Fuel gas supply

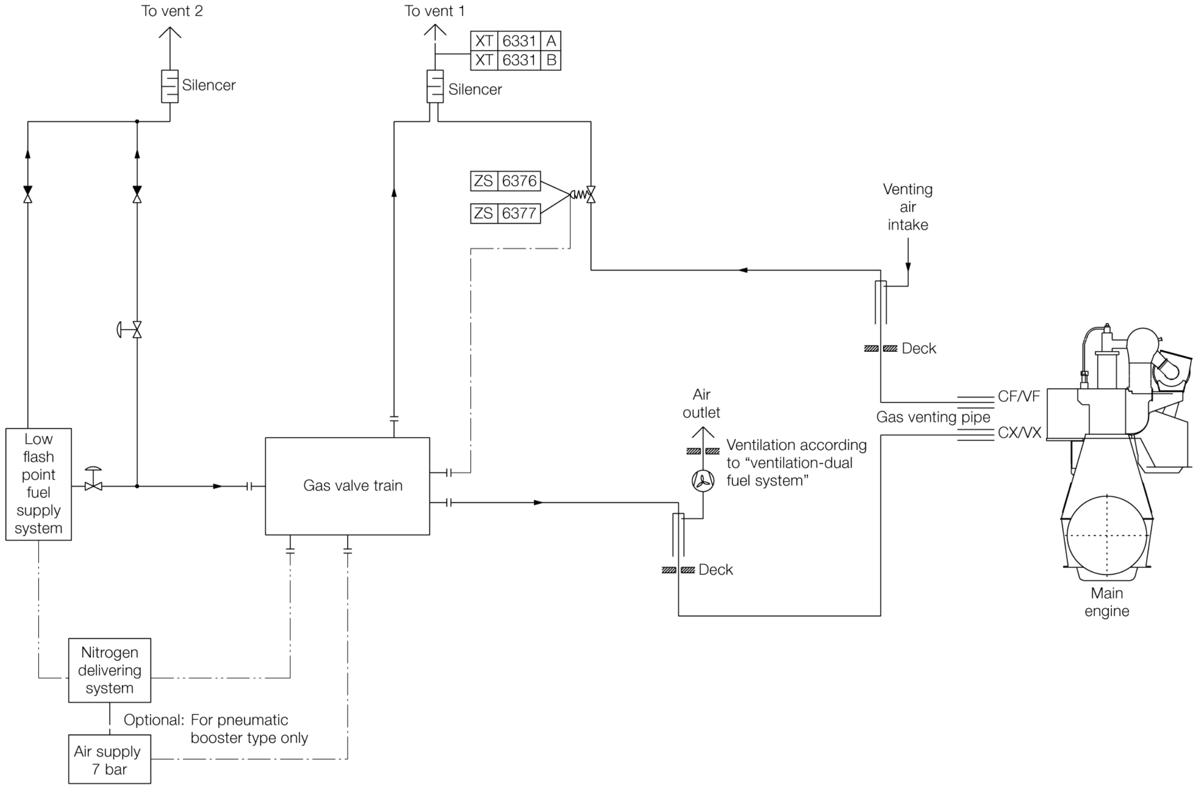

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Fig. 7.07.01a: Fuel gas supply for ME-GIE placed outside the engine room, single-engine plant

The ME-GIE engine requires fuel gas at a load-dependent pressure and a temperature as specified in Section 7.00. This requirement is met by a gas supply system consisting of:

- fuel gas supply (FGSS) system, see examples in Section 7.08
- gas valve train (GVT) for control of fuel gas flow to the engine
- auxiliary systems for leakage detection and ventilation as well as inert gas, see Section 7.09.

Figs. 7.07.01a & b show the systems placed outside the engine room for single-engine plants respectively.

The detailed design of the gas supply, FGSS, inert gas as well as the leakage detection and ventilation systems will normally be carried out by the individual shipyard/contractor, and is, therefore, not subject to the type approval of the engine.

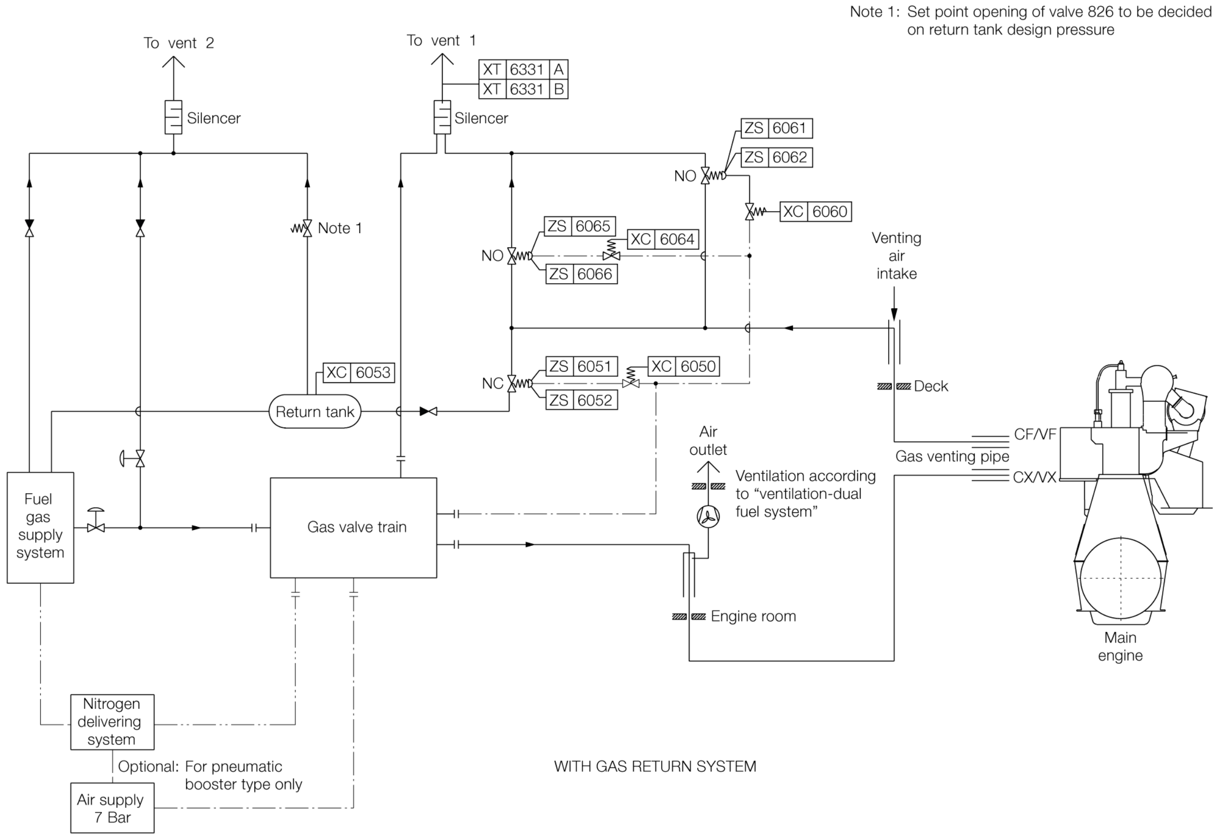

Fig. 7.07.01b: Fuel gas supply for ME-GIE with ventilated double-wall gas valve train, single engine plant

Figure 7.07.01b shows a ventilated double-wall gas valve train for a single engine plant. With this setup a GVT can be installed in machinery spaces onboard a ship eg. the main engine room.

Gas valve train

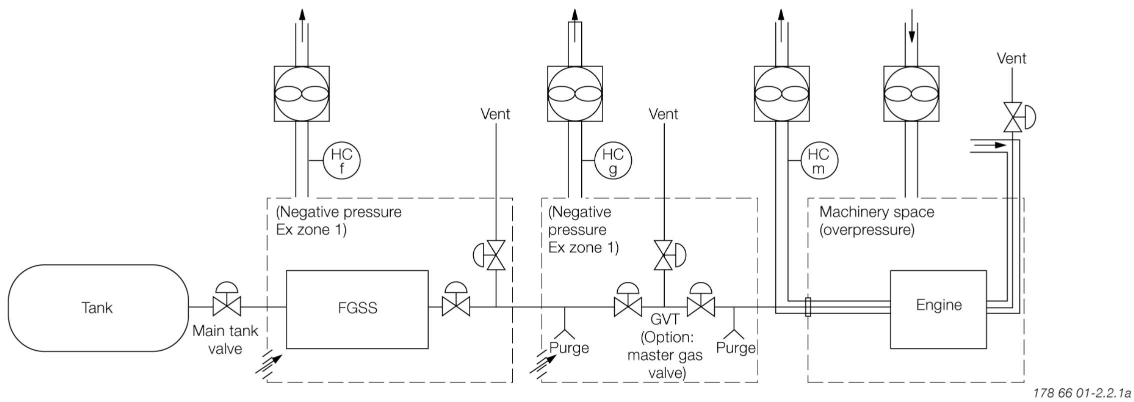

Fig. 7.07.02a: Tank, FGSS and Gas Valve Train located on deck, enclosed

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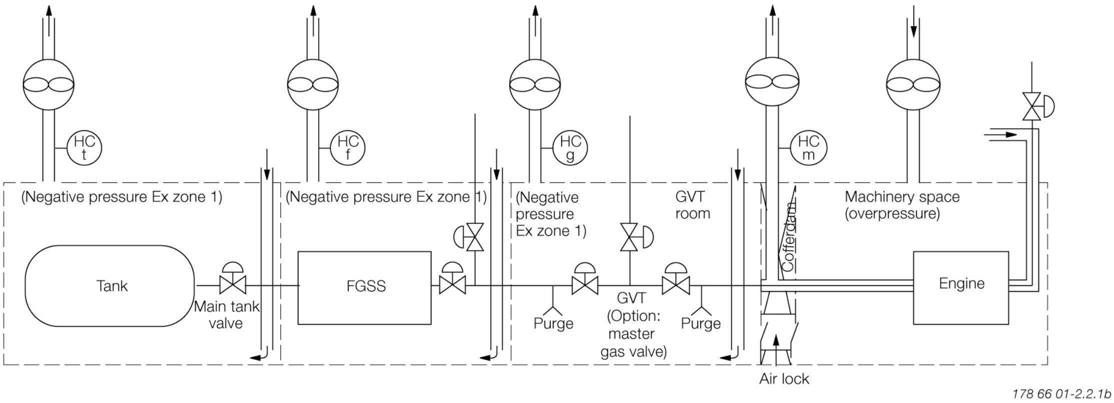


Fig. 7.07.02b: Tank, FGSS and Gas Valve Train located below deck

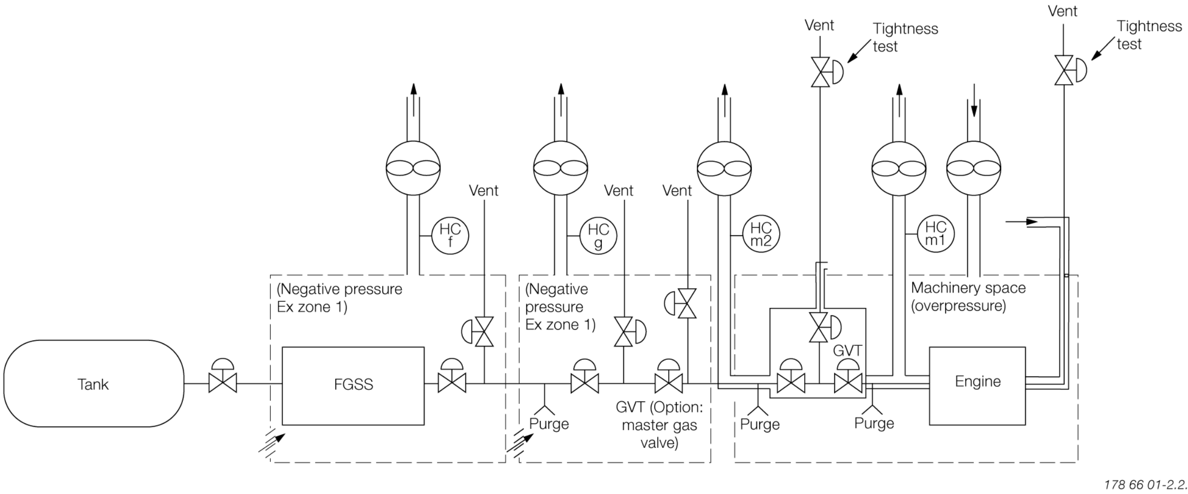


Fig. 7.07.02c: Gas Valve Train located in machinery space

The Gas Valve Train (GVT) is available as a single unit ‘block component’ from MAN Energy Solutions, option: 4 37 601.

The block GVT can be supplied with double-wall piping through the entire GVT, option: 4 37 602, if it is required to install the GVT in machinery space.

Location of the GVT above or below the deck

Careful consideration must be given to the installation of the GVT. It should preferably be placed outside the engine room as close to the engine as possible.

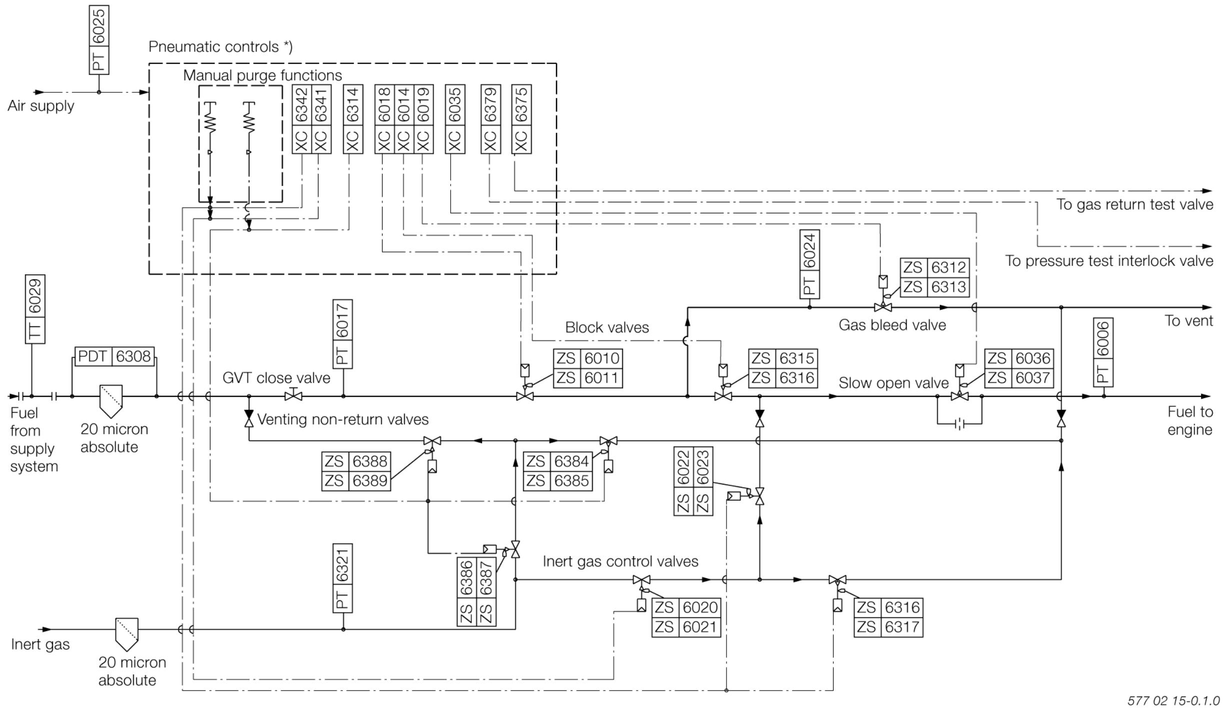
Installed on the deck, single-wall piping can be applied from the FGSS to the GVT and then double-wall piping from the GVT to the ME-GIE engine beneath the deck. In this case, it is possible to run the double-wall pipe ventilation from just after the GVT.

If it is preferred to install the GVT below deck, it is recommended to install it in a room next to the engine room.

The room where the GVT is installed must have separate ventilation providing 30 air changes per hour and a hydrocarbon (HC) sensor installed.

Figs. 7.07.02a, 02b and 02c show the three alternative locations of the GVT and the piping applied.

Gas supply system key components



*) The pneumatic functions are described as their general relation between electric signal and the related function(s) in the gas, nitrogen and vent lines. For detailed design of the pneumatic control system, GVT manufacturer's documentation must be consulted.

Fig. 7.07.03: Gas valve train schematic

Filters

The GVT inlet contains a safety filter which has the purpose of protecting the GVT and the ME-GIE from foreign particles that could damage the sealing of the gas valves. Supplementary to the GVT safety filter, and in the event that the expected quality of the delivered gas cannot be otherwise guaranteed, MAN Energy Solutions recommends that the primary filtration takes place in the FGSS and/or in the LNG bunkering system.

For further information about filters for FGSS, please contact MAN Energy Solutions,
Copenhagen at LEE4@mandieselturbo.com.

Gas valve train

The GVT basically is a double block and bleed system which will separate the FGSS from the ME-GIE during shutdown. Furthermore it contains nitrogen purging and testing functionalities. As an option, and subject to class approval, the GVT can also function as the Master Gas Valve, Fig. 7.07.02a-c.

The GVT is controlled by the Engine Control System and is closely linked to this. Fig. 7.07.03 illustrates the working principles of the GVT. Furthermore the valve control signal interface is shown in Fig. 16.02.03 'GI Extension Interface to External Systems'.

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As the GVT represents the ME-GIE interface to the external systems, it can only be delivered by suppliers which have been approved as GVT suppliers by MAN Energy Solutions.

Gas piping

For delivery of high-pressure gas to the ME-GIE main engine, double-wall gas pipe can be used in both open and enclosed spaces and is required for interior piping.

Moreover, double-wall gas pipe requires ventilation in the annular space as described in Section 7.09.

Single-wall gas piping can only be used in exterior locations in free open space. In all other locations, double-wall gas piping is required.

Double-wall piping

Design guidelines:

Bosses must be fitted for every 5 meters for inspection of outer duct, inner pipe and supports. Bosses shall also be fitted next to every pipe bend on each side.

The inner pipe support must be placed with a distance of 1,8 m of each other to prevent natural frequency vibrations. On vertical piping, two supports must be placed in the horizontal pipe right before the bend to the vertical pipe.

Pipes to be cold-drawn in order to obtain a proper inner surface finish of the outer pipe.

The pipe installation must be able to absorb deflection from hull and engine due to heat and vibration, therefore flexible elements must be installed.

A leakage test is to be carried out at shop test and at commisioning of the vessel.

For more information contact MAN Energy Solutions, Copenhagen.

Outer pipe for double-wall piping

The outer pipe must be designed in accordance with IGF code, chapter 9.8. The tangential membrane stress of a straight pipe should not exceed the tensile strength divided by 1.5 (Rm/1.5) when subjected to the critical pressure. The pressure ratings of all other piping components should reflect the same level of strength as straight pipes.

Temperature range:	−55 °C to +60 °C

Total Pressure loss (max):
Must be constructed in compliance with MAN Energy Solutions's ventilation specification, see Section 7.09, 'General data for ventilation system'.

Critical pressure:	174 bar

(Based on 320 bar design pressure for inner pipe)

Material

The recommended material is Duplex EN 1.4462 or Stainless steel 316L (EN 1.4404). Selection of this material is based on corrosion resistance and required strength, resistance to cold exposure. Therefore long maintenance intervals can be offered with this material.

Duplex Steel EN 1.4462:	
Ultimate tensile stress (UTS)	680 MPa
Yield stress	450 MPa
Stainless steel 316L (EN 1.4404):	
Ultimate tensile stress (UTS)	500 MPa
Yield stress	200 MPa

Sizing of outer pipe

Table 7.07.01 provides pipe dimension guidelines based on standard pipe sizes for EN 1.4462, and in compliance with the below mentioned formula.

Pipe dimension guidelines based on standard pipe sizes according to EN 1.4462					
Power range	Pipe OD	Thickness, t	NPS	Test pressure	Stress resulting from critical pressure
MW	mm	mm	inch	Bar	Mpa
0-45	114.30	3.05	4	175	317
>45	168.28	4.50	6	175	308

Table 7.07.01: Pipe dimension guidelines, EN 1.4462

Inner pipe

The inner pipe in double-wall gas piping for delivery of high-pressure gas to the ME-GIE main engine has the following specification:

Design pressure:	320 bar
Temperature range:	−55 ºC to +60 ºC
Total pressure loss (max) *):	5 bar
LCV:	50 MJ/kg

*) This refers to pressure loss from FGSS flange to engine flange and only due to piping.

Design calculations for the pipe are performed using the above design assumptions, using the formula specified in chapters 5.2 and 5.3 of the IGC code for calculation of pipe thickness. Pipe strength for different pipe sizes is selected based on manufacturer's information according to ASME B31.3.

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For projects using gas with a specific LCV, the maximum total pressure loss requirement is unchanged, so a larger pipe diameter will be required to maintain pressure loss with a higher flow.

Total pressure loss

The total pressure loss from the gas supply system to the ME-GIE main engine should be as low as possible, and calculated by the shipyard using:

$P_{Total} = P_{Piping} + P_{GVT} + P_{Filter} + P_{Flowmeter}$

According to FGS design a maximum total pressure loss of 15 bar is allowed at 100% SMCR. However, this requires additional energy from the FGSS so it is more desirable to improve the installation to reduce the pressure loss to a minimum.

Material

The recommended material is Duplex EN 1.4462 up to 1½" pipe dimension and Super Duplex EN 1.4410 up to 2½" pipe dimension.

Selection of this material is based on corrosion resistance, required strength, resistance to cold exposure, resistance to stress corrosion chloride cracking. Therefore long maintenance intervals can be offered with this material.

Piping should be cold-worked in order to reduce internal surface roughness.

Maximum surface roughness:	15 µm

Sizing of inner pipe

In order to dimension the piping, the guidelines provided in the table below can be used.

The pressure loss is calculated based on the length (stated in metres in Tables 7.07.02a & b) of piping from the FGSS to the main engine inlet flange, including 20 bends.

Design using welded bends is recommended, with minimum radius as per DIN 13480-3, Chapter 6.2 and 6.3.

Dimension guidelines based on standard pipe sizes according to EN 1.4462										
Power range	Max flow	Pipe OD	Thick-ness, t	SCH	NPS	DN	Test pressure	Pressure loss		
								50m	100m	200m
MW	Kg/h	mm	mm		inch		bar	bar		
0-15	2,100	33.40	3.88	40	1	25	480	1.5	2.5	4.7
15-30	4,000	42.16	4.85	80	1¼	32	480	1.4	2.6	5.0
30-45	6,000	48.26	5.08	80	1½	40	480	1.4	2.5	4.9

Table 7.07.02a: Dimension guidelines, EN 1.4462

Dimension guidelines based on standard pipe sizes according to EN 1.4410										
Power range	Max flow	Pipe OD	Thick-ness, t	SCH	NPS	DN	Test pressure	Pressure loss		
								50m	100m	200m
45-80	Kg/h	mm	mm		inch		bar	bar		
≥80	11,800	60.33	5.54	80	2	50	480	1.4	2.6	5.0
MW	19,000	73.03	7.01	80	2½	65	480	1.5	2.7	5.0

Table 7.07.02b: Dimension guidelines, EN 1.4410

Generating fuel gas pressure

The pressure can be generated by the FGSS in different ways depending on the storage condition of the gas. Some of the possibilities are:

- high-pressure gas compressor, including coolers, pulsation dampers, condensate separator etc.
- high-pressure cryogenic pump to deliver high pressure LNG to an evaporator
- a combination of the above solutions.

Examples of fuel gas supply systems is described in Section 7.08.

Control of the fuel gas supply system

A description of the ME-GIE Engine Control System (ME-GIE-ECS) is provided in Section 16.02.

The fuel gas pressure is to be controlled on the basis of the gas supply pressure set point, and the actual fuel gas load specified by the GI-ECS.

The control signal interface is shown in Fig. 16.02.03 ‘GI Extension Interface to External Systems’ and the diagram of the gas valve train is shown in Fig. 7.07.01.

The gas supply pressure set point is expected to change from 250 bar to 300 bar dependent on engine load. The allowable deviation from the gas supply pressure set point is:

Deviation from set point (dynamic)	±10 bar

This requirement is to be fulfilled at a gas flow rate disturbance frequency of 0.1 Hz, and a gas flow rate variation (kg/s) relative to the gas flow rate at MCR of ±15%. This requirement has to be fulfilled also for the lowest calorific values of the gas.

Deviation from set point (static)	±1%

When using BOG from cargo tanks like LNG tankers, the FGS must be able to read the calorific value of the supplied gas to the main engine.

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Gas supply pressure range

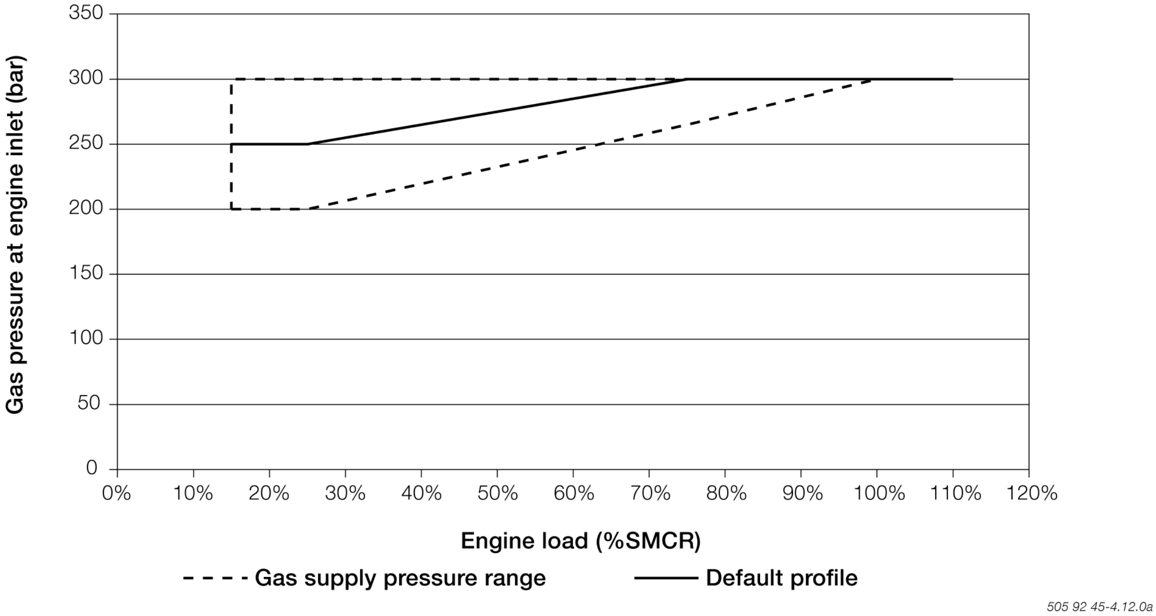

Fig. 7.07.04 Gas operating pressure range for each engine load system

The FGSS should be designed and manufactured in such a way, that it will be able to operate within the margins of the 'Gas supply pressure range' presented in Fig. 7.07.04.

The actual operating profile is determined by the ME-ECS in combination with the overall propulsion system setup.

A default operating profile is shown as an example in the bold line 'Default profile' in Fig. 7.07.04.

Suction pressure for high-pressure pump

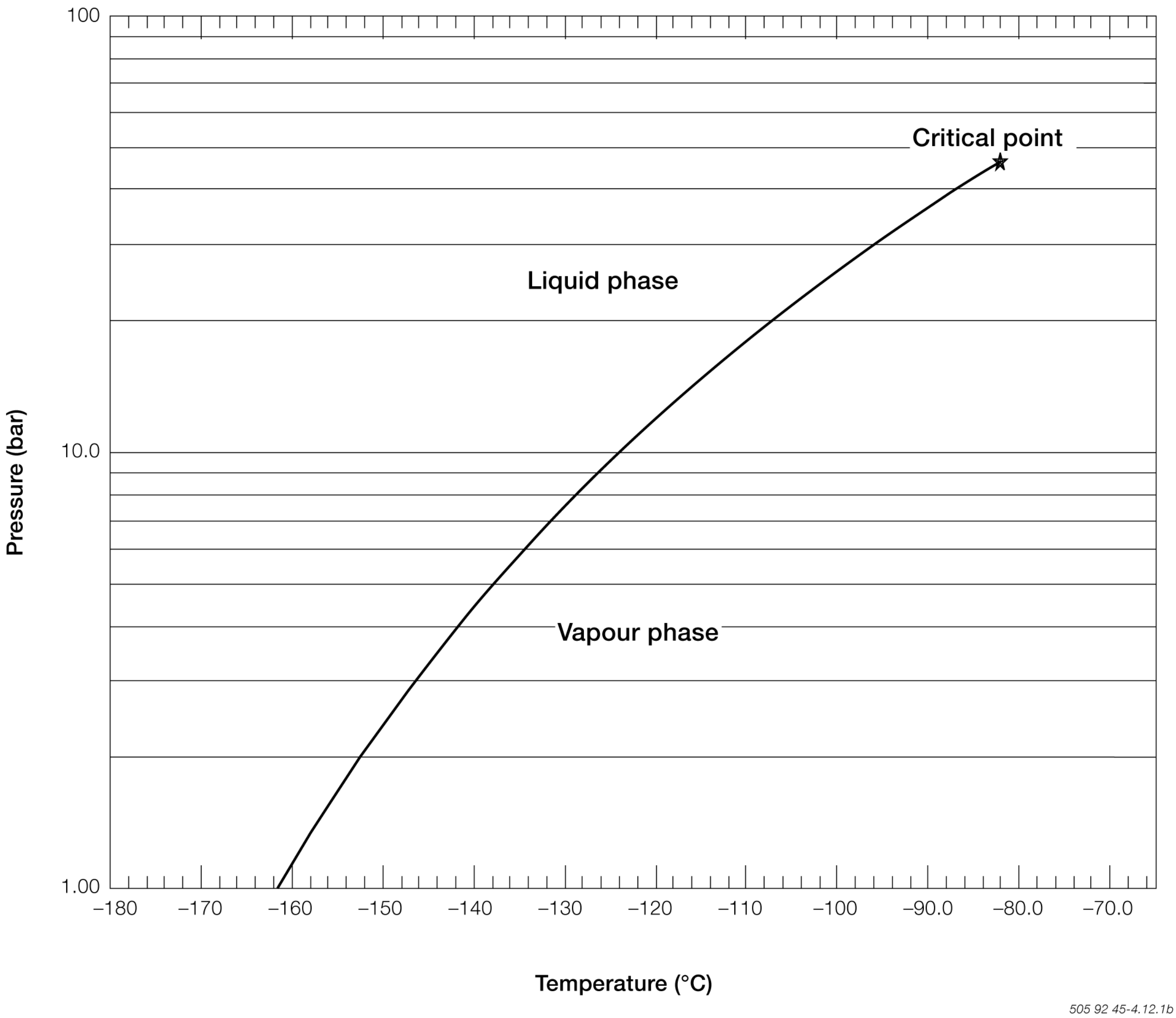

Fig. 7.07.05: LNG Pressure – Temperature diagram

To avoid vaporization of LNG on the suction side of the high-pressure pump, it is important for the SFSS supplier to maintain sufficient feed pressure.

In Fig. 7.07.05, the liquid/vapour phase is presented according to the ME-GIE Fuel Gas Specification limit composition. The designer of the FGSS should evaluate accordingly based on the actual quality/composition of the fuel to be used in the system.

Safety standards for the gas supply system

All equipment shall comply with but not necessarily be limited to the following:

1. Meet full class requirements for UMS notation and ACCU notation etc. (ABS, LRS and DNV)
2. Comply with IGF Code and/or IGC Code as applicable.

   IGF code: International Code of Safety for Ships Using Gases or other Low-Flashpoint Fuels

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IGC Code: International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

3. Comply with SOLAS and Flag State requirements for fire safety and detection systems
4. Other standards to be fulfilled:

   DNV Rules Part 6 Chapter 13 Gas Fuelled Engine Installations

   ABS applicable sections in their guidelines for propulsion and auxiliary for gas-fuelled ships

   ALPEMA SE 2000 or latest, Standards for Plate-fin Heat Exchangers

   ASME VIII div 1 Plate-fin Heat Exchangers

   ASME BPVC-VIII-3 Construction of High Pressure Vessels

   IEC 60092 Electrical installations in ships Certified according to ATEX directives.