

SPARK IGNITED GAS FUELLED ENGINES

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DESIGN AND ENGINEERING PRACTICE



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TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	ABBREVIATIONS	6
1.5	CROSS-REFERENCES	6
1.6	SUMMARY OF CHANGES SINCE PREVIOUS EDITION	7
1.7	ACTION ITEMS	7
1.8	ORDER OF PRECEDENCE	7
2.	BASIC REQUIREMENTS	8
2.1	APPLICABLE STANDARD	8
2.2	RANGE OF APPLICATION	8
2.3	POWER OUTPUT, FUEL AND LUBRICANT CONSUMPTION	8
2.4	TECHNICAL AUDIT	8
2.5	BOUGHT-OUT ITEMS AND SUB-SUPPLIERS	9
2.6	MATERIAL IDENTIFICATION AND TRACEABILITY	9
2.7	UNCONVENTIONAL MANUFACTURING METHODS	9
2.8	RESPONSIBILITY	9
2.9	OFFSHORE INSTALLATION	10
2.10	EMISSION CONTROLS	10
2.11	TROPICALISATION	11
2.12	NOISE CONTROL	11
2.13	INSTALLATIONS IN HAZARDOUS AREAS	11
2.14	ELECTRIC MOTORS	11
2.15	HEATERS	11
3.	ENGINE AND AUXILIARIES DESIGN	12
3.1	GENERAL	12
3.2	COMBUSTION AIR INTAKE SYSTEM	14
3.3	EXHAUST SYSTEM	15
3.4	FUEL SYSTEM	16
3.5	IGNITION SYSTEM	19
3.6	LUBRICATION SYSTEM	20
3.7	ENGINE COOLING	22
3.8	STARTING SYSTEMS	24
3.9	SPEED GOVERNING	26
3.10	OVERSPEED PROTECTION	27
3.11	TORSIONAL VIBRATION	28
3.12	LATERAL VIBRATION AND VIBRATION SUPPRESSION	29
3.13	SHAFT COUPLINGS AND GUARDS	30
3.14	CRANKCASE EXPLOSION RELIEF	31
3.15	BASEPLATE	32
3.16	PIPING	33
4.	INSTRUMENTATION AND CONTROLS	34
4.1	GENERAL	34
4.2	START AND STOP SEQUENCE	34
4.3	ENGINE GAUGE BOARD	34
4.4	MONITORING AND PROTECTION	35
4.5	CONTROL PANEL	35
4.6	CUSTOMER CONNECTIONS	36
5.	INSTALLATION IN HAZARDOUS AREAS	37
6.	PAINTING	39
7.	SPECIAL TOOLS	40
8.	INSPECTION AND TESTS	41

9.	PRESERVATION FOR SHIPPING	42
10.	MANUFACTURER'S INFORMATION	43
11.	ACTION ITEMS	44
12.	REFERENCES	45
13.	BIBLIOGRAPHY	48

APPENDICES

APPENDIX 1	ENGINE MONITORING AND PROTECTION INSTRUMENTATION	49
APPENDIX 2	FUEL SYSTEM	51

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for stationary spark ignited gas fuelled 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 with 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.

This DEP is a revision of the DEP of the same number dated October, 1994; a summary of the main changes since the previous edition is given in (1.5).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI and SIEP, 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, construction, 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	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 whether the service is vital.

1.4 ABBREVIATIONS

BICERI	:	British Internal Combustion Research Institute. (111/112 Buckingham Avenue, Slough SL1 4PH, England).
ESD	:	Emergency shutdown.
SAE	:	Society of Automotive Engineers (American)

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 SUMMARY OF CHANGES SINCE PREVIOUS EDITION

The previous edition of this DEP was dated October 1994. The DEP has been reviewed and revalidated. Other than editorial changes, the following are the main changes since that edition:

Old section	New section	Change
General		IEC references updated
2.1	2.1	ISO reference modified
---	2.13	New section on hazardous area installations
3.2.1	3.2.1	ASHRAE reference modified
3.5	3.5	Revised text on ignition system hardware and added requirements for functionality and installation
5	5	Revised, expanded text on hazardous area installations
12	12	References updated

1.7 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.

1.8 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 Part 1 and Parts 3 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 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.

The fuel gas composition will be given in the requisition; the Manufacturer shall be required to guarantee that the fuel is suitable for the engine at the service power.

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.

For the computing of power as defined in ISO 3046-1, engine driven lubricating oil pumps and separate lubricators for valve gear or cylinders are regarded as engine components and not auxiliaries.

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 case, 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

- (A1) 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.

NOTE: Certifying Authority design and construction rules normally relate to oil fuelled compression ignition engines. These rules should be interpreted as far as possible for their application to spark ignited engines.

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 mass/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 mass/centre of mass data sheet shall then be issued as certified final.

2.10 EMISSION CONTROLS

- (A2) 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 gas 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 shall be suitably designed and preserved to ensure reliable operation in the specified climate.

2.12 NOISE CONTROL

- (A3) 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 INSTALLATIONS IN HAZARDOUS AREAS

All electrical equipment shall be certified for, and all installation methods suitable for, use in the area installed. All installations should be suitable for a minimum Zone 2 hazardous area, unless otherwise specified by the Principal. See (5) for additional requirements for hazardous area installations.

2.14 ELECTRIC MOTORS

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

2.15 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 60947 or IEC 60898. Heat dissipation from the heating element shall not exceed 2.3 W/cm^2 on heaters in hydrocarbon heating duty.

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;
- lubricating as appropriate (e.g. governor linkage);
- checking spark plugs/ignition leads;
- checking cooling system;
- checking valve clearances;
- checking ignition 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, and 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 system 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

- (A4) 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 60529 IP 55. Particular attention is required for cable entries, junction boxes and the ignition system.

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 µm in SAE Fine test dust when tested in accordance with ASHRAE 52.1.

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 least 2m above ground to reduce the loading on the air filter.

All air filters shall be sheltered from rain ingress.

The filter shall have means for 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.

Unless absolutely essential, internal fasteners shall not be used downstream of the air filter. Where unavoidable, internal fasteners shall be positively secured.

Intake pipes 250 mm or larger in diameter shall be fitted with a BICERI type explosion relief valve with integral flame trap between the engine and the air filter (or the silencer, if fitted).

All external connections from the engine shall terminate in flanges to 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

- (A3) 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

- (A3) The exhaust silencer shall be supplied by the Manufacturer, and shall attenuate the engine exhaust to 85 dB(A) at 1 m unless otherwise specified in the requisition. The exhaust silencer shall have an integral spark arrester if the exhaust discharge is in a Zone 2 area (see (5)). An exhaust spark arrester shall be tested in accordance with SAE J 342 or J 350, in conjunction with SAE J 997.

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.

Exhaust pipes 250 mm or larger in diameter shall be fitted with a BICERI type explosion relief valve with integral flame trap between the engine and the silencer.

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.

Unless absolutely necessary, internal fasteners shall not be used in locations in the exhaust system where it is possible for them to fall back into the engine. Where unavoidable, internal fasteners shall be positively secured.

All external connections from the engine shall terminate in flanges to 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 is 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 backpressure 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

To prevent the fuel gas system from creating a hazardous area, it shall be designed and constructed strictly in accordance with this section.

NOTE: The design basis for the system specified herein is publication IM/17 and the VISA Voorschriften, both listed in the Bibliography (13).

3.4.1 Fuel gas

The gas shall be filtered and at a temperature not less than 10 °C above the hydrocarbon and water dewpoint of the gas. The Manufacturer shall state the fuel pressure required at the customer connection on the engine. The Principal shall supply fuel gas at that pressure at the ESD valve (3.4.3.1), plus a suitable allowance for pressure drop between the ESD valve and the engine. In general, fuel supply pressures in excess of 4 bar (ga) shall not be permitted.

3.4.2 On-engine fuel system

The Manufacturer's on-engine standard fuel system is acceptable. All-welded and flanged piping is preferred. Full details of the fuel system shall be supplied by the Manufacturer.

3.4.3 Fuel control

The control system for delivering fuel gas to the engine is shown in the diagram (Appendix 2) and the components are described in this section. This system shall be applied unless an alternative system is approved by the Principal.

3.4.3.1 ESD valve

This valve shall be connected into the ESD system via the engine monitoring and protection (4.4). The valve shall be capable of manual closing, but not manual opening.

NOTE: If the engine is not in an enclosure or building and is in a non-hazardous area, the ESD valve should be located 3 m from the engine package.

3.4.3.2 Isolation valve

This manual ball valve shall be located downstream from and adjacent to the ESD valve (3.4.3.1).

3.4.3.3 Strainer

The strainer shall be 200 µm nominal, and shall act only as a guard filter, the Principal having filtered the gas elsewhere to the required quality for the engine. The strainer shall be fitted with a drain valve.

3.4.3.4 Primary shutdown valve

This 3-port power operated valve shall be operated by the starting and shutdown logic in accordance with (4.2). When closed, the downstream side shall be vented to atmosphere.

Alternatively, a two-way valve may be used in conjunction with an automated vent valve (3.4.3.9) downstream of this valve.

3.4.3.5 Secondary shutdown valve

A second power operated shutdown valve in series with the primary shutdown valve (3.4.3.4). The action of this valve shall be the same as (3.4.3.4), and both together shall form a double block and bleed arrangement for isolating fuel from the engine.

3.4.3.6 Check valve

A swing-type or wing-type non-return valve to prevent pressure surges from engine "spit-back" disturbing the fuel system.