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STATUS OF NRC's PACKAGE PERFORMANCE STUDY

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ABSTRACT

The United States Nuclear Regulatory Commission staff has proposed a study to demonstrate the robustness of spent nuclear fuel (SNF) transportation casks and enhance public confidence in their design by performing a full-scale test of a SNF transportation cask under realistic conservative accident conditions. This study is known as the Package Performance Study (PPS). The current regulatory requirements, as specified in Title 10, Part 71, of the *Code of Federal Regulations* (10CFR Part 71)[1], require drop testing of a scale model of a transportation cask or another appropriate method acceptable to the NRC Commission, and do not require full scale testing of a SNF transportation cask under realistic conservative accident conditions. This paper provides a brief history of staff and Commission actions for the PPS. In addition, it will update the international community on the PPS since the discussion at PATRAM 2004. This includes detailed information on test parameters as directed by the Commission and anticipated test schedule. However, the proposed test parameters are not the final word on this issue and the project is subject to additional modifications and Commission direction.

HISTORY OF PPS

In February 2003, the staff published NUREG-1768, "Package Performance Study Test Protocols,"[1] which documented a proposed plan for performing extra-regulatory impact and fire tests (i.e., testing beyond the regulatory criteria) on certified spent fuel rail and truck transportation casks. Through extensive public meetings and comments, a wide range of stakeholders provided input for staff consideration of how the tests should be conducted. On the basis of that input, the staff identified additional testing approaches and developed a Commission paper (SECY-04-0029), dated February 23, 2004, which summarized the major public comment themes and presented testing options for the Commission's review and approval.

In response to SECY-04-0029, the Commission issued a Staff Requirements Memorandum (SRM), dated May 11, 2004, in which the Commission approved the testing of a full-scale, certified rail cask of a type that is currently being used, or is

expected to be used in the foreseeable future to transport spent fuel. The Commission also directed the staff to commence procurement of such a cask and, prior to publishing a request for bids, inform the Commission of the specific details of the cask design and the related justification. The staff provided that information in a memorandum to the Chairman, dated July 2, 2004, requesting authorization to enter into a procurement exceeding $3 million.

Additionally, the SRM for SECY-04-0029 directed the staff to submit, for Commission approval, a plan for a demonstration test with sufficient instrumentation to collect data to confirm the validity of key analytical methods and assumptions, including scaling. In particular, the Commission specified that the demonstration test should be realistically conservative and should include exposure to a fully engulfing fire. The Commission further directed the staff to interact with the U.S. Department of Energy (DOE) to determine whether DOE will provide funding for the demonstration test and to inform DOE that the PPS could be expanded in the future to include testing of a certified truck cask.

The staff subsequently submitted a Commission Paper (SECY-04-0135), dated July 27, 2004, to request the Commission's approval of a demonstration test plan. As a result, in the SRM for SECY-04-0135, dated December 10, 2004, the Commission directed the staff to prepare an information paper outlining the details and projected costs of a demonstration test that represents a viable transportation accident, and not necessarily the "worst case" scenario or a hypothetical accident requiring multiple events to occur simultaneously. The SRM specifically directed that the demonstration test should consist of a simulated crossing with a train traveling at an appropriate speed colliding at a 90-degree angle with a transportation cask on its rail carrier car in a normal transportation configuration.

In SECY-05-0051, dated March 28, 2005, the staff provided the details and projected cost of a fully assembled SNF cask, with surrogate fuel assemblies, tied to and supported on a carrier railcar that is impacted by another train, traveling at 97 km/h (60 MPH), at a 90-degree angle at a simulated rail crossing. In the related SRM, dated June 9, 2005, the Commission approved the staff's proposed test plan and projected cost for the demonstration test. In addition, the Commission directed the staff to add a fire test scenario for a rail cask involving a fully engulfing, optically dense, hydrocarbon fire for duration of one-half hour post-collision as a part of the proposed demonstration test. In the same SRM, the Commission also directed the staff to (1) negotiate and complete a signed cooperative agreement with the German Federal Institute for Materials Research and Testing (BAM); (2) provide a status update on the staff's review and analysis of the full- and quarter-scale transportation cask drop test data obtained from BAM; (3) review developments in the U.S. high-level waste program and prepare a Commission paper to recommend an appropriate time to begin executing the PPS; (4) brief the Commissioners' Technical Assistants on the details of a proposed fire test and projected costs; and (5) ask the Advisory Committee on Nuclear Waste (ACNW) to review the revised demonstration test.

The staff, in turn, generated SECY 06-0053 which provided information and an update for the tasks listed above, and requests Commission's approval of the schedule to perform the demonstration test. In SRM to SECY 06-0053, the Commission directed staff to tie the PPS milestones to DOE's procurement of transport, aging, and disposal (TAD) cask for shipments to support proposed Yucca Mountain repository operations or the issuance of NRC's transportation Certificate of Compliance (CoC) for TAD casks, whichever is later. Furthermore, the Commission directed staff to brief Commissioners' technical assistants annually, beginning in February 2007, about the status of PPS demonstration test and BAM cask drop test analyses. In addition, in the SRM to SECY 06-0053, the Commission stated that the proposed test plan is not the final word on this issue and the project is subject to additional modifications and Commission direction.

As with the case of SRM for SECY-04-0029, the Commission again directed the staff to engage with higher level management in DOE to request funding to support the PPS demonstration test.

Current PPS Demonstration Test Scope

As noted from the PPS history above, Commission had provided several directions which modified the scope of PPS demonstration test. The current PPS demonstration test scope evolved from Commission directions provided mostly after PATRAM 2004. These directions are listed in the PPS history above and are discussed below.

Cask to Be Used For PPS Demonstration Test

Consistent with prior Commission direction, the transportation cask to be used for the proposed demonstration test will be one that DOE is likely to use to transport nuclear fuel to the potential high-level waste repository at Yucca Mountain, Nevada. In addition, the transportation cask design will have a valid NRC CoC to transport commercial spent nuclear fuel, in accordance with 10CFR Part 71, which requires testing for hypothetical accident conditions, including a free drop of scale model of the cask through a distance of 9 m (30 ft) onto an unyielding surface and exposure to a fully engulfed fire for 30 minutes.

PPS Demonstration Test Configuration

The demonstration test will be performed in accordance with the Commission's direction in the SRM for SECY-05-0051. A fully assembled transportation cask with surrogate fuel assemblies tied to and supported on a carrier railcar will be impacted by a train at a 90-degree angle at a simulated rail crossing. The train to be used for the demonstration test will consist of a locomotive with several freight railcars. Structural analysis will be performed prior to the demonstration test to determine the number of freight railcars, and the loads in each railcar required to simulate the relevant momentum and energy of an average length train. The locomotive will be similar to the one that the various railroads use for hauling freight trains. The SNF transportation cask to be used for the demonstration test will be one that DOE is likely to use to transport nuclear fuel to the

potential high-level waste repository at Yucca Mountain, Nevada. In addition, the SNF transportation cask will have a current NRC CoC to transport commercial spent nuclear fuel, in accordance with 10 CFR Part 71.

It is likely that the SNF transportation casks will be shipped to a potential Yucca Mountain repository using railcars that are manufactured and certified in accordance with Standard S-2043, "Performance Specification for Trains Used to Carry High-Level Radioactive Material," [3] which the Association of American Railroads (AAR) issued for transporting spent nuclear fuel. This standard includes special requirements for railcar coupling systems, brakes, nondestructive examination, and dynamic load tests. However, the structural design requirements for the AAR Standard S-2043 railcar for the spent fuel transportation trains are the same as those for regular center depressed freight cars. Since the demonstration test is intended to determine the structural response of a transportation cask on a freight railcar, a regular freight railcar of equivalent/similar structural design will be used in the test.

The spent nuclear fuel transportation cask will likely be tied to the railcar in accordance with the retention requirements of AAR Rule 88A during transportation to a potential Yucca Mountain repository. Therefore, the mounting system for the demonstration test will also be designed to conform to AAR Rule 88A.

Before performing the demonstration test, a detailed pretest structural analysis will be performed to predict the behavior of the locomotive, railcars, and the transportation cask after impact. Based on that pretest analysis, a detailed instrumentation plan will be developed to record the stresses and deformations in the transportation cask, locomotive, and railcars. Different parts of the locomotive, transportation cask, and railcars will be painted in different colors to facilitate identification after the test.

After the demonstration test, a post-test structural analysis will be performed to address any discrepancies between the predicted and actual test results, which may be attributable to variation in train impact speed, material properties of the transportation cask, locomotive, and railcars. This will include analyses required to address the actual train impact speed and material properties of the different components.

Train Impact Speed

The train speed at a rail-to-rail crossing depends on the type of track, railroad operating procedures, and hardware installed to protect the rails at the crossing. The three types of rail-to-rail crossings currently in use are as follows:

standard diamond
one-way low-speed flange-bearing frog (OWLSFBF) diamond
two-way flange-bearing frog (TWFBF) diamond

The rails at a standard diamond crossing do not have any special reinforcements at the track intersections. The flange-bearing frog diamond crossings provide a special track

structure at track intersections to provide support for the train wheels to reduce railroad maintenance costs. The OWLSFBF diamond crossings have flange bearings for one direction, while the TWFBF crossings provide support for train wheels in both directions.

The FRA does not impose any special speed restrictions at standard diamond crossings, but requires that the maximum train speed must not exceed the maximum allowable speed for the class of track at the crossing. The railroads have to conform to certain speed restrictions and/or obtain a waiver from the FRA to install flange-bearing frog diamond crossings. However, both the FRA and the AAR have informed the staff that the individual railroads' operating procedures limit the speed at all three types of rail-to rail crossings to 72 – 80 km/h (45 – 50 MPH) for maintenance reasons.

The speed at which the demonstration test can be performed depends on the type and layout of track at the test facility, and the maximum locomotive operating speed. FRA personnel have informed the NRC staff that a track layout at the facility in Pueblo, Colorado, can be modified to perform the demonstration test at a maximum speed of 97 – 113 km/h (60 – 70 MPH). This is considerably more than the maximum speed of 80 km/h (50 MPH) at rail-to rail crossing on U.S. railroads, as described above. Therefore, during the development of the detailed test plan, the staff will target an impact speed of 97 km/h (60 MPH) to represent a viable, realistic, and conservative scenario, but not a "worst case" accident.

Fire Testing

In accordance with the Commission's direction in the SRM for SECY-05-0051, the same rail cask to be used for the impact demonstration test will be subjected to a fully engulfing, optically dense, hydrocarbon fire for duration of one-half hour after collision. However, because the overall dimensions and internal details of the transportation cask will influence the design of the fire test facility and instrumentation required to monitor the behavior of the cask during a fire test, the details of the proposed fire test cannot be determined until DOE selects a transportation cask.

PPS Demonstration Test Schedule

As noted from the PPS history above, PPS demonstration test is tied to either DOE places an order to procure the TAD casks to support proposed Yucca Mountain repository operations or the NRC issues a certificate of compliance for the TAD cask design (whichever is later). Therefore, TAD cask certification plan would impact the PPS demonstration test schedule. DOE has issued the final performance specification for the TAD cask [4] on June 19, 2007. Preliminary information obtained from DOE also indicated that TAD cask designers have submitted conceptual designs to DOE and are expected to submit final designs in applications to NRC by September/October 2008.

An optimistic PPS demonstration test schedule, based on the September/October 2008 TAD applications submittal date, would be that NRC issues CoC for the TAD casks by October 2009. It should be noted that NRC generally schedules Part 71 cases for a one

year review, with a timeliness performance goal to complete all cases within two years. Assuming NRC issues CoC for the TAD casks by October 2009 and continued Commission direction to proceed, NRC staff can start preliminary planning and procurement activities for PPS demonstration test in the same month. The staff can submit recommendations for the demonstration test protocols and costs to the Commission for consideration by February 2010. Contracts for cask and locomotive supply could be awarded by November 2010. PPS demonstration test could be performed by either late 2012 or early 2013 and PPS demonstration test final report could be issued 11 months after the test. If NRC does not issue CoC for the TAD casks by June 2008 as estimated above, PPS preliminary planning, selection of test facilities, and procurement activities would be delayed accordingly.

BAM Agreement

An implementing Agreement between the NRC and BAM was signed in June 2006. This agreement enables the staff to obtain the full- and quarter-scale cask drop test data that were conducted at BAM. BAM performed full-scale drop tests on CONSTOR cask and MHI casks. Quarter-scale model drop tests were performed on MHI cask only. The staff intends to review and analyze these drop test data to determine the extent to which the data support the objectives of the PPS, and will then recommend enhancements to the PPS project that may become apparent through this review and analysis. Analyses will involve detailed independent structural simulation and finite element analysis of the drop scenario for the full- and quarter-scale casks. Results of these analyses will also help establish the magnitude of uncertainty in finite element analysis and confirm the approach used to address the effect of scale in the structural analysis of the SNF casks in general.

To date, BAM has provided NRC the drop test data on CONSTOR cask. Because this task can proceed independently from the DOE's procurement of the transportation casks, the staff has completed the modeling of the CONSTOR cask and is currently performing analysis of the CONSTOR cask drop tests. To ensure that results of the analyses are not influenced by the drop test data, staff has not opened the CONSTOR cask drop test data provided by BAM. To generate the input file for the MHI cask, the staff needs the design and material properties information for the MHI cask. Currently, BAM is in the process of evaluating the MHI cask drop test data for correctness before sending them to the NRC. A more realistic completion date for this task will be sometimes in FY 08/09.

DOE and PPS Demonstration Test Funding

As directed by the Commission in SRM to SECY 06-0053, the staff has been in contact with DOE personnel to request funding to support the PPS activities.

Summary

The NRC Commission has approved a test plan for demonstrating robustness of the SNF transportation casks and enhances public confidence. It represents the best decision made using the information available to the Commission at the time. The Commission has indicated that this approved PPS test plan is subject to additional modifications and Commission direction once additional information becomes available. Indeed, the Commission has directed staff to provide recommendations to enhance the PPS test that may result from the review and analysis of BAM drop test data. Therefore, the PPS test to be performed could be different from what was discussed above. Depending on the results of the PPS test and the evaluation of the data, the Commission may also instruct the staff to conduct additional tests. If the need arises in the future, the staff could submit a plan to the Commission for proceeding with full-scale testing to the regulatory limits of both rail casks and truck casks.

References

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