TRANSPORTATION RESEARCH ACTIVITIES IN SUPPORT OF NUCLEAR WASTE MANAGEMENT PROGRAMS

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ABSTRACT

While the technology to transport nuclear wastes is generally viewed to be available, research and development activities in support of nuclear waste management programs are still expected to be required. The status of current base technology activities at the Transportation Technology Center (TTC) and their direction for the future are reviewed in this paper. These activities include tasks in standards and subsystems development, systems technology development, information materials and systems, institutional issue analyses and safety analyses.

*In support of the United States Department of Energy under Contract DE-AC04-76DP00789

INTRODUCTION

Transportation of nuclear materials is an important component of that part of the nuclear industry dealing with the processing, storage, and ultimate disposal of radioactive wastes. The U.S. Department of Energy (DOE) is involved in transportation as both a generator of nuclear waste and a sponsor of nuclear activities. In addition, the Nuclear Waste Policy Act (NWPA) has placed new transportation responsibilities on DOE since it is required to manage the program to take civilian spent fuel and high level waste and emplace it in storage or permanent disposal locations. This responsibility is particularly important because many issues that arise relative to the transportation of radioactive materials are specifically focused on spent fuels and nuclear wastes.

Since the early 1970's, DOE and its predecessor agencies have recognized the importance of the safe transportation of radioactive materials. Initially, this interest took the form of a series of isolated programs, each directed at providing a solution to a specific transportation problem. By the mid 1970's this approach became inadequate to address the growing complexities and interactions that characterize waste management activities, and in late FY78 the Transportation Technology Center (TTC) was established to implement a coordinated program on the transportation of radioactive materials with the Albuquerque Operations Office as the lead DOE field office and Sandia National Laboratories (SNL) as the lead contractor. The Federal Government has complete responsibility for the transport of defense radioactive wastes generated as a result of nuclear weapon and military propulsion system activities. It was expected that private industry would be responsible for aspects of transport for commercial radioactive waste materials prior to the passage of the NWPA, including acting as shipper for the materials. Consequently, DOE transportation research and development activities were focused primarily on defense program needs with the expectation that defense systems would serve as precursors for the development of commercial systems for similar materials. The passage of the NWPA increased DOE's responsibility for the shipment of commercial high-level waste materials subject to the requirement that it utilize, by contract, private industry to the maximum extent practicable.

In order to define the direction of future transportation programs for civilian radioactive waste management activities, the DOE is in the final stages of developing a transportation section of the Mission Plan, a transportation business plan, and other planning and program documents defining strategies and current directions. The transportation sections of these plans will address both near and long term transportation operations and the institutional initiatives needed to complete NWPA activities. Included will be guidelines

for research and development programs to support future transportation activities. Thus, there are a number of research issues and activities, planned or underway, which address technical needs, institutional issues, and systems analyses applicable to the transportation related requirements of both the defense program and the commercial activities. While there are no deficiencies in the present system which result in unnecessary or unacceptable risks, technology in radioactive materials transportation will continue to evolve and provide the opportunity to further reduce these already low risks and, more significantly, reduce costs and improve operations.

Thus, the questions to be addressed include at least the following:

1. How can emerging technologies be applied to the improvement of the transportation of radioactive materials?
2. What priorities should be placed upon the development efforts necessary to bring these technological improvements to fruition?
3. Who should bear the responsibility and cost for such developments?
4. How should these activities be planned and conducted to assure public acceptance of the transport of radioactive materials? Organizations responsible for the continuing technological development and use of radioactive materials transportation include government agencies, utilities, private service companies, national laboratories, transportation companies and other entities. Each organization has its own programs which may be great or small, broad or narrow.

Addressing these questions on behalf of the DOE, the TTC has organized transportation R&D activities into four programmatic categories:

BASE TECHNOLOGY
DEFENSE NUCLEAR WASTE SYSTEMS
COMMERCIAL NUCLEAR WASTE SYSTEMS
OTHER NUCLEAR MATERIAL TRANSPORTATION PROGRAMS

Activities within each of these categories are interdependent upon tasks and components of the others. The last three of these categories address areas of transportation-related needs of specific waste programs within the DOE. Examples of activities in these areas include hardware development efforts for transuranic waste transport to the Waste Isolation Pilot Plant (WIPP), defense high-level wastes from Savannah River, a transportation packaging for the Beneficial Uses Program and specific program development activities for the elements of the commercial waste management program.

This presentation will concentrate upon the elements of the Base Technology program to address the transportation research issues defined above. These activities concentrate upon research issues of interest to public, private, industrial and governmental concerns regarding radioactive waste transportation. Tasks in this category include research and development efforts, standards and regulatory support, materials investigation, interface criteria development, information development and distribution and systems analyses.

The Base Technology category is subdivided into four areas:

1. Standards & subsystem technology development
2. System technology development
3. Technology information center
4. Safety & intergovernmental issues analyses

A definition of each of these areas and examples of specific areas of research/interest follows.

Standards & Subsystem Technology Development

Standards & Subsystem Technology Development addresses the development of standards for design of nuclear waste transportation systems and provides the technological data base on materials, analytical methods and experimental techniques to support development of transportation systems. Examples of specific issues which relate to this area are:

Standards--The development of consensus standards has been the subject of activity by many national organizations, including the American National Standards Institute (ANSI), the American Society of Mechanical Engineers (ASME) and the American Society for Testing of Materials (ASTM). Generally, for radioactive materials transportation systems, the ANSI has taken the lead, but the production of timely and useful standards was limited for several years. The ASME has initiated an activity to implement into the ASME codes the requirements for shipping cask design and testing methods relative to the primary containment system.

Materials Data--A well recognized body of materials property data needs to be developed for candidate packaging materials over a wide range of material thickness, temperatures, temperature fluctuations and various strain and strain-rate environments. These data need to be documented and disseminated in a fashion which will allow them to be accepted by designers and regulators alike. Additional data need to be developed for the commonly accepted packaging containment and shielding materials such as stainless and ferritic steels, and lead and depleted uranium.

Other materials may be considered in packaging designs where new data are needed. For example, ductile cast irons are being developed which need to be qualified as structural materials.

Materials Joining--One limitation to the fabrication of large shipping casks is the ability to perform heavy section weldments and to then nondestructively evaluate these welds. Another related issue is the long term behavior of these welds during use in the transportation environments. The ability to use less costly base metals which are plated with corrosion and/or contamination resistant coatings must be developed or demonstrated.

Fabrication Technology--Many other material and fabrication issues exist where an adequate body of data are not available to provide the desirable answers. Included in this are the problems of galling of bolts on mating threads (especially with austenitics), environmental cracking (i.e., slow crack growth brought on by exposure to an active environment such as chlorides, or the existence of residual stresses), and the reduction in ductility and fracture toughness which may result from thermal cycling during normal use.

Brittle Fracture--The problem of brittle fracture of steel containment walls is an important issue which is currently constraining packaging design. A conservative design philosophy places all of the burden of failure prevention upon the material. This limits a designer to select between a few, very costly materials (generally austenitics or a few high-alloy ferritic steels). Alternates to these conservative procedures are needed which will allow the design to utilize less costly, more easily fabricated and inspected ferritics and possibly even the newly emerging ductile cast irons. The ductile cast irons provide an interesting dichotomy. The material by commonly accepted procedures has a very low fracture resistance; yet many impact tests of scale model and full scale ductile cast iron structures have shown that these materials are fracture resistant, even when cooled to sub-zero temperatures. A new fracture design philosophy for this class of materials is needed.

Closure Seals Behavior--The behavior of seals in dynamic environments is also an issue which has not been adequately addressed. Adequate sealing following a spectrum of events depends upon the contents of the packaging and the specific seal/-packaging design. The duration of seal breach events and the quantity of material released during such events also need to be evaluated to characterize seal response to dynamic environments.

Systems Technology Development

Closely coupled with the development and/or assessment of transportation systems, the objectives of this activity include provision of transport, systems handling technology necessary to meet shipping and receiving requirements of existing and developing facilities, establish and evaluate analytical and testing methodologies for development of transportation systems and provision of engineering information for future systems development. Examples of specific issues in this area are:

Standardization of Packagings and Interfaces--With the future development of large scale facilities (such as repositories) for handling and disposing of radioactive materials, there will be considerable emphasis to standardize the interface operations between the facilities and the many packages being received. For example, in order to meet repository worker radiation exposure limits dictated by guidelines generated in response to dose-reduction goals, special handling of individual packages which result in significant amounts of direct hands-on-work must be reduced. Issues include which features to standardize and whose future concept is to become the standard.

Systems Analysis Methods--Analysis techniques have become more extensive and complex over the past decades. Computer codes and a greater understanding of fundamental phenomena have enhanced evaluations of transportation system performance. Some evaluations have lead to increases in both actual and perceived levels of safety. As capabilities to perform better and more detailed analyses develop, the trend is to use these methods. The issue is to develop and use new analysis technologies that result in real and perceived increases in the level of safety and can be justified on their technical and economic merit. In order to have confidence that evaluations and predictions actually have some value, a method of feeding back and double checking predictions needs to exist. Quality assurance and testing provide a major input. Operational, non-destructive and destructive testing provide the data that can be used to develop and use analysis methodologies. Activities range from full scale extra-regulatory testing to operational handling of packagings.

Systems Testing Characteristics--The hypothetical accident conditions specified in both international (IAEA Safety Series No. 6) and in domestic (10 CFR 71) regulations are often questioned. For example, it is often pointed out that the required 9 meter drop results in only a 48 km/h impact, whereas transportation systems often travel at much higher speeds. Similarly it is often argued that fires can be hotter than the 800°C thermal exposure required by the regulations. The critiques of the existing hypothetical accident environment often neglect the engineering rationale for the regulations and the very stringent acceptance criteria for a package after the hypothetical accident conditions are applied. In this case, a better understanding of the test environments allows estimates of the effects of real accident for comparison with the regulatory requirements.

Advanced Packaging and Handling Systems--In the past, a need to ship a given material would arise and a packaging would be developed for that specific purpose. This has resulted in a large number of specialized packagings, each with a limited capability. Since both the cost and length of time required for development have increased, perhaps a family of packagings with a flexible capability would be better for the future. Joint storage/-transport applications should be evaluated. Even neglecting this approach, new packagings will be needed to transport radioactive materials in the future. There is a necessity, however, to balance the application of evolving technology against the economic lifetime of various packaging systems. In order to meet future packaging requirements that are continuously evolving, new technology will be developed. Robotic handling systems, new neutron shields, cast iron containment vessels, package/-vehicle integrated systems and improved decontamination systems may be developed in future years.

Technology Information Center

The basic function of the TTC's Technology Information Center is to convey to the public, policy makers and industry the magnitude and results of the various analytical and design efforts and the host of supporting data that relates to transporting radioactive materials. The TTC has as its goal providing answers to questions from all sectors of the public concerning radioactive material transportation. To perform this function, the TTC has pre-approved informative white papers which are keyed to often-asked questions. In addition, there are exhibits that are used, as appropriate, in meetings and hearings, and a variety of films, slides and other visual materials used in conjunction with speakers from the TTC and which are frequently provided to other requesters. Data collections which lend themselves to computerized data base formats and requirements of repeated access in different reference frames are used to speed up the response process. Some of the principal data bases developed at the TTC for use in meeting public inquiries are:

Accident/Incident Data Base. A complete file of incidents reported to DOT, NRC and some state governments involving radioactive material shipments is computerized to allow access by state, carrier, location and a variety of other search frames.

RAMPAC. A file of NRC and DOE certified packages is maintained which can be accessed by certificate number, material, cavity dimension, weight and other factors.

Legislative Data Base. A file of state legislation relating to radioactive material transportation and especially to constraints on shipping is funded by TTC and maintained at ORNL.

The underlying goal of the TIC is the quick dissemination of factual information both to meet the immediate needs of the questioner but also to build public trust in, and understanding of, the basic features of nuclear materials transportation and its record of achieving outstanding safety over the 40 years of the nuclear age.

Safety and Intergovernmental Issues Analysis

Transportation of radioactive materials of all kinds and all degrees of relative hazard is occurring but significant institutional problems exist and are continually surfacing that can act to prevent or greatly complicate the efforts of meeting the nation's goals in the radioactive waste management area. The enactment of local restrictions on time of day, transit permits, pre-notification, required liability coverage and other institutional barriers to the transport of radioactive materials are likely to become more important as the DOE approaches the point of site selection and it becomes clearer what cities and states are likely to experience waste shipments to the repositories. These institutional barriers must be assessed from the viewpoint of their impact on the cost and design of the repository program, their impact on the overall risk of waste management program and their origin in the public's beliefs that was their impetus.

Such assessments are the function of the Safety and Intergovernmental Issues Analysis component of the TTC's program. The program aims at identifying possible institutional barriers (issues) as early as possible, delineating their origin, factual basis and principal features and then, where possible, identifying positive approaches to minimizing the problem. Two recent issues which were the subject of evaluation and action were:

Emergency Response. Communities stated that lack of emergency response organizations and training were one source of reluctance to allow radioactive material shipments within their jurisdictions. Analysis indicated that emergency response planning could be improved and that there was not widespread appreciation of existing capabilities for training at the federal and state level. Two actions were generated to meet this need: 1) facilitation of the development of Federal Emergency Management Agency guidelines for transportation accident plans was accomplished and 2) a compilation of emergency response courses was undertaken.

Pre-notification of Shipments. Prenotification of shipments (especially large quantities) is frequently requested by communities on possible shipment routes. While not precluding shipment, such procedures do add to the cost of shipment without any apparent benefit. If every jurisdiction on a radioactive materials shipping route requires prenotification, instead of just states as currently required, a paperwork nightmare could result. The mechanism of pre- and post-notifications has been examined in one report and a future report will evaluate the process from a legal and case study basis to determine possible cost/benefit impacts and the susceptibility of such ordinances to preemption.

Studies of similar scope concerning HM164's routing requirements, Price-Anderson/liability coverage, legal requirements on environmental assessments, preemption, and federal agency responsibilities have been carried out or are in progress and are the subject of topical reports. Other areas of interest include:

Risk Analysis Tools--Risk and systems analysis tools are used to evaluate safety, operational and economic aspects of transportation system. These range from evaluating fleet requirements and costs for a given waste to performing risk assessments of shipment options. These evaluations are required to allow the designer or planner to fully assess the impacts of decisions prior to making an operational commitment.

Safety Assessment and Environmental Analysis--Specifically noted in the NWPA are the requirements to consider transportation risks in the process of selection of the final site. Evaluation of these transportation risks is accomplished using the RADTRAN II code. This code is an outgrowth of the NRC transportation risk assessment activity which was documented in NUREG-0170. Use of RADTRAN shows that the risks of transporting RAM are relatively small compared with those attendant to other activities of modern life. However, the fact that risks can be shown to be small by analysis in no way minimizes the careful scrutiny of RAM shipment hazards by the public. The emphasis on the very low probability/high consequence accidents which are shown to be possible, but improbable, detracts from more likely, but less spectacular, accidents and the even larger impact of normal radiological and non-radiological effects. Efforts are underway continuously to develop techniques to explain the risks and to provide an appropriate background on which to judge them.

The place where the institutional framework within which waste shipment will occur, the physical description of transportation hardware, the logistical plan for shipments and the risks of shipment will come together is the environmental analyses which must support each repository. Since these analyses include transportation issues among all others related to the selection process, extensive development of transport options within the analysis is probably not called for. Yet, because of the prominence of transportation in the public's eye, some detail is required. To meet these needs, TTC is developing a generic appendix which contains all of the general information likely to be needed in one document together with methods of specializing that data to each site. Using the generic appendix, it is expected that most waste management project's needs will be met without needless duplication among repository programs.

CONCLUSIONS

The TTC has been conducting a wide range of technical and non-technical research activities to assure the ability to transport radioactive materials in a safe, reliable, and publicly acceptable manner. These activities include tasks in Information and Intergovernmental issues, Safety Assessment and Environmental Analysis and Technology Development. Until recently, the requirements of defense waste shipments have served as a focal point for development tasks with the expectation that they would serve as a precursor for commercial activities. The passage of the Nuclear Waste Policy Act has placed additional responsibility on DOE for concerns involving the shipments of civilian materials. The development of additional research responsibilities is expected to proceed concurrently with the evolution of the transportation mission plan for civilian spent fuel and high-level wastes.