

TRANSPORT OF UF₆ UNDER TS-R-1

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ABSTRACT

The new IAEA Regulations TS-R-1 (ST-1 Revised 1996) have been fully in force for all modes of transport since 1 January 2002. Specific requirements in TS-R-1 affect the transport of non-fissile and fissile excepted uranium hexafluoride (UF₆).

Under auspices of the World Nuclear Transport Institute (WNTI), an industry working group has made preparations for the introduction of TS-R-1. The existing containers used have been evaluated against the new requirements.

The free drop test needed an improved valve protection and a new Valve Protection Assembly (VPA) has been successfully designed and tested. An H(M) approval has been applied for at the US Department of Transport (US-DOT). This approval was issued in August 2001 and has been validated in other countries in North America and Europe. Also Russia has validated the US-DOT approval.

Current activities of the WNTI industry working group concentrate on compliance with the thermal test requirement in TS-R-1. This must lead to the availability of an H(U) approval as required after 31 December 2003.

This paper describes the certification and validation for the H(M) approval and the work in progress with regard to achieving H(U) approval. The paper specifically focuses on packages for non-fissile and fissile excepted UF₆.

INTRODUCTION

IAEA Safety Series No. 6: Recommendations for the Safe Transport of Radioactive Materials^[1] (SS6), together with Safety Series No. 7: Explanatory Material, and Safety Series No. 37: Advisory Material, have been the basis for the international, national and regional transport regulations for many years.

The 1985, as amended 1990, issue of SS6 has been revised into IAEA ST-1: Regulations for the Safe Transport of Radioactive Material, published in 1996. In 2000, ST-1 was re-issued as TS-R-1 (ST-1 Revised, 1996)^[2].

While SS6 does not address UF₆ as a special category of radioactive material, TS-R-1 incorporates specific requirements for UF₆ packages. Background on how this has developed through the years from 1984 to 1996 is given in the paper “IAEA Regulations TS-R-1 and Packages for UF₆”, presented at PATRAM 2001, Chicago^[3].

TS-R-1 REQUIREMENTS FOR UF₆ PACKAGES

The specific requirements for UF₆ packages are given in Section VI, § 629-632 of TS-R-1. The most important requirements are the structural test, the free drop test and the thermal test. For the structural test reference is made to the International Organization for Standardization document ISO 7195^[4].

ISO 7195 has become a main reference for UF₆ packages in TS-R-1, not only for the structural test, but also for design requirements and other provisions. ISO 7195 covers the standard cylinders used throughout the industry, including the 48Y and 48X cylinders used for packaging of non-fissile and fissile excepted UF₆. ISO 7195 is basically the international equivalent of the American National Standards Institute document ANSI N14.1^[5]. Cylinders based on either standard are equal in terms of technical performance quality and provide for equivalent levels of safety for both transport and processing operations.

The free drop test requirement in TS-R-1 § 630(b) for 48 inch cylinders normally used for transport of natural and depleted UF₆, implies a 0.6 meter drop for a full cylinder positioned in such a way that maximum damage is expected. Satisfaction of this new requirement could not be determined from cylinder drop testing that took place in the 1960s and 1970s. Although the drop heights were larger (up to 9 meters) in these tests, the positioning of the cylinder when dropped had been different. As a result, a drop test project was started by a consortium of UF₆ users. The work and results of this project are further described under H(M) Approval below.

The thermal requirement of TS-R-1 § 630(c) is another new requirement for 48 inch cylinders. The IAEA initiated a Co-ordinated Research Programme (CRP) to evaluate the behaviour of large UF₆ cylinders in fires. However, the CRP, established in 1992, did not result in general conclusions on resistance of 48 inch cylinders to fire. Also no consensus was reached on a general computer model / calculation model. The latest draft of the CRP report is dated April 1999^[6]; the final report was not yet issued at the time this paper was written. A consortium of UF₆ users is currently evaluating solutions for thermal protection of 48 inch cylinders. The work of this thermal project is further described under H(U) Approval below.

H(M) APPROVAL

The drop test project is carried out by members of the WNTI-HEXT Industry Working Group (HEXT = uranium HEXafluoride Transport). It was decided to follow the so-called two step approach^[3] and to concentrate the work initially on the H(M) approval for 48 inch cylinders. The project was initiated to investigate how to meet the drop test requirement, specifically with regard to the aspect of maximum damage. The fully loaded cylinder had to be suspended at an angle of approximately 23° to the vertical with the valve facing downwards. The project was jointly funded by a consortium of UF₆ users and actual tests were carried out in Canada.

Initial drop tests were done by means of computer simulation using finite element models. It turned out that the existing valve guard design in ANSI N14.1 and ISO 7195 could not prevent the skirt of the cylinder from deforming inwards and damaging the valve. Consequently, a solution had to be found to protect the valve under TS-R-1 free drop test conditions. Small size, light weight and easy handling were important requirements for a new design. The design work resulted in a so-called Valve Protector Assembly (VPA),

manufactured from high-strength aluminium plate that should be bolted to the skirt of the cylinder. Photographs of the VPA fitted on a cylinder are shown in Figure 1 and 2 below.



Figure 1



Figure 2

To confirm the computer modelling, an actual drop test was carried out with a 48Y cylinder filled with steel balls to simulate the maximum UF₆ fill and with a prototype VPA fitted. The skirt of the cylinder was slightly deformed after the test, but the cylinder valve was undamaged and successfully passed the required leak test. At the same time also an empty (heeled) cylinder was successfully drop tested.

Based on the drop test results, a Safety Analysis Report (SAR) was prepared to accompany the application for an H(M) approval for 48Y and 48X cylinders. The application was submitted to US-DOT on 6 March 2001; the H(M) certificate was issued on 31 August 2001 (USA/0592/H(M)-96, Revision 0, expiring on 1 September 2006). The certificate covers the transport of full 48Y and 48X cylinders as well as empty cylinders with heels.

Before the certificate could be issued, the use of the new VPA had to be incorporated in ANSI N14.1. After acceptance by the sub-committee, an Addendum to the 2001 issue of ANSI was published. The use of alternative valve guards has also been brought into the revision process of ISO 7195.

During March 2001, after submission of the H(M) application to US-DOT, copies of that application were submitted to other relevant Competent Authorities in North America and Europe. This was done as early information in the context of requesting validation of the H(M) approval as soon as the certificate was issued.

In September 2001, copies of the US-DOT certificate USA/0592/H(M)-96, Revision 0, were sent to the Competent Authorities, following the earlier requests for validation. Canada validated the US-DOT certificate in October 2001, and Russia in March 2002. Both validations expire on 1 September 2006, the same date as the original US-DOT certificate.

Validation in Europe turned out to be more complicated. In order to allow for continuation of transports after 1 January 2002 – the date TS-R-1 came into full force for all modes of transport – interim validations were issued in the UK, France, Germany and the Netherlands. These interim validations expired on 31 March 2002. Another round of interim validations,

expiring on 30 June 2002, were issued in the UK, Germany and The Netherlands. At the time this paper was written, the following final validations had been issued in Europe:

- France (issued during March 2002)
- Belgium (issued during April 2002)
- UK (issued during June 2002)
- Germany (issued during June 2002)
- The Netherlands (issued during June 2002)
- Spain (issued during October 2002).

All these European validations expire on 31 December 2003, enforcing H(U)-validation of 48 inch cylinders from 1 January 2004 onwards. The original US-DOT H(M) certificate expires well beyond that date. There is no time limitation in TS-R-1 with regard to the use of H(M)-approvals.

H(U) APPROVAL

While the new free drop test requirement could be met in a relatively simple way, the new thermal test requirement has proven to be a more difficult issue, with much larger impact on transport operations.

In Japan, a completely new transport system has been developed, the so-called Dedicated Transport Container (DTC). At PATRAM 1998 in Paris, France, a paper on this subject was presented^[7]. An H(U) validation for the DTC has been issued in Japan during April 2002.

The HEXT Working Group has followed another approach and has been looking for solutions that allow for continued use of existing transport equipment such as cradles, dedicated trailers, tie-down systems, handling equipment, etc. Adaptation of such equipment would require excessive investment and discontinuation of use would mean destruction of capital.

The challenges for such a solution for thermal protection are multiple. A new design should have the *thermal properties* required and should be *fire resistant*. It should furthermore be of *low volume* and not increase the outer dimensions of the package much in comparison to the bare cylinder. It should have a *low total weight*, in order to avoid problems with maximum truck loads. Should it be assembled from different components, the *weight of an individual component* must be low, in order to avoid conflicts with labour condition requirements and allow for easy one man handling. The *method of application and fixture* should be quick and easy in order to reduce handling time and thus reduce additional radiation exposure time of workers. The design should be "*compactable*" when not in use and when shipped separately from a cylinder. The design should be *economic* in manufacture, use and service life time.

Similar to the drop test project, a consortium of UF₆ users have started a thermal project to find solutions for the challenges described above. Different material were evaluated, varying from insulation blankets to solid panels made from Glassfibre Reinforced Plastics (GRP) and intumescent layers. Prototypes of thermal blankets have been manufactured and are being subjected to field-testing. This testing especially focuses on working with the blankets, i.e. applying and removing them to and from the cylinder, fastening systems, working methods, working time, etc. Experiences from the field tests will be fed into the design specification. A photo of a prototype blanket is shown in Figure 3.



Figure 3

Work on the use of solid panels is ongoing and a prototype stage may be reached shortly. Work on intumescent layers has been discontinued as a, for the time being, unfeasible option.

Apart from the technical and economical issues, the demonstration of compliance with the thermal requirement in TS-R-1 presents an additional challenge. As an actual thermal test by exposing a package filled with UF_6 to a fire is not a realistic option, demonstration of compliance will have to take place through calculation and modelling. The CPR however did not result in consensus on a general calculation model and there is little prospect of reaching consensus within the next few years considering the international scientific effort that already went into reaching the conclusions of the CRP as they currently stand.

With regard to survival times, the CRP concludes a range of 25 to 35 minutes for the unprotected cylinder. In comparison to the 30-minute requirement in TS-R-1, it appears that only a small adjustment to the cylinder's fire resistance is needed. Therefore, the thermal protection consortium has proposed to take the output of the CRP as a starting point and increase the "worst-case" survival time from the CRP from 25 to above 30 minutes. This can be achieved by reducing the heat input considered in the CRP for the unprotected cylinder through use of an insulation system. In case of a reduction of about 50%, the resulting survival times would range from 50 to about 70 minutes. It is recognised that absolute certainty cannot be claimed, but it is believed that the cumulative uncertainties resulting in survival times below 30 minutes is vanishingly small. This approach will be followed in the context of the upcoming H(U) approval process, in order to have a straightforward basis for demonstration of compliance with the thermal test requirement in TS-R-1.

SUMMARY

TS-R-1 imposes additional requirements to the transport of non-fissile and fissile excepted UF_6 . Especially the free drop test requirement and the thermal test requirement have considerable technical and operational impact.

With TS-R-1, Type H packages have been introduced, requiring approvals for UF_6 packages. Certification and validation procedures have come on top of the usual transport licensing procedures and can be time consuming.

UF_6 transports are of an international nature, departing from, transiting through and arriving in different countries and using different modes of transport. Since TS-R-1 has come into

force, uniformity between international, modal, regional and national regulations and in the way these are interpreted and applied have become more important for UF₆ transport also. Industry will contribute to this necessary uniformity if and where possible, as it remains committed to safe, efficient and reliable transport of UF₆.

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