IMPACT OF THE NEW IAEA REGULATIONS ON THE TRANSPORT OF UF_6 IN 48Y CYLINDERS

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SUMMARY

The transport of uranium hexafluoride (UF_6) is chiefly regulated taking into account its radioactive risk. The 48 Y cylinders containing uranium hexafluoride with an enrichment lower than 1%, have mainly to prevent the "loss or dispersal of the radioactive contents" when subjected to a 0.60 m drop.

In 1984, the Mont-Louis ship, transporting 48Y cylinders, sank in the North Sea. All the packages were recovered with no release of contents, and therefore with no chemical or radiological contamination. However, this led the international transport community to question the adequacy of the regulations relevant to uranium hexafluoride, and prompted the IAEA and the Member States to upgrade the existing regulations applying to the transport of UF_6.

Concerning 48 Y cylinders, a unilateral approval will be granted after demonstrating their ability to withstand without rupture a 800°C fire test for 30 minutes. Neither the Franco-Japanese TENERIFE programme, nor other experiments, have yet allowed to guarantee that it is the case.

Various potential solutions, such as new cylinders, overpacks, transport frames, end covers, thermal blankets, intumescent paint are described, with a brief assessment of their respective benefits and drawbacks.

The assessment of the various solutions will take into account the direct cost of the equipment, but also expenses covering its design and licensing, as well as a possible increase of the operational costs resulting from the preparation of the cylinder, its transport, and the inventory management and maintenance of this new equipment.

BACKGROUND

The transport of uranium hexafluoride (UF_6) is chiefly regulated taking into account its radioactive risk, the physical and chemical hazards being less considered. According to the « Regulations for the Safe Transport of Radioactive Material (1985 Edition, as amended 1990) » issued by the International Atomic Energy Agency (IAEA), and widely used as the basis for national and international regulations, the 48Y cylinders containing uranium hexafluoride issued from natural uranium (LSA-I material to be transported in industrial packages Type 1), and more generally uranium with an enrichment in Uranium 235 lower than 1 % (LSA-II material to be transported in industrial packages Type 2), have mainly to prevent the « loss or dispersal of the radioactive contents » when subjected to a 0.60 m drop onto a flat, horizontal and unyielding target.

On the other hand, due to the conditions which apply when filling and emptying the packagings, the 48Y cylinders are also regulated according to the codes set forth for the pressure vessels. These cylinders have a service pressure of 1.4 MPa (14 bars) and are able to withstand an hydrostatic test with a pressure of 2.8 MPa (28 bars) without leaking.

In 1984, the Mont-Louis ship, transporting 48Y cylinders from France to Russia, sank in the North Sea, off the coast of Belgium. All the packages were recovered with no release of contents, and therefore with no chemical or radiological contamination. However, this led the international transport community to question the adequacy of the regulations relevant to uranium hexafluoride. This accident emphasized the chemical hazard, linked to the reaction of uranium hexafluoride with water or humid air, and the lack, on the cylinders, of a pressure relief system, which commonly equip the containers used for the transport of chemical products. This prompted the IAEA and the Member States to upgrade the existing regulations applying to the transport of UF_6.

TECDOC AND MODAL REGULATIONS

A first step was the issue in 1991 of TECDOC-608 « Interim Guidance on the Safe Transport of Uranium Hexafluoride » and part of its recommendations were included in regional modal transport regulations.

Thus, the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) and the Regulations concerning the International Carriage of Dangerous Goods by Rail (RID) have included, since their 1992 edition, specific requirements for packagings transporting UF_6. These requirements are relating to pressure resistance, drop tests, manufacturing, in-service inspection, and operating conditions. As an alternative to these various requirements, it is acceptable to refer to those set forth in ANSI N 14.1 standard.

1996 EDITION OF THE IAEA REGULATIONS

The second and main step was the revision of the IAEA Regulations, based on this TECDOC. The 1996 Edition, known as ST-1, included specific requirements for packages containing uranium hexafluoride.

The first requirement is to comply with the provisions of ISO 7195 standard « Packaging of Uranium Hexafluoride (UF_6) for Transport ». The other requirements, applicable to a package designed to contain 0.1 kg or more of UF_6, include withstanding a structural test at a pressure of 1.4 MPa or 2.8 MPa, a drop test onto a flat, horizontal and unyielding surface, and a fire test at 800°C for 30 minutes. According to its ability to withstand certain of these tests or not, the package will be eligible for either a unilateral or a multilateral approval. These requirements should be transferred in the modal regulations and be applicable in January 2001, as concerns the unilateral approval.

Concerning 48Y cylinders, since compliance with ISO standard and pressure test requirement is existing by essence, and since resistance to the drop test is sure, the main new item consists in the obligation to apply for competent authority approval of their design; a unilateral approval will be granted after demonstrating the ability of the cylinders to withstand without rupture of the containment system the fire test applying to Type B packages (800°C for 30 minutes).

CAN AN UNPROTECTED 48Y CYLINDER WHITHSTAND A FIRE TEST ?

Many researches have been launched to study this problem. Among them, an IAEA Co-ordinated Research Programme (CRP), one of its main components being the TENERIFE programme.

TENERIFE is an ambitious Franco-Japanese programme, mainly financed by industrial and state organizations of both countries. It was set up to conduct a series of tests on mock-ups representative of the 48Y cylinders, filled with depleted uranium hexafluoride, heated in a furnace, and equipped with all relevant safety devices. These mock ups have all the features of the 48 Y cylinders except a shorter length. The goal of this programme was to provide an in-depth knowledge of the behaviour of UF_6 contained in a cylinder submitted to fire. Testing has been carried out in CEA's Cadarache Research Centre where a building has been specially equipped to guarantee the safety required by the presence of UF_6 in the cylinders.

The conclusions to be drawn have been discussed in September 1997 during the last meeting of the CRP held in Vienna and the details of the test rig, various test conditions, results and their interpretation have been widely published otherwise. One of the main conclusions derived from elaborate testing is that the duration of an 800°C fire test that a 48Y cylinder filled with UF_6 can withstand without rupture is in the range of 30 minutes. But a more subtle question remains: does this duration precisely reach the decisive 30 minute limit ? Today all the testing done has not yet allowed to guarantee that it is the case.

Our opinion is that, even if it is not clearly and definitely established that the answer is less than 30 minutes, the probability is high enough to retain this assumption. The probability of achieving an unquestionable demonstration is still reduced when considering all the variable parameters to be taken into account: partial filling of the cylinder, steel grade and tolerances on the shell thickness, orientation of the cylinder in the fire, etc. In other words, an attempt to demonstrate that the resistance period exceeds 30 minutes would lead us to launch another huge programme, whose positive outcome is dubious but whose guaranteed cost is not commensurate with the uncertain benefit.

WHAT SOLUTIONS ?

Considering this situation, new answers have to be developed. Various potential solutions are described hereafter, with a brief assessment of their respective benefits and drawbacks.

New cylinders

The most drastic solution would be to review the whole concept of the cylinder to make it more resistant. This would lead to selecting upgraded steel for the shell, increasing its thickness, adding reinforcement rings, revisiting the valve design, etc. All or part of these improvements would certainly render the new cylinder able to survive the regulatory fire test.

This solution would obviously entail unquestionable safety advantages in a world to be created. Unfortunately, or rather fortunately for our industry, the world of UF_6 does exist: numerous facilities are in operation all around the world where 48Y cylinders are shipped and received.

The world of UF_6 is also a standardized world: the 48Y cylinders, as they are, are accepted in all the facilities, from the United States where they have originated more than 40 years ago, to Russia where they were in use way before the fall of the Berlin wall. To modify only one component of this system would lead to renegociate with all the organizations involved and in some respects to modify their facilities. To quote only one example, the valve design is the result of a complex compromise. It can be asserted that the expenses incurred would be huge, if not precisely predictable, and that in any case the time schedule would not be compatible with the regulatory time framework.

At last, it must be recalled that many of these cylinders are not used for transport, but also and mainly for storage of depleted UF_6. The future of this material is not defined precisely. Any solution must take into account these storage cylinders: their amount reaches several tens of thousands, and the transfer of the material from the existing cylinders to new ones must be considered carefully from both economic and safety standpoints.

Overpacks

Another drastic solution would be to fit the cylinder with an overpack providing thermal insulation to protect the 48Y cylinder against the effect of fire. The 30B cylinders, used for the transportation of enriched UF_6, are already equipped with such an overpack to ensure compliance with the requirements applicable to packages containing fissile material (which include, prior to the fire test, a nine-meter drop test onto a flat, horizontal and unyielding surface and a one-meter drop test onto a punch).

The advantage of this solution is that it would not imply modifications of the 48Y cylinder itself, nor substantial operational changes in the conversion or enrichment facilities. The cylinder can be installed in its overpack at a very late stage, just before shipment, and removed from it just when arriving in the consignee's facilities. Also, the number of overpacks to be manufactured can be limited to the number of cylinders which are really used for transport. On the other hand, the need for inventory management and separate transports to match the required equipment with each cylinder will obviously increase operational costs.

Overpacks have widely proved their efficiency with the 30B cylinders and have shown good long term resistance. However, their use may appear excessive for 48Y cylinders, which are virtually able to withstand the fire test even unprotected. The consequences of this overdesign on the cost effectiveness of the solution have to be carefully investigated.

Special transport frames

A solution remaining close to the overpack philosophy would be to resort to the specific transport frame developed for the importation of UF_6 in Japan. In this approach, the underlying principle is to consider globally all the problems linked to the transport of the 48Y cylinders: tie down onto a transport frame, handling of the transport frame during transfer from one mode of transport to another one, and, at last, general protection of the cylinder during transport.

This led to the adaptation of ISO 20 ft flat containers, which can be handle by means of standardized ISO corners, to incorporate tie-down equipments and covers, including a metallic screen that slide on the flat to envelope the cylinder and to protect both ends, i.e. the valve and the plug.

The reasoning behind the design of this system, now successfully in operation, follows a most interesting process. It appears to be a sophisticated system whose ability to satisfy the requirements of the new regulations has to be formally demonstrated. Its cost effectiveness has to be evaluated by the stakeholders, while its ability to remain efficient after years of operation cannot still be evaluated since it has been used recently for shipments from France to Japan at a rate of one or two transports per year.

End covers

When a bare 48Y cylinder is engulfed in a fire, even if the temperatures of the cylinder are not stricly spreaking homogeneous, they are very high throughout its content. Would there be an area with a significantly lower temperature, the pressure within the cylinder would be driven down by this lower temperature and be highly reduced. This theoretical approach, which relies on basic thermodynamics phenomena, was confirmed by one of the TENERIFE programme tests. A cylinder was equipped at each end with a cover designed to provide an efficient thermal insulation of these two areas. After 25 minutes, the pressure in the cylinder did not exceed 0.3 MPa (3 bars).

Therefore a solution consisting in adding two end covers to provide thermal insulation and create areas where UF_6 can condensate, avoiding build-up of gazeous UF_6 in the cylinder, offers interesting opportunities. The efficiency of a protection including a single cover should even be evaluated. The consequences of leaving the plug directly submitted to fire have to be considered. Since the purpose of the cover is to ensure thermal protection, it can be made of a steel multilayer, or a drum filled with a passive (mineral wool...) or active insulator.

Obviously, this solution can be implemented at a reasonable cost. The main point to solve is the fastening of the cover(s) on the cylinder and the interfaces with the tie-down and handling equipments: while remaining light, the covers must be resistant enough to afford repeated use and their shape be adapted to the existing transport and handling equipment.

Thermal protections

Relying upon the same principle as the end covers, any thermal protection which can provide a cold point is an efficient system to improve the fire resistance of a 48Y cylinder.

Thermal blankets are a simple devices with limited operational consequences but their actual efficiency has to be evaluated. Thermal blankets were used in the past to equip cylinders shipped to Japan. Intumescent painting may also provide an attractive solution although its cost can be high while its long term resistance still has to be demonstrated.

Generally speaking, the optimization of such solutions has to be completed, including detailed dimensioning and selection of precise characteristics.

CONCLUSIONS

The evolution of the "Regulations for the safe transport of radioactive material" leads to take into account a fire test for the uranium hexafluoride cylinders. The TENERIFE programme has established that a 48Y cylinder, filled with UF_6 is able to withstand a 800°C fire test with a duration of approximately 30 minutes, and rather less than 30 minutes. It also shows that it will be very difficult to demonstrate that the resistance duration actually reaches or exceeds 30 minutes.

The main principles of the available solutions have been described. It is now necessary to go further into the design and the economic evaluation of the proposals to make a decision.

This assessment must take into account not only the direct cost of the equipment, but also expenses covering its design and licensing. Obtaining a Competent Authority approval for a "cheap" solution may, as a counterpart, require extensive testing, at an expense which may not be commensurate with the benefits expected.

Finally, the evaluation must take into account a possible increase of the operational costs resulting from the preparation of the cylinder, its transport, as well as inventory management and maintenance of this new equipment.

SESSION 7.1

Transport Management Systems and Quality Assurance