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Ships and marine technology — Performance test procedures for LNG fuel gas supply systems (FGSS) for ships

Navires et technologie maritime — Procédures d'essais de performance des systèmes d'alimentation en gaz combustible GNL (FGSS) pour navires

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In response to an increased number of ships using LNG fuel, the International Maritime Organization (IMO) adopted the IGF code that specifies mandatory requirements of the LNG fuel tank, LNG fuel engine, fuel gas supply system (FGSS), bunkering, control of safety system, monitoring, and fire extinguishing systems, etc. to ensure the safety of gas-fuelled ships.

The requirements of the IGF and IGC Codes apply to the design and manufacture of LNG FGSS. However, no widely recognized standards in terms of the performance testing of FGSS has yet been established; thus, FGSS is tested according to a case-by-case agreement between the buyer and the supplier. For this reason, there have been needs to develop a standard for performance test methods of FGSS commonly acceptable to all stakeholders (e.g. shipowners, classification societies, engine makers, shipyards, etc.).

In this context, this document sets up a performance test procedure for the LNG FGSS, which consists of equipment such as pumps, heat exchangers, valves, piping, etc. With this document, it is expected that i) the performance of LNG FGSS be identified from an objective point of view, ii) useful information be provided to all stakeholders, and iii) development of more reliable LNG FGSS be facilitated, thus contributing to the growth of relevant industries and benefiting all stakeholders.

In addition, as specific requirements from classification societies and/or administrations can apply to the LNG FGSS concerned, the buyer is expected to identify those before placing a purchase order. The supplier and the buyer are further expected to agree on any additional applicable requirements.

Ships and marine technology — Performance test procedures for LNG fuel gas supply systems (FGSS) for ships

1 Scope

This document specifies evaluation methods of characteristics such as pressure, flow rate, temperature and system stability of fuel gas supply systems (FGSS), which are manufactured to use vaporized liquefied natural gas (LNG) or boil-off gas as fuel gas supply to the vessel's gas consumers. It is applicable to evaluate the performance of the LNG FGSS: (1) prior to delivery or after installation on board a ship, and (2) to assure the system characteristics are taken into account for the entire gas consumers during ship's gas trial or sea trial.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IMO, *International Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk (IGC Code)*

IMO, *International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code)*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
LNG fuel gas supply system
LNG FGSS
system that supplies gas fuel at the temperature, pressure and flow conditions required by the gas consumer, from the fuel tank(s) to the gas consumer, excluding the fuel tank(s), in-tank pump(s), tank ESD valve(s) and the master gas fuel valve(s) used to control the gas supply

3.2
maximum pressure
maximum operating pressure (MPa) measured during the test period

3.3
minimum pressure
minimum operating pressure (MPa) measured during the test period

3.4
pressure pulsation
pressure variation (MPa) during the test period, defined as the difference between the *maximum pressure* (3.2) and the *minimum pressure* (3.3)

3.5
flow rate
arithmetic mean of the mass flow rate (kg/h) measured during the test period

3.6
average temperature
arithmetic mean of the temperature (°C) measured during the test period

3.7
test temperature
temperature (°C) of the fluid during the test, designated by the client

3.8
test pressure
pressure (MPa) of the fluid during the test, designated by the client

3.9
test flow rate
flow rate (kg/h) of the fluid during the test, designated by the client

3.10
emergency shutdown system
ESD system
system that safely and effectively stops the flow of LNG and vapour in LNG operations

4 Test arrangement

4.1 Test preparation

The LNG FGSS under test shall be designed in accordance with the IGC and/or IGF Codes established by the International Maritime Organization (IMO) for the safety of systems.

The test arrangement used for the performance test shall supply a test fluid to the inlet of the system and related devices at the required test pressure, test temperature and test flow rate designated by the client, without disruption.

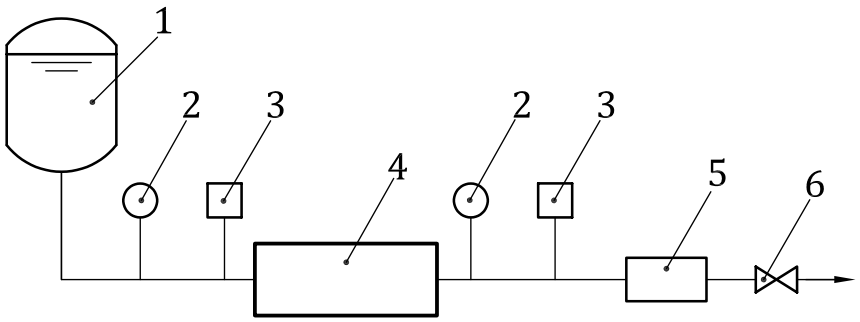
Before any test run is carried out, all relevant arrangements for the safety of attending personnel shall be available and operational, and their correct functioning shall be ensured.

For safety, the air shall be properly replaced with inert gas or a suitable medium in the test arrangement. The system and the test arrangement shall be maintained at cryogenic temperatures prior to the test.

Provisions, to the maximum extent possible, should be made to minimize the methane emission.

Figure 1 shows a typical test arrangement.

Typical examples of LNG FGSS within the scope of the test are shown in Annex B.



Key

1 cryogenic tank
2 thermometer
3 pressure gauge
4 FGSS system
5 flowmeter
6 control valve

Figure 1 — Sample flow diagram of LNG FGSS test arrangement

Other systems such as EDS valve(s), blow down valve(s), etc., should be installed in appropriate locations.

NOTE Bunkering piping is excluded from the scope of the test.

4.2 Test fluid

As a principle, LNG shall be used as the medium to verify the performance of the FGSS.

A medium other than LNG, such as liquefied nitrogen or other fluids colder than the liquefied temperature of LNG, may be used to conduct the test as a reference to the performance of the FGSS, where the system and associated components have been designed for the same colder temperatures if LNG is not practical.

If a fluid other than LNG is used, correction values should be applied as set forth in ISO 6976 (or equivalent standard) based on the actual testing result.

4.3 Test parameters

The test parameters listed in the example report of Annex A, items 3 and 4, shall be measured and recorded during the test that shall be performed according to Clause 5.

The data of pressure, flow rate and temperature of LNG FGSS shall be recorded in accordance with the FGSS clients' requirements, but in any case, no less frequently than once in every 5 s.

Ambient temperature and humidity shall be recorded before and during the test.

The measuring instruments used in the test shall be appropriately calibrated.

5 Test procedure

5.1 Safety test

5.1.1 Test of e.g. alarm and safety devices

It shall be confirmed that the alarm and safety devices, such as the ESD system, operation of valve(s), etc., are properly operative at ambient temperature and at the minimum working temperature.

The FGSS control system shall be connected and fully operative during the test.

5.1.2 Cryogenic function tests

The cryogenic function tests shall be carried out at the design temperature or lower before pressurizing the FGSS to the design pressure.

The cryogenic function tests shall include following:

a) cryogenic mechanical operation test (e.g. valve operation, leakage verification, etc.);

b) electrical integration test (control system) in cryogenic conditions.

5.1.3 ESD and blow down test

The normal operation of the ESD system shall be confirmed prior to the test set up. The test control system shall be able to shut down the ESD valves in the test setup and safely depressurize the piping system and return it to atmospheric pressure conditions by activating the blow down system. The piping system shall be pressurized with nitrogen prior to this test. This test shall confirm the test arrangement's capability to shut down (ESD system) and depressurize the FGSS to atmospheric pressure (blow down system) in case of emergency.

5.2 Performance test

The performance test of the FGSS shall be conducted as per the following load steps (refer also to Figure 2). A test report shall be produced based on the data recorded properly (at least once every 5 s) during the test, see example in Annex A.

NOTE If agreed with the client, the testing time at each step can be longer than specified below.

If the FGSS has more than one supply pipe with different supply pressures, the performance of the FGSS shall be tested for each output separately. (See Figure B.2 in Annex B.)

a) Adjust the discharge pressure of the system to the test pressure. Record the minimum flow rate.

b) Increase the flow rate to 25 %. Upon reaching step 25 % of the test flow rate, maintain the state for 30 min. Record the measurement.

c) Increase the flow rate up to 50 %. Upon reaching step 50 % of the test flow rate, maintain the state for 30 min. Record the measurement.

d) Increase the flow rate up to 75 %. Upon reaching step 75 % of the test flow rate, maintain the state for 30 min. Record the measurement.

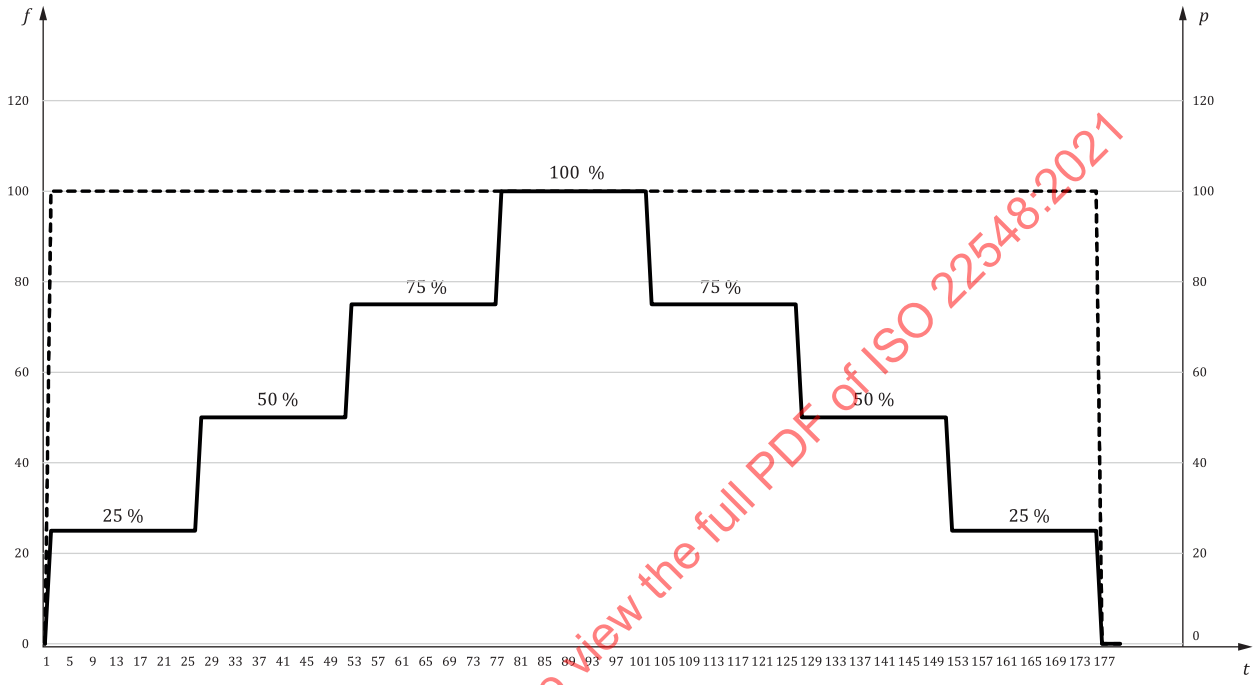
e) Increase the flow rate up to 100 %. Upon reaching step 100 % of the test flow rate, maintain the state for 30 min. Record the measurement.

f) Decrease the flow rate down to 75 % of the test flow rate, maintain the state for 30 min. Record the measurement.

g) Decrease the flow rate down to 50 % of the test flow rate, maintain the state for 30 min. Record the measurement.

h) Decrease the flow rate down to 25 % of the test flow rate, maintain the state for 30 min. Record the measurement.

i) Decrease the flow rate down to the minimum test flow rate, maintain the state for 30 min. Record the measurement.



Key

- - - - -	test pressure
———	test flowrate
f	test flow rate, expressed in per cent
p	test pressure, expressed in per cent
t	testing time, expressed in minutes

Figure 2 — Sample of load steps

6 Additional tests

6.1 Unit production test

The individual FGSS shall be subject to the unit production test at the manufacturer's premises or at the site designated by the client.

In order to conduct the unit production test, a hydrostatic or pneumatic pressure test shall be conducted in addition to the tests in Clause 5.

The extent of the unit production test should be agreed by the client. For example, the test items, upon agreement, may include measurement of e.g. vibration and noise level. Specific requirements in the IGC/IGF Codes and by classification societies or the administration apply to systems designed for marine use.

For type tested FGSS, the unit production test may be carried out for the following items instead of the tests specified in Clause 5, if required by the client. The classification society and/or the administration can require otherwise.

a) Hydrostatic or pneumatic pressure test at 1,5 times the design pressure.

b) Performance of alarm and safety devices.

c) If desired, additional tests as specified by the client may be carried out.

Test personnel should consider the risks of pneumatic testing versus hydrostatic testing when choosing the test methods.

6.2 Type test

The performance test for one of each model and capacity of the FGSS should be carried out in accordance with Clause 5. The type testing is to represent typical foreseen service characteristics of the system.

Any additional tests, other than those in Clause 5, should be carried out with the consent of the client. The classification society and/or the administration can require otherwise.

Prior to the type test, the classification society and/or the administration might need to approve the design in accordance with the applicable requirements.

Modifications of the design should require a new type test. However, in case of minor changes in non-essential components, a new type test may not be necessary upon the agreement with the client, unless otherwise specified as required by the classification society and/or the administration.

6.3 Endurance test

In addition to the performance test, an optional endurance test may be conducted to prove the endurance and stability to maintain the pressure and flow rate of the FGSS under the influence of the operation time and the different test conditions designated by the client.

7 Test report

Data such as discharge pressure, temperature and flow rate shall be measured and collected during the tests and recorded in the test report (see Annex A), with the performance curve of the LNG FGSS as shown in Figure 2.

Annex A
(informative)

LNG fuel gas supply systems (FGSS) test report — Example

Date: 0000.00.00

1. Specification of the FGSS

Project no.		Manufactured by:	
Buyer		Owner	
Type of FGSS		Model number	
Design pressure		Design flow rate	
Design temperature		Design fluid	

Additional details for individual components such as pumps, vaporizers, compressors, etc., and piping and instrumentation diagram (P&ID) to be attached.

2. Test conditions

Test pressure (MPa)		Test fluid	
Test flow rate (kg/h)		Test time	
Test temperature (°C)		Endurance test	

3. Result of the safety test

Tests	Result	Test temperature
Test of e.g. alarm and safety devices	Pass / Fail	Warm / Cold
Cryogenic function tests	Pass / Fail	Cold
Blow down test	Yes / No	

4. Performance test

Flow rate	Average pressure (MPa)	Max. pressure (MPa)	Min. pressure (MPa)	Pressure pulsation during stabilized state (MPa)	Pressure pulsation during the changes of load steps (MPa)	Average flow (kg/h)	Average temp. (°C)	Time between the load steps (Sec)	Ambient temp. (°C)
Min. flow									
25 %									
50 %									
75 %									
100 %									
75 %									
50 %									
25 %									
Min. flow									

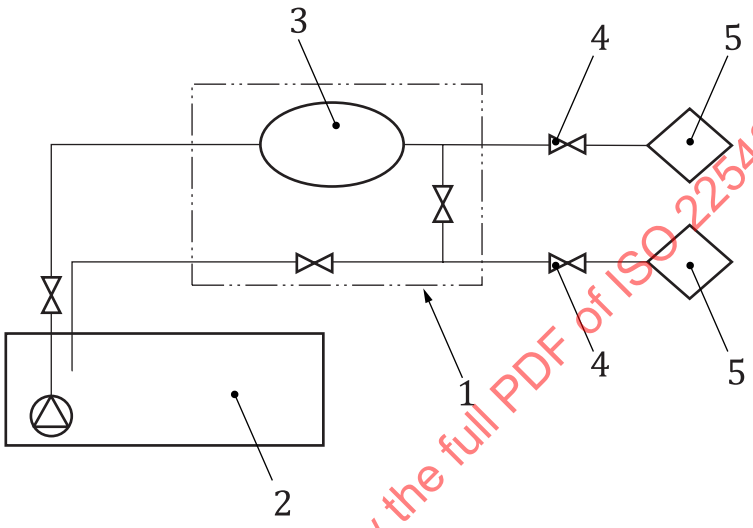
5. Performance curve

Raw test data should be attached to this test report.

Annex B
(informative)

Typical examples of LNG FGSS within the scope of the test

For low-pressure systems, see Figure B.1.

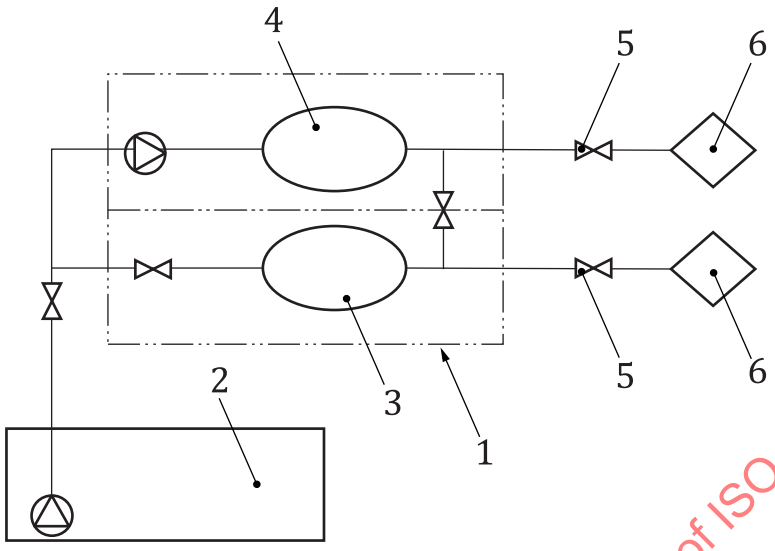


Key

1 test scope
2 fuel tank
3 vaporizer
4 master gas fuel valve
5 gas consumer

Figure B.1 — Low pressure system

For high- and low-pressure combined systems, see Figure B.2.



Key

1 test scope
2 fuel tank
3 LP vaporizer
4 HP vaporizer
5 master gas fuel valve
6 gas consumer

Figure B.2 — High- and low-pressure combined system