A Regulator's Perspective on Physical Testing for Type B Packages

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Abstract

The U.S. Nuclear Regulatory Commission has a great deal of experience certifying Type B transport packages as complying with the regulations in 10 CFR Part 71. With this experience base, supporting risk studies, and with an exceptional historical safety record for transport, we are very confident in both the current regulations and the methods we use to review and certify transportation packages. Nevertheless, we have a responsibility to remain vigilant and review our regulations and implementing practices with a view towards continuous improvement. NRC regulations permit certification through testing, analyses, comparison to similar approved designs, or combinations of these methods. Testing can be further broken into scale models, components, simple models, or full-scale models. NRC does not require full-scale testing for certification of any package; however, many applicants for package certification have conducted a physical testing program to demonstrate that the package design meets the hypothetical accident conditions. The plans for a repository at Yucca Mountain have raised significant interest in the United States of America in transportation of spent fuel, and created a broad stakeholder and public interest in transportation package testing. As an expected large increase in the number of spent fuel transports nears, this interest will likely grow. The technical and regulatory reasons for, or for not, performing tests need to be well understood and communicated to all stakeholders.

Speech

Introduction

Good Morning. Thank you for the opportunity to address this plenary session, and a special thanks to our conference hosts, for a very informative and interesting agenda. Yesterday was extraordinary for many of us; marking the first time I, and I am sure many of you have seen a full-scale regulatory drop test of a spent fuel rail cask. With that remarkable event, along with Friday’s additional test in mind, I thought a good use of my time would be to offer my views, as a regulator, on full-scale package testing. I’m obliged to acknowledge that the views I am about to offer are my personal views and do not necessarily reflect the views of the U.S. Nuclear Regulatory Commission.

I have been the Director of NRC’s Spent Fuel Project Office for about five years. There have been several interesting events during this time--most notable is NRC’s response to the tragic events of September 11, including increased security for storage and
transportation of radioactive material. During the last few years, we have also seen a significant growth in dry cask spent fuel storage in the U.S. We have also seen a marked increased interest regarding potential transportation of spent fuel to the proposed high-level waste repository at Yucca Mountain. The increased attention to the safety and security of spent fuel transportation within the United States is evident at both the national and local level. Consequently, our interactions with stakeholders have increased markedly over the past few years.

In the U.S., the Nuclear Regulatory Commission Spent Fuel Project Office approves designs for Type B and fissile material packages. For these designs, an applicant must show that they meet the performance requirements established in 10 CFR Part 71. Our regulations, as well as most other countries’ regulations, are generally compatible with IAEA Regulations for the Safe Transport of Radioactive Material, TS-R-1. The NRC staff has a great deal of experience reviewing package designs. The NRC issues about 100 approvals a year and has been averaging about six months per review. We also have a long history of sponsoring transportation research projects that support our regulatory approaches and conclusions with a view to improving safety.

This experience base, supporting risk studies, and an exceptional historical safety record for transport, lends support to the adequacy of our current regulations and the methods the NRC uses to review and certify packages. This point is worth reiterating – the NRC staff is very confident in the adequacy of the current transport regulations and the methods used to demonstrate compliance with the regulations. Nevertheless, the NRC and all other national transportation regulatory agencies have a responsibility to remain vigilant in identifying and addressing potential weaknesses in its regulations and implementing practices, and we must maintain a strong commitment towards continuous improvement. This is especially true in the U.S., as we prepare for an expected large increase in the number of spent fuel transports.

Regulatory Base

Let me say a few words about the NRC regulations and regulatory process as they relate to testing. NRC regulations permit certification through testing, analyses, comparison to similar approved designs, or combinations of these methods. The testing aspect of the certification requirements can be further broken into scale models, component, or full-scale testing. NRC does not require any particular method be used, including full-scale testing, for certification of any package. The burden of demonstrating that the package design meets the regulations lies with the applicant. The NRC technical staff independently reviews the applicant’s safety demonstration. The NRC’s review of applications is focused on safety, as confirmed through the applicant’s demonstration that the package design meets the performance standards established in the regulations, which cover a wide range of accident scenarios. We do not require or expect an applicant to perform scientific research, testing, or design optimization/improvement outside the bounds of the regulations.
The decision on the method of demonstration is solely the applicant’s. For some packages and for various reasons, full-scale tests can be the most timely, practical, and economical means for an applicant to demonstrate compliance to the NRC. Typically, spent fuel casks have been certified through a combination of engineering analyses and scale or component testing. Other transportation packages are often certified using a combination of full-scale testing and analyses.

Many applicants for package certification have conducted a physical testing program to demonstrate that the package design meets the types of hypothetical accident conditions that form the basis for the performance requirements found in 10 CFR Part 71. We very much welcome the full-scale fuel cask tests this week. We have long believed that there would be a lot to learn from such tests, in terms of our analytical and modeling capabilities and treatment of scaling. From a regulator’s point of view, the full-scale test provides valuable insights that will help focus our review, in a risk-informed way, on those aspects of the design that contribute most to safety. Several spent fuel cask vendors have demonstrated to the NRC staff, a reasonable assurance of compliance with the regulations without a full-scale test, using combinations of modeling approaches, scale and component tests; however, that is not the same as saying that a full-scale test would not add great value to the safety case. In that regard, NRC has actively engaged with GNS on their testing program through several pre-licensing interactions to share information and learn the purposes and expectations of the tests. Such pre-licensing interactions between the regulator and applicant are the key to an effective and efficient review process. We very much value and welcome the initiative by GNS and Mitsubishi to perform the full-scale spent fuel cask tests this week.

Each spent fuel shipping cask design NRC has approved has undergone some form of a scale model physical test program. Because of the relatively smaller size of, for example, a typical 1/4-scale model, drop tests can be conducted more easily for many drop orientations to meet the multiple test requirements. However, I need to recognize that in some cases, certain parameters are not amenable to scaling laws. For example, leak rates, fire (duration, intensity), fabrication techniques (such as the size of the heat affected zone near welds) and material properties (wood grain size in impact limiters, which are important to breaking phenomena) can be difficult to properly scale. If these parameters are design drivers, a bounding analysis may not be pragmatic, and a scale test alone may not provide sufficient assurance that the design meets compliance requirements. In some cases, a full-scale compliance test might be the preferred choice. For spent fuel casks, resolution of these types of issues from a regulatory compliance point of view has not required full-scale testing. In general, based on historical industry design efforts and our own historical oversight activities, the current practice of scale model drop tests and detailed finite element, numerical analysis provide reasonable assurance that spent fuel casks can safely be transported.

There are as well, many cases where applicants have decided that full-scale testing was preferred and has proved beneficial. For example, the TRUPAC-II package is a large (10-ton) package designed for transport of transuranic waste materials. The NRC first certified the TRUPAC-II design in August 1989, and the Certificate has been amended
several times and renewed twice. The package performance was demonstrated by a rigorous full-scale test program, which included the regulatory accident test sequence. Similar to our interactions with GNS in their package testing and pre-test evaluations, the NRC staff had significant interactions with the applicant for the TRUPAC II transportation package. A large fleet of TRUPAC-II packages is now being used for transuranic waste shipments to the Waste Isolation Pilot Plant in New Mexico. Partly in light of the TRUPAC II’s unique design features including the use of certain type seals, the applicant was successful in obtaining certification by using a full-scale test program supplemented by analyses, rather than a very complicated modeling and analytical program. In the U.S., the TRUPAC-II certification testing program and the public outreach associated with it has been often cited as a very successful model for simultaneously gaining greater public understanding and demonstrating regulatory compliance.

Types of Full-scale Testing

I will now discuss the rising level of public interest within the United States in performing full-scale tests, which is an important consideration that could influence the national transportation program in the US in the coming years. This discussion will set the stage for an introduction regarding the types of and considerations for performing full-scale testing of spent fuel transportation casks.

Activities associated with the proposed high-level waste repository at Yucca Mountain, Nevada, have and will continue to raise significant interest from the public and interested stakeholders with respect to the transportation of spent fuel. The NRC plans to perform a package performance study which will include a full-scale test of a transportation rail cask. NRC staff has conducted numerous open public meetings soliciting input on what type of tests should be performed. The meetings attracted a wide range of interested stakeholders including national, state, and local governments, as well as several interest groups. The NRC staff submitted a proposal which addressed the public concerns, and a proposed action is currently before the Commission for consideration. Bret Tegeler from NRC’s Office of Nuclear Regulatory Research will speak to you this week on the specifics of the NRC Package Performance Study. As a decision on the construction/operation of the proposed Yucca Mountain high-level waste repository draws near, I clearly expect an increasing public interest in transport package testing in the future. Interest in full-scale package testing has also been reflected in comments and recommendations by state and national officials’ remarks on the safety and security of spent fuel transportation.

From a technical standpoint, we clearly can make the case that the casks are designed to meet adverse and significant accident conditions, based on a successful demonstration that the cask meets the regulations’ hypothetical accident condition sequence. However, from a communications and outreach perspective, the case is not always convincing. The transportation experts have not traditionally done a good job of communicating how the regulatory tests translate to real world accidents in terms that people can understand. To a
concerned citizen, a 9 meter or 30 foot drop test which results in a 30-mile-per-hour impact does not seem severe or reflective of reality, as vehicles routinely travel at twice or even triple that speed. Further, many people do not understand the scientific meaning of an unyielding surface used in the drop test. In addition, although many people might agree that the casks are relatively straightforward engineered structures and are analyzable with engineering principles of physics and scaling, taking a common-sense approach, one might say why not test at full-scale just to be sure the design is safe.

The public comments on physical testing leads me to the potential reasons for and types of full-scale physical testing programs, and who might best perform the tests. In our outreach meetings and interactions on the package performance study, we have noticed that there is a communications gap and understanding, or perhaps misunderstanding, with respect to the types and goals of full-scale tests. In general, physical testing programs can be categorized by their objectives. Four categories could include developmental tests, compliance tests, benchmarking tests, and research tests.

Developmental tests are mainly used by designers, to support a preliminary trial design and economize the design process. The tests provide physical interpretation of the prototype packages and aid the designer in interpreting the structural performance of the package. There may often be no regulatory role in these tests.

Compliance testing is, naturally, testing to demonstrate the design against the regulatory requirements. These tests are typically initiated by the applicant. If used in a public outreach effort, much care must be taken to explain how the regulatory tests will translate to real-world accidents. Regulatory testing may not itself answer public questions if the questioner doubts the severity of the regulations and test conditions themselves.

Benchmark or model validation tests are mostly used by engineers to independently check analyses. Generally, and for efficiency and broad applicability, these tests can focus on eliminating errors that can affect the conclusions, rather than disclosing minor computational issues. Past benchmarking experiments may be available for use for widely used codes, with adequate justification of the applicability to the design at hand. When enhanced computer-aided design tools are used, an independent check through physical testing a component or prototype is very powerful tool to support the safety case showing regulatory compliance.

Finally, the fourth type of test is a research test. I will mention only two types of regulatory research sponsored by NRC – confirmatory and developmental research. Confirmatory research, such as the NRC package performance study, can be used by regulators to confirm the adequacy of a regulatory approach or requirement. Developmental research could have the goal of changing regulations or developing a new approach, such as the groundbreaking research in the 1970’s on probabilistic risk assessment techniques. The types of tests performed in this case might exceed regulatory requirements in order to investigate safety margins. The results would presumably benefit multiple licensees, show applicability to many designs, and advance the public
understanding. This research would often be sponsored and conducted by the regulator or by industry or interested organizations.

As I mentioned earlier, NRC initiated a confirmatory research program in 1999 to study the response of spent nuclear fuel transportation casks to extreme accident conditions. At PATRAM 2001 there was a plenary speech by Mr. Robert Lewis of the Spent Fuel Project Office, and a session on this project. This confirmatory research program is called the Package Performance Study (PPS). The study objective is to conduct confirmatory research using and enhanced public participatory approach to assess the analysis tools and methods used to predict spent nuclear fuel transportation cask response to extreme mechanical and thermal environments, and demonstrate the inherent safety in spent fuel cask design. Public outreach and openness is a significant element in this objective.

Conclusion

Let me conclude by again welcoming, from my perspective, the full-scale tests being performed this week. As we begin to examine and further understand the test data, I am sure we will gain information that will improve cask design techniques, transport safety and our broader understanding of the robustness of the spent fuel transportation casks. This will in turn contribute to maintaining the exceptional record of safety that the world-wide transportation industry has compiled – a safety record, by any measure, of which we all should be proud.

Thank you. I look forward to our continued dialogue and interactions today, during the rest of this conference, and in our continued transportation program interactions.