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(1996)

Control and Safety Systems for Dual Fuel Diesel Engines

M59.1 Application

In addition to the requirements for oil firing diesel engines by the Classification Societies, and the requirements contained in chapter 5 and 16 of the IGC Code*, as far as found applicable, the following requirements are to be applied to dual-fuel diesel engines utilising high pressure Methane gas (NG: Natural Gas) fuel injection (hereinafter referred to as DFD engines).

M59.2 Operation mode

- 2.1 DFD engines are to be of the dual-fuel type employing pilot fuel ignition and to be capable of immediate change-over to oil fuel only.
- 2.2 Only oil fuel is to be used when starting the engine.
- 2.3 Only oil fuel is, in principle, to be used when the operation of an engine is unstable, and/or during manoeuvring and port operations.
- 2.4 In case of shut-off of the gas fuel supply, the engines are to be capable of continuous operation by oil fuel only.

M59.3 Protection of crankcase

- 3.1 Crankcase relief valves are to be fitted in way of each crankthrow. The construction and operating pressure of the relief valves are to be determined considering explosions due to gas leaks.
- 3.2 If a trunk piston type engine is used as DFD engine, the crankcase is to be protected by the following measures.
 - (1) Ventilation is to be provided to prevent the accumulation of leaked gas, the outlet for which is to be led to a safe location in the open through flame arrester.
 - (2) Gas detecting or equivalent equipment. (It is recommended that means for automatic injection of inert gas are to be provided).
 - (3) Oil mist detector.
- 3.3 If a cross-head type engine is used as DFD, the crankcase is to be protected by oil mist detector or bearing temperature detector.

M59.4 Protection for piston underside space of cross-head type engine

- 4.1 Gas detecting or equivalent equipment is to be provided for piston underside space of cross-head type engine.

M59.5 Engine Exhaust System

- 5.1 Explosion relief valves or other appropriate protection system against explosion are to be provided in the exhaust, scavenge and air inlet manifolds.

* International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, mandatory under the 1983 amendments to 1974 SOLAS Convention.



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- 5.2 The exhaust gas pipes from DFD engines are not to be connected to the exhaust pipes of other engines or systems.

M59.6 Starting air line

- 6.1 Starting air branch pipes to each cylinder are to be provided with effective flame arresters.

M59.7 Combustion Monitoring

- 7.1 A failure mode and effect analysis (FMEA) examining all possible faults affecting the combustion process is to be submitted.

Details of required monitoring will be determined based on the outcome of the analysis. However, the following table may serve as guidance:

Faulty condition	Alarm	Aut. shut-off of the interlocked valves*
Function of gas fuel injection valves and pilot oil fuel injection valves	X	X
Exhaust gas temperature at each cylinder outlet and deviation from average	X	X
Cylinder pressure or ignition failure of each cylinder	X	X

* It is recommended that the gas master valve is also closed.

M59.8 Gas fuel supply to engine

- 8.1 Flame arresters are to be provided at the inlet to the gas supply manifold for the engine.
- 8.2 Arrangements are to be made so that the gas supply to the engine can be shut-off manually from starting platform or any other control position.
- 8.3 The arrangement and installation of the gas piping are to provide the necessary flexibility for the gas supply piping to accommodate the oscillating movements of DFD engine, without risk of fatigue failure.
- 8.4 The connecting of gas line and protection pipes or ducts regulated in 9.1 to the gas fuel injection valves are to provide complete coverage by the protection pipe or ducts.

M59.9 Gas fuel supply piping systems

- 9.1 Gas fuel piping may pass through or extend into machinery spaces or gas-safe spaces other than accommodation spaces, service spaces and control stations provided that they fulfil one of the following :
- (1) The system complying with 16.3.1.1 of the IGC Code, and in addition, with (a), (b) and (c) given below.



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- (a) The pressure in the space between concentric pipes is monitored continuously. Alarm is to be issued and automatic valves specified in 16.3.6 of the IGC Code (hereinafter referred to as “interlocked gas valves”) and the master gas fuel valves specified in 16.3.7 of the IGC Code (hereinafter referred to as “master gas valve”) are to be closed before the pressure drops to below the inner pipe pressure (however, an interlocked gas valve connected to vent outlet is to be opened).
- (b) Construction and strength of the outer pipes are to comply with the requirements of 5.2 of the IGC Code.
- (c) It is to be so arranged that the inside of the gas fuel supply piping system between the master gas valve and the DFD engine is to be automatically purged with inert gas, when the master gas valve is closed; or
- (2) The system complying with 16.3.1.2 of the IGC Code, and in addition, with (a) through (d) given below.
- (a) Materials, construction and strength of protection pipes or ducts and mechanical ventilation systems are to be sufficiently durable against bursting and rapid expansion of high pressure gas in the event of gas pipe burst.
- (b) The capacity of mechanical ventilating system is to be determined considering the flow rate of gas fuel and construction and arrangement of protective pipes or ducts, as deemed appropriate by the Classification Society.
- (c) The air intakes of mechanical ventilating systems are to be provided with non-return devices effective for gas fuel leaks. However, if a gas detector is fitted at the air intakes, these requirements may be dispensed with.
- (d) The number of flange joints of protective pipes or ducts is to be minimised; or
- (3) Alternative arrangements to those given in paragraph 9.1(1) and (2) will be specially considered based upon an equivalent level of safety.
- 9.2 High pressure gas piping system are to be ensured to have sufficient constructive strength by carrying out stress analysis taking into account the stresses due to the weight of the piping system including acceleration load when significant, internal pressure and loads induced by hog and sag of the ships.
- 9.3 All valves and expansion joints used in high pressure gas fuel supply lines are to be of an approved type.
- 9.4 Joints on entire length of the gas fuel supply lines are to be butt-welded joints with full penetration and to be fully radiographed, except where specially approved by the Classification Society.
- 9.5 Pipe joints other than welded joints at the locations specially approved by the society are to comply with the appropriate standards recognised by the society, or those whose structural strength has been verified through tests and analysis as deemed appropriate by the Classification Society.
- 9.6 For all butt-welded joints of high pressure gas fuel supply lines, post-weld heat treatment are to be performed depending on the kind of material.

M59.10 Shut-off of gas fuel supply

- 10.1 In addition to the causes specified in 16.3.6 of the IGC Code, supply of gas fuel to DFD engines is to be shut off by the interlocked gas valves in case following abnormality occurs;



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- (1) Abnormality specified in 7.1
- (2) DFD engine stops from any cause
- (3) Abnormality specified in 9.1 (1)(a)

10.2 In addition to the causes specified in 16.3.7 of IGC Code, the master gas valve is to be closed in case of any of the following:

- (1) Oil mist detector or bearing temperature detector specified in 3.2(3) and 3.3 detects abnormality.
- (2) Any kind of gas fuel leakage is detected.
- (3) Abnormality specified in 9.1(1)(a)
- (4) Abnormality specified in 11.1

10.3 The master gas valve is recommended to close automatically upon activation of the interlocked gas valves.

M59.11 Emergency stop of the DFD engines

11.1 DFD engine is to be stopped before the gas concentration detected by the gas detectors specified in 16.2.2 of the IGC Code reaches 60% of lower flammable limit.

M59.12 Gas fuel make-up plant and related storage tanks

12.1 Construction, control and safety system of high pressure gas compressors, pressure vessels and heat exchangers constituting a gas fuel make-up plant are so arranged as to the satisfaction of the Classification Society.

12.2 The possibility for fatigue failure of the high pressure gas piping due to vibration is to be considered.

12.3 The possibility for pulsation of gas fuel supply pressure caused by the high pressure gas compressor is to be considered.

