



BSI Standards Publication

Nuclear energy — Packagings for the transport of uranium hexafluoride (UF₆)

National foreword

This British Standard is the UK implementation of ISO 7195:2020.

The UK participation in its preparation was entrusted to Technical Committee NCE/9, Nuclear Installations, Processes & Technologies.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Published by BSI Standards Limited 2020

ISBN 978 0 539 04366 2

ICS 27.120.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2020.

Amendments/corrigenda issued since publication

Date	Text affected
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INTERNATIONAL STANDARD

ISO
7195

Third edition
2020-11-20

Nuclear energy — Packagings for the transport of uranium hexafluoride (UF₆)

*Energie nucléaire — Emballages pour le transport de l'hexafluorure
d'uranium (UF₆)*



Reference number
ISO 7195:2020(E)
Documents
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 5, *Nuclear installations, processes and fuel technologies, WG4, Transport of radioactive material*.

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.

This third edition cancels and replaces the second edition (ISO 7195:2005), which has been technically revised. The main changes compared to the previous edition are:

- The title of the document has been slightly changed to better reflect its scope;
- The general structure of the document has been partly reorganized to enhance clarity and to ease comparison with ANSI N14.1;
- The cylinder model 48G has been removed and the cylinder model 30C added;
- The socket head plugs for 30 in and 48 in cylinders have been added (alternative to hex head plugs);
- The list of references and the list of terms and definitions used have been updated;
- “Quality assurance programme” has been replaced by “management system”;
- Clauses related to manufacture, periodic inspection and recertification have been redrafted for better clarity;
- The possibility for 30B, 48X and 48Y cylinders to use non-destructive examinations as an alternative to hydrostatic testing during their periodic inspections, with the condition that additional examinations are carried out at the time of their manufacturing, has been introduced;
- The use of leak test methods other than the specified one is now permitted;

- The existing tie down requirements have been replaced by a reference to the new Appendix IV of IAEA SSG-26;
- The reuse of valves and plugs removed from cylinders is no longer permitted;
- All the figures have been revised to correct errors, increase clarity and add missing information.

Introduction

The transport of uranium hexafluoride (UF₆) is an essential operation in the nuclear industry. The packaging and transport of UF₆ is subject to the relevant transport regulations for dangerous goods of each of the countries through or into which the material is transported. This document does not take precedence over applicable regulations, nor does it relieve the consignor and other parties from compliance with these regulations. For more detailed information, the user of this document is encouraged to consult the appropriate regulatory document.

According to IAEA Regulations for the Safe Transport of Radioactive Material (SSR-6), and all regulations based on, except as allowed in its para. 634, uranium hexafluoride in quantities of 0,1 kg or more is required to be packaged and transported in accordance with the provisions of this document.

ANSI N14.1 has been used internationally as an industry reference and the standard cylinders included in ANSI N14.1 have been used widely for international transport of UF₆. However, in some cases minor adaptations of the American standard were required to meet local conditions in a particular country. For example, equivalent materials may have been used instead of the materials specified. Moreover, the certification of cylinders as pressure vessels can have required equivalent authorization procedures appropriate in the countries concerned, rather than the US procedure specified.

This document presents primarily information on UF₆ packagings (including cylinders and valve protection). It is intended to provide for compatibility of UF₆ cylinders among different users within the nuclear industry. It has been developed from ANSI N14.1, but with incorporation of, and allowance for, other equivalent materials and national certification procedures.

Throughout this document and in conformity with standard ISO practice, SI metric units are used in preference to imperial units (which are given in parenthesis for information). However, generic cylinder designations are based on the diameter expressed in imperial units (48" for instance).

If a common, commercially available component uses features that are defined in an appropriate non-SI metric-based Standard document, only the relevant base units are quoted.

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Nuclear energy — Packagings for the transport of uranium hexafluoride (UF₆)

1 Scope

This document provides the following:

- specifications for cylinders for the transport of uranium hexafluoride (UF₆) to provide compatibility among different users,
- description of cylinder designs, but is not intended to develop new designs,
- fabrication requirements for the procurement of new cylinders designed for the transport of 0,1 kg or more of uranium hexafluoride,
- fabrication requirements for the procurement of new valve protections, valves and plugs, and
- requirements for cylinders and valve protections in service.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitute 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 263, *ISO inch screw threads — General plan and selection for screws, bolts and nuts — Diameter range 0,06 to 6 in*

[ISO 6508-1](#), *Metallic materials — Rockwell hardness test — Part 1: Test method*

[ISO 9712](#), *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 12807, *Safe transport of radioactive materials — Leakage testing on packages*

ANSI/ASME B1.1, *Unified Inch Screw Threads (UN and UNR Thread Form)*

ANSI/ASME B1.5, *Acme Screw Threads*

ANSI/ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ANSI/ASME B16.11, *Forged Steel Fittings, Socket-Welding and Threaded*

ANSI/AWS A5.8M/A5.8, *Specification for Filler Metals for Brazing and Braze Welding*

ANSI/AWS A5.14/A5.14M, *Specification for Nickel and Nickel-Alloy Bare Welding Electrodes and Rods*

ANSI/AWS D1.1/D1.1M, *Structural Welding Code — Steel*

ANSI/CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*

ASTM A20/A20M, *Standard Specification for General Requirements for Steel Plates for Pressure Vessels*

ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*

ASTM A53/A53M, *Standard Specification for Pipe, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

ASTM A105/A105M, *Standard Specification for Carbon Steel Forgings for Piping Applications*

ASTM A106/A106M, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*

ASTM A108, *Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished*

ASTM A131/A131M, *Standard Specification for Structural Steel for Ships*

ASTM A193/A193M, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications*

ASTM A234/A234M, *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service*

ASTM A240/A240M, *Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*

ASTM A285/A285M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low and Intermediate-Tensile Strength*

ASTM A354, *Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners*

ASTM A516/A516M, *Standard Specification for Pressure Vessel Plates, Carbon Steel for Moderate- and Lower-Temperature Service*

ASTM A574, *Standard Specification for Alloy Steel Socket-Head Cap Screws*

ASTM A575, *Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades*

ASTM B16/B16M, *Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines*

ASTM B32, *Standard Specification for Solder Metal*

ASTM B127, *Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip*

ASTM B150/B150M, *Standard Specification for Aluminum Bronze Rod, Bar, and Shapes*

ASTM B160, *Standard Specification for Nickel Rod and Bar*

ASTM B161, *Standard Specification for Nickel Seamless Pipe and Tube*

ASTM B162, *Standard Specification for Nickel Plate, Sheet, and Strip*

ASTM B164, *Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire*

ASTM B165, *Standard Specification for Nickel-Copper Alloy (UNS N04400) Seamless Pipe and Tube*

ASTM B209, *Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate*

ASTM B211, *Standard Specification for Aluminum and Aluminum-Alloy Bar, Rod, and Wire*

ASTM B249/B249M, *Standard Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings*

ASTM B366/B366M, *Standard Specification for Factory-Made Wrought Nickel and Nickel Alloy Fittings*

ASTM E2375, *Standard Practice for Ultrasonic Examination of Wrought Products*

IAEA SSR-6, *Regulations for the Safe Transport of Radioactive Material*

SAE J512, *Automotive Tube Fittings*

SAE J513, *Refrigeration Tube Fittings — General Specifications*

NUREG/CR-6407, *Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the IAEA SSR-6 and the following 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/>

NOTE 1 Units are those of the International System, with other units shown in brackets for information.

NOTE 2 Throughout this document, the words *suggested* and *typical* denote an example for weld constructions, dimensions and/or layout, and means that other solutions may be used provided they comply with the requirements in the code and this document, as appropriate.

NOTE 3 Throughout this document, the words *nominal* and *Schedule* qualify a thickness of a material from stock (plate, bar, pipe, etc.), for which the tolerance is according to the standard specification for the relevant material.

3.1

authorized inspector

individual who is qualified by the jurisdictional authority/inspection authority as requested by the code

3.2

clean and washed out cylinder

cylinder that has been previously used and has been cleaned to remove residual quantities of uranium and other contaminants

3.3

code

pressure vessel code that is acceptable to the transport competent authority

EXAMPLE Section VIII of ANSI/ASME Boiler and Pressure Vessel Code is an example.

3.4

competent authority

national or international regulatory body or authority designated or otherwise recognized as such for any purpose in connection with the relevant transport regulations for dangerous goods

3.5

competent inspector

individual who is qualified according to the owner's requirements regarding inspection activities as detailed in its quality assurance program

3.6

cylinder

pressure vessel, equipped with its valves and plugs, as applicable

3.7

fabricator

manufacturer, repairer, or modifier of cylinders and valve protection

3.8

heel

residual amount of UF₆ and/or non-volatile reaction products of uranium

3.9

heeled cylinder

cylinder containing a heel in quantities equal to or less than those specified

Note 1 to entry: See [Table 8](#).

3.10

jurisdictional authority/inspection authority

entity with the power, right, or authority to interpret and enforce laws, rules, or ordinances pertaining to the code

3.11

maximum allowable working pressure

MAWP

maximum allowable working pressure as defined by the code

3.12

minimum design metal temperature

MDMT

minimum design metal temperature as defined by the code

3.13

new cylinder

cylinder that has been cleaned to remove fabrication debris and contaminants that would react with UF₆ and that has never been filled with UF₆

3.14

owner

individual, agency, contractor, company, or corporation that carries or will carry title to the cylinder during its use

3.15

outer protection

mechanical and/or thermal protection during transport for cylinders containing UF₆

3.16

package

packaging containing UF₆ or heel prepared for transport in compliance with the relevant transport regulations for dangerous goods

3.17

packaging

cylinder equipped with all its outer protection necessary to ensure the containment and the other safety functions of the package in compliance with the relevant transport regulations for dangerous goods

3.18

pressure vessel

container designed, fabricated, examined, inspected, tested and certified in accordance with the code

3.19

service life

period of time from initial stamping at the end of manufacturing until the pressure vessel is no longer suitable for transport of UF₆ and is not repaired and returned to service and/or scrapped to prevent further use

3.20

tare

cylinder mass with valve(s), including cap(s), and plug(s) without valve protection with an internal air or nitrogen total absolute pressure corrected to 34,5 kPa (5 lbf/in²)

3.21

water capacity

water mass in kilogram, corrected to a temperature of 15,6 °C (60 °F)

4 Management system

In alignment with the IAEA SSR-6, a management system based on international, national or other standards acceptable to the transport competent authority shall be established and implemented for all activities (including the manufacture, maintenance and repair of cylinder and outer protection) within the scope of this document, to ensure compliance with its relevant provisions. Certification that the design specification has been fully implemented shall be available to the transport competent authority. The manufacturer or owner shall be prepared:

- a) To provide facilities for inspection during manufacture and use;
- b) To demonstrate compliance with this document to the transport competent authority.

For guidance, see the IAEA SSG-26.

5 General requirements for cylinders and valve protection

5.1 Design of cylinders and valve protection

NOTE 1 Codes and standards listed in [Clause 2](#) with corresponding versions using metric units can be used interchangeably.

NOTE 2 With respect to this document, American Society of Mechanical Engineers (ASME) material and filler metal specifications, identified by the prefix “S,” are interchangeable with corresponding ASTM International (ASTM) and American Welding Society (AWS) specifications referenced herein and listed in [Clause 2](#).

Cylinders shall

- be as shown in [Figures 3 to 11](#) and in accordance with the requirements specified in [6.1 to 6.8](#), and
- comply with the code.

In order to minimize points of leakage, only one valve and one plug (where applicable) should be installed. However, if the purchaser deems additional valves or plugs necessary, they shall be installed in accordance with the requirements specified in [6.3 to 6.8](#).

Additional holes in skirts are permitted and shall be designed such that the fitness for purpose of the package is not impaired.

Details of pressure vessel (including skirts, stiffening rings, lifting lugs), valve, and plug are given in [Figures 1 to 16](#).

Valve protection for specific cylinders shall be as shown in [Figures 5 to 12](#).

Threads identified in this document shall conform to ISO 263 or ANSI/ASME B1.20.1, unless otherwise specified.

Metric units shown in this document may have been converted from Imperial units. Rounding of values is acceptable when not in conflict with the functional specification.

Annotations to dimensions used in figures: “typical” means “example” and “REF” means “indicative” only.

The parameters given in [Table 1](#), along with the values for the minimum volume shown in [Table 3](#), shall be the basis by which the pressure vessel parts of the various cylinders are designed.

Table 1 — UF₆ cylinder design conditions

Cylinder model	Clause	Pressure vessel			Minimum design transport temperature
		Design pressure/temperature			
		MAWP External	MAWP Internal	MDMT	
1S	6.1	172 kPa gauge (25 lbf/in ² gauge)	1,38 MPa gauge at 121 °C (200 lbf/in ² gauge at 250 °F)	−196 °C at 1,38 MPa gauge (−320 °F at 200 lbf/in ² gauge)	−40 °C (−40 °F)
2S	6.2				
5B	6.3				
8A	6.4				
12B	6.5				
30B	6.6	172 kPa gauge (25 lbf/in ² gauge)	1,38 MPa gauge at 121 °C (200 lbf/in ² gauge at 250 °F)	−29 °C at 1,38 MPa gauge (−20 °F at 200 lbf/in ² gauge)	
30C	6.7				
48X and 48Y	6.8				

5.2 Fabrication of new cylinders

5.2.1 General

Fabrication of valves and plugs are considered in [7.1](#).

Pressure vessels shall be fabricated and stamped in accordance with the code.

Longitudinal seam, head-to-shell girth seams, skirts, stiffening rings, lifting lugs, etc., shall be welded as shown in the relevant figures. Fillet welds shall be in accordance with ANSI/AWS D1.1/D1.1M and the code. All butt welds shall be full penetration unless otherwise specified. Longitudinal skirt welds shall be away from lifting holes, holes for valve protector alternate and weep holes. Circumferential pressure vessels seams should be welded without backing rings. Optionally, circumferential pressure vessel seams may be welded with backing rings, as shown in [Figure 1](#).

All welders and welding procedures (brazing included) shall be qualified in accordance with the code.

Where the material of construction is steel per [Table 3](#), at least one test weld representing each welding procedure to be used in the fabrication of the pressure vessel shall be Charpy V-notch impact tested. Test plates, including those for the appendages, shall have butt-type weld joints. The specimens shall be taken across the weld with the notch in the weld metal. Each specimen shall be oriented so that the notch is normal to the surface of the material, and one face of the specimen shall be within 1,6 mm (1/16 in) of the surface of the material. Each weld procedure shall be qualified with impact testing. This testing shall be as specified by the code utilized for the material being welded. Acceptance criteria shall be in accordance with the grade of steel to be used in fabrication of the pressure vessel. Procedures and qualifications shall be documented as required by the code. The fabricator shall receive the purchaser's formal acceptance of the test results prior to pressure vessel fabrication.

The minimum design transport temperature requirement is met when

- either the MDMT is lower than -40 °C, or
- the steel has been Charpy V-notch impact tested as specified in [6.6.2 a\)](#) or [6.8.2 a\)](#) for test temperatures of -40 °C or lower.

Where couplings are to be installed in pressure vessel, they should be installed by first screwing an appropriately sized National Pipe Thread (NPT) plug into the coupling prior to welding. Between welding passes and after welding is completed, the coupling should be allowed to cool. The coupling threads shall be inspected following removal of the plug. Tapped threads shall be free of all burrs, gouges, scratches, and the like. An appropriately sized NPT tap shall be used for a light chase. The coupling shall be gauged to assure compliance with ANSI/ASME B1.20.1.

5.2.2 Radiography and other non-destructive examinations (NDEs)

All NDE personnel shall be certified in accordance with ASNT SNT-TC-1A or [ISO 9712](#) or other equivalent standard. All examinations shall be carried out using code-compliant procedures.

The weld imperfections indicated by NDEs shall not exceed the defects permitted by the code for pressure retaining parts and ANSI/AWS D1.1/D1.1M for non-pressure retaining parts (statically loaded non-tubular connection Table 6.1). Any weld defects not permitted shall be repaired.

Radiography is applicable for 5B, 8A, 12B, 30B, 30C, 48X and 48Y cylinders, in accordance with the appropriate section of the code.

For 5B, 8A, 12B, 30B, 48X and 48Y cylinders, the minimum number of spot-radiographic examinations for each cylinder shall be as required by the code. Unless otherwise directed by an authorized inspector, the locations of spots shall be as follows:

- a) 5B cylinders: at the circumferential head-to-shell weldment, alternating ends for successive cylinders.
- b) 8A, 12B, 30B, 48X, and 48Y cylinders: at the junctions of the longitudinal seam and the circumferential head weld, alternating ends for successive cylinders.

Alternatively (for the purpose of [5.3.4.2.3](#)), for 30B, 48X and 48Y cylinders without backing bars, the following may be specified:

- complete (100 %) radiography of the longitudinal seam and the head-to-shell girth seams for each pressure vessel, and
- additional magnetic examination (MT) or penetrant examination (PT) on the external surface of the pressure vessel for: the shell longitudinal seam, the head-to-shell girth seams, the skirt-to-head girth seams, and the valve and plug coupling welds.

For 48X and 48Y cylinders, the stiffening ring butt welds shall be examined to ensure full weld penetration.

The welds of the lifting lugs shall be subjected to magnetic examination (MT) or penetrant examination (PT).

For 30C cylinders, the following shall be required:

- complete (100 %) radiography of the longitudinal seam and the head-to-shell girth seams for each pressure vessel, and
- additional magnetic examination (MT) or penetrant examination (PT) of other welds (as listed above for the 30B, 48X and 48Y cylinders) and valve protector cover (VPC) assembly welds.

5.2.3 Testing

- a) Hydrostatic strength test: Pressure vessels shall be subjected to a hydrostatic strength test of the type set forth in the code. No leaks shall be permitted. The test pressure shall be twice the MAWP. Prior to inspection for leaks, the pressure may be lowered to 1,5 times the MAWP. Defects, if any, shall be repaired as permitted in the code, and a retest shall follow.

An authorized inspector shall witness all hydrostatic strength tests for new construction.

- b) Pneumatic leak test: cylinders shall be subjected to a pneumatic leak test at 690 kPa gauge (100 lbf/in² gauge) to be carried out on the tapered thread connection of valve and plug and on the valve seat, using an appropriate leak-testing fluid. A leak rate larger than 1×10^{-4} Pa·m³·s⁻¹ SLR (Standardized Leakage Rate) per threaded-connection/valve-seat shall not be permitted. Corresponding leak testing methods can be found in ISO 12807 or ANSI N14.5.

CAUTION — Pneumatic testing shall be applied with extreme caution to prevent personal injury. Pressure shall be raised slowly to the test pressure. The pressure source shall be valved off when the test pressure is attained.

Alternative methods of leak test are acceptable provided that they assure a Standardized Leakage Rate lower than $1 \times 10^{-4} \text{ Pa} \cdot \text{m}^3 \cdot \text{s}^{-1}$. Leak testing methods can be found in ISO 12807 or ANSI N14.5.

A competent inspector shall witness the leak test.

5.2.4 Cylinder marking

Cylinders shall be identified with, as a minimum, the information shown in [Table 2](#) for that cylinder model.

Information may be presented in SI metric units and/or in imperial units.

5.2.5 Reports, certification, and records

The fabricator shall supply the necessary documentation for the purchaser's and other entities' retention, as required by the code and this document. This will include a written certification that the cylinders comply with all fabrication, test, and cleanliness requirements specified in this document, and also a certified mill test report of the materials used in fabricating the cylinders.

The fabricator shall measure the actual water capacity of each cylinder and shall provide written certification of this measured value, identified by cylinder serial number, to the purchaser. The actual water mass shall be accurate to $\pm 0,1 \%$. For a cylinder to be acceptable, the quotient of the certified water mass divided by 0,999 2 (mass in kilogram of one litre of water at 15,6 °C) shall not be less than the minimum volume specified in [Table 3](#).

The fabricator shall provide for the purchaser:

- a) a copy of the "as built" drawing pertaining to the cylinder or cylinders involved, and
- b) one copy of each radiograph report and NDE report (where applicable), properly identified with the cylinder identification and location to which it applies.

The fabricator shall retain fabrication and inspection records in accordance with the code.

The purchaser shall retain the copies of the quality record file, drawings, and certifications on file in accordance with regulatory requirements but in any case, for a minimum of 5 years. The manufacturer's data report, as required by the code, shall be retained for the lifetime of the pressure vessel. All retained purchaser documents shall be transferred with the cylinder upon change of ownership.

The tare shall be established and recorded before the new cylinder is placed in service.

Table 2 — Cylinder marking

Markings	Model ^a		
	1S and 2S	5B, 8A, 12B, 30B and 30C	48X and 48Y
Nameplate figure	n/a ^b	2 a)	2 b)
Minimum character height mm (in)	3 (1/8)	4 (5/32)	6,35 (1/4)
Code stamp	n/a	According to the code requirements	
Code number	n/a	According to the code requirements	
MAWP ^c	Yes		
MDMT ^c	Yes		
Owner's name or symbol	Yes		
Owner's serial number	Yes		
Tared ^d	No	Yes	Yes
Water capacity	No	Yes	Yes
Maximum mass of UF ₆ ^e	Yes		
Manufacturer's ID	Yes		
Date of the hydrostatic strength test ^f	Yes		
^a To be presented as "MODEL No." followed by the model number as given above.			
^b The information required shall be durably marked directly on the valve end of the cylinder.			
^c To be presented as shown in Table 1 .			
^d To be denominated in kilograms (pounds).			
^e To be presented as "MAX. NET WT. UF ₆ " followed by values given in Table 3 for maximum fill limits.			
^f Month and year, in this order.			

5.2.6 Outer surface

After completion of testing a carbon steel pressure vessel and cleaning its interior, its exterior surfaces shall be cleaned to remove rust, scale, dirt, and other foreign matter. Where a protective coating system is to be applied, the pressure vessel shall be prepared to the coating system manufacturer's requirements. This also applies to valve protection. A protective coating system should be suitable for service conditions and shall be applied in accordance with the manufacturer's instructions.

5.2.7 Cleanliness

After any welding, water capacity assessment, and hydrostatic strength testing are completed, the inside of the pressure vessels shall be thoroughly cleaned of all grease, scale, slag, oxides, dirt, moisture, and other foreign matter. The surfaces shall be left clean, dry, and free of all contamination. For drying, the cylinders shall be purged to a maximum dew point of -35 °C (-30 °F), using filtered dry oil-free air or nitrogen of similar quality. Other equivalent methods may also be used. Cylinders shall be sealed, as specified by the purchaser, immediately after drying and final inspection of the internal surfaces.

The procedures to be used shall be described in detail and approved by the purchaser.

CAUTION — The cleanliness of UF₆ cylinders is of serious concern to the nuclear industry and shall be applied with extreme caution, because the reaction of UF₆ with hydrocarbon oils and some other impurities is quite vigorous and can result in serious explosions. The purity of the UF₆ contained can also be appreciably affected.

5.2.8 Standard cylinders

[Table 3](#) provides requirements for new cylinders.

Cylinders and valve protection manufactured to the previous editions of this document, or to a standard that remains acceptable to the transport competent authority, are acceptable for continued use, provided that:

- a) they are used within their original design limitations,
- b) they are inspected, tested, and maintained in accordance with the intent of this document and the requirements stated in [Table 4](#).

The above may also apply to cylinders and valve protection manufactured before the first edition of this document had been issued, provided that, in addition, the manufacturing, periodic inspection and maintenance history of these cylinders and valve protection is assessed against the current edition of this document and found acceptable by the transport competent authority.

5.3 In-service cylinders and valve protection

5.3.1 Cleanliness

A clean and washed out cylinder may be required for refilling to ensure product purity and also when maintenance or hydrostatic strength testing is performed.

Any material left behind on the inside surface of the cylinder after the cleaning operation shall:

- a) not obstruct the internal examination as required in [5.3.4.2.2 a\)](#),
- b) not influence the quality and chemical purity of the next UF₆ fill, and
- c) not react with UF₆.

CAUTION — The cleanliness of UF₆ cylinders is of serious concern to the nuclear industry and shall be applied with extreme caution, because the reaction of UF₆ with hydrocarbon oils and some other impurities is quite vigorous and can result in serious explosions. The purity of the UF₆ contained can also be appreciably affected.

5.3.2 Testing

- a) Hydrostatic strength test: Pressure Vessels shall be subjected to a hydrostatic strength test as described in [5.2.3 a\)](#)

An authorized inspector or a competent inspector, as required by national regulations, shall witness all hydrostatic strength tests.

- b) A leak test, as described in [5.2.3 b\)](#), shall be carried out.

Table 3 — Standard cylinder data

Model number	Nominal diameter mm (in)	Material	Minimum volume m ³ (ft ³)	Approximate tare (without valve protection) kg (lb)	Maximum enrichment g of ²³⁵ U/ 100 g of U	Maximum fill limit ^a kg (lb) of UF ₆
1S	38,1 (1,5)	Ni or Ni-Cu alloy	1,50 × 10 ⁻⁴ (5,3 × 10 ⁻³)	0,794 (1,75)	100	0,45 (1,0)
2S	88,9 (3,5)	Ni or Ni-Cu alloy	7,19 × 10 ⁻⁴ (2,54 × 10 ⁻²)	1,9 (4,2)	100	2,2 (4,9)
5B	127 (5)	Nickel	8,04 × 10 ⁻³ (0,284)	25 (55)	100	24,9 (54,9)
8A	203,2 (8)	Ni-Cu alloy	37,35 × 10 ⁻³ (1,319)	54,4 (120)	12,5	115 (255)
12B	304,8 (12)	Ni-Cu alloy	0,067 4 (2,38)	83,9 (185)	5	208 (460)
30B and 30C	762 (30)	Steel	0,736 (26,0)	635,0 (1 400)	5 ^{b,d}	2 277 (5 020)
48X	1 219,2 (48)	Steel	3,084 (108,9)	2 041 (4 500)	4,5 ^{b,c}	9 539 (21 030)
48Y	1 219,2 (48)	Steel	4,040 (142,7)	2 359 (5 200)	4,5 ^{b,c}	12 501 (27 560)

^a The maximum fill limit may be adjusted in accordance with the actual volume, maintaining the ullage limits specified hereafter. Fill limits are based on liquid UF₆ density at a maximum temperature of 121 °C (250 °F), 3 257 kg/m³ (203,3 lb/ft³), certified minimum internal volumes for all cylinders, and a minimum cylinder ullage of 5 % as specified in the applicable Transport Regulations. These operating limits apply to UF₆ with a minimum purity of 99,5 %. More restrictive measures are required if additional impurities are present. This maximum temperature shall not be exceeded.

^b These maximum enrichments require moderation control equivalent to a UF₆ purity of 99,5 %. Without moderation control, the maximum permissible enrichment is 1,0 %.

^c Enrichment up to 5 % is allowed subject to additional criticality safety assessment.

^d Enrichment up to 6 % is allowed subject to additional criticality safety assessment.

5.3.3 Routine inspections

All UF₆ cylinders shall be routinely examined on receipt prior to any other activity (sampling, emptying, filling, or shipping) to ensure that they remain in a safe, usable condition. Leakage, cracks, excessive distortion, bent or broken valves or plugs, broken or torn stiffening rings, lifting lugs or skirts, or other conditions that may affect the safe use of the cylinder shall warrant appropriate precautions, including removing the cylinder from service until the defective condition is satisfactorily corrected. Questionable conditions should be referred to a competent inspector for evaluation and for recommendations concerning use, repair, or condemnation of the cylinder in question.

Valve protection devices shall be routinely examined prior to shipment. Questionable conditions should be referred to a competent inspector for evaluation and for recommendations concerning use, repair, or replacement.

5.3.4 Periodic inspections and tests

5.3.4.1 One-year periodic inspection and tests on 30C cylinders

All 30C cylinders except those already filled at the one-year expiration date shall be periodically inspected and tested throughout their service life at intervals not to exceed one year. However, cylinders that have not been inspected and tested within the required one-year period shall not be refilled until they are properly reinspected and retested.

The one-year periodic inspection and tests for 30C cylinders shall consist of the following:

- a) Measured leakage rate of the VPC equal to or less than $1 \times 10^{-6} \text{ Pa} \cdot \text{m}^3 \cdot \text{s}^{-1}$ SLR in accordance with ISO 12807 definitions.
- b) Fit-up of the VPC to demonstrate a clearance of not less than 6 mm ($\frac{1}{4}$ in) in every place between the valve and the VPC.

5.3.4.2 Five-year periodic inspection and tests for all cylinders

5.3.4.2.1 General

Cylinders shall be periodically certified (i.e. inspected, tested, weighed and stamped) throughout their service life at intervals not to exceed five years.

Cylinders containing UF₆ at the five-year expiration date, including heeled cylinders, are exempted from this requirement provided that, prior to shipment, they are inspected in accordance with a monitoring programme. The goal of the monitoring programme is to ensure that cylinders comply with the requirements of this document. The monitoring programme shall include a visual inspection for degradation of the pressure vessel wall as well as all associated components of the cylinder. Any questionable conditions should be referred to a competent inspector and investigated further, including NDEs [ultrasonic examination (UT) and/or magnetic examination (MT) or penetrant examination (PT)], if appropriate. Cylinders shall not be refilled until they are recertified.

When the five-year periodic inspection and tests are performed by a third party, a copy of the manufacturers data report (5.2.5), for example Form U-1A of the ASME Boiler and pressure vessel code, should be made available by the cylinder owner.

5.3.4.2.2 Five-year periodic inspection and tests

The five-year periodic inspection and tests shall consist of the following:

- a) An internal and external inspection of the pressure vessel by an authorized inspector or a competent inspector, as required by national regulations.
- b) A hydrostatic strength test of the type set forth in the code. The hydrostatic strength test shall be applied at a pressure equal to the original test pressure, conforming to 5.3.2 a).
- c) A leak test conforming to 5.3.2 b).
- d) For 30C cylinders, each five-year periodic inspection shall also include tests conforming to 5.3.4.1 a) and 5.3.4.1 b).
- e) For 48X and 48Y cylinders a visual examination of the lifting lugs welds, supplemented by a magnetic examination (MT) or penetrant examination (PT).

After a clean and washed out cylinder is tested, its outer shell may be cleaned and repainted. At each five-year periodic inspection, the cylinder shall have the tare re-established and restamped (excluding 1S and 2S cylinders), even if the tare appears to be the same as the previous one. When the last stamped tare is found to be incorrect before a next reinspection is due (e.g. following a cleaning/wash operation),

the last stamped tare shall be erased or crossed out on the name plate and the new established tare be stamped on or near that location.

A cylinder that passes the periodic inspection and tests shall be restamped with the month and year in which the hydrostatic strength test was performed.

The stamping shall be placed in close proximity to the previous or original stamping and shall expire on the last day of the stamped month of the fifth subsequent year. The supplemental nameplate shown in [Figure 2 c](#)) may be used for the stamping. The cylinder owner shall retain records of periodic inspection and tests for a period of five years or until a subsequent periodic inspection and tests have been performed and recorded.

5.3.4.2.3 Alternative five-year periodic inspection and tests

Alternatively to the requirements set forth in [5.3.4.2.2](#), for 30B, 48X and 48Y cylinders that have been subjected to the alternative requirements in [5.2.2](#), and for 30C cylinders, the five-year periodic inspection and tests may consist of the following:

- a) An ultrasonic thickness examination of the shell and heads and ultrasonic examination (UT) (or other equivalent method) of the welds for pressure retaining parts. The imperfections indicated by NDEs shall not exceed the defects permitted by the code for pressure retaining parts. Witnessing of the substitute inspection shall be done by an authorized inspector.
- b) A leak test conforming to [5.3.2 b](#)). For cylinders which contain UF₆ (including heeled cylinders), the leak test shall be performed on the valve seat only.
- c) For 30C cylinders, tests conforming to [5.3.4.1 a](#)) and [5.3.4.1 b](#)).
- d) For 48X and 48Y cylinders, a visual examination of the lifting lugs welds, supplemented by a magnetic examination (MT) and/or penetrant examination (PT).

A cylinder that passes the alternative periodic inspection and tests shall be restamped with the month and year in which the substitute inspection was performed. The letter "A" shall be added to the date for cylinders that were containing UF₆ (including heeled cylinders) at the periodic inspection. The letter "A" denotes that, after the next emptying, the cylinder shall be cleaned and washed out, a leak test conforming to [5.3.2 b](#)) be performed and the tare weight be re-established and restamped (even if the tare appears to be the same as the previous one). After a clean and washed out cylinder is leak tested, its outer shell may be cleaned and repainted before the tare weight is re-established, and the letter "A" shall be erased or crossed out.

The stamping shall be placed in close proximity to the previous or original stamping and shall expire on the last day of the stamped month of the fifth subsequent year. The supplemental nameplate shown in [Figure 2 c](#)) may be used for the stamping. The cylinder owner shall retain records of periodic inspection and tests for a period of five years or until a subsequent periodic inspection and tests have been performed and recorded.

5.3.4.2.4 Removal of cylinders from service

A cylinder shall be removed from service (for repair or scrapping) when it is found to contain:

- leaks, corrosion, cracks, bulges, dents, gouges, defective valves, damaged stiffening rings, lifting lugs or skirts, or
- weld imperfections in excess of the limits specified in [5.2.2](#), for the cylinders that have been subjected to the substitute inspection mentioned in [5.3.4.2.3 a](#)), or
- other conditions that, in the opinion of a competent inspector, render it unsafe or unserviceable in its existing condition.

A cylinder shall no longer be used in UF₆ service when the shell thickness has decreased below the values given in [Table 4](#), as interpreted by code criteria (e.g. NBIC).

Table 4 — Minimum thickness

Cylinder model	Thickness mm (in)
1S and 2S	1,59 (1/16)
5B and 8A	3,18 (1/8)
12B	4,76 (3/16)
30B and 30C	7,94 (5/16)
48X and 48Y	12,7 (1/2)

5.3.5 Cylinder maintenance/repair/alteration

A cylinder repair and/or alteration is authorized if the following criteria are met:

- a) it does not deviate from the intent of this document,
- b) it complies with the design, material, fabrication, welding qualification, and inspection requirements of the code, and
- c) it meets the approval of an authorized inspector.

Weld repairs or alterations to code-stamped pressure vessel parts shall be conducted by an entity approved by the jurisdictional authority/inspection authority. Such repairs shall also be inspected and accepted by an authorized inspector in accordance with the code (e.g. NBIC Part 3).

Valve or plug replacements shall be followed by a pneumatic leak test conforming to [5.3.2 b\)](#).

For 30C cylinders, the replacement of the VPC O-rings shall be followed by the measured leakage test described in [5.3.4.1 a\)](#).

When the ownership changes during the service life of a cylinder, this may be changed on the name plate. Except for 1S and 2S cylinders, this may be done by affixing a stainless steel tag with the new owner's name or symbol at location d on the nameplate (see [Figure 2](#)) by welding or an appropriate adhesive. Alternatively, the new owner's name or symbol may be shown on a supplemental plate inside the skirt.

5.3.6 Maintenance of valves specified in [8.2](#) and [8.3](#)

- a) *Retighten packing nut.* The packing nut of cylinder valves as described in [8.2](#) or [8.3](#) may be retightened but in accordance with [7.1.8](#). The torque applied should be the minimum required to stop any leak but shall be no more than the maximum identified in [Table 6](#).
- b) *Stem and/or packing replacement.* New packing shall be used for stem and/or packing replacement. All replacement items shall be as described in [8.2](#) or [8.3](#), as appropriate, and the packing nut shall be torqued in accordance with [7.1.8](#). The seat/stem and/or valve packing shall be subjected to a leak test (valve closed) conforming to [5.3.2 b\)](#).
- c) *Packing nut replacement.* A packing nut removed where there is no prior indication of stem leak may be replaced and shall be tightened using a minimum torque in accordance with [7.1.8](#).
- d) *Port cap replacement.* A port cap may be replaced at any time, using a maximum torque in accordance with [7.1.8](#).

An adjustable or indicating torque measuring wrench/device shall be used for all operations where a torque value is specified. The use of an impact type wrench/device is not permitted.

6 Specific requirements for cylinders and valve protection

6.1 1S Cylinder

6.1.1 Design conditions

1S cylinders shall conform to [5.1](#), [Table 1](#), [Table 3](#) and [Figure 3](#). The use of a welded cylinder as an alternative to the seamless cylinder is allowed, provided it is acceptable by the transport competent authority which issued the current certificate of approval of the package design.

6.1.2 Materials

The materials used in the fabrication of new 1S cylinders shall meet the following requirements.

- a) *Pressure vessel*. ASTM B162, nickel (UNS N02200); or ASTM B127, nickel-copper alloy (UNS N04400).

NOTE For alternate welded design, equivalent material is selected for shell and caps.

- b) *Fittings*.

1) Adaptor: ASTM B16/B16M, brass (UNS C36000); ASTM B160, nickel (UNS N02200); or ASTM B164, nickel-copper alloy (UNS N04400/N04405).

2) Connector: ASTM B164, nickel-copper alloy (UNS N04400/N04405).

3) Cap/plug: ASTM B16/B16M, brass (UNS C36000).

- c) *Seal loop* (optional). Tubing, ASTM B161, nickel (UNS N02200) or ASTM B165, nickel-copper alloy (UNS N04400).

- d) *Brazing alloys*. AWS A5.8M/A5.8, classification BAg-7 or BAg-8.

- e) *Filler material*. In accordance with the code.

6.1.3 Fabrication

Fabrication of 1S cylinders shall conform to [5.2.1](#).

6.1.4 Radiography

Radiography of 1S cylinders shall conform to [5.2.2](#) when a welded design is used. 100 % radiography shall be performed.

6.1.5 Valve

Valves for 1S cylinders shall conform to [8.1](#).

6.1.6 Plug

Not applicable.

6.1.7 Valve installation

Care shall be taken to keep the valve body cool when the adaptors are brazed or welded onto the inlet and outlet connections. The valve and connections shall be clean, dry, and free of contamination before the valve is threaded into the pressure vessel. A UF₆-compatible thread sealant shall be used.

6.1.8 Testing

Testing of 1S cylinders shall conform to [5.2.3](#).

6.1.9 Cylinder marking

Marking of 1S cylinders shall conform to [5.2.4](#), [Table 2](#).

6.1.10 Cleaning

Cleaning of 1S cylinders shall conform to [5.2.7](#).

6.1.11 Certification

Certification of 1S cylinders shall conform to [5.2.5](#).

6.1.12 External surface treatment

Not applicable.

6.2 2S Cylinder

6.2.1 Design conditions

2S cylinders shall conform to [5.1](#), [Table 1](#), [Table 3](#) and [Figure 4](#). The use of a welded cylinder as an alternative to the seamless cylinder is allowed, provided it is acceptable by the transport competent authority which issued the current certificate of approval of the package design.

6.2.2 Materials

The materials used in the fabrication of new 2S cylinders shall meet the following requirements:

- a) *Pressure vessel*. Shall conform to [6.1.2](#) a).
- b) *Fittings*.
 - 1) *Adaptor*: Shall conform to [6.1.2](#) b) 1).
 - 2) *Connector*: Shall conform to [6.1.2](#) b) 2).
 - 3) *Cap/plug*: Shall conform to [6.1.2](#) b) 3).
- c) *Seal loop* (optional). Plate, sheet or strip, ASTM B162, nickel (UNS 02200) or ASTM B127, nickel-copper alloy (UNS N04400).
- d) *Brazing alloys*. Shall conform to [6.1.2](#) d).
- e) *Filler material*. In accordance with the code.

6.2.3 Fabrication

Fabrication of 2S cylinders shall conform to [5.2.1](#).

6.2.4 Radiography

Radiography of 2S cylinders shall conform to [5.2.2](#) when a welded design is used. 100 % radiography shall be performed.

6.2.5 Valve

Valves for 2S cylinders shall conform to [8.1](#).

6.2.6 Plug

Not applicable.

6.2.7 Valve installation

The installation on 2S cylinders shall conform to [6.1.7](#).

6.2.8 Testing

Testing of 2S cylinders shall conform to [5.2.3](#).

6.2.9 Cylinder marking

Marking of 2S cylinders shall conform to [5.2.4](#), [Table 2](#).

6.2.10 Cleaning

Cleaning of 2S cylinders shall conform to [5.2.7](#).

6.2.11 Certification

Certification of 2S cylinders shall conform to [5.2.5](#).

6.2.12 External surface treatment

Not applicable.

6.3 5B Cylinder

6.3.1 Design conditions

5B cylinders shall conform to [5.1](#), [Table 1](#), [Table 3](#) and [Figure 5](#).

6.3.2 Materials

The materials used in the fabrication of new 5B cylinders shall meet the following requirements.

- a) *Shell*. Pipe, ASTM B161, nickel (UNS N02200).
- b) *Heads*. Cap, ASTM B366/B366M, Grade WPN, nickel (UNS N02200).
- c) *Foot ring*. Pipe, ASTM B165, nickel-copper alloy (UNS N04400).
- d) *Neck ring*. Pipe, ASTM B165, nickel-copper alloy (UNS N04400).
- e) *Valve protector cap*. Pipe, ASTM A53/A53M, Grade B; plate, ASTM A285/A285M, Grade C; ASTM A575 Grade 1008-1020 (optional 5B handles)
- f) *Dip pipe*. Tube, ASTM B165, nickel-copper alloy (UNS N04400).
- g) *Couplings*. ASTM B160, ASTM B161, and/or ASTM B366/B366M, nickel (UNS N02200).
- h) *Dip pipe tab*. Plate, ASTM B127, nickel-copper alloy (UNS N04400).

- i) *Handles and support ring.* Rod, ASTM B164, nickel-copper alloy (UNS N04400); and pipe, ASTM B165, nickel-copper alloy (UNS N04400).
- j) *Nameplate.* Sheet, ASTM B127, nickel-copper alloy (UNS N04400).
- k) *Filler metal.*
 - 1) Brazing AWS A5.8M/A5.8, classification BAg-7; and
 - 2) Welding AWS A5.14/A5.14M, classification ERNi-1 & ERNiCu-7.

6.3.3 Fabrication

Fabrication of 5B cylinders shall conform to [5.2.1](#).

6.3.4 Radiography

Radiography of 5B cylinders shall conform to [5.2.2](#).

6.3.5 Valve

Valves for 5B cylinders shall conform to [8.2](#).

6.3.6 Plug

Not applicable.

6.3.7 Valve installation

The valve shall be disassembled and cleaned before any brazing or installation. The dip pipe shall be brazed to the applicable valve. Valve bodies shall be installed in the coupling such that at least seven valve threads are inserted and at least one thread is showing. The valve bodies shall be brazed to couplings before reassembly of the valve.

6.3.8 Testing

Testing of 5B cylinders shall conform to [5.2.3](#).

6.3.9 Cylinder marking

Marking of 5B cylinders shall conform to [5.2.4](#), [Table 2](#).

6.3.10 Cleaning

Cleaning of 5B cylinders shall conform to [5.2.7](#).

6.3.11 Certification

Certification of 5B cylinders shall conform to [5.2.5](#).

6.3.12 External surface treatment

Not applicable.

6.4 8A Cylinder

6.4.1 Design conditions

8A cylinders shall conform to [5.1](#), [Table 1](#), [Table 3](#) and [Figure 6](#).

6.4.2 Materials

The materials used in the fabrication of new 8A cylinders shall meet the following requirements:

- a) *Shell*. Plate, ASTM B127, nickel-copper alloy (UNS N04400).
- b) *Heads*. Formed, ASTM B127, nickel-copper alloy (UNS N04400).
- c) *Foot ring and head ring*. Plate, ASTM B127, nickel-copper alloy (UNS N04400).
- d) *Neck ring*. Shall conform to [6.3.2](#) d).
- e) *Valve protector cap*. Shall conform to [6.3.2](#) e).
- f) *Dip pipe*. Shall conform to [6.3.2](#) f).
- g) *Couplings*. Shall conform to [6.3.2](#) g).
- h) *Dip pipe tab*. Shall conform to [6.3.2](#) h).
- i) *Nameplate*. Shall conform to [6.3.2](#) j).
- j) *Filler metal*. Shall conform to [6.3.2](#) k).

6.4.3 Fabrication

Fabrication of 8A cylinders shall conform to [5.2.1](#).

6.4.4 Radiography

Radiography of 8A cylinders shall conform to [5.2.2](#).

6.4.5 Valve

Valves for 8A cylinders shall conform to [8.2](#).

6.4.6 Plug

Not applicable.

6.4.7 Valve installation

The installation on 8A cylinders shall conform to [6.3.7](#).

6.4.8 Testing

Testing of 8A cylinders shall conform to [5.2.3](#).

6.4.9 Cylinder marking

Marking of 8A cylinders shall conform to [5.2.4](#), [Table 2](#).

6.4.10 Cleaning

Cleaning of 8A cylinders shall conform to [5.2.7](#).

6.4.11 Certification

Certification of 8A cylinders shall conform to [5.2.5](#).

6.4.12 External surface treatment

Not applicable.

6.5 12B Cylinder

6.5.1 Design conditions

12B cylinders shall conform to [5.1](#), [Table 1](#), [Table 3](#) and [Figure 7](#).

6.5.2 Materials

The materials used in the fabrication of new 12B cylinders shall meet the following requirements:

- a) *Shell*. Shall conform to [6.4.2](#) a).
- b) *Heads*. Shall conform to [6.4.2](#) b).
- c) *Foot ring and head ring*. Plate, shall conform to [6.4.2](#) c), and (if used) Pipe, ASTM B165, nickel-copper alloy (UNS N04400).
- d) *Neck ring*. Shall conform to [6.3.2](#) d).
- e) *Valve protector cap*. Shall conform to [6.4.2](#) e).
- f) *Dip pipe*. Shall conform to [6.3.2](#) f).
- g) *Couplings*. Shall conform to [6.3.2](#) g).
- h) *Dip pipe tab*. Shall conform to [6.3.2](#) h).
- i) *Nameplate*. Shall conform to [6.3.2](#) j).
- j) *Filler metal*. Shall conform to [6.3.2](#) k).

6.5.3 Fabrication

Fabrication of 12B cylinders shall conform to [5.2.1](#).

6.5.4 Radiography

Radiography of 12B cylinders shall conform to [5.2.2](#).

6.5.5 Valve

Valves for 12B cylinders shall conform to [8.2](#).

6.5.6 Plug

Not applicable.