

Translated English of Chinese Standard: GB/T18442.7-2017

[www.ChineseStandard.net](http://www.ChineseStandard.net) → Buy True-PDF → Auto-delivery.

[Sales@ChineseStandard.net](mailto:Sales@ChineseStandard.net)

# GB

NATIONAL STANDARD OF THE  
PEOPLE'S REPUBLIC OF CHINA

ICS 23.020.40

A 82

## GB/T 18442.7-2017

**Static vacuum insulated cryogenic pressure vessels - Part**

**7: Rules of pressure strengthening for inner vessels**

固定式真空绝热深冷压力容器

第 7 部分:内容器应变强化技术规定

**Issued on: November 01, 2017**

**Implemented on: May 01, 2018**

**Issued by: General Administration of Quality Supervision, Inspection and Quarantine;**

**Standardization Administration of the People's Republic of China.**

## Table of Contents

Foreword.....	3
1 Scope.....	4
2 Normative references.....	4
3 Terms, definitions and symbols .....	6
4 General requirements .....	7
5 Material .....	7
6 Design.....	9
7 Manufacture and inspection .....	11
Annex A (informative) Important quality control points during manufacturing process of pressure strengthening inner vessels.....	18
Annex B (informative) Approximate control and requirements of Austenitic stainless-steel number .....	20
Annex C (informative) Requirements for test of pressure strengthening process verification.....	21
Annex D (informative) Test piece pre-tensile and test rules .....	27
Annex E (normative) Pressure strengthening treatment .....	31

# Static vacuum insulated cryogenic pressure vessels - Part 7: Rules of pressure strengthening for inner vessels

## 1 Scope

This Part of GB/T 18442 specifies the technical requirements for material, design, manufacture and inspection of the inner vessels of static vacuum insulated cryogenic pressure vessels (hereinafter referred to as the inner vessels) that are manufactured by pressure strengthening technology.

This Part is applicable the inner vessels that meet the following conditions at the same time:

- a) in accordance with the provisions of 1.2 of GB/T 18442.1, the medium is frozen liquefied gas;
- b) the material is austenitic stainless steel;
- c) the nominal thickness is not less than 4mm and not more than 24mm, consisting of a single diameter cylinder and a standard oval head;
- d) the strain strengthening is completed at room temperature.

This Part is not applicable to the inner vessels that contain mediums of which the toxicity hazard is moderate and above.

## 2 Normative references

The following referenced documents are indispensable for the application 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.

GB/T 150 (all parts), *Pressure vessels*

GB/T 228.1, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature*

GB/T 229, *Metallic Materials - Charpy Pendulum Impact Test Method*

GB/T 232, *Metallic materials - Bend test*

- GB/T 2653, *Methods of bend and compression tests for welded joint*
- GB/T 3808, *Verification of pendulum-type impact testing machines*
- GB/T 12160, *Calibration of extensometers used in uniaxial testing*
- GB/T 14976, *Seamless stainless-steel pipes for fluid transport*
- GB/T 16825.1, *Verification of static uniaxial testing machines - Part 1 : Tension/compression testing machines - Verification and calibration of the force-measuring system*
- GB/T 18442.1~18442.6, *Part 1~Part 6 of Stationary Vacuum Thermal-Insulating Cryogenic Pressure Vessel*
- GB/T 24511, *Stainless steel and heat resisting steel plate, sheet and strip for pressure equipment*
- NB/T 47010, *Stainless and heat-resisting steel forgings for pressure equipment*
- NB/T 47013.2, *Nondestructive testing of pressure equipment Part 2: Radiographic testing*
- NB/T 47013.5, *Nondestructive testing of pressure equipment Part 5: Penetrant testing*
- NB/T 47013.11, *Nondestructive Testing of Pressure Equipment Part 11: Standard practice for X-ray digital radiography*
- NB/T 47014, *Welding procedure qualification for pressure equipment*
- NB/T 47016, *Mechanical Property Tests of Product Welded Test Coupons for Pressure Equipment*
- NB/T 47018.1, *Technical permission of welding materials for pressure equipment - Part 1: General rule*
- NB/T 47018.2, *Technical permission of welding materials for pressure equipment - Part 2: Electrodes for steel*
- NB/T 47018.3, *Technical permission of welding materials for pressure equipment - Part 3: Steel electrodes and rods for gas shielded arc welding*
- NB/T 47018.4, *Technical permission of welding materials for pressure equipment - Part 4: Electrodes and fluxes for submerged arc welding*
- JB 4732-1995, *Steel Pressure Vessels - Design by Analysis (confirmed in 2005)*

## 4 General requirements

**4.1** In addition to all parts of this Standard, the material, design, manufacture and inspection as well as marks of the inner vessels shall also comply with the relevant laws, regulations, safety technical specifications and relevant standards promulgated by the country.

**4.2** When the inner vessels manufactured by pressure strengthening technology beyond the scope of this Part, it shall be implemented in accordance with the relevant provisions of TSG 21.

**4.3** The manufacturer shall carry out the manufacture of the inner vessels in its organization, verify the welding process and pressure strengthening process adopted by it, and be responsible for the correctness and completeness of the process documents.

**4.4** The manufacturer shall upload the mechanical performance data of the welded test piece and the data of the pressure strengthening test process to the national strain-enhanced cryogenic container manufacturing information public service platform.

**4.5** The special equipment supervision and inspection agency shall supervise and inspect the pressure strengthening process adopted by the inner vessels and the important quality control points proposed in Annex A, which shall meet the requirements of this Part.

## 5 Material

### 5.1 Steel plate

**5.1.1** The designation and mechanical properties of the steel plate shall comply with the requirements of Table 1. The supply status is solid solution heat treatment and meets the requirements of GB/T 150.2 and GB/T 24511.

**5.1.2** The steel plate shall be re-inspected. It shall at least contain the following information:

- a) Check the surface quality and material marking of the steel plate one by one;
- b) Re-inspect the tensile properties of steel plate at room temperature;
- c) If the open plate is used, the re-inspection requirements shall also comply with the relevant provisions of GB/T 150.4.

**5.1.3** The sampling quantity and position of tensile test shall be in accordance

When using the materials other than Table 1 and Table B.1 to manufacture the inner vessels with the pressure strengthening technology, it shall also comply with the relevant provisions of TSG 21.

## 6 Design

### 6.1 General

**6.1.1** In addition to the provisions of this Part, the design of the inner vessels shall also comply with the provisions of TSG 21, GB/T 150 and GB/T 18442.3.

**6.1.2** The designer shall issue a risk assessment report for the vacuum insulated cryogenic pressure vessels manufactured by pressure strengthening technology. The content of the report, in addition to the provisions of GB/T 150.1, shall also include the failure mode as well as risk control caused by pressure strengthening technology.

**6.1.3** The design of the inner vessels shall indicate "using pressure strengthening technology", as well as strengthening pressure, diameter before strengthening.

**6.1.4** The diameter and thickness of the inner vessel involved in this chapter are the parameters before the pressure strengthening treatment. Does not consider changes after pressure strengthening treatment.

**6.1.5** The product nameplate shall be marked with "pressure strengthening vessel", the symbol is "PS".

### 6.2 Load

**6.2.1** When designing the inner vessel, the corresponding load and its combination shall be considered in accordance with the provisions of GB/T 18442.3.

**6.2.2** In the process of pressure strengthening treatment, the reaction force and the strengthening pressure load generated at the support of the inner vessel shall also be considered.

### 6.3 Allowable stress

**6.3.1** The allowable stress of the steel plate for the cylinder and the head is determined according to Table 2.

**6.3.2** The allowable stress of pressure components such as adapters and forgings is determined according to GB/T 150.2.

**6.3.3** When the local stress of the adapters, the inner vessel supports and the

## 6.8 Pressure of pressure resistance test

The pressure of pressure resistance test shall comply with the provisions of GB/T 18442.3.

## 6.9 Pressure of leak test

Perform according to the provisions of GB/T 18442.3.

## 6.10 Structure design

**6.10.1** Except the last closed ring welds, the type A and type B weld joints shall be full penetration butt joints. Closed ring welds allow the use of butt joints with permanent backing.

**6.10.2** The hole-opening diameter of the inner vessel shall not be greater than 150 mm. When setting the craft manhole, the edge of the hole shall be within 0.8  $D_i$  of the center of the head. The center line of the opening is along the normal direction of the housing.

**6.10.3** The splicing weld of the reinforcing ring shall be a full-section penetration weld joint. The weld between the reinforcing ring and the cylinder shall be continuously welded on both sides. The height of the solder fillet shall not be less than the thickness of the cylinder and the thickness of the reinforcing ring.

**6.10.4** An overflow shall be placed on the inner vessel at the rated full rate. When determining the rated full rate, the inner volume of the inner vessel before pressure strengthening is generally used.

**6.10.5** In the design of the structure, the influence of the plastic deformation of the inner vessel on the low-temperature insulation performance of the vessel, the installation of the outer casing and the piping system shall also be considered.

# 7 Manufacture and inspection

## 7.1 General

**7.1.1** In addition to the provisions of this Part, the manufacture, inspection and acceptance of the inner vessels shall also meet the requirements of other parts of GB/T 18442 and design documents.

**7.1.2** The manufacturer shall have plant facilities, strengthening equipment and corresponding testing equipment suitable for the pressure strengthening process.

**7.1.3** Before the manufacturer uses the pressure strengthening technology for

**7.4.4.2** The second pressure strengthening treatment can be exempted when welding is applied under the following conditions. But it shall carry out the pressure resistance test. The test pressure shall be determined according to 6.8:

- a) only withstand the spot welding of small load accessories;
- b) the length of the weld seam of adapter is not more than 10% of the inner diameter of the inner vessel, and not exceed 100mm;
- c) slight welding rework does not have significant impact on the main structure.

#### **7.4.5 Product welding test piece**

**7.4.5.1** The product welding test piece shall be prepared piece by piece. The test piece shall be welded at the same time at the extension of the longitudinal weld of the cylinder section and at the cylinder section. Before strengthening, perform longitudinal welding for the inner vessel of which the geometric volume is less than or equal to 5 m<sup>3</sup>. When using the same welding process, it is allowed to prepare product welding test pieces by batch. The inner vessels of same model, of same lot, of same material designation, of same welding process and of same strengthening process can be batched. Each batch does not exceed 20 pieces.

**7.4.5.2** Product welding test pieces shall be pre-tensile according to the provisions of Annex D. The number of welding test pieces and samples of the product shall comply with the provisions of NB/T 47016. The tensile at room temperature test, the bending at room temperature test and low temperature impact (not higher than the minimum design metal temperature) test after pre-tensile as well as their qualification indicators shall comply with the provisions of Table 3.

#### **7.5 Nondestructive testing**

##### **7.5.1 Testing before pressure strengthening implementation**

- a) All type A, B weld joints of inner vessels shall be subjected to 100% radiation testing according to NB/T 47013.2 or NB/T 47013.11. The testing technology level is not lower than AB level. Except that the qualification level of the closed weld joint with the backing plate is not lower than level II, the qualification level of the other weld joints is not lower than level I.
- b) Stress concentration parts such as inner vessel types A, B, D, E weld joints as well as strengthening circle and corner joint weld joint of inner vessels shall be subjected to 100% penetration test according to NB/T 47013.5. The qualification level is not less than level I.



## **Annex A**

(informative)

### **Important quality control points during manufacturing process of pressure strengthening inner vessels**

#### **A.1 Design documents**

**A.1.1** Risk assessment report.

**A.1.2** Document integrity and standard compliance.

**A.1.3** "PS" logo in design documents.

#### **A.2 Material retesting**

**A.2.1** Inner vessel materials shall meet the requirements of Clause 5.

**A.2.2** The materials of the cylinder and the head shall also comply with the provisions of 7.2.

#### **A.3 Forming control**

**A.3.1** The forming of the cylinder and the head shall comply with the provisions of 7.3.

**A.3.2** The shape and size of the weld seam shall comply with the provisions of 7.4.2.

#### **A.4 Welding procedure assessment**

Welding procedure assessment shall comply with the provisions of 7.4.1. The mechanical properties and bending performance of the weld joints after pre-tensile shall be in accordance with the requirements of Table 3.

#### **A.5 Welding**

**A.5.1** Weld according to the qualified welding process.

**A.5.2** The selection of welding consumables shall comply with the provisions of 5.4.

#### **A.6 Product welding test piece**

Product welding test piece shall comply with the provisions of 7.4.5. The mechanical properties and bending performance indicators shall meet the

## Annex C

(informative)

### Requirements for test of pressure strengthening process verification

#### C.1 General

**C.1.1** The process documentation of the inner vessel shall be verified by process validation test before manufacturing. The verification test uses trial sample vessel. Perform relevant test according to the requirements of Annex D.

**C.1.2** The design, manufacture and inspection of the sample vessel shall be in accordance with the requirements of this Standard. And before the trial production, the welding process qualification is carried out according to the requirements of this Part and related standards. Develop process documents such as welding procedure instructions, pressure strengthening process instructions, and test outlines.

**C.1.3** The relevant requirements of the verification test shall be in accordance with the content and requirements of the test program.

#### C.2 Structure requirements for sample vessel

**C.2.1** The structure requirements for sample vessel are as follows.

- a) The tank body has at least 2 cylinder sections. The width of each section is not less than 1500 mm. The butt ring is set to the weld at the maximum deformation of the estimated inner vessel.
- b) The inner diameter is not less than 1800 mm. The nominal wall thickness is not less than 8 mm.
- c) The tank body does not have binding parts such as reinforcement rings, manholes, and support pads.
- d) The butt joint weld seam of the cylinder and the head shall be capable of simulating the weld joint form of the joint closed weld seam of the inner vessel.

**C.2.2** The strength calculation shall be performed for the structure and design parameters of sample vessel.

**C.2.3** The numerical simulation shall be performed for pressure strengthening process of sample vessel. By comparing with the test results, the rules of the plastic deformation of the cylinder and the deformation amount caused by the

located in the middle of the parallel section of the sample. The thickness of the sample shall be equal to or close to the thickness of the sample base material. When the thickness of the base material on both sides of the weld seam is inconsistent, the thickness of the sample shall be consistent with the thinner side.

### **D.3.2 Tensile method at room temperature**

The tensile test at room temperature shall be carried out according to the requirements of GB/T 228.1.

## **D.4 Impact sample and test method**

### **D.4.1 Impact sample**

**D.4.1.1** Prepare a Charpy V-notch impact sample with dimensions of 10mm × 10mm × 55mm. It is also possible to prepare a Charpy V-notch impact sample having a size of 7.5mm × 10mm × 55mm or 5mm × 10mm × 55mm according to the thickness of the test piece. The impact sample shall comply with the provisions of GB/T 229.

**D.4.1.2** The V-notch of each impact sample is measured with a dedicated notch projector. Carry out the test after it is qualified.

### **D.4.2 Impact test method**

The impact test method shall comply with the provisions of GB/T 229.

### **D.4.3 Sample cooling**

When the sample is subjected to the impact test, it shall be cooled to the specified temperature. The holding time is not less than 5 min.

## **D.5 Bending sample and test method**

### **D.5.1 Bending sample**

The thickness of the bending sample is the original thickness of the sample. The weld seam shall be located at the center of the sample. And remove the weld seam reinforcement. When the surface of the sample needs to be leveled, the thickness of the sample shall be as close as possible to the thickness of the test piece. The length L of the sample is 200 mm and the width W is 38 mm, see Figure D.2.

## Annex E

(normative)

### Pressure strengthening treatment

#### E.1 Pressure strengthening treatment

##### E.1.1 General

**E.1.1.1** The pressure strengthening site shall have reliable safety protection facilities and be approved by the organization technical person in charge and the safety department. During the pressure strengthening process, the test site shall not perform work unrelated to the test, and unrelated personnel shall not stay at the test site.

**E.1.1.2** The inner vessels shall meet the requirements of this Part and the design documents.

**E.1.1.3** Parts welded to the inner vessel shall be welded before strengthening.

**E.1.1.4** Before the pressure strengthening is implemented, the weld joint shall pass the non-destructive test according to the requirements of 7.5.

**E.1.1.5** The chloride ion content in pressure strengthening water does not exceed 25 mg/L.

**E.1.1.6** The top of the inner vessel (the highest part) shall be provided with an exhaust pipe. The filling port is located at the bottom of the inner vessel. When pressure is strengthened, the setting of the support shall not affect the deformation of the inner vessel. After filling the container with water, wait at least 15 min for the gas dissolved in the water to drain completely.

**E.1.1.7** The outer surface of the inner vessel shall be kept dry during the pressure strengthening process. After the strengthening is completed, the water shall be drained and dried.

**E.1.1.8** Special equipment supervision and inspection institutions shall witness and test the pressure strengthening process. And sign the confirmation in the s pressure strengthening report.

##### E.1.2 Testing equipment and control system

**E.1.2.1** The pressure gauge accuracy shall be no less than level 1.6. The number of pressure gauges shall be no less than 2. The range of the pressure gauge shall be 1.5 times to 3.0 times the strengthening pressure. The pressure

**This is an excerpt of the PDF (Some pages are marked off intentionally)**

**Full-copy PDF can be purchased from 1 of 3 websites:**

1. <https://www.ChineseStandard.us>

- SEARCH the standard ID, such as GB 4943.1-2022.
- Select your country (currency), for example: USA (USD); Germany (Euro).
- Full-copy of PDF (text-editable, true-PDF) can be downloaded in 9 seconds.
- Tax invoice can be downloaded in 9 seconds.
- Receiving emails in 9 seconds (with download links).

2. <https://www.ChineseStandard.net>

- SEARCH the standard ID, such as GB 4943.1-2022.
- Add to cart. Only accept USD (other currencies - <https://www.ChineseStandard.us>).
- Full-copy of PDF (text-editable, true-PDF) can be downloaded in 9 seconds.
- Receiving emails in 9 seconds (with PDFs attached, invoice and download links).

3. <https://www.google.com/search?tbm=bks&q=ChineseStandard.net>

- SEARCH the standard ID, such as GB 4943.1-2022.
- Google Books -- Select your currency.
- Processed by Google (delivery, tax invoice etc.). Delivered in 9 seconds by Google.
- Tips: Download an unprotected **True-PDF** (text-editable) from Google-Books:
  1. <https://play.google.com/books> → 2. Sign in → Google account
  3. Find the **BOOK** you bought → 4. Click "3-dots" → Export
  5. Save as "\*.pdf" (Save True-PDF to your local computer for offline reading/printing)

Translated by: Field Test Asia Pte. Ltd. (Incorporated & taxed in Singapore. Tax ID: 201302277C)

Accountable person and shareholder: Wayne Zheng

About Us (Goodwill, Policies, Fair Trading...): <https://www.chinesestandard.net/AboutUs.aspx>

Contact: Wayne Zheng, [Sales@ChineseStandard.net](mailto:Sales@ChineseStandard.net)

Linkin: <https://www.linkedin.com/in/waynezhengwenrui/>

----- The End -----