INTERNATIONAL STANDARD

ISO 7195

First edition
1993-11-01

Packaging of uranium hexafluoride (UF_6) for transport

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

Reference number
ISO 7195:1993(E)

Contents

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

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.

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.

International Standard ISO 7195 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Sub-Committee SC 5, *Nuclear fuel technology*.

Annexes A, B, C and D form an integral part of this International Standard.

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 come to be 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. There are, however, in some cases minor adaptations of ANSI N14.1 to meet local conditions in a particular country. For example, in the manufacture of UF_6 cylinders, equivalent materials may have been used because they were more readily obtainable in the particular country concerned than the materials specified in ANSI N14.1 (see annex D). Moreover, the certification of transport cylinders as pressure vessels may have used an equivalent authorization procedure, appropriate to the country concerned, rather than the US certification procedure specified in ANSI N14.1.

This International Standard lays down the internationally accepted guidelines and procedures for the transport packaging of UF_6 based on the 1987 revision of ANSI N14.1. 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 will be transported.

This International Standard is consistent with but does not replace the recommendations of the International Atomic Energy Agency contained in *Regulations for the Safe Transport of Radioactive Materials* (IAEA Safety Series No. 6, 1985 and Supplement 1986) and also includes the additional IAEA recommendations arising from TECDOC 423, TC 587 and TC 587.2. It should be noted that extensive use is made of these IAEA recommendations in the various countries engaged in nuclear transport activities and also that the IAEA Regulations form the essential basis of regulations for international transport (RID, ADR, IMDG, ICAO). There are nevertheless minor differences in practice in the various countries. However, these differences are not considered significant in relation to this International Standard and do not affect the guidelines stated.

The annexes given in this International Standard form an integral part of this International Standard. However, it should be emphasized that the information contained in the annexes has been derived from widespread practical applications and is, therefore, the result of international experience. As this experience grows, so inevitably improved designs of cylinders and valves will come forward. Although the cylinders and valves illustrated in the annexes satisfy the current requirements of ANSI N14.1 and IAEA Regulations, an improved design for the type 48Y valve protector is under consideration at the present time to satisfy current regulations. Improvements will be subject to approval by competent authorities.

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 parentheses), even though the basic units used in the specifications derived from national standards are imperial units.

Packaging of uranium hexafluoride (UF_6) for transport

1 Scope

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

It applies to

— the design, manufacture and testing of transport cylinders and packaging;

— the in-service testing and shipping requirements.

2 Definitions

For the purposes of this International Standard, the following definitions apply.

2.1 protective packaging: Outer packaging used to enclose cylinders usually containing enriched UF_6 exceeding 1 % (m/m) of ^{235}U to total uranium that enables the UF_6 package to withstand the tests for severe accident conditions.

2.2 discharged cylinder: A cylinder containing a residual amount of UF_6 and non-volatile reaction products of uranium (heel) in quantities less than those referred to in table A.1.

2.3 clean cylinder: A cylinder which has been decontaminated to remove the residual quantities of uranium and other contaminants or a new cylinder which has been cleaned to remove oil and other manufacturing debris.

2.4 qualified inspector: The competent pressure vessel inspector appointed by the national competent authority of the country of manufacture, or of the country of ownership, or of the country of use for the functions specified in this International Standard.

2.5 exclusive use: The sole use, by a single consignor, of a vehicle or a large freight container, or of a hold or compartment of an inland waterway craft, or of a hold, a compartment or a defined deck-area of a sea-going vessel, in which all initial, intermediate and final loading and unloading are carried out in accordance with the directions of the consignor or consignee.

2.6 transport index (TI) for a package: The number placed on a package to designate the degree of control to be exercised by the carrier during transport. The transport index is the larger value of either

a) 100 times the number expressing the maximum radiation level in millisieverts per hour at 1 m from any accessible external surface of the package; or

b) the number obtained by dividing 50 by the value of N, i.e. $TI = 50/N$, where N is the maximum allowable number of packages derived in the criticality assessment of the particular package and stated in the package design "certificate of approval".

2.7 packaging: The assembly of the cylinder, the closures of penetrations (valves and plugs) and any item either permanently attached to or assembled with the cylinder as presented for transport.

2.8 package: The packaging with its specified contents as presented for transport.

2.9 excepted package: A packaging that contains excepted radioactive material and is designed to withstand the general requirements and the conditions of routine transport (incident free conditions).

2.10 type A packaging: A packaging that is designed to withstand the normal conditions of transport, including loading and unloading, as evidenced by the fact that the integrity of the containment and shielding are maintained to the extent required by the appropriate tests in IAEA recommendations. Any tie-down attachments shall not impair the ability of the package to meet these requirements.

Under these conditions, the contents of the package shall not be released nor the surface dose rates increased by more than 20 %.

2.11 type B packaging: A packaging (including its tie-down attachments) that is designed to withstand the damaging effects of a severe transport accident as evidenced by the fact that the integrity of containment and shielding are maintained to the extent required in IAEA recommendations.

The basic philosophy underlying the design of a type B package is that, as far as is practicable, no operational controls are required during transport to safeguard integrity of the containment and shielding features. Furthermore, the design is required to be such that if the package becomes involved in a severe accident entailing impact followed by fire, the containment and shielding features can be maintained within set limits.

2.12 competent authority: The national body in each country that is responsible for the approval and certification of specified package designs and shipment arrangements associated with the transport of radioactive materials. In accordance with the laws and customs of different countries, it may be necessary to issue national regulations complementary to the international guidelines.

3 Transport cylinders

3.1 Design

3.1.1 General

Annex B provides details of typical cylinders that have been used in practice and therefore have international acceptance. Alternative designs may be used provided that these have the full approval of the competent authority. In particular, the 48G cylinder has been approved for national use but requires multilateral approval for international transport.

3.1.2 Maximum allowable working pressure

The pressure-containing portion of the vessel shall be designed to withstand the pressure rating specified in annex B for the type of cylinder to be fabricated. The design shall provide a strength margin of at least 10 % between the maximum stress reached when the vessel is hydrostatically tested at the test pressure specified in 3.5.1 and the yield point (or 0,2 % proof stress) of the material used.

3.1.3 Maximum allowable temperature range

The pressure-containing portion of the vessel shall be designed to withstand a service temperature range as listed in annex B.

Packages shall be capable of withstanding the pressure developed by the liquid and gaseous contents after total engulfment in a fire according to current IAEA criteria.

3.1.4 Materials

Materials used for the pressure-containing portion shall be such that they are compatible with UF_6, meeting ASTM specification C787-90, and have the necessary chemical and metallurgical properties to meet the design criteria (annexes B and C).

3.1.5 Valves and plugs

Valves and plugs shall be suitable for withstanding the internal service pressure and service temperature without movement or rupture and shall be leakproof under all working conditions.

NOTES

1 In order to minimize the possible points of leakage, it is desirable to fit only one valve and one plug to the cylinder. However, if additional valves or plugs are considered necessary, they may be fitted provided that all valves are fitted in a similar manner and all plugs likewise.

2 It is recommended that valves are fitted which meet the UF_6 valve specifications, given in annex C, as these valves have been proved in practice and are considered to be of a suitable type affording the least possible chance of leakage.

3.1.6 Valve protection

A valve protection arrangement shall be fitted to all cylinders not carried in a protective package and be of a design that will protect the valve from damage during transport according to the conditions of 3.1.7.

3.1.7 Impact resistance

Packages shall be designed so as to prevent any leakage when subjected to a free drop test onto a flat, horizontal and unyielding surface. The height of the drop from the lowest point of the package to the flat surface should be not less than the distance specified in IAEA TECDOC 423 or current IAEA requirements.

3.2 Quality control

3.2.1 Procedures

The manufacturer of new or reworked cylinders shall establish and maintain written quality control procedures for manufacturing, cleaning, inspection and testing to ensure that the finished product meets the requirements of the specifications. The quality assurance programme shall be acceptable to the competent authority and shall be provided to the customer or buyer.

NOTE 3 The procedures may consist of, or be based upon, the manufacturer's written specifications for similar work or may be developed to meet requirements of the specifications for cylinder manufacture.

3.2.2 Approvals

The manufacturer shall, prior to the start of the manufacturing process, submit to the purchaser for approval copies of his proposed procedures. Changes in previously approved procedures shall not be made during manufacture without written approval from the purchaser.

The manufacturer shall notify the purchaser in advance of the start of the manufacturing process to allow the purchaser's representative to witness initial production. The purchaser or the purchaser's representative shall be granted access to the manufacturing facilities at any reasonable time to verify that the quality control procedures are being implemented.

3.2.3 Responsibilities

The requirements for certification of materials and control of quality throughout inspection and testing shall be the responsibility of the manufacturer, who will also impose them on his subcontractors, if any.

3.3 Manufacturing process

3.3.1 Welding

The cylinder shall be rolled from plate and seam-welded by the metal arc process to give full-depth, full-strength welds. The surface to be welded shall be free of foreign matter, such as oil, grease, rust, etc. Before the closing weld, the interior surfaces shall be cleaned.

The manufacturing process shall comply with the appropriate boiler and pressure vessel requirements in the country of manufacture and shall conform to the applicable drawings and specifications. Approval shall be obtained from a qualified inspector.

3.3.2 Testing of welders and procedures

The testing of welders and welding procedures shall comply with the requirements for pressure vessel manufacture in the country concerned.

3.3.3 Weld testing

At least one test weld representing each weld procedure used in the manufacture of the cylinder shall be impact-tested at the lower end of the design temperature range.

The impact tests shall be performed in accordance with current codes of practice for weld testing and examination for the type and grade of steel used in the manufacture of the cylinder.

The test results shall be approved by the qualified inspector.

3.3.4 Inspection of welds

All welds shall be visually inspected for the proper fit of the weld joints, full compliance with the previously qualified welding procedure and the absence of imperfections and defects in the finished welds as specified by the appropriate boiler and pressure vessel requirements in the country concerned.

All groove welds shall be spot-radiographed and quality standards for judging the acceptability of the welds shall be in accordance with the relevant standards.

Radiographs shall be examined and certified by the qualified inspector.

3.4 Cylinder capacity and mass

The manufacturer shall determine the cylinder capacity by completely filling it with water. The mass of water and the water temperature shall be recorded and shall be accurate to $\pm$ 0,25 %. The water capacity, in kilograms at 15 °C, shall be determined and shall be not less than the specified minimum for the cylinder design.

On completion of the manufacturing process, painting and evacuation of the cylinder, the tare weight shall be determined. The valve protector shall not be included in the tare weight.

The manufacturer shall check the calibration of the weighing-scale at regular intervals during the manufacturing process. He shall use certified test weights and shall ensure that the calibration is maintained to within $\pm$ 0,1 % of the certified test weights.

3.5 Testing

3.5.1 Hydrostatic testing of cylinders

NOTE 4 All pressures in pascals are differential (gauge) pressures, unless otherwise specified.

3.5.1.1 Sampling cylinder (see figures B.1 to B.3 for typical examples)

The sampling cylinder shall be hydrostatically tested by water-jacket or other suitable method at a pressure of $2{,}76 \times 10^6$ Pa (400 psig). If leaks are detected, the defects shall be repaired in accordance with the appropriate manufacturing and welding standards to the approval of the qualified inspector. Following repair, the cylinder shall be retested in accordance with the conditions previously specified.

3.5.1.2 Transport cylinder (see figures B.5 to B.10 for typical examples)

The transport cylinder shall be hydrostatically tested to twice the maximum allowable working pressure, then the pressure shall be lowered to 1,5 times this pressure while the cylinder is inspected for leaks. If leaks are detected, the defects shall be repaired in accordance with the appropriate manufacturing and welding standards within the quality control procedure. Following repair, the cylinder shall be retested in accordance with the conditions previously specified. When testing, the temperature of the cylinder shall not be significantly lower than the ambient temperature.

3.5.2 Valve leak test

After cleaning and installation of the valve have been carried out, a test air pressure of $6{,}9 \times 10^5$ Pa (100 psig) shall be applied and all vessels, fittings and connections shall be tested for leaks, including the valve seat and packing. Detection of leaks shall be made using a suitable test. The test equipment used shall be capable of detecting a leak rate of 0,1 Pa·l/s. No leakage shall be permitted and any found shall be rectified. Alternative tests of equivalent sensitivity may be applied.

3.6 Cleaning

3.6.1 Inside of cylinders

The cleanness of UF_6 containers is important since UF_6 reacts vigorously with some impurities left from manufacture, particularly hydrocarbon oils. Therefore, after hydrostatic testing, the inside of the cylinder shall be thoroughly cleaned of all grease, oil, scale, slag and other foreign matter, and the surfaces shall be left clean, dry and free of all contamination. The cleaning method shall be acceptable to the purchaser.

NOTE 5 A suitable process would normally involve degreasing with an alkali cleaning solution at an elevated temperature (80 °C to 90 °C) followed by a thorough washing with warm water at the same temperature. The cylinder should then be blown dry with filtered dry air with a dewpoint of – 40 °C (– 40 °F). Drying should be continued until the air exhausting from the cylinder has a dewpoint of – 34,4 °C (– 30 °F) or lower.

3.6.2 Valves

Valves that are procured, properly cleaned, lubricated and assembled in sealed packages using quality control practices, as described in 3.2, can be installed in cylinders as received. Otherwise, prior to the installation into the cylinder, they shall be disassembled and cleaned according to the criteria of 3.6.1.

3.6.3 Exterior of cylinders

After interior cleaning and all testing have been completed, the exterior surface of the cylinder shall be cleaned and treated to prevent corrosion. The surface finish shall be easily decontaminable.

3.7 Certification

The manufacturer shall provide the purchaser with a certified copy of all test certificates and reports identified against the serial number of the cylinder as follows:

a) test certificates for the chemical analysis and physical tests for each heat of material used in manufacturing the cylinder;

b) copy of completed route sheet certified by a competent official of the manufacturer;

c) test certificate for the valve leak test where the manufacturer has fitted the valve;

d) certificate relating to the water capacity of the cylinder;

e) certificate relating to the inspection of welds and cleaning.

3.8 Identification

Each cylinder (except those of the types shown in figures B.1 and B.2) shall have a stainless steel nameplate permanently attached in a manner not detrimental to the performance of the container. The nameplate shall include the following information:

a) the qualified inspector's stamp of approval;

b) the model or type number;

c) the owner's name;

d) the serial number of the cylinder;

e) the tare weight, in kilograms (pounds);

f) the water capacity, in kilograms (pounds) at 15 °C;

g) the maximum permissible filling mass of UF_6, in kilograms (pounds);

h) the date of manufacture and initial hydrostatic test;

i) the design temperature range, in degrees Celsius (Fahrenheit);

j) the test pressure, in pascals (psig);

k) the design pressure, in pascals (psig);

l) the manufacturer's name;

m) the dates of initial certification and recertification, which are required at five-year intervals.

NOTE 6 Room shall be left on the nameplate for the inclusion of the dates of recertification.

The stamp of approval and vessel identification should also be marked on the skirt of the cylinder (not on the body, to avoid potential damage to the pressure vessel after manufacture).

4 Protective packaging

4.1 Design

In order to meet type B and/or fissile material packaging requirements, an outer protective packaging can be provided to enclose the cylinder containing UF_6. The protective packaging shall be designed so that it forms an integral component with the cylinder, complete with its contents during transport.

NOTE 7 Figure B.12 shows a typical design of protective packaging.

4.2 Inspection

Inspection by the purchaser at the manufacturer's plant shall be limited to dimensional, material and structural checks to ensure that the approved design has been followed.

4.3 Certification

The manufacturer shall provide the purchaser with a certificate for each item of packaging, identified by the packaging number, to show that the packaging complies with the above requirements.

5 In-service tests

5.1 Transport cylinders

5.1.1 Routine operational inspection and maintenance

All UF_6 transport cylinders shall be routinely examined prior to filling, emptying or shipping operations in order to ensure that they remain in a safe, usable condition.

Leakage, corrosion, cracks, excessive distortion, bent or broken valves or plugs, broken or torn skirts are examples of unacceptable damage which warrant the removal of the cylinder from service for repairs.

NOTES

8 Examples of acceptable and unacceptable damage are given in figure 1.

9 Any doubts about the condition of the pressure vessel which might impair its containment capability should be referred to the qualified inspector who will make recommendations for use or repair or may prohibit further use of the cylinder if the damage warrants such a decision.

All repairs and alterations to the pressure vessel parts of the cylinders shall conform to the requirements of this International Standard and shall be referred to the qualified inspector for approval. Any repairs to pressure parts shall be followed by the hydrostatic pressure test, and repairs to valves or plugs shall be followed by the air leak test.

NOTE 10 Repairs to structural attachments, such as stiffening rings or skirts, will not normally require pressure or leak test checks unless the repair work also involves the pressure vessel parts. Similarly, routine maintenance work, such as painting or coating with an anti-corrosive agent, does not require a check test.

5.1.2 In-service cleaning

"Heels" of UF_6 and of residual non-volatile materials such as UO_2F_2 and uranium daughters and possibly also fission products and transuranic elements from irradiated uranium remain in UF_6 cylinders after emptying. If the cylinder is to be shipped either empty or after refilling, it is necessary to ensure that radiation levels from the localized heel do not exceed the limits indicated in table 1. Suitable cleaning may be necessary to satisfy regulatory requirements or to meet the material specification on refilling. This is normally done by washing with water, followed by steam cleaning. It is extremely important, in cases where the dimensions of the cylinder concerned are not geometrically safe for the enrichment level of the uranium heel, to monitor and check the use of water in the cleaning operation. For each cylinder, it is necessary to obtain

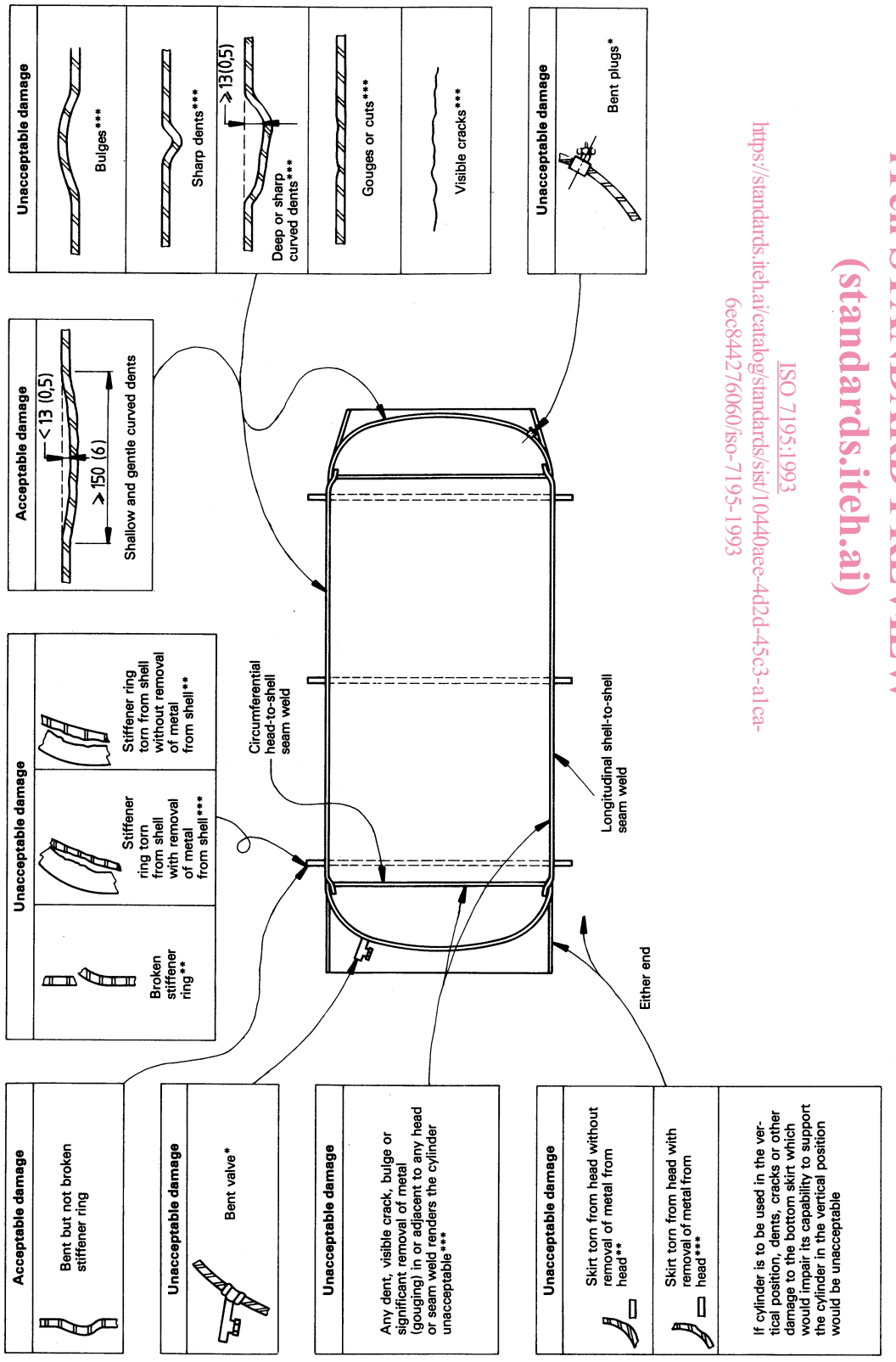
a) the dates for the last filling and emptying operations;

b) the isotopic abundance of the UF_6 last contained in the cylinder;

c) the quality of the UF_6 (whether from an irradiated or unirradiated source).

Where cleaning of cylinders containing residual quantities of UF_6 is necessary, a nuclearly safe procedure that has the full approval of nuclear safety personnel shall be used. In particular, the amounts of wash solution added to the cylinders shall be carefully checked and a neutron absorber, such as a boron solution, shall be added where necessary for criticality control. Following all cleaning procedures, it is important that the cylinder be kept dry and free of contamination.

Dimensions in millimetres
(Dimensions in inches in parentheses)



NOTE — Cylinders with unacceptable damage may be returned to service as follows:

* indicates items requiring only the replacement of the damaged plug and/or valve providing that no damage has been done to the half coupling;

** indicates items requiring only repair of the damage sustained;

*** indicates items requiring repair of the damage sustained, followed by a hydrostatic test.

Figure 1 — Examples of acceptable and unacceptable damage to UF_6 cylinders

5.1.3 External surface contamination

Cylinder surfaces shall be monitored by swab testing and, where necessary, cleaned to ensure the surface level of contamination is less than the limits given in table 1.

Table 1 — Maximum permissible levels for external surface contamination

Form of UF_6	Maximum permissible limit Bq/cm²	
	Excepted packages	Other than excepted packages
Natural and depleted	0,4	4
Enriched	0,04	0,4

The permissible contamination levels given in table 1 shall apply when averaged over any area of 300 cm^2 of any part of the surface.

NOTES

11 The absorbent material (swab) used to collect the smear should be taken to have an area of approximately 10 cm^2 and the area rubbed should be 300 cm^2. It may be assumed that one-tenth of the surface contamination has been transferred to the swab from the surface rubbed. The swab should be measured for alpha contamination in a normal counting assembly.

12 Cleaning of the cylinder surfaces may be carried out by steam jets or, in extreme cases, high-pressure water hoses.

5.1.4 Periodic inspection and tests

At intervals not exceeding five years, the cylinders shall be retested and the qualified inspector shall issue a test certificate in the country concerned. The test shall consist of

a) external and internal examination;

b) hydrostatic pressure test in accordance with 3.5.1.1 or 3.5.1.2 or an equivalent procedure acceptable to the competent national authority;

c) valve leak test in accordance with 3.5.2;

d) a measurement of wall thickness if there is evidence of excessive corrosion of the cylinder or if the cylinder has been out of use in store for more than 10 years.

NOTE 13 Table B.1 provides details of the minimum permissible thicknesses for typical examples of cylinders.

Any defects shall be repaired, if appropriate, and the cylinder retested so that it meets with the approval of the qualified inspector for continuing in service.

NOTE 14 Approval will normally be indicated by stamping the cylinder to show it has passed the tests, together with the corresponding dates of the tests. [See 3.8 m).]

Cylinders which are full at the time of expiry of the five-year period need not be emptied for this inspection and test, and may be transported while full after inspection according to a programme acceptable to the competent authority. However, after emptying and prior to refilling, they shall be properly re-inspected, retested and restamped.

5.1.5 Cold pressure test

The suitability of the cylinder for the transport of UF_6 under partial vacuum conditions shall be demonstrated by a cold pressure test at $6{,}9 \times 10^4$ Pa (10 psia), with evacuation down to this limit if necessary.

The test shall be subject to agreed quality assurance procedures.

5.2 Protective packaging

5.2.1 Inspection

Protective packaging shall be inspected prior to each use to ensure its continued integrity and ability to comply with the standards of the competent authority. Excessive distortion or other damage of the packaging which would prevent a tight closure of the package, allow excessive clearances for the inner container within the liner, reduce assembly fastener strength of the container, reduce the thermal insulation in any area or in any way make the integrity of the protective packaging suspect as a fire- and shock-resistant housing, shall be corrected prior to use of the packaging for the shipment.

NOTES

15 Any doubts about the condition of the packaging should be referred to the competent authority for evaluation and for recommendations concerning the use, repair or condemnation of the package.

16 The protective packaging should be weighed annually to determine if water has leaked into the packaging thus causing a resultant weight gain so that the integrity of the packaging could be suspect.

5.2.2 Repairs

Any repairs made to the protective packaging to preserve its integrity shall be in accordance with the original approved design so that the certification supplied by the manufacturer will still apply.

6 Shipping requirements

6.1 Clean cylinders

Clean cylinders, i.e. new cylinders or those cleaned in service (see clause 5), may be shipped with no special precautions other than those used in normal shipping operations provided the shipper can demonstrate that residual contamination within the cylinder has a specific activity less than 74 Bq/g.

Clean cylinders should be fitted with a tamper indicating device (T.I.D.) before shipment.

6.2 Full and discharged cylinders

The additional requirements specified in 6.2.1 to 6.2.9 apply to the shipping of full and discharged cylinders containing heel UF_6.

6.2.1 Security seal

The outside of every package shall incorporate a feature, such as a seal, which is not readily breakable and which, while intact, will be evidence that the package has not been opened.

6.2.2 Maximum fill

The limits of maximum fill are based upon the maximum UF_6 working temperature of the cylinder (UF_6 density = 3 257 kg/m^3 for cylinders with a 121 °C maximum working temperature), the certified minimum internal volume of the cylinder, a minimum UF_6 purity of 99,5 % and a minimum safety margin of 5 % free volume when the UF_6 is in the liquid state at the maximum working temperature. (See table B.1.)

6.2.3 Tie-down arrangements

Tie-down arrangements shall be made to withstand the stresses due to acceleration or deceleration which occur during normal transport (see table 2).

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

*) 10 m/s^2 ≈ 1 g_n

6.2.4 External surface contamination

The non-fixed radioactive contamination on any external surface of the package shall be kept as low as practicable. Under normal conditions of transport, contamination shall not exceed the levels given in table 1.

The level of contamination shall be monitored by a swab test in accordance with 5.1.3.

6.2.5 Fissile materials

The uranium 235 isotope is a fissile material and, for UF_6 containing uranium of greater than 1 % enrichment, the material shall be packed and shipped in such a manner that criticality cannot be reached under any foreseeable circumstances during transport. In particular, the following aspects shall be considered:

a) water leaking into or out of packages;

b) the loss of efficiency of built-in neutron absorbers or moderators;

c) rearrangement of the package contents into more reactive arrays, either within the package or as a result of loss from the package;

d) reduction of space between packages or contents;

e) packages becoming immersed in water or buried in snow;

f) increase of reactivity due to temperature changes.

The control of criticality to meet these requirements shall be ensured by the design of the package and by the supervision and checks carried out by the carrier during transport. A criticality safety assessment taking account of the above requirements shall be drawn up by the consignor and this shall be approved by the competent authority.

NOTE 17 For uranium enriched to a maximum of 1 % (m/m), the concentration of uranium 235 is so low that the material cannot be made critical under any conditions considered credible during transport, including those resulting from accident conditions and subsequent recovery operations. Therefore, the transport of UF_6 containing uranium of up to 1 % enrichment may be regarded as excepted from the above requirements.

6.2.6 Valve protectors

The design of the package shall be such that the normal hazards of handling do not damage the package and reduce the effectiveness of containment. In order to meet the requirement, all valves shall be fitted with valve protectors unless the cylinders concerned are already contained within an outer

protective package during shipment. (See 3.1.6 and figure B.14.)

6.2.7 Categorization of packages for labelling purposes

The packages shall be placed into categories for labelling purposes in accordance with the regulations of IAEA Safety Series No. 6 (1985) and Supplement 1986.

6.2.8 Labelling and marking

The precise labelling and marking requirements shall be as detailed in the relevant transport (road, rail, air, etc.) regulations in the country concerned. The minimum requirements are to comply with current IAEA regulations.

Each package shall bear at least two radioactive material labels unless excepted. The labels shall be affixed to two opposite sides of the package. Each freight container shall bear radioactive material labels affixed to all four sides of the container.

Natural and depleted UF_6 may be transported as low specific activity radioactive material and, under "exclusive use" conditions, are excepted from labelling requirements. The package shall, however, be marked or stencilled "RADIOACTIVE LSA-1".

6.2.9 Additional hazards

The formation of dangerous products by interaction of uranium hexafluoride with atmospheric moisture or liquid water should be taken into account (see annex C). The appropriate transport regulations for dangerous goods of each country through or into which the material is to be transported and of the transport organisation shall be complied with. Packages shall be further labelled to indicate the corrosive characteristics, as required by the relevant transport regulations.