plastic battery box. The box lid shall be constructed such that, in the event of mechanical damage, the battery terminals will not be short circuited. The lid shall also be securable when open as well as when closed. The battery boxes shall protect the batteries against displacement, excessive temperature, vibration, mechanical impact or flooding with water. The batteries within their boxes shall be readily accessible for servicing.

(A11) Batteries shall be charged either by an AC mains charger supplied by the Manufacturer or by an engine driven alternator as specified in the requisition. Both an engine driven alternator and a mains battery charger may be specified in the requisition, in which case an automatic change-over system shall also be supplied.

Battery chargers and change-over systems shall be installed in the engine control panel, if supplied.

Dual sets of batteries shall be provided for engines driving fire pumps unless two alternative methods of starting are supplied. Each set of batteries shall provide the performance specified herein. Start attempts shall alternate between battery sets.

3.8.3 Pneumatic start

The Manufacturer shall state whether the engine starts by a pneumatic motor driving the flywheel or direct air injection into the cylinders.

The pneumatic system will be specified in the requisition, using either compressed air or hydrocarbon gas. The latter may be specified if the engine drives a gas compressor or a pump on a production installation.

Exhausts from hydrocarbon gas pneumatic starters shall be piped to discharge vertically upwards outside any hazardous area which may be created by the driven equipment, and outside the radius from the engine air intake for the Zone 1 area created by the starter exhaust. The exhaust line shall have a drain leg to prevent rain ingress reaching the starter motor.

The Manufacturer shall supply control and shutdown valves to admit the pneumatic supply to the starter. The control valves shall be integrated into the engine starting control logic. The starters shall disengage when the engine has reached self-sustaining speed and not after a fixed period of time. However, if the engine fails to start within the time required for 12 complete revolutions the starting controls shall abort the start.

Turbine type starter motors are preferred over sliding vane or other type of starter motor requiring lubricant to be injected into the pneumatic supply. All starter motors shall be fitted with overspeed cut-out valves.

Engines with direct air injection starting shall be fitted with a check valve at the supply end of the starting air manifold on the engine. The starting air manifold shall also be fitted with a bursting disc to relieve explosion pressure within the manifold. An oil coalescer shall be fitted to the air supply to the engine, upstream of the starting air control valve and check valve.

3.8.4 Starting air system

(A12) If a starting air supply system is specified in the requisition to be supplied by the Manufacturer, it shall comprise two starting air compressors, air receiver, safety relief valves, air blast coolers, start and stop switches and swing adsorber units.

The air compressors shall be sized for replenishing the air receivers to full starting air pressure from the minimum allowable starting air pressure in not more than 15 minutes. An air compressor driven by the engine should be either declutched or unloaded following completion of filling the air receivers.

The air receiver shall be sized for six consecutive starts of any engine served by the system, including any turbocharger starting air assistance. Physical size may require more than one vessel for the air receiver; use of multiple vessels shall be agreed with the Principal. A DN 25 flanged connection (ANSI/ASME B16.5) with isolation and check valves in the starting air system shall be provided for connection to the Principal's air system for initial charging.

3.8.5 Hydraulic start

3.8.5.1 Hydraulic system

The hydraulic start system shall be complete and integrated with the engine.

The accumulator shall be automatically recharged by an engine-driven pump. The engine-driven pump shall be sized to completely charge the accumulator in not more than 15 minutes when operating at design speed. The Manufacturer shall describe the method of declutching the engine-driven pump once recharging is complete. The power absorbed by the engine driven pump shall be advised by the Manufacturer. A hand pump for recharging the accumulator shall be supplied with the system.

(A13) If specified in the requisition the Manufacturer shall provide an additional charging pump, either powered electrically or by the Principal's compressed air system.

3.8.5.2 Accumulator capacity

The accumulator capacity shall be sufficient for a minimum of six starts unless otherwise specified in the requisition. One or more accumulators may be necessary depending on the size of the pressure vessels.

The Manufacturer shall advise on the feasibility of providing a large accumulator to be recharged by the engine-driven pump or other mechanical pump, plus an accumulator sufficient for one start which may be recharged by hand pumping.

3.8.5.3 Depletion of the accumulator

Each start attempt shall be distinct and separate. If the engine fails to start within the time required for 12 complete revolutions the starting control system shall abort the start.

3.8.5.4 Monitoring

An alarm shall annunciate when the accumulator pressure falls to a level below which an engine start cannot be completed. Pressure gauges shall be provided to enable system performance to be monitored.

3.9 SPEED GOVERNING

The engine speed shall be governed in accordance with the requirements of ISO 3046-4.

The type of governor will depend on the driven machine. For governor requirements for generator drives, refer to DEP 33.65.11.32-Gen. Mechanical governors will generally be acceptable on mechanical drives. For mechanical drives, accuracy Class B2 is required for variable speed operation.

The Manufacturer shall advise the power variation band as defined in Clause 5.4.3 of ISO 3046-4.

The maximum downward speed range of the drive will be dependent on the match of engine torque at reduced speed to the torque required by the driven machine at the same speed. The minimum speed shall be determined by a minimum of 10% margin between the engine torque and the driven machine torque under the process conditions when the driven machine is running at the reduced speed.

NOTE: Reciprocating compressors impose a severe restraint on engine speed reduction since their mean torque is virtually independent of speed.

The requisition will state if external speed control is required to be applied to the governor.

3.10 OVERSPEED PROTECTION

The engine shall be fitted with an overspeed device in accordance with ISO 3046-6. This device shall shut down the engine by shutting off the fuel independently of the speed governor.

The overspeed device shall be manual reset only.

See (5) for engines installed in a hazardous area.

3.11 TORSIONAL VIBRATION

The assessment and prevention of torsional vibration in the engine and its driving train shall be as specified in ISO 3046-5.

The Manufacturer shall provide all the necessary information regarding the engine to the packager to enable the torsional vibration calculations to be done.

Alternator drives shall be regarded as having a speed range of 90 to 110% of synchronous speed for the torsional analysis.

Use of torsionally flexible couplings and torsional dampers (separate from those fitted as standard to the engine) for tuning the torsional critical speeds will require the approval of the Principal.

The Manufacturer shall advise the life of viscous type torsional dampers fitted to the engine.

3.12 LATERAL VIBRATION AND VIBRATION SUPPRESSION

The Manufacturer shall provide the anticipated lateral vibration levels of the engine relating to measurements made directly on the crankcase or main frame of the engine, expressed both as a filtered response at each of the major excitation frequencies and as unfiltered vibration with the engine running at rated power and speed. The vibration information shall include the magnitude and direction of unbalanced primary and secondary unbalanced forces and couples.

Suitable anti-vibration mounts shall be supplied to limit the engine vibrations transmitted to the foundations or surroundings if a vibration analysis study reveals that the package requires isolation from the supporting structure. Anti-vibration mounts shall be of totally enclosed design suitable for the environment, and shall have an isolation efficiency of at least 90% in respect of all engine induced vibrations.

Unless otherwise dictated by the arrangement of the engine and the driven equipment or by the lateral vibration analysis, any anti-vibration mounts required shall be installed between the baseplate and the supporting structure. The packager shall supply the anti-vibration mounts if the baseplate falls within his scope of supply, otherwise they shall be supplied by the Manufacturer.

Full details, including drawings, of the anti-vibration mounts shall be submitted to the Principal together with the frequencies and magnitude of any unbalanced forces and moments that will be transmitted through the supports into the supporting structure.

3.13 SHAFT COUPLINGS AND GUARDS

The packager will usually supply any shaft couplings between the engine and the driven equipment, unless otherwise stated in the requisition.

All couplings shall be either flange bolted to shafts or be hydraulically fitted to cylindrical or tapered shafts. Couplings requiring heating for installation or removal are prohibited.

All couplings shall be of the non-lubricated type.

All moving parts shall be protected from human contact by suitable guards of either sheet or mesh material. All such guards shall be non sparking. Aluminium is not regarded as a non-sparking material.

Guards for belt drives (3.7.5) shall be of the open mesh type.

3.14 CRANKCASE EXPLOSION RELIEF

Engines having a crankcase volume of over 0.6 m^3 shall be provided with crankcase explosion relief devices. Explosion relief valves of the BICERI design (or approved equal) with integral flame traps shall be used. Sufficient relief valves shall be installed to provide more than 115 cm^2 of relief valve free lift area per m^3 of crankcase volume.

Dipsticks and/or filler caps shall be effectively secured against ejection following a crankcase explosion.

The crankcase breather shall be as small as possible and located to minimise air inrush into the crankcase following an explosion.

3.15 BASEPLATE

(A14) Unless otherwise specified in the requisition, engines and driven equipment shall be mounted on a single rigid baseplate for ease of alignment and installation.

If the Manufacturer provides a baseplate under the engine, it shall be designed to be bolted and dowelled to the driven machine baseplate to form a single, rigid continuous baseplate supporting the complete driving train. The engine and driven equipment shall be rigidly attached to the baseplate. Any anti-vibration or three-point mounts shall connect the baseplate to the supporting structure, see (3.12).

All baseplates shall have a drip pan and rim with DN 50 class 150 ANSI/ASME B16.5 flanged drain connections in strategic locations.

NOTE: The baseplate will usually be supplied by the packager.

3.16 PIPING

Piping shall be designed in accordance with ANSI/ASME B31.3, or alternative approved by the Principal.

The Manufacturer's on-engine piping shall be designed in accordance with ANSI/ASME B31.3, or alternative approved by the Principal.

All connections shall be conveniently located near the extremities of the engine or appropriate auxiliary, without the need for the Principal to route piping on the engine or its auxiliaries. All connections shall be rigidly anchored and fitted with flexible connections in a material suitable for the service. Reinforced elastomers are acceptable for non-hydrocarbon duty. For lubricants and fuel, convoluted stainless steel reinforced by stainless steel braid flexible connections shall be supplied. Flexible elements shall be flanged to ANSI/ASME B16.5.

All external connections from the engine shall be flanged to ANSI/ASME B16.5.

The Manufacturer shall review the design of interconnecting piping for correct size, rating and to ensure that unacceptable strains are not imposed on the engine or its auxiliaries.

Seawater piping on the package shall be of a corrosion resistant material approved by the Principal.

4. INSTRUMENTATION AND CONTROLS

4.1 GENERAL

(A15) The requisition will state the operating mode of the engine. The following outlines a range of possible alternatives:

- fully manual with a minimum of automation
- manual initiation of an automatic start or stop sequence
- fully automatic start, load acceptance and stop initiated by a local or remote signal.

The instrumentation for control and monitoring supplied with the engine shall implement the proposed operating mode.

For engines not supplied with a control panel the sequencing and protection equipment shall be installed in a weathertight enclosure mounted on the engine.

ESD pushbuttons shall be either flap-protected or of the twist-and-push type.

Instrumentation and control systems shall be fail-safe.

4.2 START AND STOP SEQUENCE

Irrespective of the operating mode selected in (4.1), the following sequences shall be observed during starting and stopping of an engine.

4.2.1 Starting

The engine shall start directly upon receiving the start signal. If prelubrication is required, the start shall be delayed until prelubrication has been completed. However, starting shall not be delayed on engines in vital duty, in which case the requirements of (3.6.4) shall provide prelubrication.

Engines fitted with automatic starting systems shall abort the start if the engine fails to fire after 12 revolutions. The engine shall rest for eight seconds before another start is attempted. After six abortive start attempts the engine shall shut down, lock out and an alarm shall be raised.

4.2.2 Stopping

For a normal stop of the engine it shall be unloaded and, if the nature of the driven machine allows, the speed shall be reduced to idling for a cool-down period. The Manufacturer shall advise the required cool-down idling period. The engine shall then be stopped by cutting off the injection of fuel.

Upon receipt of an ESD signal, the engine shall be stopped directly.

4.2.3 Electric auxiliaries

If an automatic sequence is specified, electrical auxiliaries such as cooling fans shall be started and stopped by signals initiated in the Manufacturer's start and stop sequence controls. The signal shall operate the electrical starters in the Principal's motor control centre.

4.3 ENGINE GAUGE BOARD

A stainless steel gauge board shall be attached to the engine, equipped with the following:

- Lubricating oil pressure gauge
- Engine coolant temperature gauge
- Lubricating oil temperature gauge
- Engine tachometer and service hours meter (if not fitted in a control panel)
- Start and stop pushbuttons
- ESD pushbutton.

4.4 MONITORING AND PROTECTION

(A16) The engine shall be supplied with monitoring and protection instruments as specified in the requisition. The requisition will call for a selection of the monitoring and protection functions from (Appendix 1). The selection will be made according to the size of the engine and the nature of the installation, whether in vital or other service, manned or unmanned operation.

All solid-state programmable logic monitoring and protection is preferred. If electric power is not available, a fully pneumatic control and monitoring system shall be supplied. Monitoring and control systems which are a mix of electronics and pneumatics should be avoided.

Annunciators shall indicate the status of the engine. For example: running, stopped and ready, stopped and unavailable, and ESD. Annunciators shall indicate the status of all alarm and shutdown functions. Annunciators shall indicate "first-out" of any alarm or shutdown. The colour of annunciators will be given in the requisition.

Irrespective of the operating mode of the engine, all controls shall be centralised either at the gauge board or the control panel as appropriate.

The engine ESD system shall accept a signal from the Principal's system to initiate an engine ESD. Upon any ESD affecting the engine, manual reset of the engine's system at the engine or its control panel shall be required before restarting.

If automatic start and stop sequences are specified, a selector switch shall be fitted with the following positions:

- Engine off and unavailable
- Ready to start - local manual start
- Ready to start - remote signal

The positions for permitting the engine to start shall permit a local pushbutton or a remote signal for the two starting positions respectively to implement an engine automatic starting or stopping sequence.

4.5 CONTROL PANEL

(A17) If specified in the requisition the engine shall be supplied with a free-standing control panel. The control panel shall be waterproof and manufactured from type 316L stainless steel not less than 2 mm thick, with all panel hardware in stainless steel in compatible grades. The control panel shall be designed in accordance with the hazardous area classification specified in the requisition. If the control panel is to be located in an exposed environment or in a firewater deluge area, the enclosure shall be designed to provide protection to a minimum of IEC 529 IP 55. Gaskets or seals shall be provided for all joints.

The control panel shall be supplied complete with all internal electrical wiring and/or pneumatic circuits. Wiring shall be loomed with identified terminations within the control panel. Panel equipment operating at more than 24 volts shall be protected to a minimum IP 30 in accordance with IEC 529. Power, analogue and digital instrument wiring shall be segregated into different trays or ducts within the panel and shall have separate terminal strips.

An anti-condensation heater and thermostat shall be installed, in accordance with (2.14). Only natural ventilation shall be used for cooling.

The location of the control panel, whether adjacent to the engine or in a control room, will be given in the requisition. If the control panel is to be installed adjacent to the engine it shall be supported on suitable anti-vibration mounts.

The engine control panel shall include the control functions to fulfil the requirements of (4.4). In addition, it shall have:

- annunciator panel
- start and stop buttons
- lamp test button (only for electrical system)
- alarm/shutdown accept button
- ESD pushbutton

Alarm acceptance shall change the fault indication from a flashing to a steady light (only for electrical system).

The control panel shall provide sufficient space and openings to accommodate the applicable driven equipment instrumentation, indicators and controls. Alternatively, the control panel shall be designed for installation as part of a suite of control panels for the package. It shall be the responsibility of the packager to coordinate these requirements with the Manufacturer.

4.6 CUSTOMER CONNECTIONS

All customer instrumentation, control and power connections to the engine or control panel shall be terminated on terminal strips in separate junction boxes. Separate junction boxes shall be provided for analogue and digital signals and for power and pneumatic connections.

5. INSTALLATION IN HAZARDOUS AREAS

(A17) Wherever possible engines should not be installed in hazardous areas as defined by IEC 79. However, the nature of the driven machine may dictate otherwise. In exceptional circumstances it may be necessary to install an engine in vital duty in a Zone 1 area, such as in fire pump duty. No engine should be installed in a Zone 0 area.

Engines installed in hazardous areas shall comply with EEMUA 107 and this DEP.

Air intakes shall be located in a non-hazardous area.

Screwed pipe fittings shall not be used on any part of the fuel system piping or on the day tank (3.4). Seamless tubing with stainless steel compression fittings will be acceptable.

An exhaust conditioner box is not required if the exhaust discharge is in a non-hazardous area.

If flame arresters or traps are installed, they shall comply with BS 7244.

Exhaust manifolds and turbocharger turbine casings shall be water cooled or water jacketed. Permeable dry insulation is not acceptable for limitation of surface temperature.

All electrical equipment shall be certified for the hazardous area, including electric starter motors and starter solenoids. The starter batteries shall be installed outside the hazardous area.

The control panel shall be designed for the hazardous area classification if it is to be mounted adjacent to the engine. Air pressurisation of the panel is not an acceptable means of meeting the required classification.

Radiator fan blades shall be of non-metallic material.

Engines driving pumps for flammable liquids shall be separated from the pump by means of a sealed diaphragm wall of sufficient size to prevent liquids leaking from the pump from spraying onto the engine. The diaphragm wall shall be designed to allow maintenance of the engine and driven equipment with the minimum of dismantling. Extra long spacer couplings or quill shafts may be required to fulfil this requirement.

In addition to the protection devices listed in (Appendix 1), the engine shall additionally shut down on high coolant or lubricating oil temperature.

6. PAINTING

The engine and auxiliaries shall be painted in accordance with the Manufacturer's standard for a marine environment, subject to approval by the Principal. The Manufacturer shall submit the painting specification for review. The specification shall include surface preparation, paint materials, application, film thicknesses and the paint Supplier's data sheets. Stainless steel components shall not be painted.

7. SPECIAL TOOLS

All special tools necessary for assembly, dismantling and service of the engine and its auxiliaries and controls shall be supplied by the Manufacturer. The special tools shall be supplied in a lockable steel cabinet with the engine.

One set of special tools will be sufficient for multiple engines to be installed on the same site.

A list of the special tools and their application shall be included in the operating manual.

8. INSPECTION AND TESTS

The engine shall be subjected to tests in accordance with ISO 3046-2 before delivery from the Manufacturer's works. The measurements and measuring points shall be in accordance with the engine group number as defined by ISO 3046-2.

Engines for installation offshore shall in addition be subjected to the tests required by the responsible classification society.

(A18) The fuel used for performance tests shall be as close as practicable to the specified fuel. If necessary, the Principal will supply a sufficient quantity of the specified fuel for the tests if it is not commercially available.

If the engine is purchased for operation in a hot climate the works performance test shall be conducted with coolant and intake air temperatures adjusted to correspond with the maximum ambient temperatures on site.

NOTE: On engines with turbocharger aftercoolers the intake manifold temperature may be adjusted by regulating the coolant flow to the aftercooler for the test.

Any special tests per list E of ISO 3046-2 shall be conducted as dictated by the requirements of the requisition. These will include compliance with emission limits where these are imposed.

Tests in conjunction with the package driven machinery will be defined in the requisition.

Pressure vessels shall be tested in accordance with the code to which they were designed.

The Principal reserves the right to witness any or all tests.

9. PRESERVATION FOR SHIPPING

The engine and its auxiliaries shall be prepared for the type of shipment specified, including blocking of rotors if necessary. Blocked rotors shall be identified by corrosion-resistant tags attached with stainless steel wire. The preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment with no disassembly required before operation. If storage for a longer period is contemplated, the Principal will consult with the Manufacturer regarding the recommended procedures to be followed.

The packager shall provide instructions for maintaining the integrity of the preservation for the period between arrival at the job site and startup. If the engine is to be incorporated into a package, the Manufacturer shall provide instructions for preservation of the engine during packaging and any subsequent storage.

The equipment shall be prepared for shipment after all tests and inspections have been completed, the equipment painted and released by the Principal for shipping.

The interior of all equipment shall be clean, free from scale, welding spatter and foreign objects. Mechanical equipment shall be sprayed or flushed with a suitable rust preventive that can be removed with solvent. Rust preventive shall be applied through all openings while the engine is slow-rolled.

Internal steel areas of the engine and carbon steel oil systems, auxiliary equipment and piping shall be coated with a suitable oil-soluble rust preventive.

Preservation agents containing calcium or silicone compounds are prohibited as they cause subsequent foaming of the lubricating oil.

All coolants shall be drained from the engine, radiator and piping. The interior of the coolant system shall be preserved by a water soluble film.

To preserve the fuel system on the engine during transport and storage, the engine shall be run in the Manufacturer's works for sufficient time to purge the entire fuel system with BS 2869 Class A1 or Class A2 fuel doped with suitable corrosion and gum inhibitors.

All flanged openings shall be closed with metal closures 5 millimetres thick, with elastomer gaskets and at least four full-diameter bolts. Plastic or wooden plates/closures are not acceptable. All open ends of drains, vents, instrument tubing and small bore piping connections shall be capped or plugged with metal caps or plugs, as applicable. Threaded caps and plugs shall be used for threaded connections. Grease fittings shall be protected with plastic caps.

Exposed shafts and shaft couplings shall be wrapped with waterproof, mouldable waxed cloth or vapour phase inhibitor paper. The seams shall be sealed with oil proof adhesive tape.

Auxiliary piping connections on the engine and its auxiliaries shall be die stamped or permanently tagged to agree with the Manufacturer's connection table or general arrangement drawing.

If vapour phase inhibitor compounds in bags are inserted into large cavities the bags shall be attached in an accessible area for ease of removal. Vapour phase inhibitor locations shall be clearly identified by corrosion resistant tags and metal wire.

Internal bracing or supports for shipping shall be clearly identified, preferably by painting in a distinctive colour.

See (3.8.2) for battery shipping requirements.

Lifting points and the centre of gravity shall be clearly identified on the equipment package. A recommended lifting arrangement shall be provided by the Manufacturer.

The equipment shall be identified by item and serial number. Material shipped separately shall be identified by securely attached corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended. Crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the crate.

A copy of the Manufacturer's standard installation and operating instructions shall be packed with the engine.

10. MANUFACTURER'S INFORMATION

The Manufacturer shall provide information to the Principal in accordance with ISO 3046-1 as a minimum. Information shall be conveyed primarily by completing the requisition. The list below is typical of the information required:

- Graphs of specific fuel consumption, power and torque vs. speed shall be furnished for variable speed drives.
- Statements of lateral and torsional critical speeds, Campbell diagrams for critical speeds in accordance with (3.11).
- Unbalanced forces and couples in accordance with (3.11).
- Weights, dimensions and centres of gravity.
- Arrangement and detail drawings.
- Operating and maintenance manuals containing information for the correct installation, commissioning and maintenance of the engine and its auxiliaries. The manual shall contain information such as special alignment and grouting procedures, utility specifications including quantities for first fill and replenishment.
- Complete spare parts lists for both initial commissioning, two years operation and insurance spare parts.

Unless otherwise specified in the requisition, the language of all documentation shall be English.

11. ACTION ITEMS

Within this DEP there are sections where the Principal is required to supply information to the Manufacturer. The main action items are listed in this section, together with the section number to which they refer.

A1 If the engine is in vital service and starting in less than 10 seconds is required. (2.2).

A2 Advise if the engine requires certification by a certifying authority or classification society. (2.9.1).

A3 State the requirements for emission controls. (2.10).

A4 Allowable noise levels. (2.12), (3.2.5), (3.3.1).

A5 The application of ANSI/NFPA 20 to the engine. (2.15).

A6 Location of an engine in an area likely to be subjected to firewater deluge. (3.1.6).

A7 Fuel specification. (3.4.1).

A8 Requirement for a fuel day tank, its fittings and location. (3.4.5).

A9 Cold climates. The minimum ambient temperature at which jacket coolant heaters are required. (3.7.2).

A10 Type of starting system to be chosen. (3.8.1).

A11 Engine driven alternator for battery charging. (3.8.2).

A12 Starting air system by Manufacturer or others. (3.8.4).

A13 Additional charging pump on a hydraulic start system. (3.8.5.1).

A14 Supply of baseplate. (3.15).

A15 Operating mode. (4.1).

A16 The scope of monitoring and protection instrumentation. (4.4) and (Appendix 1).

A17 Supply of a control panel. (4.5).

A18 Location of the engine in a hazardous area. (5).

A19 Principal to supply fuel for tests, if not commercially available. (8).

12. REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments, supplements or revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Data sheet for weight control	DEP 30.10.01.92-Gen.
Data/requisition sheet for internal combustion engines	DEP 31.29.80.93-Gen.
Packaged unit AC generator sets	DEP 33.65.11.32-Gen.
Electric motors Cage-induction and synchronous type	DEP 33.66.05.31-Gen.

AMERICAN STANDARDS

General purpose pipe threads	ANSI/ASME B1.20.1
Pipe flanges and flanged fittings	ANSI/ASME B16.5
Chemical plant and petroleum refinery piping	ANSI/ASME B31.3

Issued by:
American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017
USA.

Standard for the installation of centrifugal fire pumps	ANSI/NFPA 20

Issued by:
American National Standards Institution
11 W. 42nd Street
New York, NY 11036
USA.

Method of testing air- cleaning devices used in general ventilation for removing particulate matter	ASHRAE 52

Issued by:
American Society of Heating, Refrigeration
and Air Conditioning Engineers
1791 Tullie Circle N.E.
Atlanta, GA 30329
USA.

BRITISH STANDARDS

Fuel oils for non-marine use - Parts 1 and 2	BS 2869
Flame arresters for general use	BS 7244

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
England
United Kingdom.

Recommendations for the protection of diesel engines for use in zone 2 hazardous areas	EEMUA 107

Issued by:
The Engineering Equipment and
Materials Users Association
14 Belgrave Square
London SW1X 8PS
United Kingdom.

INTERNATIONAL STANDARDS

Electrical apparatus for explosive gas atmospheres	IEC 79
Degrees of protection provided by enclosures (IP Code)	IEC 529
Circuit breakers for overcurrent protection for household and similar installations	IEC 898
Low voltage switchgear and control gear	IEC 947

Issued by:
Central Office of IEC
3 Rue de Varembé
1211 Geneva 20
Switzerland.

Belt drives; pulleys; limiting values for adjustment of centres	ISO 155
Quality, finish and balance of transmission pulleys	ISO 254
Antistatic endless V-belts - electrical conductivity-characteristics and methods of test	ISO 1813
Reciprocating internal combustion engines - Vocabulary	ISO 2710
Reciprocating internal combustion engines:	
Part 1 - Specifications for standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption	ISO 3046-1
Part 2 - Test Methods	ISO 3046-2
Part 3 - Specification for test measurements	ISO 3046-3
Part 4 - Speed governing	ISO 3046-4
Part 5 - Torsional vibrations	ISO 3046-5
Part 6 - Specification for overspeed protection	ISO 3046-6
Part 7 - Specification for codes for engine power	ISO 3046-7
Belt drives - classical and narrow V-belts - Grooved pulleys	ISO 4183
Belt drives - Classical and narrow V-belts - lengths	ISO 4184

Industrial V-belt drives - calculation of power ratings ISO 5292

Issued by:
Central Secretariat of the ISO
P.O. Box 56, CH1211 Geneva 20
Switzerland.

Copies can also be obtained from national standards organizations.

APPENDIX 1 ENGINE MONITORING AND PROTECTION INSTRUMENTATION

(A16) This list is comprehensive and is intended to cover all types of installation. It does not imply that all the instrumentation, alarms and shutdowns listed herein are to be installed on every installation. It should be remembered that the reliability of an engine installation is seriously compromised by an improper selection of instrumentation, in particular alarms and shutdowns.

The minimum essential instruments are indicated with an asterisk.

Whether an indicator is local or on the control panel will be dictated by the site installation. Note (4.3) for the engine gauge board requirements.

Refer to (5) for additional instrumentation for engines operating in a hazardous area.

MONITORING AND PROTECTION INSTRUMENTATION			
Function	Indication	Alarm	Shutdown
GENERAL			
Engine speed	X*	H L	HH* LL
Hours run	X*		
Turbocharger speed	X	H L	HH LL
Engine vibration	X		HH
Cylinder head vibration(1)	X		
Turbocharger vibration	X	H	HH
Fan vibration	X	H	HH
Start sequence	X		
Start sequence fail	X	X	X
Controls fail	X	X	X
Mode of operation (4.1)	X		
Crankshaft keyphaser	X		
TEMPERATURE			
Lube oil to engine	X*	H L(3)	HH
Lube oil to cooler	X	H	HH
Lube oil from cooler	X	H L	HH
Coolant to engine	X	H L	HH
Coolant from engine (2)	X*	H	HH*
Air inlet manifold	X		
Exhaust - each cylinder	X	XH XL	
Exhaust - turbocharger inlet	X		
Exhaust - turbocharger outlet	X		
Main bearings	X		HH
Big end bearings	X		HH
Turbocharger bearings	X		HH

Function	Indication	Alarm	Shutdown
PRESSURE			
Lube oil	X*	L	LL*
Coolant	X	L	LL
Air inlet manifold	X		
Exhaust to turbocharger	X		
Starting air	X*	L	
Hydraulic start accumulator	X*	L	
DIFFERENTIAL PRESSURE			
Lube oil filter	X*	H	HH
Air filter	X*	H	HH
LEVEL			
Lube oil sump	X*	L	LL
Coolant	X*	L	LL
Air filter oil bath	X*		
Fuel day tank	X*	H L	
ELECTRICAL/INSTRUMENTS			
Mains power	X*		
Battery voltage	X*	L	
Battery charger on	X*	L	
Instrument power	X*	L	
Instrument pneumatic pressure	X*	L	

* Indicates essential indication and ESD functions.
(1) One per cylinder head for combustion diagnostics.
(2) Sensing points on each cylinder block.
(3) Start permissive.
X Indicates a requirement.
H Indicates alarm on high warning.
L Indicates alarm on low warning.
HH Indicates shutdown on high exceedance.
LL Indicates shutdown on low exceedance.