

Guideline No.P-04 (202211)



**P-04**

**STAINLESS STEEL CORRUGATED  
HOSE AND METAL BELLOWS  
EXPANSION JOINT**

Issued date: November 15, 2022

© China Classification Society

## Foreword

China Classification Society (hereinafter referred to as CCS) Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at <http://www.ccs.org.cn>. Your comments or suggestions are welcomed and may be sent to our email addressed [mp@ccs.org.cn](mailto:mp@ccs.org.cn).

Historical versions and release date: P-04(201510) October 20, 2015

P-04(201705) May 9, 2017

### Main changes:

1. Bellows definition is revised according to GB/T14525-2010 standard;
2. In Article 2, the Rules for Construction and Equipment of Ships Carrying Liquefied Gas in Bulk, IGC Code, IGF Code, Rules for Construction and Equipment of Ships Carrying Dangerous Liquid Chemicals in Bulk and IBC Code are added;
- 3.4.1. Article (2) is revised according to the feedback of the expert group;
4. The new version of Product Inspection Guide has no general provisions, and Article 4.3 is revised;
5. Article 6.1 (1) is revised according to the feedback from the expert group;
6. Add the requirement of Section 6.1 (2) according to Section 5.4.1 of Chapter 5 of Title 3 of the Rules for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk;

7. Article 6.2.2 is revised according to the feedback from the expert group;

8.7.2 (1) ③ Supplementary requirements according to DNV Ruler;

9.7.2 (2) ③ Add relevant test requirements in accordance with Section 5.13.1.2, Chapter 5, Title 3, Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk;

10. Section 7.3 (5) ②, (6) ② and (10) test requirements are revised according to GB/T12777-2019 standard; (8) Make supplementary requirements according to DNV Rules; (11) Add relevant test requirements according to Section 5.13.1.2, Chapter 5, Title 3, Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

## CONTENTS

1 Application.....	5
2 Basis for approval and inspection .....	5
3 Terms and definitions.....	5
4 Drawings and documents .....	6
5 Welding procedures qualification .....	6
6 Design and technical requirements .....	6
7 Type test.....	7
8 Unit/batch inspection .....	14

## **STAINLESS STEEL CORRUGATED HOSE AND METAL BELLOWS EXPANSION JOINT**

### **1 Application**

1.1 This Guideline applies to general-purpose stainless steel corrugated hoses and metal bellows expansion joints used in the structure of ships and relevant products.

1.2 General-purpose stainless steel corrugated hoses apply to: nominal diameter (DN) DN4 (mm) - DN300 (mm), nominal pressure (PN) PN0.5 (bar) - PN250 (bar).

### **2 Basis for approval and inspections**

2.1 The following standards are the bases for approval and inspection in this Guideline:

- (1) CCS Rules for Classification of Sea-Going Steel Ships
- (2) CCS Rules for Materials and Welding
- (3) CCS Rules for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
- (4) Resolution MSC.370(93) International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)
- (5) Resolution MSC.391(95) International Code of Safety for Ships Using Gas or Other Low Flash Point Fuels (IGF Code)
- (6) CCS Rules for Construction and Equipment of Ships Carrying Dangerous Liquid Chemicals in Bulk
- (7) Resolution MSC.4(48) International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)
- (8) CCS Guidelines for Inspection of Welding on Ships
- (9) ISO 10380: 2012 (E) Pipework — Corrugated Metal Hose and Hose Assemblies

### **3 Terms and definitions**

3.1 Bellow: A pipe-shaped housing with corrugated generatrix. Generally, bellows include helical bellows, circular bellows and reinforced.

3.2 Metal bellows expansion joint: A device composed of one or several bellows and structural parts and used to absorb the dimensional changes of pipeline and (or) equipment due to heat expansion and cold contraction.

3.3 Design pressure: It is the maximum allowable working pressure which is to be not less than

the maximum setting pressure of safety or spill valves.

3.4 Nominal pressure: Values given in technical documents of products.

3.5 Sensitive bellows: Bellows having higher requirements on indexes of sensitivity or rigidity and residual deformation value after displacement and so on.

3.6 General-purpose bellows: Bellows having strict requirements on indexes of working temperature, displacements and tightness and stability under the influence of pressure and forces.

#### **4 Drawings and documents**

4.1 When applying for approval, applicants are to submit the following plans and documents to CCS for approval:

- (1) Main product performance specification table (including nominal diameter, nominal pressure, design pressure, design temperature and designed fatigue life (where applicable) and applicable medium, etc. of the entire series of products to be approved);
- (2) Product plans and fatigue life of expansion joint etc.relevant design calculation book;
- (3) A list of physicochemical properties of materials of main parts;
- (4) Type test program.

4.2 The following plans and documents are to be submitted to CCS for information:

- (1) Documents of main process and self-inspection procedures of products;
- (2) Product instructions, marking and quality certificate (sample).

4.3 Other required documents:

- (1) Documents required by Article 3.2.1 of Part One GENERAL of Guidelines for Inspections of products of CCS.

#### **5 Welding procedures qualification**

5.1 The welding procedure of stainless steel corrugated hoses and metal bellows expansion joints with welded structure are to be approved by CCS. Welding procedures qualification is to be performed according to the standards accepted by CCS.

#### **6 Design and technical requirements**

6.1 Marine environmental conditions

- (1) Marine stainless steel corrugated hoses and metal bellows expansion joints shall be

designed and manufactured according to their design pressure, design temperature, applicable medium and application situation, etc., and shall comply with the relevant provisions of normative reference documents of this Guide or the standards accepted by this Society to ensure that they can work normally.

- (2) If the product is used for liquefied gas and chemical pipelines, the minimum design pressure should not be less than 1MPa (gauge pressure).

## 6.2 Materials

- (1) Materials used for bellows are to be selected according to working conditions including working medium, external environment, working pressure and working temperature, etc.
- (2) When transporting dangerous chemicals and liquefied gas medium, the manufacturer should ensure that the selection of product materials is compatible with the working medium, and there is enough evidence to show that the selected materials meet the requirements of use.
- (3) If the factory purchases stainless steel as raw materials, the quality certificate of raw materials is to include the content of intergranular corrosion test; if not, the factory is to conduct intergranular corrosion test to each batch of stainless steel according to lot grouping principles specified in the recognized standards.

## 7 Type test

### 7.1 Selection of typical sample

The typical samples selected for approval are to cover the level of production and processing and test capabilities. At least three representative samples with different dimensions are to be selected for each series of bellows. Consideration may be taken to select samples according to parameters like structure, application, design pressure and design temperature, etc.

### 7.2 Test items

- (1) Type test items for corrugated hoses are to include:
  - ① Visual inspection;
  - ② Inspection of geometric dimensions;
  - ③ Non-destructive test of weld seam (where applicable);
  - ④ Intergranular corrosion test of weld seam of stainless steel;
  - ⑤ Hydraulic test;
  - ⑥ Air tightness test;

- ⑦ Bending test;
- ⑧ Bursting test/Low temperature bursting test (for liquefied gas, chemical medium) ;
- ⑨ Tensile test;

(2) Type test items of expansion bellows as follows:

- ① Visual inspection;
- ② Inspection of geometric dimensions;
- ③ Non-destructive test of weld seam (where applicable);
- ④ Intergranular corrosion test of weld seam of stainless steel;
- ⑤ Hydraulic test;
- ⑥ Air tightness test;
- ⑦ Fatigue test;
- ⑧ If the product is used for liquefied gases or chemical media, the tests shall be carried out in addition to the above test items, as detailed in Section 7.3 (11).

7.3 Test methods and technical requirements are to meet the following requirements:

(1) Visual inspection

- ① The surface of products is to be free from visible defects like sharp pit, indentation, scratch and crack which can cause stress concentration and affect the strength and life. Slight mold indentation is excluded.
- ② The appearance and shape of products are to be free from visible defect of uneven wave distance.
- ③ The surface of products is to be free from visible rust and scale.
- ④ The surface of products is to be free from visible defects like large water stain and uneven color, etc.
- ⑤ The surface of products is to be free from visible defects like crack, welding spatter, and scratch and pit which are more than lower deviation of plate thickness, etc. And the scratch and pit less than the lower deviation of plate thickness are to be grinded for

smooth transition.

(2) Inspection of geometric dimensions

The structural dimensions and machining accuracy of main products are to be examined according to the design plans of products and the standards accepted by CCS.

(3) Non-destructive test of weld seam (where applicable)

The test is to be performed according to the standards accepted by CCS.

(4) Intergranular corrosion test of weld seam of stainless steel

The test is to be performed according to Parts One & Two and Section 7 of *CCS Rules for Materials and Welding* or the standards accepted by CCS.

(5) Hydraulic test

① Stainless steel corrugated hose:

The test is to be performed according to Clause 5.3 of ISO 10380: 2012 (E).

② Metal bellows expansion joint:

(a) In principle, hydrostatic test is to be performed. On occasions where hydrostatic test is not applicable, pneumatic test is to be performed. Effective safety measures must be taken when pneumatic test is performed.

(b) When the test is performed, the test device is to ensure that the two ends of expansion joint are fixed and effectively sealed and the bellows is in the state of a straight line.

(c) Water stain is to be cleaned after the hydrostatic test. If this requirement cannot be met, the chlorine ion content of testing water is to be controlled to be not more than 25 mg/L. The medium of pneumatic test is to be dry and clean compressed air or inert gas.

(d) The hydrostatic test of internal pressure type expansion joint is to be calculated by the following formulae, whichever is lesser:

$$P_t = 1.5 p_d (\sigma) b / (\sigma) b_t \text{ ----- (1)}$$

$$P_t = 1.5 p_s c (E) b / (E) b_t \text{ ----- (2)}$$

The pneumatic test of internal pressure type expansion joint is to be calculated by the following formulae, whichever is lesser:

$$P_t = 1.1 p_d (\sigma) b / (\sigma) b_t \text{ ----- (3)}$$

$$P_t = 1.1 p_{sc} (E) b / (E) b_t \text{ ----- (4)}$$

$P_t$ : test pressure, in MPa;

$p_d$ : design pressure, in MPa;

$(\sigma) b$ : permissible stress of materials for bellows under test temperature, in MPa;

$(\sigma) b_t$ : permissible stress of materials for bellows under design temperature, in MPa;

$P_{sc}$ : limit design pressure of column squirm when the two ends of bellows are fixed, in MPa;

$(E) b$ : modulus of elasticity of materials for bellows under test temperature in this Guideline, in MPa;

$(E) b_t$ : modulus of elasticity of materials for bellows under design temperature, in MPa;

- (e) For external pressure expansion joints, the hydrostatic test is to be calculated by formula (1) while pneumatic test is to be calculated by formula (3).
- (f) Two pressure gauges with the same range and qualified by inspection shall be used in the pressure resistance test. The measuring range of the pressure gauge is about 2 times the test pressure, but should not be less than 1.5 times and higher than 3 times the test pressure. The accuracy class of the pressure gauge shall not be lower than 1.6. Pressure is to be increased slowly during test. After the specified test pressure is reached, the pressure holding time is to last for at least 10 min. Expansion joint is to be free from leakage, structural parts are to be free from obvious deformation and the corrugated part is to be free from squirm. For unreinforced U-shaped bellows, compared with the original wave distance, if the maximum change rate of wave distance under test pressure is more than 15%, the product is deemed as squirm; for reinforced U-shaped and  $\Omega$ -shaped bellows, compared with the original wave distance, if the maximum change rate of wave distance under test pressure is more than 20%, the product is deemed as squirm.
- (g) When the nominal diameter of bellows is equal to or greater than 1,500 mm and the nominal pressure is 0.25 MPa, pressure test may be replaced by air jet-soap bubble test or kerosene leakage test. The pressure of air jet test is to be not less than 0.8 MPa; the dip-coating time of kerosene is to be not less than 30 min.
- (h) Pressure test for expansion joint under vacuum condition may be replaced by internal pressure test with a test pressure of 1.5 times the designed differential pressure (the differential pressure is equal to atmospheric pressure value minus vacuum value), or use the vacuum test to detect.

(6) Air tightness test

① Stainless steel corrugated hoses:

The test is to be performed according to Clause 5.2 of ISO 10380: 2012 (E).

② Metal bellows expansion joint:

- (a) The air tightness test shall be carried out after the pressure resistance test is qualified, the test device is to ensure that two ends of expansion joint are fixed and effectively sealed and the bellows is in the state of a straight line.
- (b) The air tightness test can be carried out simultaneously with the air pressure test.
- (c) The test medium is dry and clean compressed air or inert gas.
- (d) The pressure of air tightness test is equal to design pressure.
- (e) Pressure is to be increased slowly during test. After the specified test pressure is reached, the pressure holding time is to last for at least 10 min. Expansion joint is to be free from leakage.
- (f) Leakage inspection may be performed with soap bubble and water tank.

(7) Bending test

The test is to be performed according to 5.7 of ISO 10380: 2012 (E).

(8) Bursting test

- ① The length of specimen of hose is to be not less than 500 mm or 3 times the nominal diameter (DN), whichever is greater.
- ② Test medium is clean tap water or hydraulic oil.
- ③ Place the specimen flatly. Install a plug with an exhaust valve on one end, connect the other end with outlet pipe of pump, inject water or hydraulic oil into pipe, exhaust air and close the exhaust valve.
- ④ After the pressure is to be increased slowly to four times the design pressure, the pressure holding time is to last for at least 1 min. During this period, bellows are to be free from leakage. Then continue to increase the pressure till the hose bursts, record the bursting pressure of specimen and burst; but with the approval of the onsite Conveyor, it is allowable to not to continue the test till the hose bursts.

If used for liquefied gas and chemical medium, low-temperature bursting test should be carried out:

- ① The test is suitable for liquefied gas, chemical medium;
- ② Each size and specification shall be tested.

The requirements of low-temperature bursting test are as follows:

- ① Perform 200 pressure cycles at normal ambient temperature and from zero to at least twice the specified maximum operating pressure.
- ② After the pressure circulation test, the bursting prototype test should be carried out at the lowest design temperature and 5 times the maximum design pressure, and the pressure should be held for 1 minute at this pressure and then released;
- ③ After the prototype test, the product shall be subjected to a hydraulic test of 1.5 times the maximum design pressure at room temperature, and the product shall be free of cracks and leaks.

(9) Tensile test

- ① The length of specimen of hose is to be not less than 500 mm or 3 times the nominal diameter (DN), whichever is greater.
- ② Select one sample with a rated length, increase the pressure slowly to 1.5 times the design pressure and hold the pressure for at least 1 min. Then release the pressure slowly. After the pressure is released completely, measure the length of the sample and the permanent elongation is to not exceed 1% of the length of the samples before the test.

(10) Fatigue test

Fatigue test method for bellows with design temperature lower than material creep temperature:

- ① The test is to be performed on the special fatigue test device. Fatigue test device is to ensure that pressure thrust and displacement reaction of bellows can be restricted and the applied axial cyclic displacement is coaxial with the axis of bellows. The initial state of the bellows is in a straight line with its free length.
- ② Bellows to be tested are to be all bellows with not less than 3 waves conforming to all other type test items. Structure of other parts in test specimens may be designed according to test device to meet the test requirements.
- ③ Test medium may be tap water, compressed air, inert gas, or oil, etc.

- ④ The test temperature is room temperature, and the test pressure gauge should meet the requirements of (5) ② (f) above.
- ⑤ Test pressure is equal to design pressure. During test, the fluctuating value of pressure is to be not more than  $\pm 10\%$  of test pressure.
- ⑥ The cyclic displacement of the test is to be axial displacement. The cyclic displacement range of the test is to be equal to design axial displacement or designed equivalent axial displacement. The test cycle displacement should be carried out according to the symmetry axial displacement. The cycle rate of the test is to be determined according to the time required to enable displacement to be evenly distributed in each wave and is to be less than 25 mm/s.
- ⑦ The number of test cycles: The number of cycles of circular bellows is to be more than 2 times the design fatigue life; the number of cycles of rectangular bellows is to be more than design fatigue life. Bellows are to be free from leakage within the specified number of cycles of the test. If the test medium is water, bellows are to be free from water leakage; if the test medium is gas, the surface of bellows is to be free from gas leakage through soap bubble test.

Fatigue test method for bellows with design temperature within the creep temperature range of materials:

- ① The test was carried out in accordance with the requirements in Appendix D of GB/T12777-2019.
  - ② Number of test cycles: the number of circular bellows test cycles should be greater than the calculated average failure cycles. The bellows shall be free of leakage within the specified number of test cycles.
- (11) If the product is used for liquefied gas or chemical medium, in addition to the above test items, the following items shall be tested for each size and specification:
- ① The bellows element without pre-compression shall be subjected to a pressure test of not less than 5 times the design pressure without rupture, and the test duration shall be not less than 5 min;
  - ② The prototype expansion joint with all accessories such as flanges, tie bars and hinged parts shall be subjected to a pressure test of twice the design pressure without permanent deformation at the minimum design temperature and the maximum displacement recommended by the manufacturer;
  - ③ The complete expansion joint shall be subjected to a cycle test (thermal motion). Under conditions of pressure, temperature, axial motion, rotational motion and transverse motion, the complete expansion joint shall be able to withstand at least as many cycles as it is encountered in actual use. When these tests are as rigorous as those at operating temperatures, they are allowed to be carried out at room

temperature; and

- ④ The complete expansion joint shall be subjected to cyclic fatigue testing (hull deformation) without internal pressure, that is, at least 2,000,000 cycles at a frequency not higher than 5 Hz (cycles per second) by simulating the motion of bellows equivalent to compensating tube segments. However, such tests are required only if the piping arrangement is actually subject to hull deformation loads.

## **8 Unit/batch inspection**

8.1 The unit/batch inspection where a CCS marine product certificate is to be issued is to be conducted only when those products have been qualified as deliverable in the factory inspection/test.

8.2 Unit/batch inspection of products of manufacturer approved in the type approval by CCS

- (1) The inspection items to be witnessed are to be conducted according to the inspection plan approved at the time of approval but usually inclusive of:
  - ① Visual and dimensional inspection;
  - ② Hydraulic test;
  - ③ Air tightness test.
- (2) The above tests are to be completed by the factory according to its inspection procedures (internal control standards) independently and complete reports are to be submitted to the Surveyor for review.
- (3) In addition, the Surveyor is to randomly take at least 1~3% (or 1 unit) products per batch/specification for re-test of the above inspections and tests, and to witness on site at the time of re-test.
- (4) When applying for unit/batch inspection, applicants are to submit Quality Certificate of Raw Materials of Main parts of that batch of products to CCS for review.