Proceedings of the 15th International Symposium on the Packaging and Transportation of Radioactive Materials
PATRAM 2007
October 21-26, 2007, Miami, Florida, USA

THE TESTING OF RAM PACKAGES - AN INDUSTRIAL VIEW

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ABSTRACT

The International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Materials, TS-R-1, set the standards for the packages used in the transport of radioactive materials under both normal and accident conditions. The underlying philosophy is that safety is vested principally in the proper use of correctly designed and fabricated packages
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There is a large body of evidence which demonstrates that the current IAEA tests for high duty Type B packages are severe tests which cover all the impact, fire and submergence accident situations in transport which can be realistically envisaged This conclusion is also supported by over 50 years of safe and efficient operating experience.

Packages designed for the transportation of radioactive materials have in the past have also been subjected to a variety of tests which are different from those specified in the IAEA transport regulations. These tests have often taken the form of spectacular demonstrations such as high speed road or rail crashes, large drops greater than the regulatory requirement, for example from a helicopter, high temperature long duration fires and also explosions. However, such tests or tests more severe than the current IAEA tests could not be justified on quantitative cost/ benefit safety grounds and would present an unnecessary economic burden on the radioactive material transport industry. Such tests should not be required as part of the regulatory process.

It is vital that public/political confidence in the current regulatory regime should not be undermined. We must continue our efforts to reassure the public that radioactive material transport is a necessary, safe and secure operation. We must dispel exaggerated claims and irrational fears. Wider public dissemination of the relevance of the current IAEA regulations in ensuring safety under severe accident conditions and the results of other tests and public demonstrations to simulate real accidents could both be beneficial in this regard.

1. INTRODUCTION

The International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Materials, TS-R-1, set the standards for the packages used in the transport of radioactive materials under both normal and accident conditions. The underlying philosophy is that safety is vested principally in the proper use of correctly designed and fabricated packages.

Packages designed for the transport of radioactive materials have in the past also been subjected to a variety of tests which are different from those specified in the IAEA transport regulations. These tests have often taken the form of spectacular demonstrations. Typical of these have been tests on packages such as high speed road or rail crashes, large drops greater than the regulatory requirement, for example from a helicopter, high temperature long duration fires and also explosions.

The relevance of the IAEA tests and the role of extra-regulatory tests to ensuring the safety and security of high duty packages for the transport of nuclear fuel cycle materials will be considered from the industrial perspective.

2. RELEVANCE OF THE IAEA TESTS TO SAFETY UNDER ACCIDENT CONDITIONS

The IAEA Regulations, TS-R-1, for high duty Type B(U) and B(M) packages (henceforth denoted as “Type B” packages), notably casks for the transport of spent fuel and high-level wastes and casks for the transport of mixed oxide fuel, which have been of particular interest, specify tests to examine the performance under impact, fire and submergence accident conditions.

Impacts

The impact tests include a requirement for packages to survive a 9m drop test onto an unyielding, i.e. a completely rigid surface, without giving rise to a significant release of radioactivity. An unyielding target is a hypothetical concept. The surfaces of objects which a package could impact in real-life situations, such as concrete roads, bridge abutments and piers, would yield to some extent and therefore a proportion of the energy of the moving package would be absorbed by the object. The 9m drop test, which results in an impact speed of 13 metres per second (48 kilometres per hour) (30 miles per hour) onto an unyielding surface, is therefore relevant to impacts onto real-life surfaces at much higher speeds, for example more than 100 meters per second (360 kilometres per hour) (230 miles per hour) onto a hard soil [1]. The IAEA drop test would therefore cover any realistic transport impact accident.

Fire

Fire also is a concern in the transport of nuclear fuel cycle materials. Several studies have been carried out to investigate the ability of spent fuel casks to withstand long duration fully engulfing fires which could be caused by the rupture of an oil or gas pipeline or fires resulting from a train crash involving highly inflammable cargoes such as gasoline. The results indicated that the spent fuel cask remained sound and the conditions generated in the regulatory test, which specifies that Type B packages for the more radioactive nuclear fuel cycle materials must be able to withstand a fully engulfing fire of 800^0C for 30 minutes without significant release of activity, were more severe than in the realistic accident [2]. A recent study has indicated that even under conditions equivalent to the Baltimore and Caldecott tunnel fires in the USA, spent fuel casks would have survived and the release of radioactivity, if any, would have been very small [4].

Analysis also indicates that in the case of UF6 packages the regulatory tests are unlikely to be exceeded in real transport accidents involving either fires or impacts [3].

Submergence

For collisions at sea, extensive analytical work on the structural behaviour of ships and spent fuel and vitrified high-level waste (VHLW) packages concluded that damage to the casks would be small because the collision forces would be relieved by the collapse of the ship structures and not taken by the casks. The forces on the cask would be less than the forces imposed by the 9m drop test [5].

Type B packages for spent fuel (and VHLW) are required to withstand immersion for 1h at 200m and the containment system must not rupture; at depths of 200m the cask would be recoverable.

If the cask were to sink at greater depths and not be recovered the rate of release of radioactive material into the sea would be very slow since the containment of the cask would be unlikely to have been lost and spent oxide fuels and VHLW are very insoluble. In this case, the radiation doses received by people who consume marine foods affected by the accident would be negligible compared with doses from the natural background due to the refractory nature of the material and the vast dilution which would occur. The same would apply to other nuclear fuel cycle materials, the activity of which is much less.

3. RELEVANCE OF TESTS OTHER THAN THE IAEA TESTS

The effects of spectacular demonstrations such as train crashes, drops from helicopters, hydrocarbon fires etc., the results of which have been carefully analysed and modeled have shown that they present less severe challenges to packages than the corresponding IAEA tests. The objective in such work has been primarily a qualitative demonstration of the robustness of the package rather than a quantitative test under which the stresses on the package were known. Nevertheless this work is relevant to both the safety of packages under accident conditions of transport and the risks which may arise from potential malicious acts and terrorist activity since it may be helpful in promoting public confidence.

The USA Department of Energy commissioned a detailed study of twelve very severe road and rail accidents which did not involve nuclear fuel cycle materials. The accidents, which occurred in the USA in the past 20 years involved high impacts, fires, explosions, or water immersion. They have been analysed to determine how the conditions generated in these accidents compare with the regulatory tests and how they would have affected spent fuel transport casks [6].

Some of these accidents involved impacts such as high speed train derailments and the collapse of bridges and viaducts which resulted in road vehicles falling onto concrete roads or plunging into rivers. The impacts which a spent fuel cask would have experienced in these accidents were much less severe than in the regulatory 9m drop test.

Some accidents involved fires, such as one which occurred when a liquid propane tanker collided with a bridge support in a road crash, and others which included explosion and hazardous chemicals, were also investigated. The conclusion was that such accidents would not have resulted in significant damage to a near-by spent fuel transport cask.

However, such tests or tests more severe than the current IAEA tests could not be justified on quantitative cost/ benefit safety grounds and would present an unnecessary economic burden on the radioactive material transport industry. Such tests should not be required as part of the regulatory process. Moreover it is vital that public/political confidence in the current regulatory regime should not be undermined.

4. MALICIOUS ACTS AND TERRORISM

The main concern in the past has been theft and diversion of nuclear material which has a potential weapons capability and requirements are already in place to ensure its physical protection [7].

However, recent tragic events have heightened sensitivities to security against potential terrorist action. The IAEA has initiated work on the need for enhanced measures to ensure security in the transport of all radioactive materials, including nuclear fuel cycle materials, to complement the security requirements in the UN "Model Regulations". The Model Regulations contain a basic security level for the transport of all dangerous goods as well as additional requirements for an enhanced security level for goods defined as 'high consequence dangerous goods'.

The physical properties of radioactive materials are important factors. Highly radioactive materials (spent fuel, VHLW, cobalt 60 sources etc.) are generally very refractory, insoluble and not easily dispersed. The same is true of mixed uranium/plutonium oxide, MOX. Uranium ore concentrate is dispersible but is of low activity. The same is true of uranium hexafluoride although it is chemically toxic.

The properties of the radioactive materials, the robust design of the package to ensure safety under accident conditions and the current operating regime which complies with IAEA and UN requirements ensure that the risks due to radiation exposure following malicious acts are therefore not great.

5. PUBLIC PERCEPTIONS

Based on science and engineering as well as many years of operating experience it is fair to claim that the real risks from the transport of radioactive materials under the current regulatory regime to man and the environment are not great. This is true not only for severe accident scenarios but also for malicious acts. Nevertheless the risks perceived by the public are great and so are the potential risks of public panic and long term disruptions which could follow an incident, however small.

There is an urgent need to reassure the public to alleviate this problem which could have a serious economic impact, not only on transport operations. Whereas the possibility of a malicious act or a severe accident cannot be ruled out a risk based approach, where the risk is the product of the probability of an event and its consequences, could be helpful in this task. The consequence could be significant but the probability would be very small. This coupled with the tolerability of risk concept [8] which is generally adopted in the nuclear industry is also important and could be beneficial in restoring public confidence in transport operations.

CONCLUSIONS

There is therefore a large body of evidence which demonstrates that the current IAEA tests for high duty Type B packages are severe tests which cover all the impact, fire and submergence accident situations which can be realistically envisaged in the transport of radioactive materials. This conclusion is also supported by over 50 years of safe and efficient operating experience.

Tests more severe than the current IAEA tests could not be justified on quantitative cost/ benefit safety grounds and would present an unnecessary economic burden on the radioactive material transport industry. Such tests should not be required as part of the regulatory process.

It is vital that public and political confidence in the current regulatory regime should not be undermined. We must continue our efforts to reassure the public that radioactive material transport is a necessary, safe and secure operation. We must dispel exaggerated claims and irrational fears. Wider public dissemination of the relevance of the current IAEA regulations in ensuring safety under severe accident conditions and the results of other tests and public demonstrations to simulate real accidents could both be beneficial in this regard.

REFERENCES

[1] D J Ammerman, "NUREG/CR-6672: Response of Generic Casks to Collisions", Proceedings, PATRAM 2001, Chicago, IL., USA, Sept. 2001

[2] C Ito et al, ''Demonstration of the Safety of Spent Fuel Transport Casks under Regulatory Tests and Realistically Severe Accidents', Proceedings, PATRAM 2001, Chicago, IL., USA, September 2001

[3] C Lopez, et al, ''Comparison of UF6 packages under Test and Accident Conditions'', PATRAM 2007, Miami, USA, Paper 322

[4] C S Bajwa et al, ''Effects of Tunnel Fires on the Behavior of Spent Nuclear Fuel Casks", PATRAM 2007 Miami, USA, paper

[5] International Atomic Energy Agency, TRANSSC, Vienna, 5-9 February 2001, paper TC-983.6

[6] USA Department of Energy National Transportation Program, ''Comparison of Selected Highway and Railway Accidents to 10CFR71 Hypothetical Accident Sequence and NRC Risk'', 8 April 2003

[7] The Physical Protection of Nuclear Material and Nuclear Facilities INFCIRC/225/Rev.4 (corrected), IAEA, Vienna, 20 July 2000

[8] United Kingdom Health and Safety Executive, ''Reducing Risks, Protecting People'', HSE London 2001