

INTERNATIONAL TRANSPORT SAFETY RESEARCH

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ABSTRACT

The International Atomic Energy Agency (IAEA), periodically publishes the *Regulations for the Safe Transport of Radioactive Materials*, which serve as regulations for its own activities and as a model for regulations issued by international organizations and domestic regulatory bodies throughout the world. In order to support technical considerations for revisions to these Regulations, the IAEA may undertake "Coordinated Research Programs in which Member States and international organizations may offer to participate. Five such programs are currently active in the area of radioactive material transport safety, and the purpose and status of each of these is discussed in this paper.

INTRODUCTION

The International Atomic Energy Agency's (IAEA) "Regulations for the Safe Transport of Radioactive Material" form a consistent, technically robust basis for international and national regulations governing the packaging and transport of radioactive materials. Changes to the IAEA regulations occur periodically, and can be expected to be reflected in international modal requirements and national regulations. Thus, the IAEA's Transport Regulations have direct impacts on shippers and carriers of these materials.

Since their inception in 1961, the IAEA Transport Regulations have been periodically revised to keep them technically up to date and consistent with modern transportation operations technologies. These revisions are typically based on proposals made by Member States and International Organizations. They may include changes which are based on research results. In cases where proposals for change require additional supportive information, the IAEA can undertake "Coordinated Research Programs" (CRPs) to address the relevant areas. A CRP typically involves 5-7 Member States contributing their research efforts on a defined topic and the preparation of a consolidated report of the results.

There are several CRPs which are either ongoing or have been completed but have not yet been finally published. These CRPs may result in new regulatory requirements being developed and may form the basis for proposals to change the regulations. These include:

- Assessment of safety of uranium hexafluoride transport packages in fire environments,

WM'00 Conference, February 27 - March 2, 2000, Tucson, AZ

- Development of relevant accident data for quantifying risks associated with the transport of radioactive material,
- Accident severity at sea during transport of radioactive material,
- Accident severity during air transport of radioactive material, and
- Development of a radiological basis for the transport safety requirements for low specific activity materials and surface contaminated objects.

Each of these CRPs are described below with an explanation of the scope of the research and its current status. The potential application of the results of the research to the revision of the Transport Regulations is described, including the timing of such events.

ASSESSMENT OF SAFETY OF URANIUM HEXAFLUORIDE TRANSPORT PACKAGES IN FIRE ENVIRONMENTS

Six agreements were put in place between the IAEA and Argentina, France, Germany, Japan, United Kingdom and USA.

The goals of this CRP, which was started in 1993, were:

1. To assess:
 - (a) whether an existing 48Y uranium hexafluoride (UF₆) cylinder, with its fill valve and plug, can remain intact for 30 minutes when exposed to an engulfing 800°C fire,
 - (b) if a release occurs within 30 minutes, the time of release, mode of release, release rate, and duration of the release,
 - (c) those remedial changes needed to prevent and/or significantly delay any release.
2. To provide the IAEA Revision Panels (meetings which recommend changes to the IAEA Transport Regulations) with the methodology for a computer program capable of accurately predicting failure times for shipping cylinders with a variable geometry and a for a set of variable fire conditions.
3. To provide the Revision Panel with the technical information, conclusions, and recommendations which will assist it in its consideration of the appropriateness of applying the standard IAEA fire-test criteria to UF₆ transport packages.

The third and final Research Co-ordination Meeting (RCM) was convened in Vienna in September 1997. At this meeting, a detailed assessment of the then current status of satisfying the goals of the CRP was developed. The Chief Scientific Investigators (CSIs) noted that significant steps had been made by the CRP participants in understanding the behaviour of large UF₆ cylinders in fire environments. Specifically, it was noted that:

WM'00 Conference, February 27 - March 2, 2000, Tucson, AZ

- the TENERIFE program, with major contributions from France and Japan, had made a major contribution to significantly enhancing this body of knowledge,
- the work of the other participating Member States had also contributed significantly to the advancement of knowledge relative to the behaviour of large UF₆ cylinder in fire environments, and
- significant progress had also been made on understanding the consequences arising from releases which might occur.

However, the participants also noted that consensus could not be reached by the six participating Member States as to whether a 48Y UF₆ cylinder would rupture in the regulatory fire test specified in ST-1, and if it did rupture, the six CSIs could not fully agree on either:

- what time in the fire exposure the rupture would occur, or
- what would be the mode and rate of release.

Thus, the participants concluded that additional efforts were needed to strive for a broader consensus amongst the CSIs. Efforts in some of the Member States continued, and an ad-hoc meeting was convened in Paris, France in May 1998, at which some of the CSIs were able to participate. At the ad-hoc meeting, additional and extensive results were presented and discussed. Much of this work added to the body of knowledge already available, and assisted in clarifying some areas where agreement could not be attained. As this meeting directly followed the 1998 International Symposium on the Packaging and Transportation of Radioactive Materials (PATRAM '98), much of the work discussed had already been presented during that symposium. There still remained some areas where consensus could not be attained (e.g., whether or not a 48Y cylinder without a valve would rupture during the 30 minute thermal test).

It was agreed at the end of that meeting that final individual reports would be prepared by the CSIs and submitted to the Agency. Also, it was agreed that these reports would serve as the basis for preparation of an IAEA Technical Document (TECDOC) summarizing the results of the CRP and formally documenting the final reports from each CSI. A consultant worked at the Agency during early April 1999 at which time a TECDOC was drafted summarizing the results of this CRP. The draft TECDOC is in two volumes. The first volume of this draft provides background, history, and brief summaries of each report prepared by the CSIs and an assessment of the satisfaction of each of the goals listed above. The second volume of this draft provides the six complete reports submitted by the CSIs from the six participating Member States. The draft TECDOC for this CRP is under review by IAEA staff and will be sent to the individual CSIs in early calendar year 2000 for their review. It is expected that TECDOC summarizing the results of this effort will be published later in calendar year 2000.

WM'00 Conference, February 27 - March 2, 2000, Tucson, AZ

DEVELOPMENT OF RELEVANT ACCIDENT DATA FOR QUANTIFYING RISKS ASSOCIATED WITH THE TRANSPORT OF RADIOACTIVE MATERIAL

Eight research agreements were put into place between the IAEA and Canada, France, Germany, India, Japan, Sweden, United Kingdom and USA. In addition, research contracts were put into place by the IAEA with China and Romania.

The first RCM was held in Vienna in July 1996. The second RCM was also held at the Agency's Headquarters in November 1998, and the final meeting was held in Vienna in November 1999.

At the first RCM, it was agreed that the end product of the CRP, in addition to the different reports from Member States, should consist of a common report containing: guidelines for development of accident rate databases (including examples); information on package response and release fractions; advice on how to present input data and results; advice on how to treat human errors; and, descriptions of quality criteria for the input data and results.

The second RCM provided the CSIs with an opportunity to share research accomplishments, determine what further work needed to be done to allow completion of the CRP in 1999, and reach agreement on the CRP final report form and general content.

At the third RCM, it was decided that the final report of this CRP would be a TECDOC. Its contents were discussed in detail and approved by all participants. The main sections will be:

1. Introduction
2. INTERTRAN2 risk assessment tool
3. Incident free analysis
4. Accident analysis
5. Health effects modeling
6. Uncertainties
7. Human errors
8. Quality assurance
9. Conclusion

Work still remains to be done by some members of the CRP. A Consultant Services Meeting (CSM) is planned to be convened in June 2000 to finalize the TECDOC which then should be published before the end of calendar year 2000. The updated version of the international risk assessment code, INTERTRAN2, which will work under the windows environment, and its supporting documentation should also be available in June 2000.

ACCIDENT SEVERITY AT SEA DURING TRANSPORT OF RADIOACTIVE MATERIAL

Eight research agreements were put into place by the IAEA with France, Germany, Japan (two separate agreements, one with PNC and the other with CRIEPI), Sweden, United Kingdom, USA and IMO.

WM'00 Conference, February 27 - March 2, 2000, Tucson, AZ

The agreed objectives of this CRP were:

1. Perform closer studies to find out whether the existing Regulations take adequate account of accidents at sea, taking into account probability and consequence through:
 - assessing the severity of accidents on radioactive material packages and their expected frequencies of occurrence during sea transport,
 - conducting and examining new studies on fire and impact environments on board ships,
 - considering additional research on sea transport, and
 - providing input data to the IAEA regulatory review and revision process, through the executive summary report, that allows an evaluation of the adequacy of the design and performance requirements of the IAEA Regulations for Type B packages transported by sea.
2. Write an executive summary report followed by chapters describing the work done by Member States. The audience for this report is the IAEA Secretariat, the Transport Safety Standards Advisory Committee and the Revision Panels.

The first RCM was held in Vienna in November 1995. An informal meeting was then held in Cologne, Germany, in May 1996. The second RCM was held in Albuquerque, NM, USA, in September 1997. The third RCM was held in Vienna in December 1998.

All research projects, amounting to eleven reports, were duly completed and submitted to the final Research Co-ordination Meeting in December 1998. A further CSM was convened in March 1999 in Vienna to consolidate the individual reports into a TECDOC. Summaries of the contributed reports from the six contributing Member States will be included as appendices to this TECDOC. The draft has been sent to the CSIs for comments. It is expected that the TECDOC will be finalized and published during the first half of calendar year 2000. In addition, full reports of each institution's efforts pertaining to this CRP are available, on request, from the originating institutions.

The principal technical conclusions resulting from this CRP are:

1. Ship collisions depend on ship traffic density and thus on the region of the ocean in which a ship is sailing. Traffic density does not affect the frequency of ship fires. Instead the chance of a fire during a voyage increases directly with voyage distance or sailing time.
2. Ship collisions and ship fires are infrequent events. Most ship collisions and ship fires will not subject a radioactive material package being transported on a ship to any mechanical or thermal loads. The chance that a ship collision or a ship fire will subject a radioactive material transport package to loads that might fail the package is very small.

3. If a ship collision subjects a radioactive material cask to crush forces, the magnitude of these forces will be less than or at most comparable to the inertial forces experienced by the cask during the regulatory certification impact test.
4. Ship collisions are unlikely to damage a radioactive material cask, because collision forces will be relieved by collapse of ship structures, not cask structures.
5. Ship fires are not likely to start in the radioactive material hold. If a fire starts elsewhere on the ship, its spread to the radioactive material hold is not very probable. Even if a fire spreads to the radioactive material hold, the lack of fuel or air will usually prevent the fire from burning hot enough and long enough in the radioactive material hold to cause the release of radioactivity from a radioactive material cask or, given cask failure due to a preceding collision, to significantly increase the release of radioactivity from the failed cask.
6. Heat fluxes from smaller fires that progress through the ship and do not engulf the radioactive material hold are unlikely to exceed the heat fluxes developed by the regulatory cask certification test fire.
7. Most radioactive materials released to the interior of a radioactive material cask as a result of an accident will deposit on interior cask surfaces. As a result, cask retention fractions are large and cask-to-environment release fractions are small.
8. Should a ship collision or fire lead to the sinking of a radioactive material transport ship and thus loss of a radioactive material cask into the ocean, recovery of the cask is likely if the loss occurs on the continental shelf. If it is not recovered, the rate of release of radioactivity from the cask into ocean waters will be so slow that the radiation doses received by people who consume marine foods contaminated as a result of the accident will be negligible compared to background doses.
9. If a radioactive material transport ship, while in port or sailing in coastal waters, were involved in a severe collision that also initiates a severe fire, the largest amounts of radioactivity that might be released to the atmosphere as a result of the accident would result in individual radiation exposures well below background.

Thus, since the probabilities of severe ship collisions and severe ship fires are small and the individual radiation doses that might result should such a collision or fire occur are smaller than normal background doses, the risks of maritime transport of highly radioactive material in Type B packages, such as spent nuclear fuel and vitrified high-level waste, are very small.

ACCIDENT SEVERITY DURING AIR TRANSPORT OF RADIOACTIVE MATERIAL

Eight research agreements have been established by the IAEA with Canada, France, Germany, Sweden, United Kingdom, USA, and IFALPA and ICAO for this CRP.

WM'00 Conference, February 27 - March 2, 2000, Tucson, AZ

A CSM was convened in March 1998 in Vienna to define the objectives of the CRP. The overall objective defined for this CRP was to develop a better understanding of aircraft accident conditions.

The first RCM was held in Ottawa, Ontario, Canada in September 1998. A follow-on ad-hoc meeting was convened in San Francisco, USA in September 1999.

During these meetings, the following actions were achieved:

- Agreement was reached on the information required for analysis of the accident severities. A questionnaire was developed to obtain this information. The CRP members will assist in filling out the questionnaires with information available from the Accident Database Reports (ADREP) from the International Civil Aviation Organization (ICAO). The areas where additional information would be required would be left blank. The need for further assistance for completion of the questionnaires has been communicated to the International Federation of Airline Pilots Associations (IFALPA) and ICAO in order to obtain their support.
- Agreement was reached on definitions, terminology and the analysis method with the understanding that some aspects of the analysis method need further development. It was further agreed that the details for the analysis method should be agreed by the next Research Co-ordination Meeting (RCM) which will be held in London, United Kingdom in July 2000 in order to facilitate the analysis work which should be completed by the third RCM approximately 18 months later.

The results of this CRP should then be published during the year 2002.

DEVELOPMENT OF A RADIOLOGICAL BASIS FOR THE TRANSPORT SAFETY REQUIREMENTS FOR LOW SPECIFIC ACTIVITY MATERIALS AND SURFACE CONTAMINATED OBJECTS

During the development of the latest edition (1996) of the Transport Regulations several possible changes in the LSA/SCO area were being considered, but it was concluded that a sound radiation protection basis should be developed to support any major changes in the LSA/SCO transport requirements. The LSA/SCO CRP was established to provide this basis.

Initially, five research agreements were put into place by the IAEA with Brazil, France, Germany, United Kingdom and USA.

The first RCM was held in Oak Ridge, TN, USA, in December 1997. Canada attended as an observer and followed up with a research agreement, which was accepted under this CRP. The second RCM was held in Rio de Janeiro, Brazil, in March 1999. At the second meeting, in addition to ten representatives from the six participating countries, there was one observer from South Africa. Since that meeting, South Africa has submitted a research agreement that has also been accepted under this CRP by the IAEA.

WM'00 Conference, February 27 - March 2, 2000, Tucson, AZ

The LSA/SCO CRP work has been developing in parallel two areas:

1. defining a new system, called the G-system, that provides a radiological basis for classifying LSA/SCO materials and for their packaging requirements; and
2. preparing a better radiological basis and guidance for the existing classification of LSA/SCO, in particular in the area of LSA ores.

Both of these approaches are providing valuable additional information and understanding regarding LSA/SCO materials and shipments, but neither has developed sufficiently to provide a comprehensive radiological basis for any major changes to the current LSA/SCO requirements.

A CSM was held 13-17 December 1999 in Vienna to assess the ongoing CRP and to help decide on further work either as part of the ongoing CRP, as topics for additional CSMs, or perhaps a separate CRP. The recommendations from this CSM will be considered in addition to the ongoing work. Canada has offered to host an ad-hoc meeting in April 2000. This meeting provides an opportunity for updating the progress of the work under the individual agreements. The third and possibly final RCM is scheduled for February 2001 in South Africa. If the CRP is completed at that time then the results will be published later in 2001.

CONCLUSION

The IAEA CRP final reports will provide useful products, such as an updated INTERTRAN code, and useful technical results. Those CRPs that are related to the requirements of the Transport Regulations will provide input to the technical committees and other bodies which will consider issues related to the revision of the Transport Regulations. The results of the two CRPs which address accident severities at during sea and air transport will be of particular interest since they provide information on the adequacy of the regulatory requirements for packages. The international transport community might wish to remain alert for the publication of the TECDOCs which will present the results of the CRPs since these could have implications for future regulatory revisions.