M78
(July 2018)
(Rev.1
Feb 2021)
(Rev.2
Jan 2024)
(Rev.3
Apr 2025
Complete
revision)
(Rev.4
Dec 2025)

Reciprocating Internal Combustion Engines Fuelled by Gases or Low-flashpoint Fuels

1 General

1.1 Scope

1.1.1 Type of engines and fuels used

This UR addresses the requirements for marine reciprocating internal combustion engines using gases or low-flashpoint fuels.

The engines can be dual fuel engines (hereinafter referred to as DF engines), gas fuel only engines (hereinafter referred to as GF engines), or any variations thereof including fuel sharing (variable fuel oil / gas ratio) capability.

The fuels covered by this UR include the following fossil, bio or synthetic variants of:

- Natural gas (predominantly methane)
- Ethane
- LPG (predominantly mixes of propane and butane)
- Methyl/ethyl alcohols (methanol/ethanol)
- Ammonia (anhydrous ammonia)

1.1.2 Application

This UR is to be applied in association with other relevant IACS internal combustion engine UR's, as far as found applicable to the specific engine design.

The mandatory IMO international codes for gas carriers (IGC Code) using their cargoes or other gaseous fuels as fuel, and for all other ship types burning gases or low flashpoint fuels (IGF Code), must also be considered, as applicable.

The internal combustion engine specific requirements of IGF Code 10.3 apply. For gas carriers, IGC Code 16.7 applies.

Specific requirements of the IGF Code as referenced in this UR shall be applied to engine types covered by this UR installed on any ship, regardless of type, size and trading area, as long as the IGC Code is not referenced or explicitly specified otherwise.

For IGF Code applications using methyl/ethyl alcohol fuels, MSC.1/Circ.1621 – *Interim Guidelines for the Safety of Ships using Methyl/Ethyl Alcohol as Fuel* apply.

For IGF Code applications using LPG as fuel, MSC.1/Circ.1666 – *Interim Guidelines for the Safety of Ships using LPG Fuels* apply.

For IGC Code applications using LPG cargo as fuel, MSC.1/Circ.1679 – *Interim Guidelines for use of Liquefied Petroleum Gas (LPG) Cargo as Fuel* apply.

M78
(cont)

For IGF Code applications using ammonia as fuel, MSC.1/Circ.1687 – *Interim Guidelines for the Safety of Ships using Ammonia as Fuel* apply.

Gases or low-flashpoint fuels are not permitted for engines used as the emergency source of power. Emergency generator engines used as a source of electrical power in port, may operate on all fuels for which they are designed when providing electrical power in port, but are not permitted to operate on gases or low-flashpoint fuels when providing the emergency source of power.

Notes:

1. The requirements of UR M78 are to be uniformly implemented by IACS Societies for engines for which the date of an application for type approval certification is dated on or after 1 July 2019.

2. The "date of an application for type approval" is the date of documents accepted by the Classification Society as request for type approval certification of a new engine type or of an engine type that has undergone substantive modifications, as defined in UR M44, in respect of the one previously type approved, or for renewal of an expired type approval certificate.

3. Engines with an existing type approval on 1 July 2019 are not required to be re-type approved in accordance with this UR until the current Type Approval becomes invalid. For the purpose of certification of these engines, the current type approval and related submitted documentation will be accepted in place of that required by this UR until the current type approval expires or the engine type has undergone substantive modifications, as defined in UR M44.

4. Rev.1 of this UR is to be uniformly implemented by IACS Societies for engines for which the date of an application for type approval certification is dated on or after 1 July 2022.

5. Rev.2 of this UR is to be uniformly implemented by IACS Societies for engines for which the date of an application for type approval certification is dated on or after 1 January 2025.

6. Rev.3 of this UR is to be uniformly implemented by IACS Societies for engines for which:
   i) The application date for type approval certification is on or after 1 January 2027;
   ii) New ships contracted for construction on or after 1January 2027.

7. Rev.4 of this UR is to be uniformly implemented by IACS Societies for engines for which:
   i) The application date for type approval certification is on or after 1 July 2027.
   ii) New ships contracted for construction on or after 1 July 2027.

M78
(cont)

1.2 Definitions

1.2.1 *Certified safe equipment* is equipment certified by an independent national test institution or competent body to be in accordance with a recognised standard for electrical apparatus in hazardous areas.

Note: Refer to IEC 60079 series, Explosive atmospheres and IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features

1.2.2 *Double block and bleed valves* means the set of valves referred to in:

- IGC Code, 16.4.5
- IGF Code, 2.2.9 and 9.4.4 to 9.4.6

1.2.3 *Dual fuel engine* ("DF engine") means an engine that can burn gases or low-flashpoint fuels (gas mode), and also always has the capability of running on fuel oil only (fuel oil mode).

1.2.4 *Explosion relief device* means a device to protect components and personnel against a determined overpressure in the event of an explosion. The device may be a valve, a rupture disc or other, as applicable.

1.2.5 *Fuel oil* means residual or distillate liquid marine fuels with a closed-cup flash point as required by SOLAS Chapter II-2, Part B, Regulation 4.2.1.1 and 4.2.1.2, and typically to the ISO 8217:2024 standard *Products from petroleum, synthetic and renewable sources – Fuels (class F) – Specifications of marine fuels*.

1.2.6 *Gas* means, for the purposes of this UR, gases or low-flashpoint fuels, whether in a liquid, liquefied or gaseous state.

Note: For DF engines the gas fuel is sometimes referred to as the 'alternative' or 'secondary' fuel. Gases and low-flashpoint fuels include natural gas (methane), ethane, LPG, methyl/ethyl alcohols and ammonia, including bio or synthetic variants.

1.2.7 *Gas admission valve* is a valve or injector on the engine, which controls gas supply to the cylinder(s) according to the engine's gas demand.

1.2.8 *Gas engine* means a DF engine, a GF engine, or any variations thereof.

1.2.9 *Gas fuel only engine* ("GF engine") means an engine capable of operating on gas fuel only and not able to switch over to fuel oil operation.

1.2.10 *Gas piping* means piping containing gas or air / gas mixtures.

1.2.11 *High pressure gas* means gas with a maximum working pressure greater than 10 bar gauge.

Note: For methyl/ethyl alcohol fuels, the applicability of high pressure requirements to be agreed with the Classification Society. Refer also to the footnotes to 7.3.6 and 7.3.12.6 of MSC.1/Circ.1621.

1.2.12 *IGC Code* means the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IMO Resolution MSC.370(93)), as amended.

M78
(cont)

1.2.13 *IMO* means the International Maritime Organisation.

1.2.14 *IGF Co*de means the International Code of Safety for Ships Using Gases or other Low-Flashpoint Fuels (IMO Resolution MSC.391(95)), as amended.

1.2.15 *Low-flashpoint fuel* means gaseous or liquid fuel having a flashpoint lower than otherwise permitted under paragraph 2.1.1 of SOLAS regulation II-2/4.

1.2.16 *Low pressure gas* means gas with a maximum working pressure lower or equal to 10 bar gauge. For methyl/ethyl alcohol applications see note to 1.2.11.

1.2.17 *Lower Heating Value* ("LHV") means the amount of heat produced from the complete combustion of a specific amount of fuel, excluding latent heat of vaporization of water.

1.2.18 *Methane Number* ("MN") is a measure of resistance of a gas fuel to knock, which is assigned to a test fuel based upon operation in a knock testing unit at the same standard knock intensity.

Note: MN is an indicator of the gas suitability for combustion of natural gas (predominantly methane) in gas engines using the Otto combustion process before knocking may occur and engine control system de-rating may occur. Pure methane is used as the knock resistant reference fuel, that is, methane number of pure methane is 100, and pure hydrogen is used as the knock sensitive reference fuel, methane number of pure hydrogen is 0.

1.2.19 *Pilot fuel* means the fuel that is injected into the cylinder to ignite the main gas-air mixture.

1.2.20 *Pre-mixed engine* means an engine where gas is supplied in a mixture with air through a common manifold for all cylinders, e.g. mixed before or after the turbocharger. Inlet manifold, turbo-charger, charge air cooler, etc. may contain gas/air mixtures during normal operation.

1.2.21 *Recognized standards* means applicable international or national standards acceptable to the Classification Society or standards laid down and maintained by an organisation which complies with the standards adopted by IMO and which are recognized by the Classification Society.

1.2.22 *Safety Concept* is a document describing the safety philosophy with regard to gas as fuel.

1.3 Documents and drawings to be submitted

1.3.1 Documents and drawings to be submitted for the approval of DF and GF engines.

The following documents are to be submitted for the approval of DF and GF engines, in addition to those required in UR M44.

All existing M44 documents that require updates due to the gas and low-flashpoint fuel specific changes to the design are also to be submitted.

M78
(cont)

No.	Item
1	Schematic layout or other equivalent documents of gas system on the engine
2	Gas piping system, assembly and details (including double-walled arrangement where applicable)3)
3	Parts for gas admission system, assembly and details (including sealing and cooling systems where applicable)3)
4	Arrangement of explosion relief valves (crankcase1), charge air manifold, exhaust gas manifold and exhaust gas system on the engine) as applicable
5	List of certified safe equipment and relevant certification
6	Safety concept4)
7	Report of the risk analysis2) (for information)
8	Gas specification(s) (for information)

1.3.2 Documents and drawings to be submitted for the approval of DF engine

No.	Item
9	Schematic layout or other equivalent documents of pilot fuel system
10	Shielding of high pressure fuel pipes for pilot fuel system, assembly
11	High pressure parts for pilot fuel injection system3)

1.3.3 Documents and drawings to be submitted for the approval of GF engine

No.	Item
12	Schematic layout or other equivalent documents of the ignition system

1.3.4 Where considered necessary, the Classification Society may request further documents to be submitted.

Footnotes:

1) If required by UR M44, see also 2.2.4.1.
2) See 1.4.
3) The documentation to contain specification of design pressures, working pressure, pipe dimensions and materials.
4) See 1.5.

M78
(cont)

Note: Operation and maintenance (service) manuals, as required by UR M44 Table 1 Footnote 4, are to be updated for the gas and low-flashpoint fuel specific aspects – see 1.5.1 of this UR.

1.4 Risk analysis

1.4.1 Scope of the risk analysis

The risk analysis is to address:

- a failure or malfunction of any system or component involved in the gas operation of the engine
- a gas leakage downstream of the double block and bleed valves (for methyl/ethyl alcohol fuels downstream of the remote operated shut-off valve required by 9.6.5 of MSC.1/Circ.1621)
- the safety of the engine in case of emergency shutdown or blackout, when running on gas
- the interactions between the gas supply system, the gas return/recovery system, the ammonia release mitigation systems (ARMS), as applicable, and the engine.

Note: With regard to the scope of the risk analysis it shall be noted that failures in systems external to the engine, such as gas storage, gas supply, gas return/recovery systems or ammonia release mitigation systems, may require action from the engine control and monitoring system in the event of an alarm or fault condition. Conversely failures in these external systems may, from the vessel perspective, require additional safety actions from those required by the engine limited risk analysis required by this UR. Such actions are to be detailed in the engine safety concept.

Note: A number of technologies may be used for ammonia release mitigation, for example, gas combustion, water scrubbing, absorption, air dilution, etc.

1.4.2 Form of the risk analysis

The risk analysis is to be carried out in accordance with international standard *IEC 31010:2019: Risk management - Risk assessment techniques*, or other recognized standards.

The required analysis is to be based on the single failure concept, which means that only one failure needs to be considered at the same time. Both detectable and non-detectable failures are to be considered. ~~Consequences~~ Consequential failures, i.e. failures of any component directly caused by a single failure of another component, are also to be considered.

1.4.3 Procedure for the risk analysis

The risk analysis is to:

a) Identify all the possible failures in the concerned equipment and systems which could lead:

M78
(cont)

1) to the presence of gas in components or locations not designed for such purpose, and/or

2) to ignition, fire, explosion or toxic releases (for methanol and ammonia engines).

b) Evaluate the consequences (see also 2.1.2)

c) Where necessary, identify the failure detection method

d) Where the risk cannot be eliminated, identify the mitigating measures:

1) in the system design, such as:

- redundancies
- safety devices, monitoring or alarm provisions which permit restricted operation of the system

2) in the system operation, such as:

- initiation of the redundancy
- activation of an alternative mode of operation.

The results of the risk analysis are to be documented.

1.4.4 Equipment and systems to be analysed

The risk analysis required for engines is to cover at least the following aspects:

a) failure of the gas-related systems or components, in particular:

- gas piping and its enclosure, where provided
- gas admission valves and sealing systems, as applicable

Note: Failures of the gas supply components not located directly on the engine, such as block-and-bleed valves and other components of the gas supply system, gas return/recovery system or ammonia release mitigation system, are not to be considered in the analysis, unless within the scope of supply, or specification, of the engine designer and are integral to the engine safety concept.

b) failure of the ignition system (pilot fuel injection, sparking plugs, glow plugs)

c) failure of the air to fuel ratio control system (charge air by-pass, gas pressure control valve, etc.)

d) for engines where gas is supplied upstream of the turbocharger compressor, failure of a component likely to result in a source of ignition (hot spots)

e) failure of the gas combustion or abnormal combustion (e.g. misfiring, knocking)

f) failure of the engine monitoring, control and safety systems

M78
(cont)

Note: Where engines incorporate electronic control systems, a failure mode and effects analysis (FMEA) is to be carried out in accordance with UR M44, Table 1, Footnote 5.

g) presence of gas in engine components (e.g. air inlet manifold or scavenge space and exhaust manifold) and in the external systems connected to the engines (e.g. exhaust duct, cooling water systems, lubricating oil system, hydraulic oil system, sealing oil system, etc.).

h) changes of operating modes for DF engines

i) hazard potential for crankcase gas accumulation for trunk-piston engines or gas accumulation in piston underside space for cross head engines, refer to IGF Code 10.3.1.2 and UR M10.6.

j) risk of crankcase explosion in connection with active crankcase ventilation which produces a flow of external air into the crankcase, (see UR M10).

k) hazard potential of toxic releases or leakage from crankcase and crankcase vent systems for trunk-piston engines, or the piston underside space (scavenge air space) for cross head engines, using methanol or ammonia as fuel.

l) as applicable, hazard potential of toxic release in case of leakage from expansion bellows or flexible hoses used in methanol or ammonia systems.

m) hazard potential of toxic releases from explosion relief devices including crankcase explosion relief valves for engines using methanol or ammonia as fuel.

1.5 Safety concept

1.5.1 Scope and general content of the safety concept

The safety concept is to describe the DF or GF arrangements of the engine and how the risks of using the gas or low-flashpoint fuel are mitigated, including any specific instructions to be included in the maintenance and operation manuals.

The document is to identify the safety philosophy of the engine design and describe how the risks associated with the fuel are controlled under reasonably foreseeable abnormal conditions as well as possible failure scenarios and their control measures.

To support understanding of the safety philosophy, the document is to describe the established safety concepts, including, as applicable but not limited to:

- combustion control;
- operating modes;
- double barriers including ventilation air requirements;
- gas leakage detection;
- sealing systems;
- safety valve arrangements;
- gas supply system including purging and draining philosophy (for both inner pipes and outer pipes);
- gas supply cooling systems;
- crankcase venting arrangements including active ventilation and underpressure arrangements (see 2.2.4.3);
- crankcase or piston underside space monitoring of gas accumulation;

M78
(cont)

- electrical equipment specifications including the necessity of using certified safe equipment;
- monitoring, control and safety actions related to gas supply systems, covering double block and bleed and master gas valve actions;
- monitoring, control and safety actions related to the gas return/recovery system and ARMS;
- gas return/recovery system and ARMS;
- nitrogen purging and venting systems;
- off-engine exhaust system explosion relief devices;
- off-engine exhaust system fan purging;
- auxiliary systems (e.g. lubricating systems);
- use of expansion bellows or flexible hoses (see 2.2.1.2 and 2.2.1.3); and
- safety principles regarding potential toxic releases from components and explosion relief devices, including crankcase explosion relief valves, for engines using methanol or ammonia as fuel (see 1.4.4 k) to m)).

1.5.2 Additional content of the safety concept

The results of the risk analysis, see 1.4, shall be reflected in the safety concept.

A detailed evaluation regarding the hazard potential of overpressure in crankcases, air inlet manifolds, scavenge spaces and exhaust systems, including potential of injury from a possible explosion and/or toxic release, and including how crankcase overpressure or fault condition is to be monitored, is to be carried out and reflected in the safety concept of the engine. Refer to 2.2.3 and 2.2.4.1.

Information regarding the crankcase ventilation and monitoring arrangements. Refer to 2.2.4.3.

Details regarding any single cylinder cut off functionality in gas mode operation. Refer to 2.2.5 and 3.2.1.

As applicable, information regarding potential gas leaks from pre-mixed engines. The safety concept is to consider the need for flame arresters before each cylinder. Refer to 3.3.1.

As applicable, information regarding possible gas accumulation in scavenge spaces and/or failure of piston rod stuffing box. Refer to 3.4.

The safety concept is to clearly identify the equipment that is part of the engine, gas supply system, gas return/recovery system and ARMS safety philosophy but is not within the scope of supply, or boundary, of the base engine. The equipment may be installed by (and is the responsibility of) third parties or integrators such as ship designers and shipyards. Exhaust system explosion relief valves and auxiliary system gas detection are examples.

Actions required of, or affecting, the engine control and monitoring system from equipment outside of the base engine, such as gas storage, gas supply, gas return/recovery or ARMS systems, are to be detailed in the engine safety concept.

The safety concept is to demonstrate how the requirements of this UR and the additional requirements of the IGF Code and IGC Code are complied with, including how any applicable goals and functional requirements are satisfied. Where deviations or alternatives from the prescribed requirements exist, or conflicts exist between the IGF and IGC Code requirements, the arrangements are to be justified by the safety concept.

M78
(cont)

Note: Deviations from the statutory requirements are to be agreed with the responsible flag Administration on a case-by-case basis.

2. Design Requirements

2.1 General Principles

2.1.1 The manufacturer is to declare the allowable gas composition limits for the engine and, as applicable, the minimum and maximum methane number.

2.1.2 Components containing or likely to contain gas are to be designed to:

a) minimise the risk of fire and explosion so as to demonstrate an appropriate level of safety commensurate with that of an oil-fuelled engine;

b) mitigate the consequences of a possible explosion to a level providing a tolerable degree of residual risk, due to the strength of the component(s) or the fitting of suitable explosion relief devices of an approved type.

The strength of the component(s) and arrangement of the explosion relief devices shall be documented (e.g., as part of the safety concept/risk analysis) or otherwise demonstrated to be sufficient for a worst-case explosion.

Also refer to the IGF Code 10.2.

2.1.3 Discharge from explosion relief devices shall prevent the passage of flame to the machinery space and be arranged such that the discharge does not endanger personnel or damage other engine components or systems.

For methanol and ammonia engines, where discharges may pose a risk due to toxicity, such releases are to be documented by the safety concept and considered by the risk analysis.

2.2 Design Requirements

2.2.1 Gas piping

2.2.1.1 General

The requirements of this section apply to engine-mounted gas piping. The piping shall be designed in accordance with the criteria for gas piping (design pressure, wall thickness, materials, piping fabrication and joining details etc.) as given in the IGF Code chapter 7, or IGC Code chapter 5 and 16, as applicable, for natural gas as fuel.

For IGF Code applications, MSC.1/Circ.1621 chapter 7 applies ~~for~~to methyl/ethyl alcohols, MSC.1/Circ.1666 chapter 7 applies ~~for~~to LPG and MSC.1/Circ.1687 chapter 7 applies for ammonia.

For IGC Code applications MSC.1/Circ.1679 also applies ~~for~~to LPG as fuel.

M78
(cont)

Table 1: Design pressure for gas pipes

	Design pressure	
Gas pipe, low pressure		
– Natural gas (methane)	see IGF Code 7.3.3.1	see IGC Code 5.4.1
- Methyl/ethyl alcohol	see MSC.1/Circ.1621, 7.3.1	-
- LPG	see MSC.1/Circ.1666; IGF Code 7.3.3.1	see MSC.1/Circ.1679; IGC Code 5.4.1
- Ammonia	see MSC.1/Circ.1687, 7.3.1	-
Gas pipe, high pressure		
– Natural gas (methane)	see IGF Code 7.3.3.1 and 7.3.4.4	see IGC Code 5.4.1 and 16.4.4
- Methyl/ethyl alcohol	see MSC.1/Circ.1621, 7.3.6	-
- LPG	see MSC.1/Circ.1666; IGF Code 7.3.3.1 and 7.3.4.4	see MSC.1/Circ.1679; IGC Code 5.4.1 and 16.4.4
- Ammonia	see MSC.1/Circ.1687, 7.3.1	-
Outer pipe, low pressure		
– Natural gas (methane)	see IGF Code 9.8.1 and 9.8.2	see IGC Code 5.4.4
- Methyl/ethyl alcohol	see MSC.1/Circ.1621, 9.4.4	-
- LPG	see MSC.1/Circ.1666, 9.3.6; IGF Code 9.8.2	see MSC.1/Circ.1679; IGC code 5.4.4
- Ammonia	see MSC.1/Circ.1687; IGF Code 9.8.2	-
Outer pipe, high pressure		
– Natural gas (methane)	see IGF Code 9.8.1 and 9.8.2	see IGC Code 5.4.4
- Methyl/ethyl alcohol	see MSC.1/Circ.1621, 9.4.4	-
- LPG	see MSC.1/Circ.1666, 9.3.6; IGF Code 9.8.2	see MSC.1/Circ.1679; IGC Code 5.4.4
- Ammonia	see MSC.1/Circ.1687; IGF Code 9.8.2	-
Open ended pipes		
– Natural gas (methane)	see IGF Code 7.3.3.2	see IGC Code 5.4.1
- Methyl/ethyl alcohol	-	-
- LPG	see MSC.1/Circ.1666; IGF Code 9.8.1 and 9.8.2	see MSC.1/Circ.1679; IGC code 5.4.1
- Ammonia	-	-

2.2.1.2 Expansion bellows

Where expansion bellows are permitted to be used in the gas system on the engine, these shall be double walled (except for single wall piping systems arranged in accordance with 2.2.2.2), equipped with a leakage detection system and type approved based on the requirements of IGF Code 16.7.2, and IGC Code 5.13.1.2, as applicable.

The number of cycles, pressure, temperature, axial movement, rotational movement and transverse movement which the bellows will encounter in actual service on the engine is to be specified by the engine designer.

M78
(cont)

Endurance against high cycle fatigue due to vibration loads shall be verified by testing or alternatively be documented by the Expansion Joint Manufacturers Association, Inc. (EJMA) calculation or equivalent (i.e., more than 10^7 cycles).

Note: The fatigue test due to ship deformations in IGF 16.7.2.4 is considered not relevant for bellows which are an integral part of the engine.

Where expansion bellows are permitted to be used in the gas system on the engine these are to be considered by the risk analysis and detailed in the safety concept.

2.2.1.3 Flexible hoses

Where flexible hoses are permitted to be used on the engine, these shall be double walled (except for single wall piping systems arranged in accordance with 2.2.2.2), equipped with a leakage detection system and type approved based on the requirements of UR P2.12 and are to be considered by the risk analysis and detailed in the safety concept.

Note: As per UR P2.12, flexible hoses are limited to 1,5 m in length.

2.2.2 Arrangement of the gas piping system on the engine

2.2.2.1 Normal “double wall” arrangement

The gas piping system on the engine shall be arranged according to the principles and requirements of the IGF Code 9.6. For gas carriers, IGC Code 16.4.3 applies.

The design criteria for the double pipe or duct are given in the IGF Code 9.8 and 7.4.1.4.

In case of a ventilated double wall, the ventilation inlet is to be located in accordance with the provisions of IGF Code, regulation 13.8.3. For gas carriers, IGC Code 16.4.3.2 and 16.9.5 applies.

In ventilated double wall piping systems, the outer pipe or duct is to be pressure tested at the design pressure calculated in accordance with 9.8.1 or 9.8.2 of the IGF Code to ensure gas tight integrity.

In pressurized double wall piping systems, the outer pipe or duct is to be pressure tested at 1.5 x the design pressure of the outer pipe or duct.

For IGF Code applications using methyl/ethyl alcohol fuels the double wall arrangement is to be in accordance with MSC.1/Circ.1621.

For IGF Code applications using LPG fuels the double wall arrangement is to be in accordance with MSC.1/Circ.1666.

For IGF Code applications using ammonia as fuel the double wall arrangement is to be in accordance with MSC.1/Circ.1687.

For ammonia systems, if the ammonia concentration in the secondary enclosure exceeds 110 ppm an alarm is to be activated. If the ammonia concentration exceeds 220 ppm the ventilation air is to be sent to the ARMS, or equivalent arrangement. Alternative alarm and shutdown levels may be considered where justified by the risk analysis and documented in the safety concept.

M78 (cont)

For IGC Code applications using LPG fuels the double wall arrangement is to be in accordance with MSC.1/Circ.1679.

2.2.2.2 Alternative arrangement

Single walled gas piping is only acceptable for natural gas (methane):

a) for engines supplied with low pressure gas and installed in ESD protected machinery spaces, as defined in IGF Code 5.4.1.2 and in compliance with other relevant parts of the IGF Code (e.g. 5.6);

b) in the case as per footnote 18 to paragraph 9.6.2 of IGF Code.

Note: For gas carriers, the IGC Code applies and ESD machinery spaces are not permitted.
.
Note: For IGF Code applications, single wall piping in LPG machinery spaces containing consumers is not to be applied, unless subject to special consideration by the Classification Society.

2.2.3 Charge air system and exhaust gas system on the engine

The charge air system and the exhaust gas system on the engine are to be designed in accordance with 2.1.2 above.

In case of a single propulsion engine installation, the engine is to be capable of operating at sufficient load to maintain power to essential consumers after opening of the explosion relief devices caused by an explosion event. Sufficient power for propulsion capability is to be maintained.

For single propulsion engine installations, explosion relief devices shall be of a self-closing type.

Continuous relief of exhaust gas (through open rupture disc) into the engine room or other enclosed spaces is not acceptable.

Note: Load reduction is to be considered on a case-by-case basis, depending on engine configuration (single or multiple) and relief mechanism (self-closing valve or rupture disk).

Explosion relief devices for air inlet and exhaust manifold, including those for exhaust pipes after the turbocharger, if fitted, shall be type approved according to UR M82.

The necessary total relief area and the arrangement of the explosion relief devices shall be determined taking into account:

- the worst-case explosion pressure depending on initial pressure and gas concentration,
- the volume and geometry of the component, and
- the strength of the component.

The arrangement shall be determined in the risk analysis (see 1.4.4.g) and reflected in the safety concept.

2.2.4 Engine crankcase

2.2.4.1 Crankcase explosion relief valves

M78
(cont)

Crankcase explosion relief valves are to be installed in accordance with UR M9. Refer also to IGF Code 10.3.1.2.

For engines not covered by UR M9, the detailed evaluation as required in 1.4.4.i is to determine if crankcase explosion relief valves are necessary.

For methanol and ammonia engines, where discharges may pose a risk due to toxicity, such releases are to be documented by the safety concept and considered by the risk analysis (see 1.4.4.m).

For methanol and ammonia trunk piston engines, a warning notice is to be fitted either on the local control stand or, preferably, next to the explosion relief devices on the engine. The warning notice is to indicate the risks identified in the safety concept, in particular the risk to personnel associated with the opening of the explosion relief devices.

2.2.4.2 Inerting

For maintenance purposes, on engines with a crankcase volume of 0,6 m^3 and above, a connection, or other means, are to be provided for crankcase inerting and ventilating and gas concentration measuring.

2.2.4.3 Crankcase ventilation

Ventilation of crankcase is to comply with UR M10.

Relevant evidence of the crankcase ventilation arrangements, together with details on the crankcase vent piping system, is to be documented in the safety concept.
The ventilation systems for crankcase, sump and other similar engine spaces are to be independent from the systems on the other engines.

Note: Closed crankcase ventilation systems may be considered.

2.2.4.3.1 Crankcase ventilation for methanol and ammonia engines

For methanol and ammonia trunk-piston engines where gas concentration in the crankcase is above the defined limits, the crankcase and connected vent piping shall be operated at underpressure relative to the engine room to prevent potential leakage.

For ammonia as fuel, crankcase underpressure ventilation is to be applied if the crankcase ammonia concentration is above 110 ppm, or as otherwise justified by the risk analysis and documented in the safety concept.

For methanol as fuel, crankcase underpressure ventilation is to be applied if the crankcase methanol concentration is above 730 ppm, or as otherwise justified by the risk analysis and documented in the safety concept.

Crankcase pressure is to be monitored and in case of loss of underpressure, the double block and bleed valves are to be automatically activated and switch to fuel oil mode (or shutdown for GF engines) is initiated in accordance with the safety concept and in accordance with Table 2.

For ammonia trunk-piston engines, the safety concept is to clearly indicate measures to control release of ammonia from crankcase vent systems.

M78
(cont)

2.2.5 Control, monitoring, alarm and safety systems

The engine control system is to be independent and separate from the safety system.

The gas admission valves are to be controlled by the engine control system or by the engine gas demand.

Combustion is to be monitored on an individual cylinder basis. In the case of knocking or misfiring, either the unstable combustion shall be corrected automatically by the control system, e.g. transient adjustments, or if a failure has occurred and can no longer be corrected by the control system the safety system is to be activated in accordance with Table 2.

In the event that poor combustion is detected on an individual cylinder, gas operation may be allowed in the conditions specified in IGF Code 10.3.1.6.

Where validated by the safety concept and risk analysis, the engine monitoring and safety system may be configured so that the gas supply double block-and-bleed valves and the switch to fuel oil (or shutdown for GF engines) may not be activated in case of specific failures affecting one cylinder, provided that the concerned cylinder can be individually cut off from gas operation and engine operation is acceptable with respect to torsional vibrations. Operation of the functionality is to be demonstrated at type test. Refer 4.1.7.2.

If monitoring of combustion for each individual cylinder is not practicable due to engine size and design, common combustion monitoring may be accepted.

Unless the risk analysis required by 1.4 of this UR proves otherwise, the monitoring and safety system functions for DF or GF engines are to be provided in accordance with Table 2 of this UR in addition to the general monitoring and safety system functions given by the Classification Societies.

2.2.6 Gas admission valves

Electrically operated gas admission valves shall be certified safe.

If they are not rated for the zone they are intended for, it shall be documented that they are suitable for that zone. Documentation and analysis are to be based on IEC 60079-10-1:2020 or IEC 60092-502:1999.

Gas admission valves operated by hydraulic oil system are to be provided with appropriate sealing arrangement to prevent gas from entering the hydraulic oil system.

M78
(cont)

TABLE 2: Monitoring and Safety System Functions for DF and GF Engines

Parameter	Alarm	Automatic activation of the double block-and-bleed valves[10)]	Automatic switching over to fuel oil mode[1)]	Engine shutdown
Abnormal pressures in the gas supply line	X	X	X	X [5)]
Gas supply systems - malfunction	X	X	X	X [5)]
Malfunction of ammonia release mitigation system	X			
Leak detection in annular space of double walled pipes[11)]	X	X	X	X [5)]
Pilot fuel injection or spark ignition systems - malfunction	X	X [2)]	X	X [2) 5)]
Exhaust gas temperature after each cylinder - high [12)]	X	X [2)]	X	X [2) 5)]
Exhaust gas temperature after each cylinder, deviation from average – low [3) 12)]	X	X [2)]	X	X [2)5)]
Cylinder pressure or ignition - failure, including misfiring, knocking and unstable combustion [12)]	X	X [2) 4)]	X [4)]	X [2) 4) 5)]
Oil mist concentration in crankcase or bearing temperature - high [6)]	X	X		X [9)]
Pressure in the crankcase – high [8)]	X	X	X	
Engine stops - any cause	X	X		
Failure of the control-actuating medium of the block and bleed valves	X	X	X	
Failure of crankcase ventilation system, if applicable [13)]	X	X [7)]	X [7)]	

Footnotes:

1) DF engine only, when running in gas mode.

2) The double block-and-bleed valves and the engine shutdown may not be activated in case of specific failures affecting only one cylinder, provided that the concerned cylinder can be individually cut off from gas operation. See 2.2.5.

3) Required only if necessary for the detection of misfiring.

4) In the case where the failure can be corrected by an automatic mitigation action, only the alarm may be activated. If the failure persists after a given time, the safety actions are to be activated. See 2.2.5.

M78
(cont)

5) GF engine only.

6) Where required by UR M10.

7) Automatic safety actions to be activated as specified by the engine manufacturer, see UR M10.

8) Only for trunk piston engines. Method for crankcase overpressure, or fault condition, monitoring to be detailed in the safety concept. See 1.5.2.

9) Only for trunk piston engines. For crosshead engines slow down shall apply (see UR M35 Tab.1).

10) For methyl/ethyl alcohol fuels activation of the remote operated shut-off valve required by 9.6.5 of MSC.1/Circ.1621.

11) Gas detection alarms and shutdowns in accordance with IGF Code Table 1: 'Monitoring of gas supply system to engines' or IGC Code 16.4.8. For methyl/ethyl alcohol fuels gas and liquid detection in accordance with MSC.1/Circ.1621 Table 15.1. For LPG fuels in accordance with MSC.1/Circ.1666. For ammonia in accordance with MSC.1/Circ.1687. Alternative alarm and shutdown levels will need to be justified by the risk analysis and documented in the safety concept. Note leak detection of annular space may be off-engine and not within engine scope of supply. See 2.2.2.1.

12) Where monitoring of exhaust temperature or combustion for each cylinder is not practicable due to the engine size and design, common combustion monitoring may be accepted. See 2.2.5 and UR M35.

13) Applies to crankcase and vent piping extraction ventilation systems required by 2.2.4.3 for ammonia and methanol engines, and where required by the engine safety concept.

M78
(cont)

3. Specific Design Requirements

3.1 DF Engines

3.1.1 Engine rating

The maximum continuous rating (MCR) that a DF engine can develop in gas mode may be lower than the fuel oil mode MCR of the engine, depending on the engine combustion concept, design features and gas composition.

This maximum continuous rating in gas mode and the corresponding conditions shall be stated by the engine manufacturer.

Where variable fuel oil / gas ratio modes of operation are offered by the engine manufacturer, details are to be included in the engine particulars and operation manuals.

3.1.2 Starting, changeover and stopping

DF engines are to be arranged to be started using either fuel oil or gas fuel with pilot fuel for ignition. The engines are to be arranged for rapid changeover from gas use to fuel oil use. In the case of changeover to either fuel supply, the engines are to be capable of continuous operation using the alternative fuel supply without interruption to the power supply.

Changeover to gas fuel operation is to be only possible at a power level and under conditions where it can be done with acceptable reliability and safety as demonstrated through testing.

Changeover from gas fuel operation mode to fuel oil operation mode is to be possible at all situations and power levels.

The changeover process itself from and to gas operation is to be automatic but manual interruption is to be possible in all cases.

If the power level or other conditions do not allow safe and reliable gas operation, changeover to fuel oil mode shall be automatically performed.

In case of shut-off of the gas supply, the engines are to be capable of continuous operation by fuel oil only.

3.1.3 Pilot fuel injection

Gas supply to the combustion chamber is not to be possible without operation of the pilot fuel injection.

In case of failure of the pilot fuel injection, the engine is to switch to fuel oil mode except if this failure is limited to one cylinder, subject to immediate cut off of the affected cylinder gas supply and provided that the safe operation of the engine is substantiated by the safety concept/risk analysis, is acceptable with respect to torsional vibrations and is demonstrated at the type test.

Note: Pilot fuel injection is to be monitored for example by fuel oil pressure and combustion parameters.

M78
(cont)

3.2 GF Engines

3.2.1 Spark ignition system

In case of failure of the spark ignition, the engine is to be shut down except if this failure is limited to one cylinder, subject to immediate cut off of the cylinder gas supply and provided that the safe operation of the engine is substantiated by the safety concept/risk analysis and demonstrated at type test.

3.3 Pre-Mixed Engines

3.3.1 Charge air system

Failures of charge air system components likely to result in a gas leakage are to be considered in the safety concept and risk analysis.

Flame arresters are to be installed before each cylinder head, unless otherwise justified in the safety concept/risk analysis, considering design parameters of the engine such as the gas concentration in the charge air system, the path length of the gas-air mixture in the charge air system, etc.

3.4 Two-stroke engines

3.4.1 Scavenge air system

The risk analysis required in 1.4 is to cover the possible gas accumulation in a scavenge space.

3.4.2 Crankcase

The risk analysis required in 1.4 is to cover the possible failure of a piston rod stuffing box.

3.5 Ammonia fuelled engines

3.5.1 Ammonia fuel system

The ammonia fuel system is to be designed to prevent direct release of ammonia to atmosphere in all normal operating modes and during any foreseeable and controllable abnormal scenario.

In cases where the master gas valve is automatically shutdown by the safety system, the complete fuel supply line downstream of the double block and bleed valve shall be:

- purged to the fuel tank or gas-liquid separator or similar device; and/or
- purged to the ARMS to gas free the engine fuel lines.

Where the ammonia fuel system has additional functionality when not delivering fuel, e.g. utilised for cooling fuel system components, then the arrangements are to be considered by the risk analysis required in 1.4 and detailed in the safety concept required by 1.5.

Note: Off-engine recovery or treatment systems will be required to recover or treat fuel or vent releases to acceptable levels, as required by MSC.1/Circ.1687. These ARMS are not within the scope of this UR but, as applicable, are to be considered by the engine risk analysis and safety concept - see 1.4 and 1.5.

M78
(cont)

3.5.2 Exhaust system

Exhaust systems are to be designed with a minimum number of flange connections.

The exhaust gases at point of release, including from emissions abatement systems (where fitted) are not to exceed 110 ppm ammonia concentration in normal operation.

Note: This may be verified during the statutory air emissions certification process or as requested by the Classification Society.

4. Type Testing, Factory Acceptance Tests and Shipboard Trials

4.1 Type Testing

4.1.1 General

Type approval of DF and GF engines is to be carried out in accordance with UR M71, taking into account the additional requirements below.

4.1.2 Type of engine

In addition to the criteria given in UR M87.5.2.1 the type of engine is defined by the following:

- gas admission method (cylinder injection after compression stroke, cylinder-individual injection before compression stroke or pre-mixed)
- gas admission valve operation (mechanical or electronically controlled)
- ignition system (pilot fuel injection, spark ignition, glow plug or gas self-ignition)
- ignition system (mechanical or electronically controlled)

Note: Cylinder-individual injection before compression stroke may be port injection into the air inlet channel before the cylinder inlet valve, injection into the cylinder before or during compression stroke, or similar arrangements.

4.1.3 Safety precautions

In addition to the safety precautions mentioned in UR M71.9.2, measures to verify that gas fuel piping on engine is gas tight are to be carried out prior to start-up of the engine.

4.1.4 Test programme

The type testing of the engine is to be carried out in accordance with UR M71.6, taking into account the additional requirements of this UR.

The influence of methane number and LHV for natural gas (methane), together with the scope of potential gas compositions specified for the range of fuels covered by this UR, is not required to be verified during the Stage B type tests. It shall however be justified by the engine designer through the internal Stage A tests or calculations and documented in the type approval test report.

4.1.5 Measurements and records

M78
(cont)

In addition to the measurements and records required in UR M71.7, the following engine data are to be measured and recorded:

- Each fuel index for fuel oil and gas as applicable (or equivalent reading)
- Gas pressure and temperature at the inlet of the gas manifold
- Pilot fuel temperature and pressure (supply or common rail as appropriate)
- Gas concentration in the crankcase
- Gas concentration in the double wall piping or secondary enclosure

Note: The gas concentration in the crankcase may be measured inside the crankcase or at the crankcase outlet (crankcase vent pipe). Gas concentration measurements may be carried out as part of Stage A if the method and the results are properly documented.

Additional measurements may be required in connection with the design assessment.

4.1.6 Stage A – internal tests

In addition to tests required in UR M71.8, the following conditions are to be tested:

- DF engines are to run at the load points defined in UR M71.8 in both fuel oil (with and without pilot fuel injection in operation, as applicable) and gas modes as found applicable for the engine type.
- For DF engines with variable fuel oil / gas ratio, the load tests are to be carried out at different ratios between the minimum and the maximum allowable values.
- For DF engines, switch over between fuel oil and gas modes are to be tested at different loads.
- The influence of methane number and LHV of the gas on the engine's maximum continuous power available in gas mode is to be verified and documented in the type approval test report.

4.1.7 Stage B – witnessed tests

4.1.7.1 General

Gas engine testing is to be carried out in accordance with the different tests specified in UR M71.9, as applicable.

In case of DF engine,

- All tests must be run in both fuel oil and gas modes that apply for the engine type as defined by the engine designer. The load tests are to be carried out in fuel oil mode and in gas mode at the different percentages of the engine's applicable MCR.
- The independent overspeed protection device need only be tested in fuel oil mode (UR M71.9.2.2).
- The operation with damaged turbocharger test required by UR M71.9.3.2 need only be verified in fuel oil mode.

M78
(cont)

- For engines with variable fuel oil / gas ratio, selected load tests are to be carried out at different ratios between the minimum and the maximum allowable values. The most relevant and critical loads and ratios are to be selected for the test and agreed with the Classification Society before testing.

- The maximum continuous rated power available in gas mode (see 3.1.1) is to be demonstrated.

- Overload testing is not required in gas mode for DF engines, provided that the engine is designed for automatic changeover to fuel oil mode in case of overload.

  Note: Those engines that are designed to operate in gas mode under overload conditions are to be tested at overload condition in gas mode.

4.1.7.2 Functional tests

In addition to the functional tests required in UR M71.9.3.1, the following tests are to be carried out:

- For DF engines, the lowest specified speed is to be verified in gas mode.

- For DF engines, switch over between fuel oil and gas modes are to be tested at different loads.

- For DF engines, verification of automatic changeover to fuel oil mode when the load demand exceeds the maximum continuous power available in gas mode and when load demand leaves the gas mode operation range (see 3.1.1 and 3.1.2).

- As applicable, the gas mode cylinder cut off functionality is to be demonstrated.

- The effectiveness of the ventilation and gas detection arrangement or other approved principal of the double walled gas piping system is to be demonstrated.

- Automatic activation of double block and bleed valves, switching to fuel oil mode and engine shutdown functions as per Table 2 are to be tested.

Engines intended to produce electrical power are to be tested as follows:

- Capability to take sudden load and loss of load in accordance with the provisions of UR M3.2.

- For GF and pre-mixed engines, the influences of LHV, methane number and ambient conditions on the dynamic load response test results are to be theoretically determined and specified in the test report. Referring to the limitations as specified in 2.1.1, the margin for satisfying dynamic load response is to be determined.

Notes:

1. For DF engines, automatic switchover to fuel oil during the test is acceptable.

2. Application of electrical load in more than 2 load steps can be permitted in the conditions stated in UR M3.2.3.

4.1.7.3 Integration Tests

M78
(cont)

GF and DF engines are to undergo integration tests to verify that the response of the complete mechanical, hydraulic and electronic engine system is as predicted for all intended operational modes.

The scope of these tests is to be agreed with the Classification Society for selected cases based on the required safety concept, risk analysis and FMEA (see 1.4 and 1.5 of this UR), and shall at least include the following incidents:

- Failure of ignition (spark ignition or pilot fuel injection systems), both for one cylinder unit and common system failure
- Failure of a gas admission valve
- Failure of the combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.)
- Abnormal gas pressure
- Abnormal gas temperature

Note: The above tests, as required under 4.1.7.3 for integration tests, may be carried out using simulation or other alternative methods, subject to special consideration by the Classification Society.

4.1.8 Stage C – Component inspection

Component inspection is to be carried out in accordance with the provisions of UR M71.10. The components to be inspected after the test run are to include also:

- gas admission valve including pre-chamber, as applicable
- spark igniter (for GF engines)
- pilot fuel injection valve (for DF engines)

4.1.9 Engine type approval certificate

For DF engines, the maximum continuous power available in gas mode is to be specified on the type approval certificate in addition to the maximum continuous rating in fuel oil mode if differing.

4.2 Factory Acceptance Test

4.2.1 General

Factory acceptance tests of DF and GF engines are to be carried out in accordance with UR M51, taking into account the additional requirements below.

For DF engines, the tests referred to in UR M51.7.2 are to be carried out in fuel oil mode and in gas mode at the different percentages of the engine's applicable MCR.

Maximum continuous rated power available in gas mode is to be demonstrated (see 3.1.1).

The overspeed test referred to in UR M51.5.1.3 need only be verified in fuel oil mode.

M78
(cont)

The hot surface test referred to in UR M51.7.5.1 is to be verified in the mode with the highest exhaust gas temperatures.

The Category C turbocharger surge margin test referred to in UR M51.7.3.2 is also to be verified in gas mode unless documented that a greater surge margin exists for gas mode than fuel oil mode.

4.2.2 Safety precautions

In addition to the safety precautions mentioned in UR M51.5.1, measures to verify that gas piping on the engine is gas tight are to be carried out prior to start-up of the engine.

4.2.3 Records

In addition to the records required in UR M51.6, the following engine data are to be recorded:

- Fuel index, both fuel oil and gas as applicable (or equivalent reading)
- Gas pressure and temperature
- Pilot fuel temperature and pressure (supply or common rail as appropriate)

4.2.4 Test loads

Test loads for various engine applications are given in UR M51.7.2. DF engines are to be tested in all operating modes (fuel oil mode, gas mode, variable fuel oil / gas ratio mode) as found applicable. In addition, the scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons.

Overload testing is not required in gas mode for DF engines, provided that the engine is designed for automatic changeover to fuel oil mode in case of overload.

Note: Those DF engines that are designed to operate in gas mode under overload conditions are to be tested at overload condition in gas mode.

4.2.5 Functional tests

Automatic activation of double block and bleed valves, switching to fuel oil mode and engine shutdown functions as per Table 2 are to be tested.

4.2.6 Integration tests

GF and DF engines are to undergo integration tests to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes.

The scope of these tests is to be agreed with the Classification Society for selected cases based on the required safety concept, risk analysis and FMEA (see 1.4 and 1.5 of this UR) and shall at least include the following incidents:

- Failure of ignition (spark ignition or pilot fuel injection systems), for one cylinder unit
- Failure of a gas admission valve

M78
(cont)

- Failure of the combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.)
- Abnormal gas pressure
- Abnormal gas temperature

Note: The above tests, as required under 4.2.6 integration tests, may be carried out using simulation or other alternative methods, subject to special consideration by the Classification Society.

4.3 Shipboard Trials

4.3.1 General

Shipboard trials are to be carried out in accordance with the provisions of UR M88, considering the additional requirements below.

A leak test is to be carried out for the gas piping system (IGF Code 16.7.3.3) after assembly on board.

The effectiveness of the ventilation and gas detection arrangement, or other approved principle, of the double walled gas piping system is to be demonstrated.

4.3.2 Test loads

For DF engines, the test loads required in UR M88.5.3 are to be carried out in all operating modes (fuel oil mode, gas mode, variable fuel oil / gas ratio mode) as applicable (see 3.1.1).

Note: If a test load is performed in all applicable operation modes without interruption (direct changeover at same power and speed), the duration as required in UR M88.5.3 may be considered as the total duration demonstrated in all fuel modes. However, demonstration at each mode shall not be less than one hour.

4.3.3 Overload testing for DF engines driving generators

Overload testing is not required in gas mode for DF engines driving generators, provided that the engine is designed for automatic changeover to fuel oil mode in case of overload.

Note: Those DF engines that are designed to operate in gas mode under overload conditions are to be tested at overload condition in gas mode.

4.3.4 Starting capability

The starting maneuvers required in UR M88.5.1 are to be carried out in fuel oil mode and gas mode, if applicable.

4.3.5 Functional tests

Automatic activation of double block and bleed valves, switching to fuel oil mode and engine shutdown functions as per Table 2 are to be tested.

Further, manual change over from fuel oil mode to gas mode and vice versa is to be tested.

M78
(cont)

5. Certification of Engine Components

The principals, definitions, symbols and general requirements of UR M72 apply.

In addition to those components specified in UR M72, the gas piping components on the engine listed in Table 3 shall be documented as listed in the table.

TABLE 3: Required documentation for engine components.

Part	Material properties	Non-destructive examination	Pressure testing [8]	Visual inspection (surveyor)	Component certificate
Low-pressure gas pipes, double walled	W(C+M)	W [2), 6)]	W [4)]	X post welding	SC: D ≥ 200mm
Single walled gas pipes	W(C+M)	W [1)]	W [4)]	X post welding	SC: D ≥ 200mm
High-pressure gas pipes, double walled	W(C+M)	W [1)]	W [4)]	X post welding	SC
Secondary enclosure for gas pipes	W(C+M)	W [2)]	W [3)]	X post welding	SC: All except low pressure D < 200mm
Flanges, gas pipe low-pressure	W(C+M)	W [2), 6)]			
Flanges, gas pipe high-pressure	W(C+M)	W [1)]			
Fittings and other components, gas pipe low-pressure	W(C+M)		W [4)]		
Fittings and other components, gas pipe high-pressure	W(C+M)		W [4)]	X	SC
Bodies of valves, gas pipe low-pressure [7)]	W(C+M)		W [4)]		
Bodies of valves, gas pipe high-pressure	W(C+M)		W [4)]	X	SC
Gas venting pipes and flanges, built-up pressure less than 5.0 bar, single walled	TR(C+M)	W [2)]	W [4)]		
Gas venting pipes and flanges, built-up pressure at 5.0 bar or more with secondary enclosure	TR(C+M)	W [2)]	W [4)]		
Gas venting pipes and flanges, built-up pressure at 5.0 bar or more, single walled	W(C+M)	W [1)]	W [4)]	X	SC: D ≥ 200mm
Secondary enclosure for gas venting pipes			W [5)]		
Gas pipe expansion bellows [9)]	W(C+M)	W [2)]	W [4)]	X	
Gas pipe flexible hoses [9)]	W(C+M)	W [2)]	W [4)]	X	

Footnotes:
1) 100 % radiographic or ultrasonic inspection of all butt-welded joints (IGF Code 16.6.3.1).
2) 10 % radiographic or ultrasonic inspection of butt-welded joints (IGF Code 16.6.3.4).

M78
(cont)

3) In ventilated double wall piping systems the outer pipe is to be pressure tested at the design pressure calculated in accordance with 9.8.1 or 9.8.2 of the IGF Code. In pressurized double wall piping systems the outer pipe or duct is to be pressure tested at 1.5 x the design pressure of the outer pipe or duct. Refer to 2.2.2.1.
4) Pressure test at 1.5 x design pressure.
5) Leak test.
6) If inside diameter > 75 mm or wall thickness > 10 mm: 100 % radiographic or ultrasonic inspection of all butt-welded joints (IGF Code 16.6.3.1).
7) If nominal diameter > 25 mm.
8) Pressure testing typically performed on the component itself prior to assembly on the engine.
9) To be type approved. Refer to 2.2.1.2 and 2.2.1.3.

End of Document