Guideline No.T-08 (202502)

T-08

Reliquefaction Device

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Foreword

The product inspection guideline of China Classification Society (hereinafter referred to as "CCS") specifies the applicable technical requirements and inspection and test requirements for classification products and authorized statutory products of ships to be approved/inspected by CCS.

The Guidelines allow users to adopt alternative test methods and requirements, provided they meet or exceed the standards set by the Guidelines.

The Guidelines are prepared and updated by CCS and published on http://www.ccs.org.cn. In case of any comments and suggestions, please contact CCS via service@ccs.org.cn.

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Reliquefaction Device

1 Scope of Application

The Guideline is applicable to the reliquefaction device of reverse Brayton refrigeration cycle and mixed working medium throttling refrigeration cycle for ships carrying or using liquefied natural gas. Requirements for equipment such as compression-expansion integrated machine, heat exchangers and valves for reliquefaction devices are given in other Guidelines of the CCS.

2 Normative References

2.1 The basis for approval and inspection used in the Guidelines are as follows:

(1) CCS Rules for Classification of Sea-Going Steel Ships

(2) CCS Rules for Materials and Welding

(3) CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

(4) International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and its amendments

(5) CCS Rules for Natural Gas Fuel Used in Ships

(6) API617 Axial and Centrifugal Compressors and Expander-Compressors for Petroleum, Chemical and Gas Industry Services

(7) API 619 Screw Compressors for Petroleum, Chemical and Gas Industry Services

3 Terms and Definitions

The terms and definitions defined in the above survey basis are applicable to the Guidelines. For the convenience of preparation and use, the following definitions are directly quoted or supplemented in the Guidelines.

3.1 Reliquefaction device: A device that liquefies the boil-off gas (BOG) in the liquid cargo hold or deep-cools the liquid natural gas (LNG) in the liquid cargo hold and then reconveys it back to the liquid cargo hold. There are mainly two systems: ①Nitrogen and helium expansion refrigeration system generally includes compressor, compression-expansion integrated machine (reverse Brayton cycle), electrical control system, heat exchanger, cold box, valve, instrument, piping system, etc. ②The mixed working medium throttling refrigeration system generally includes compressor, cooler, heat exchanger, gas-liquid separator, throttle valve, cold box, electrical control system, valve, instrument, piping system, etc.

3.2 Compression-expansion integrated machine: An electric-driven magnetic suspension compression-expansion integrated machine that does work through expansion based on the reverse Brayton cycle principle and is driven by a coaxial motor, so that the compression impeller has sufficient capacity to compress the working medium and make the working medium obtain the required low temperature cooling capacity from the expansion impeller.

3.3 Cooling capacity: Enthalpy change of BOG or LNG after flowing through the reliquefaction device within unit time under rated conditions.

3.4 Power consumption: The total power consumption of reliquefaction device within unit time under rated conditions.

4 Drawings and Data

The following drawings and data shall be submitted for approval:

4.1 The following drawings and data shall be submitted to CCS for approval:

(1) Table of main performance specifications of the product (including the model, maximum allowable pressure, cooling capacity, power consumption, working medium and working medium flow rate of the product to be accredited);

(2) Schematic diagram of reliquefaction system;

(3) General arrangement plan;

(4) Piping and instrument diagram;

(5) Control system diagram;

(6) Schematic diagram of monitoring and alarm;

(7) Drawings of main parts and components;

(8) List of physical and chemical properties of main parts and materials;

(9) Equipment list;

(10) Type test program.

4.2 The following drawings and data shall be submitted for information:

(1) Process flow chart and main process documents (welding process, heat treatment, etc. (if applicable));

(2) Design calculation sheet (including cooling capacity calculation sheet,

pipeline stress calculation sheet, piping system wall thickness calculation sheet and structural strength calculation sheet, etc.);

(3) Product instructions, nameplate and factory certificate sample (if it is used for international voyage ships, a bilingual version in Chinese and English should be provided);

(4) FMEA analysis report.

4.3 Approved drawings/materials shall at least include the following contents:

(1) Factory overview: factory name, address, production history, production capacity, technical and inspection personnel, main products, affiliation, product trademarks, etc.;

(2) Details of the product to be approved;

(3) List of main production equipment;

(4) List of main testing equipment;

(5) Brief production process of the product to be approved;

(6) Quality management documents or quality system certificates;

(7) Enterprise registration certificate;

(8) Qualification certificate and/or production license, if applicable;

(9) Product quality certificate or sample of certificate;

(10) Quality control plan, if applicable;

(11) List of qualified suppliers, if applicable;

5 Technical Requirements

5.1 Material requirements

5.1.1 The material shall be selected with consideration given to corrosiveness of contact medium and to the suitability for its maximum working pressure and temperature. In addition to meeting the requirements of the Guidelines, its materials shall also meet the requirements of CCS *Rules for Materials and Welding* and/or *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, Rules for Natural Gas Fuel Used in Ships and relevant Guidelines. If new materials are used, relevant data shall be submitted for approval. Additionally, special tests may be required if necessary.

5.2 Requirements for connecting pipeline

The welding of connecting pipelines shall be subject to welding procedure qualification. Non-destructive testing shall be carried out in accordance with the standards accepted by CCS, followed by hydrostatic test at 1.5 times the maximum working pressure or air pressure test at 1.25 times the maximum working pressure, and then tightness test at the maximum working pressure.

(1) The pipeline shall be welded as far as possible, and the use of flange connection shall be minimized. Anti-blowout gaskets (stainless steel spiral wound with boss type) shall be used.

(2) The piping system for conveying goods shall also have reliable electrical connection.

(3) Drip trays shall be provided underneath locations where there is a risk of leakage (e.g., at cargo pump shaft seals and flanges).

(4) The pipeline shall be effectively thermally isolated to prevent frostbite or scald, and at the same time avoid frosting and condensation. The thermal insulation materials used shall at least meet the requirements of low flame spreading.

5.3 Requirements for motor, frequency converter and electrical control box

Motor, frequency converter and electrical control box shall meet the relevant technical requirements of the standards cited in the Guidelines. The technical requirements of electrical control box shall meet the requirements of *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* and applicable Guidelines.

5.4 Technical requirements for compressor

The technical requirements of the compressor shall meet the specifications, guidelines and accepted standards of the CCS. The overspeed test and dynamic balance test of the impeller shall meet the requirements of the standards accepted by the CCS. Shafts are to be subjected to non-destructive testing in accordance with a standard accepted by the CCS. The bearing selection shall meet the requirements of relevant applicable standards. Compatibility with media and factors such as strength, thermal conductivity and thermal expansion rate shall be considered, and bearing temperature sensors shall be provided.

5.5 Selection of pipeline and accessory materials

The selection of pipeline and accessory materials shall meet the requirements of Article 5.1; the coarse filter shall be provided with differential pressure display; the

selection of instruments and meters shall meet the requirements of relevant technical standards, and electrical equipment shall meet the explosion-proof requirements.

5.6 Medium compatibility requirements

Refrigerant working media or additives used for reliquefaction shall be compatible with the fuel in contact with them (without causing harmful reactions or excessive corrosive substances). In addition, if a plurality of refrigerant working media or additives are used and may contact each other, they shall be compatible with each other.

5.7 Monitoring of sealing system

Corresponding monitoring means shall be provided to confirm the reliability of sealing system, such as monitoring by differential pressure sensor.

5.8 Waste gas treatment of reliquefaction system

If during pressure control operation and within the design conditions, the reliquefaction system produces waste gases containing methane, these shall be treated as far as practicable without venting to atmosphere.

5.9 Design requirements for emergency shutdown (ESD) system

The design of emergency shutdown (ESD) system for reliquefaction device shall meet the requirements of Table 18.1 in Chapter 18 of Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and Rules for Natural Gas Fuel Used in Ships.

6 Raw Materials, Parts and Components

6.1 Main parts and components

Compressors, compression-expansion integrated machines, cold boxes, valves, heat exchangers (plate type, plate-fin type, shell and tube type, spiral wound type, etc.), motors, frequency converters, electrical control boxes, low-temperature steel pipes (applicable to natural gas and mixed working medium) and accessories shall be provided with CCS CERTIFICATE OF MARINE PRODUCT. Electrical products with explosion-proof requirements shall be provided with CERTIFICATE OF MARINE PRODUCT (including explosion-proof requirements) and/or explosion-proof certificates. Expansion joints shall be provided with the CERTIFICATE OF TYPE APPROVAL of CCS.

6.2 Raw material requirements

Relevant material requirements shall meet the relevant provisions of CCS Rules for Materials and Welding, Rules for Construction and Equipment of Ships Carrying

Liquefied Gases in Bulk, applicable guidelines and standards, as well as the requirements applicable to marine environmental conditions.

7 Type Test

7.1 Selection of typical samples

Upon approval, each model/specification shall be subject to type test.

7.2 Type test items

7.2.1 Air tightness test

Air tightness test shall be carried out for the refrigeration working medium air circuit and liquefied natural gas or BOG circuit of the reliquefaction device. The test pressure shall be 1.0 times the design pressure (if equivalent measures are taken, it shall be approved by the surveyor). All welds, equipment connections and other parts shall be tested with a leak detector to meet the design requirements.

7.2.2 Pipeline air pressure test

The air pressure test shall be carried out for the refrigeration working medium circuit, liquefied natural gas or BOG circuit of the reliquefaction device with a test pressure of 1.25 times the design pressure. If there is no deformation, leakage and abnormality in all parts of the refrigeration working medium circuit, liquefied natural gas or BOG circuit, it shall be deemed as qualified.

7.2.3 Pipeline purging test

Fill nitrogen and other similar gases into the pipeline through the filling port for purging, and use instruments to detect the dew point and oxygen content of outlet gas. When the gas dew point is not higher than -40°C and the oxygen content of natural gas pipeline does not exceed 2%, it shall be deemed that there is no air or other impurity gases in the piping system.

7.2.4 Hydrostatic test of cooling water pipeline system

The cooling water pipeline shall be subject to hydrostatic test to survey the strength and tightness. The hydrostatic test pressure shall be 1.5 times the maximum working pressure, and the holding time shall not be less than 10min. There shall be no abnormality in the cooling water pipeline and no damage or leakage at the joint.

7.2.5 Operation test

The actual function verification test shall be carried out for each design operation mode (generally precooling mode, cooling mode and warm-up mode), and the results shall meet the corresponding design condition standards.

For the cooling mode operation test, if the manufacturer does not have the test conditions, an equivalent scheme shall be submitted and verified on a real ship.

7.2.6 Insulation resistance test

Cold and hot insulation resistance tests shall be carried out on the reliquefaction device, and the test results shall meet the requirements of technical documents approved by CCS.

7.2.7 Performance test

(1) The reliquefaction device shall be adjusted to the rated speed, and after running for 1 hour or reaching steady state operation, test and record the LNG flow rate through the reliquefaction device, inlet and outlet temperature and pressure, expander/throttle valve inlet and outlet temperature and pressure, and calculate the output cooling capacity of the reliquefaction device under rated conditions.

(2) The reliquefaction device shall have the ability to operate under variable working condition. The system working conditions are adjusted by speed regulation or other measures to change the flow rate of the reliquefaction device and the temperature and pressure at the inlet and outlet of the expander/throttle valve, so as to meet the 0~100% cooling capacity demand of the reliquefaction device. During the test, linear changes such as no-load, 25%, 50%, 75% and 100% load can be tested according to the manufacturer's arrangement, and relevant test data shall be recorded.

7.2.8 Test of safety protection and alarm device

According to the safety protection measures approved by CCS, at least alarm device tests such as low suction pressure and high suction temperature of the compressor; high/low compressor outlet pressure, low cooling water pressure, high cooling water temperature, high cold box temperature difference (if applicable), low oil supply differential pressure (if applicable), high/low outlet temperature, high/low oil supply temperature (if applicable), high filter differential pressure and high gas-liquid separator liquid level (if applicable) shall be included; as well as emergency shutdown ESD, safety valve utility test and other shutdown protection utility tests. Corresponding tests shall be added according to the FMEA assessment requirements.

8 Unit/Batch Inspection

8.1 The survey for issuing CERTIFICATE OF MARINE PRODUCT shall be conducted after the manufacturer has completed the required surveys/tests and the product has passed surveys/tests, reaching a deliverable state.

8.2 Unit/batch survey of products from manufacturers that have obtained CCS

type approval includes:

(1) Air tightness test;

(2) Pipeline air pressure test;

(3) Pipeline purging test;

(4) Hydrostatic test of cooling water pipeline system;

(5) Operation test;

(6) Insulation resistance test;

(7) Test of safety protection and alarm device.

8.3 The unit/batch inspection for the products of manufacturers without CCS approval shall include:

(1) The applicant shall submit drawings/technical data to CCS in accordance with the requirements of Article 4 of this Guidelines;

(2) Type test shall be carried out for the first product inspection. See Article 7.2 of this Guidelines for type test items;

(3) For products that have undergone type test, the delivery test shall be carried out in accordance with the requirements of Article 8.2 of this Chapter during subsequent product inspection.