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Ships and marine technology — Performance test procedures for high-pressure pumps in LNG fuel gas supply systems (FGSS) for ships

Navires et technologie maritime — Procédures d'essai de performance des pompes haute pression dans les 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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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.

Ships and marine technology — Performance test procedures for high-pressure pumps in LNG fuel gas supply systems (FGSS) for ships

1 Scope

This document specifies performance and additional tests for high-pressure pumps in marine fuel gas supply systems (FGSS) supplying liquefied natural gas (LNG) to ships. It is applicable to positive displacement pumps (hereinafter "pumps") to assess the mechanical features of the pumps and their auxiliary devices.

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.

ISO 1996-1, *Acoustics — Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures*

ISO 10816-6, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 6: Reciprocating machines with power ratings above 100 kW*

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

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

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
high pressure
maximum working pressure greater than 1,0 MPa

3.2
LOS
lubricating oil system
system to supply lubricant to the pump crank chamber

3.3
seal gas
gas used to separate the pump piston from the driving part and to prevent ice formation

3.4
test temperature
temperature of the fluid during the test, designated by the client

3.5
test pressure
pressure of the fluid during the test, designated by the client

3.6
test flow rate
flow rate of the fluid during the test, designated by the client

3.7
temperature stabilization
state at the conclusion of cool-down, when the temperature variation of the pump is within ±2 °C/min

4 Test arrangement

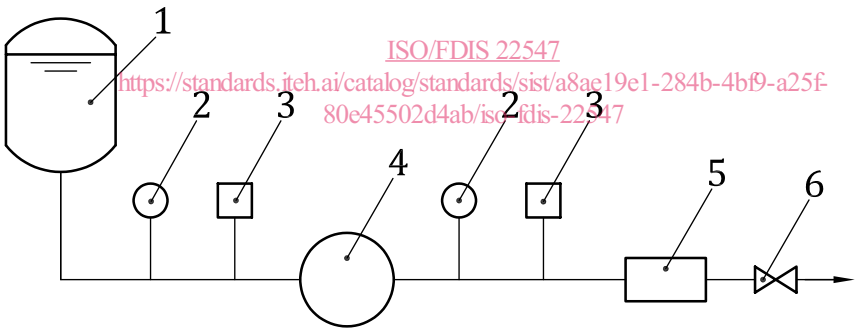
4.1 Test preparation

The client, prior to setting the test parameters, shall review the information provided by the manufacturer to ensure that the test parameters at a minimum meet the requirements of the manufacturer.

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

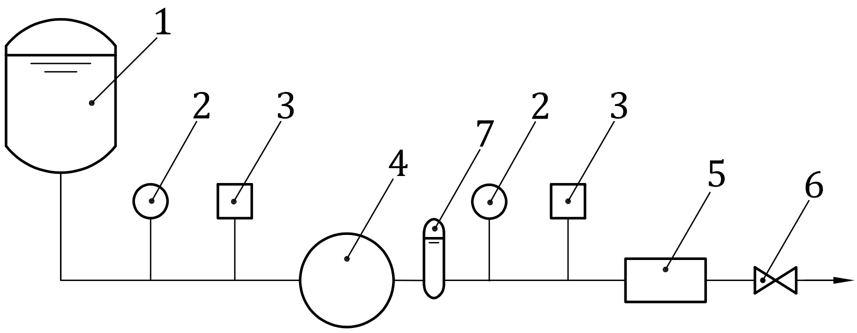
In order to prevent industrial accidents during the test, the test arrangement and/or the equipment shall be reviewed and checked in advance.

Figures 1 and 2 show a conceptual diagram of a typical test arrangement.



Key
1 cryogenic tank
2 thermometer
3 pressure gauge
4. test pump
5 flowmeter gauge
6 control valve

Figure 1 — Conceptual diagram of the test arrangement



Key

1 cryogenic tank
2 thermometer
3 pressure gauge
4 test pump
5 flowmeter
6 control valve
7 surge chamber

Figure 2 — Conceptual diagram of the test arrangement, including the surge chamber

4.2 Test fluid

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

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 pumps, where it has 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

Pressure, temperature, and flow rate shall be measured as the minimum test parameters. Other additional factors listed in the example report of Annex A, item 3., may be measured.

The test parameters shall be measured by appropriately calibrated measuring instruments.

Measuring sensors shall be installed as close to the pump as practicable.

The test parameters in Annex A, item 3., shall be recorded twice, once every 5 min, during each load step.

4.3.1 Total pressure

The total pump hydraulic pressure (H), in megapascals (MPa) shall be calculated as follows:

$$H = H_{dis} - H_{suc}$$

where

H_{dis} is the hydraulic pressure at discharge (MPa);

H_{suc} is the hydraulic pressure at suction (MPa).

4.3.2 Total efficiency

The total efficiency of a pump (η) is expressed as a percentage as follows:

$$\eta = P_w/P \times 100$$

where

P_w is the theoretical hydraulic power (kW);

P is the actual pump input power (kW).

a) **Theoretical hydraulic power (P_w)**

The theoretical hydraulic power, P_w, in kilowatts (kW), is calculated as follows:

$$P_w = 2{,}78 \times 10^{-1} QH$$

where

Q is the discharge volumetric flow rate (m^3/h);

H is the total pump pressure (MPa).

b) **Actual pump input power (P)**

The actual pump input power (P), in kilowatts (kW), can be measured using the torque and revolution speed of the motor. The motor output can be taken as the actual pump input, regardless of the arrangement of the power transmission system between the motor and the pump.

5 Test procedure

5.1 Precooling and starting

The pump and the test arrangement shall be maintained at cryogenic temperatures during the test.

A preliminary inspection shall be conducted before testing, as follows:

a) Visual inspection of the pump and related devices.

b) Visual inspection of the LOS of the pump and related devices (if applicable).

c) Visual inspection of the electricity supply to the pump.

d) Visual inspection of the communications and data collection system.

e) Visual inspection of the open/close positions of the valves for the initial operation of the pump test arrangement.

After precooling the test pump, start the pump if the operation conditions meet the set parameters, including temperature and suction pressure, and conduct the test according to the designated test procedures. The surge chamber (accumulator) shall be included in the test scope, if provided with the pump by the client.

Precooling is used to prepare both the pump and the test arrangement at cryogenic conditions. A cryogenic test fluid at a certain flow rate is supplied from the tank to the test arrangement to lower the temperature of the test arrangement and the pump. The target temperature of precooling shall be designated by the client.

The precooling procedure of the high-pressure pump to the relevant minimum operating temperature shall be documented in the test report (see example of a test report in Annex A).

The test pump shall be started after temperature stabilization and the speed of the pump, which shall be adjusted to the test pressure. The flow rate shall be increased up to the test flow rate; then the control valve shall be slowly throttled until it reaches the test pressure to start the performance test.

5.2 Performance test

The performance test shall be conducted according to the load steps shown in Figure 3. A test report shall be produced based on the data recorded every 5 min during the test, see example in Annex A. Different load steps may be applied taking into account the characteristics of gas consumer.

NOTE 1 If agreed with the client, the testing time at each step can be longer than specified below.

NOTE 2 Additional load step test (e.g. zero to 100 %) can be conducted if required by the client.

The performance test shall be carried out as follows.

a) Adjust the discharge pressure of the pump to the test pressure.

b) Upon reaching step 25 % or minimum of the test flow rate, whichever is lower, maintain the state for 10 min. Record the measurement.

c) Raise the flow rate up to 50 %. Upon reaching step 50 % of the test flow rate, maintain the state for 10 min. Record the measurement.

d) Raise the flow rate up to 75 %. Upon reaching step 75 % of the test flow rate, maintain the state for 10 min. Record the measurement.

e) Raise the flow rate up to 100 %. Upon reaching step 100 % of the test flow rate, maintain the state for 10 min. Record the measurement.

6 Additional tests

6.1 Unit production test

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

For type-tested pumps, the unit production test shall be carried out for the following items:

a) requirements from the IGC and IGF Codes;

b) requirements from classification societies;

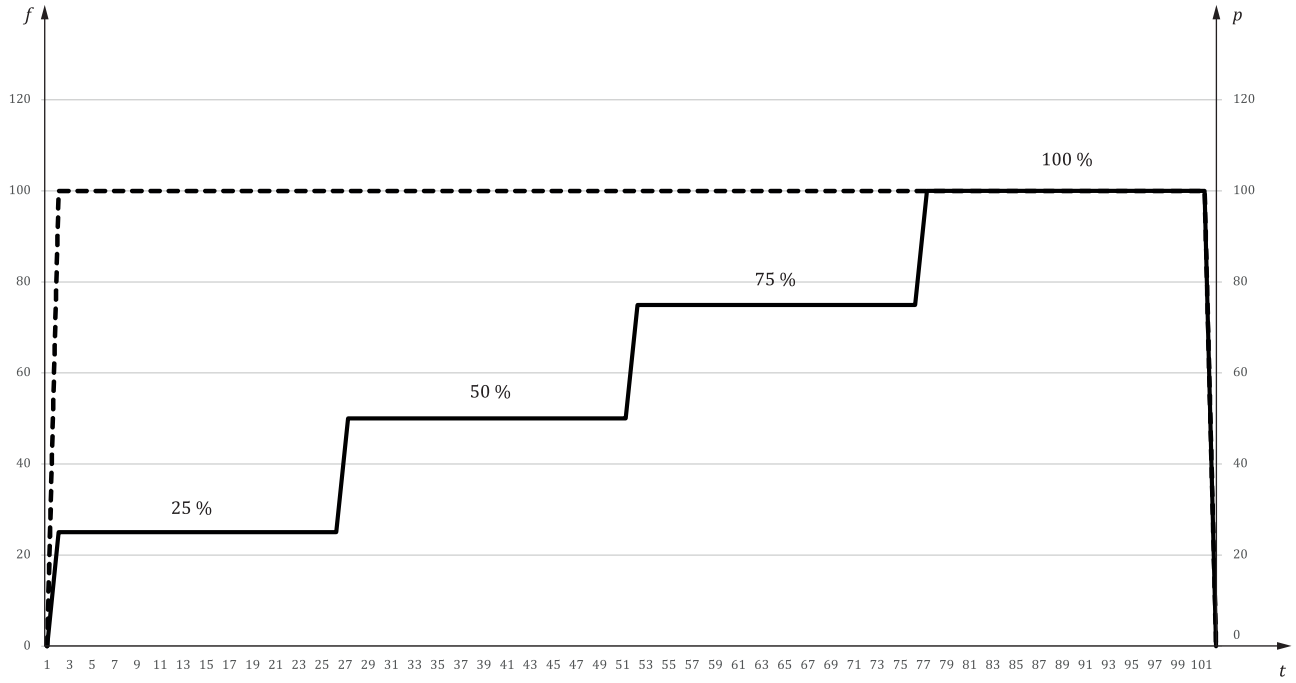
c) requirements specified by the client, which may include measurement of vibration, noise and others,

d) flag state requirements.

Pressure testing shall be done at 1,5 times the design pressure.

Performance of safety devices should also be conducted.

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



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 3 – Sample of load steps

6.2 Type test

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

Any additional tests, other than those in Clause 5, should be carried out with the consent of the client, unless otherwise specified as the requirements of the classification society.

The design of the pumps shall also be in compliance with the requirements in the IGC and IGF Codes and from the classification society.

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.

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 pump under the influence of the operation time and the different test conditions designated by the client.

6.4 Overhaul inspection

After the test, pump overhaul inspection should be conducted, if needed.