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Nuclear energy — Packaging of uranium hexafluoride (UF_6) for transport

Énergie nucléaire — Emballage de l'hexafluorure d'uranium (UF_6) en vue de son transport

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 7195 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 5, *Nuclear fuel technology*.

This second edition cancels and replaces the first edition (ISO 7195:1993), which has been technically revised.

Introduction

The packaging of uranium hexafluoride (UF_6) for transport is an essential operation in the nuclear industry. The United States Standard ANSI N14.1 (first issued in 1971) has been used internationally as an accepted procedure for packaging UF_6, and the standard cylinders and protective packages included in ANSI N14.1 have been used widely as accepted designs for international transport of UF_6. 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 certification procedure specified.

This International Standard has been developed from and is based on ANSI N14.1, but with incorporation of, and allowance for, other equivalent technical solutions and national authorization and certification procedures. IAEA recommendations relevant to UF_6 have also been taken into consideration. ISO 7195 was first issued in 1993 and the revision process started in 1998.

This International Standard specifies the internationally accepted guidelines and procedures for packaging of UF_6 for transport. It does not relieve the consignor from compliance with the relevant transport regulations for dangerous goods of each of the countries through or into which the material is transported.

This International Standard is consistent with, but does not replace, the recommendations of the International Atomic Energy Agency contained in IAEA Safety Standards Series No. TS-R-1:1996 (as revised 2003). Quoting from the Introduction to these Regulations,

“The objective of these Regulations is to protect persons, property and the environment from the effects of radiation during the transport of radioactive material. Protection is achieved by requiring containment of the radioactive contents, control of external radiation levels, prevention of criticality and prevention of damage caused by heat. These requirements are satisfied firstly by applying a graded approach to contents limits for packages and conveyances and to performance standards applied to package designs depending upon the hazard of the radioactive contents. Secondly, they are satisfied by imposing requirements on the design and operation of packages and on the maintenance of packagings, including a consideration of the nature of the radioactive contents. Finally, they are satisfied by requiring administrative controls including, where appropriate, approval by competent authorities.”

In addition, due to the chemical risks associated with UF_6, there are special requirements for packages containing this material.

It should be noted that the IAEA Regulations form the essential basis of regulations for international transport (Agreement for the safe transport of dangerous goods by rail, RID; European agreement for the safe transport of dangerous goods by road, ADR; International maritime dangerous code, IMDG; and Technical instructions for the safe transport of dangerous goods by air issued by the International Civil Aviation Organization, ICAO) that accordingly form the basis for national regulations. There are nevertheless minor differences in practice in the various countries. However, these minor differences are not considered significant in relation to this International Standard and do not affect the guidelines stated. Individual countries may issue national standards for packaging of UF_6 for transport, for which this International Standard can form the basis. This International Standard does not take precedence over applicable governmental regulations.

This International Standard presents information on UF_6 cylinders, valves, protective packages and shipping. However, it should be emphasized that this information has been derived from widespread practical applications and is therefore the result of international experience. As this experience grows, improved designs of cylinders and valves may come forward. Improvements shall be subject to approval by competent authorities. Authorized improvements may be considered for incorporation in this International Standard on the occasion of future revisions. Annex A of this International Standard is provided for information.

Throughout this International Standard 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, if the original type identification of a cylinder is based on its size, the imperial units are maintained (e.g. 48” cylinder, 48Y, 30B, etc.). 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.

Nuclear energy — Packaging of uranium hexafluoride (UF_6) for transport

1 Scope

This International Standard specifies requirements for packaging of uranium hexafluoride (UF_6) for transport.

It applies to

- packages designed to contain uranium hexafluoride in quantities of 0,1 kg or more,
- design, manufacture, inspection and testing of new cylinders and protective packagings,
- maintenance, repair, inspection and testing of cylinders and protective packagings,
- in-service inspection and testing requirements for cylinders and protective packagings.

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.

ISO 263, *ISO inch screw threads — General plan and selection for screws, bolts and nuts — Diameter range 0.06 to 6 in*

ISO 898-1:1999, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs*

ISO 9453, *Soft solder alloys — Chemical compositions and forms*

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

IAEA Safety Standards Series No. TS-R-1, *Regulations for the Safe Transport of Radioactive Materials, 1996 Edition (as revised 2003)*

ANSI/ASME B1.1:2003, *Unified Inch Screw Threads, UN and UNR Thread Form*

ANSI/ASME B1.20.1:1983 (R2001), *Pipe Threads, General Purpose, inch*

ANSI/ASME B16.11:2001, *Forged Steel Fittings, Socket-Welding and Threaded*

ANSI/AWS A5.8/A5.8M:2004, *Specification for Filler Metals for Brazing and Braze Welding*

ANSI/AWS A5.14/A5.14M:1997, *Specification for Nickel and Nickel Alloy Bare Wire Electrodes and Rods*

ANSI/A5.18:1993, *Specification for Nickel and Nickel Alloy Bare Wire Electrodes and Rods*

ANSI/CGA V-1:2003, *Compressed Gas Cylinder Valve Outlet and Inlet Connections*

EN 10025:1990, *Hot rolled products of non-alloy structural steels — Technical delivery conditions*

EN 10025:1990/A1:1993, Amendment 1

EN 10028-3:2003 *Flat products made of steels for pressure purposes — Part 3: Weldable fine grain steels, normalized*

EN 10088-2:1995, *Stainless steels — Part 2: Technical delivery conditions for sheet/plate and strip for general purposes*

ASTM A20/A20M-B:2004a, *Standard Specification for General Requirements for Steel Plates for Pressure Vessels*

ASTM A36/A36M:2004, *Standard Specification for Carbon Structural Steel*

ASTM A53/A53M:2004a, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

ASTM A105/A105M:2003, *Standard Specification for Carbon Steel Forgings for Piping Applications*

ASTM A106/A106M:2004b, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*

ASTM A108:2003, *Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished*

ASTM A131/A131M:2004ae1, *Standard Specification for Structural Steel for Ships*

ASTM A240/A240M:2004, *Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*

ASTM A285/A285M:2003, *Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength*

ASTM A516/A516M:2004, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

ASTM A575/A575M:1996 (2002), *Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades*

ASTM B16/B16M:2000, *Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines*

ASTM B32:2004, *Standard Specification for Solder Metal*

ASTM B127:1998, *Standard Specification for Nickel-Copper Alloy Plate, Sheet, and Strip*

ASTM B150:1998, *Standard Specification for Aluminum Bronze Rod, Bar, and Shapes*

ASTM B160:1999, *Standard Specification for Nickel Rod and Bar*

ASTM B161:2003, *Standard Specification for Nickel Seamless Pipe and Tube*

ASTM B162:1999, *Standard Specification for Nickel Plate, Sheet, and Strip*

ASTM B164:2003, *Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire*

ASTM B165:1993 (2003)e1, *Standard Specification for Nickel-Copper Alloy Seamless Pipe and Tube*

ASTM B366:2004, *Standard Specification for Factory-Made Wrought Nickel and Nickel Alloy Fittings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the IAEA Safety Standards Series No. TS-R-1:1996 (as revised 2003), Section II, and the following apply.

NOTE 1 Throughout this International Standard, the word *shall* denotes a requirement; the word *should* denotes a recommendation; the word *may* denotes a permission, neither a requirement nor a recommendation.

NOTE 2 Units are those of the International System, with other units shown in brackets for information.

3.1
clean cylinder
new cylinder that has been cleaned to remove oil and other manufacturing debris, or a cylinder that, after contact with UF_6, has been decontaminated to remove residual quantities of uranium and other contaminants

3.2
effective threads
threads that are capable of providing reasonable engagement in mating threads; the first effective thread at a runout begins one thread length below the runout scratch

3.3
empty cylinder
cylinder containing a heel in quantities equal to or less than those specified in Table 1

Table 1 — Maximum mass and enrichment limits of heel for empty cylinders

Cylinder type	Maximum heel mass kg (lb)	Maximum enrichment g ^{235}U/100 g U
5B	0,045 (0,1)	100
8A	0,227 (0,5)	12,5
12B	0,454 (1,0)	5,0
30B	11,4 (25,0)	5,0
48X	22,7 (50,0)	4,5
48Y	22,7 (50,0)	4,5
48G	22,7 (50,0)	1,0

3.4
heel
residual amount of UF_6 and non-volatile reaction products of uranium, uranium daughters and (if the cylinder has contained irradiated uranium) fission products and transuranic elements

3.5
maximum allowable working pressure
MAWP
maximum value of cylinder design gauge pressure (rounded up to two significant figures) at the maximum value of cylinder design temperature

3.6
minimum design metal temperature
MDMT
minimum value of design metal temperature at the maximum value of cylinder design pressure to meet ASME Code requirements

3.7
protective packaging
outer packaging or device used to provide additional protection to a cylinder during transport

3.8
qualified inspector
pressure-vessel inspector who has a demonstrated level of expertise relevant to the task being undertaken and designated or otherwise recognized as such for any purpose in connection with satisfying the national pressure-vessel code requirements

3.9
tare
as-built cylinder mass without valve protector with an internal air or nitrogen total pressure of 34,5 kPa (5 lbf/in^2)

NOTE The tare, colloquially designated tare weight, is denominated in kilograms (pounds).

4 Quality assurance

4.1 General

Quality assurance programmes [see IAEA TS-R-1:1996 (as revised 2003), paragraph 310] shall be established for the design, manufacture, testing, documentation, use, maintenance and inspection of UF_6 packagings and for transport and in-transit storage operations to ensure conformity to the regulations and/or particular provisions of the competent national authorities. Where the term “quality assurance programme” is used in this International Standard it can be related or equated to a “Quality management system/programme” as recommended by ISO 9000. If competent authority approval for design or shipment is required, this will take into account and be contingent upon the adequacy of the quality assurance programme. Certification that the design specifications have been fully implemented shall be available to the competent authority. The manufacturer, owner, consignor, consignee or shipper of any package design shall be prepared to provide facilities for competent authority inspection of the packaging during construction and use and to demonstrate to any cognizant competent authority

— that the construction methods and materials used for the construction of the packaging conform to the approved design specifications, and

— that all packagings built to an approved design are periodically inspected, and as necessary, repaired and maintained in good condition so that they conform to all relevant requirements and specifications, even after repeated use.

NOTE The IAEA safety standard series TS-G-1.1:1996[3], Appendix IV, provides advice on acceptable ways of achieving and demonstrating compliance with the quality assurance criteria from package fabrication to transport usage.

4.2 Procedures

The manufacturer or repairer of packaging shall establish and maintain written quality control procedures for materials and components procurement, manufacture, repair, cleaning, inspection and testing to ensure that the finished product conforms to this International Standard. The quality assurance programme shall be acceptable to the competent authority (but prior approval is not necessarily a requirement of the competent authority), and shall be provided to the customer or buyer and should conform to recognized standards such as ISO 9001.

The procedures may consist of, or be based upon, the manufacturer’s written specifications for similar work or should be developed in accordance with specifications for cylinder manufacture.

4.3 Approval

The manufacturer, repairer or servicing agent shall, prior to the manufacturing, repairing or servicing process, submit for purchaser approval, copies of all relevant proposed procedures. Any proposed changes to such procedures shall be agreed and approved in writing by the purchaser before being introduced during manufacture, repair or servicing.

The manufacturer, repairer or servicing agent shall notify the purchaser in advance of the start of the manufacturing, repair or servicing process to allow the purchaser or the purchaser's representative to witness initial production, repair or any other agreed aspect of the subject process. The purchaser or the purchaser's representative shall be granted access to the manufacturing, repair or servicing facilities at any reasonable time to verify that all purchasing requirements, including applicable approved procedures, are being implemented.

Appropriate records, within the applicable quality assurance programme, shall be established and maintained by the manufacturer, repairer, servicing agent or purchaser to confirm compliance with all applicable purchasing requirements and the requirements of this International Standard.

5 General requirements for packagings

5.1 General

Cylinders (see Clauses 6 and 7) and protective packagings (see Clause 8) individually and in combination are examples of packaging and they shall therefore conform to this clause.

UF_6 shall be packaged for transport in cylinders meeting the manufacture, inspection, testing, certification and service requirements of this International Standard and may be shipped in protective packagings meeting the requirements of IAEA TS-R-1.

5.2 Design requirements

Packages shall be designed in accordance with the requirements of this International Standard and so that normal hazards of handling do not damage the package and reduce the effectiveness of containment. Package and packaging designs shall conform to IAEA TS-R-1:1996 (as revised 2003), paragraph 629. Competent authority approval shall be obtained prior to shipment as required in IAEA TS-R-1:1996 (as revised 2003), paragraph 802.

Tie-down arrangements shall be designed, as a minimum, to withstand the stresses due to accelerations or decelerations which occur during normal transport (see Table 2). Additionally, package acceleration factors to be applied shall be determined by reference to national and international transport modal standards and regulations. Tie-down design shall use the worst-case scenario, recognizing, as appropriate, the potential for ambiguity of designation of longitudinal and lateral directions.

Table 2 — Minimum acceleration/deceleration values for tie-down arrangements

Mode of transport	Minimum acceleration/deceleration values to be withstood by tie-down arrangements m/s^2		
	Longitudinal	**Lateral**	**Vertical**
Road	20	10	± 10
Rail	20	10	± 10
Water	20	10	± 20
Air	30	15	± 30
Standard acceleration due to gravity ≈ 10 m/s^2.			

5.3 Design certification

Competent authority approval shall be obtained for packages designed to contain 0,1 kg or more of UF_6 [see IAEA TS-R-1:1996 (as revised 2003), paragraph 802 (a) (iii)]. Approved packages shall be marked with the identification mark assigned by the competent authority and indicated on the approval certificate [see IAEA TS-R-1:1996 (as revised 2003), paragraph 538 (a)].

5.4 Preparation for transport

5.4.1 Physical conditions

UF_6 shall be shipped only in the solid state and when the vapour pressure within the cylinder is below atmospheric [see IAEA TS-R-1:1996 (as revised 2003), paragraph 419].

5.4.2 Security seal

Packaging shall be shipped with a feature (a tamper-indicating device), such as a seal, that is not readily breakable and that, while intact, shall be evidence that the packaging has not been opened.

6 General requirements for cylinders

6.1 Design of cylinders

6.1.1 General

Cylinders shall be designed and fabricated in accordance with a pressure vessel code, of which Section VIII of ANSI/ASME Boiler and Pressure Vessel Code is an example, that is acceptable to the competent authority.

Stiffening rings should be relieved to bridge the shell longitudinal weld and minimize the influence of the heat-affected zones.

Lifting lugs shall be designed, using an appropriate safety factor, to allow the gross mass of the cylinder to be lifted and restrained during transport (see 5.2) using two diagonally opposed cylinder lifting lugs loaded perpendicular to their lifting/tie-down plane. Cylinders fitted with lifting lugs and containing more than heel quantity of material shall be handled using a four-point attachment. Additional holes or slots may be provided in lifting lugs, e.g. for tie-down, and shall be designed such that the fitness for purpose of the lifting lug is not impaired.

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

Unless otherwise specified, threads identified in this International Standard shall conform to ISO 263.

Cylinders shall be marked as specified in Clause 7.

In all cases, for transport approval, compliance with the requirements of IAEA TS-R-1:1996 (as revised 2003), paragraphs 629 to 632, as applicable, is mandatory.

6.1.2 Maximum allowable working pressure

The pressure-containing portion of the cylinder shall be designed to withstand the pressure rating specified in Clause 7 for the type of cylinder. The design shall provide a strength margin of at least 10 % between the maximum stress reached when the cylinder is hydrostatically tested at the test pressure specified in 6.2.4.1 and the yield point (or 0,2 % proof stress) of the material used.

During normal operating conditions, the maximum value of the design gauge pressure shall not be exceeded, account being taken of the effects of impurities on the total gas pressure.

6.1.3 Leak-tightness

If valves or pipe plugs are used in addition to those shown on cylinder drawings, they shall be manufactured, prepared, inspected, installed and tested in accordance with the requirements of this International Standard.

Cylinders, valves and pipe plugs shall be leak-tight in accordance with the standard indicated, as demonstrated with equipment able to detect a standardized leak rate of 1×10^{-4} Pa·m^3/s. Detection of leaks shall be made using a suitable test and shall include fittings, connections, valve seat and packing. No detectable leakage shall be permitted. Leakage requirements stated in IAEA TS-R-1 relating to the radioactive-material package category shall also apply.

6.1.4 Maximum allowable temperature range

The pressure-containing portion of the cylinder, its valve and pipe plug shall be able to withstand the service temperature range as specified in Clause 7.

6.1.5 Materials

Materials for cylinder pressure envelopes shall comply with the pressure vessel code and, together with valves and pipe plugs, shall be compatible with UF_6 and shall have chemical and metallurgical properties as specified in Clauses 6 and 7.

6.1.6 Maximum transport fill

Maximum transport-fill limits (see Table 3 for values for existing cylinders) shall conform to IAEA TS-R-1:1996 (as revised 2003), paragraph 419, and be based on liquid UF_6 density at 121 °C (250 °F), 3 257 kg/m^3 (203,3 lb/ft^3), minimum cylinder volume and a minimum UF_6 purity of 99,5 %.

Allowable fill limits for cylinders containing tails with a minimum UF_6 purity of 99,5 % may be higher than the limit shown in Table 3 but shall not result in a free-volume safety margin of less than 5 % of the actual certified volume when the cylinder is at the higher design temperature value. More restrictive allowable fill limits shall be adopted if additional impurities are present.

Cylinders shall not be heated above the design temperature value for the cylinder.

Table 3 — Standard data for UF_6 cylinders

Cylinder type	Minimum wall thickness mm (in)	Minimum volume m^3 (ft^3)	Maximum enrichment g ^{235}U/100 g U	Maximum transport fill kg (lb)
1S	1,59 (1/16)	$1{,}50 \times 10^{-4}$ ($5{,}30 \times 10^{-3}$)	100	0,45 (1,0)
2S	1,59 (1/16)	$7{,}21 \times 10^{-4}$ ($2{,}55 \times 10^{-2}$)	100	2,2 (4,9)
5B	3,18 (1/8)	$8{,}04 \times 10^{-3}$ (0,284)	100	24,9 (54,9)
8A	3,18 (1/8)	0,037 4 (1,32)	12,5	115 (255)
12B	4,76 (3/16)	0,067 4 (2,38)	5,0	208 (460)
30B	7,94 (5/16)	0,736 (26,0)	5,0[a]	2 277 (5 020)
48X	12,7 (1/2)	3,084 (108,9)	4,5[a]	9 539 (21 030)
48Y	12,7 (1/2)	4,041 (142,7)	4,5[a]	12 501 (27 560)
48G	6,35 (1/4)	3,936 (139,0)	1,0	12 174 (26 840)

[a] These enrichment percentages require moderation control equivalent to a minimum UF_6 purity of 99,5 %. Without moderation control, the maximum permissible enrichment in ^{235}U shall be 1 g ^{235}U/100 g U.

6.2 Manufacturing process for cylinders

6.2.1 Process

6.2.1.1 General

The manufacturing process for cylinders shall conform to this International Standard and the pressure vessel code requirements as agreed with the cylinder purchaser's competent authority and shall conform to the applicable drawings and specifications. Approval shall be obtained from a qualified inspector.

Couplings, after having cooled from being welded into the pressure envelope and before the valve or pipe plug is inserted, may have a 1 in 11 1/2 NGT or 1 1/2 in 11 1/2 NGT tap, as appropriate, used, if necessary, to lightly chase the threads. Thread forms shall conform to ANSI/CGA V-1. Conformity to specification of the thread and coupling shall be confirmed in accordance with the agreed quality control plan.

6.2.1.2 Welding/brazing

Surfaces to be welded or brazed shall be free from foreign matter (oil, grease, rust, etc.). Interior surfaces of the cylinder shall be inspected and cleaned before closure is effected.

UF_6 cylinder welds and brazes shall be designed such that they conform to the requirements of the pressure vessel code or other code agreed with the competent authority and be formed in accordance with procedures given in the code(s) agreed with the competent authority. Welds detailed in Figures 1, 5 to 8 and 10 to 14 may be taken as typical. All welds shall be full penetration welds unless otherwise specified. Circumferential cylinder seams should be welded without backing rings. Optionally, circumferential cylinder seams may be welded with backing rings, as shown in Figure 1. Welders and brazers shall be qualified to each specific procedure used in cylinder fabrication. Each weld procedure shall be qualified with impact testing. This testing shall be as specified by the pressure vessel code utilized for the material being welded. Procedures and qualifications shall be documented as required by the specified codes.

6.2.1.3 Inspection of welds/brazes

All welds and brazes shall be visually inspected for proper fitting of the joints, full compliance with the previously qualified procedure and absence of imperfections and defects in the finished joints as specified by the pressure vessel code requirements. As a minimum, each cylinder shall be radiographed in accordance with code requirements and shall be spot radiographed at the junction of the longitudinal seam and the circumferential head weld in accordance with code acceptance criteria. Stiffening ring butt welds shall be examined to ensure full weld penetration. The qualified inspector shall examine radiographs.

6.2.2 Cylinder capacity and tare

The manufacturer shall determine the cylinder capacity by completely filling it with water. The mass and temperature of water shall be recorded and shall be accurate to ± 0,1 %. The water capacity, in kilograms (pounds) at 15,6 °C (60 °F), shall be determined and shall be not less than the specified minimum for the cylinder design (see Table 3 or cylinder design parameters).

On completion of the manufacturing process, painting and evacuation of the cylinder, the tare weight, in kilograms (pounds) at the specified internal pressure, shall be determined. The cylinder mass and internal pressure shall be recorded and shall be accurate to ± 0,1 %. The valve protector, if provided, shall not be included in the tare weight.

6.2.3 Cleaning

6.2.3.1 Interior of the cylinders

After hydrostatic testing, the inside of the cylinder shall be inspected and thoroughly cleaned of grease, oil, scale, slag, oxides, dirt, moisture and other foreign matter. The surfaces shall be clean, dry and free of contamination. The cleaning method shall be agreed with the purchaser.

NOTE The cleanliness of UF_6 cylinders is important since UF_6 reacts vigorously with some impurities left from the manufacturing process, particularly hydrocarbon oils.

The cleaning process should involve degreasing with an alkali cleaning solution at between 80 °C and 90 °C (176 °F and 194 °F) followed by a thorough washing with water within the same temperature range. The cylinder should then be blown dry with filtered, oil-free, dry air with a dew-point of – 40 °C (– 40 °F). Drying should be continued until air exhausting from the cylinder has a dew-point of – 35 °C (– 30 °F) or lower.

Other methods of cleaning and drying that achieve the same result may be applied.

6.2.3.2 Exterior of cylinders

The outer surface of the cylinder shall be easily decontaminable. After cleaning the inside of the cylinder and completion of testing, the exterior surface of the cylinder shall be blasted to remove rust, scale, dirt and other foreign matter. Where a protective coating system is to be applied, the cylinder shall be blasted to the protective coating system manufacturer's requirements. A protective coating that should be suitable for service conditions should be applied to the outside of the cylinder and shall be applied in accordance with the coating manufacturer's instructions.

6.2.3.3 Valves

Valves that are procured, cleaned, lubricated and assembled in sealed packages using quality control practices conforming to Clause 4 may be installed in cylinders as received. Otherwise, prior to installation into the cylinder, the valve shall be disassembled and cleaned to remove all traces of machining lubricants, metal chips, oxide film and other foreign substances in accordance with 6.2.3.1.

Prior to re-use, valves that have been removed from cylinders shall be refurbished in accordance with a quality control plan conforming to the requirements of the competent authority and to the drawings and specification of this International Standard.

6.2.4 Testing

6.2.4.1 Hydrostatic testing of cylinders

Cylinders shall be hydrostatically tested. No leakage shall be permitted. The test pressure shall be twice the maximum admissible working pressure, (gauge pressure). The MAWP shall be rounded up to two significant figures. Prior to inspection of the cylinder for leaks, the pressure shall be lowered to 1,5 times the MAWP or to a gauge pressure of 1,38 MPa (200 lbf/in^2 gauge), whichever is the higher. Defects shall be repaired in accordance with the appropriate manufacturing and welding standards within the quality control procedure and as permitted in the relevant code. After being repaired, the cylinder shall then be subjected to a retest in accordance with the original requirements. Packages for transport shall conform to IAEA TS-R-1:1996 (as revised 2003), paragraph 630 (a).

6.2.4.2 Valve and pipe-plug leak test

After installation of the pipe plug and cleaning and installation of the valve, a test air pressure of 690 kPa gauge (100 lbf/in^2 gauge) shall be applied and the fittings, connections and valve seat and packing tested for leaks. Leak detection shall be as specified in 6.1.3. Defects shall be repaired in accordance with the appropriate standards within the quality control procedure and as permitted in this International Standard. After being repaired, the cylinder shall then be subjected to a retest to the original requirements.

Alternative test of equivalent sensitivity as described in ISO 12807 or other standard as authorized by the competent authority may be applied.

6.2.5 Certification

The manufacturer shall certify in writing to the purchaser that cylinders conform to the fabrication, test and cleanliness requirements of this International Standard. The manufacturer shall also provide the following:

a) "as-built" drawings and design calculations;