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U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

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NRCB 96-04

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

July 5, 1996

NRC BULLETIN 96-04: CHEMICAL, GALVANIC, OR OTHER REACTIONS IN SPENT FUEL STORAGE AND TRANSPORTATION CASKS

Addressees

This bulletin is being sent to:

All holders of operating licenses or construction permits for nuclear power reactors.

All holders of, and applicants for, certificates of compliance for transportation casks for commercial spent fuel.

All holders of, and applicants for, certificates of compliance for storage casks for commercial spent fuel.

All vendors of storage and transportation casks for commercial spent fuel.

All registered users of transportation casks for commercial spent fuel.

It is expected that all recipients will review the information for applicability to their facilities and consider actions as appropriate to avoid problems similar to those discussed here. However, action is only requested from those addressees who are licensees with independent spent fuel storage installations, vendors of spent fuel storage or transportation casks, and holders of certificates of compliance for spent fuel storage or transportation casks (“action addressees”).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this bulletin to: (1) notify addressees about the potential for chemical, galvanic, or other reactions among the materials of a spent fuel storage or transportation cask, its contents, and the environments the cask may encounter during use, that may produce adverse conditions in cask loading/unloading/handling operations or degrade the integrity and performance of the cask; (2) request that all action addressees implement the actions described herein; and (3) require that all action addressees provide, to NRC, written responses to this bulletin, relating to implementation of the requested actions. This bulletin also

requires that certain information on the subject matter of this bulletin be submitted to NRC.

Background

On May 31, 1996, NRC Information Notice 96-34 was issued as notification of a hydrogen gas ignition event that occurred during the welding of the shield lid on a spent fuel storage cask at the Point Beach Nuclear Plant.

Description of Circumstances

On May 28, 1996, a hydrogen gas ignition occurred during the welding of the shield lid on a ventilated storage cask (VSC-24) multi-assembly sealed basket (MSB). The gas ignition displaced the shield lid (weighing about 2898 kilograms [6390 pounds]), leaving it in place but tipped at a slight angle, with one edge about 7.6 centimeters [3 inches] higher than normal.

The loaded VSC-24 multi-assembly transfer cask (MTC), a shielded lifting device used to transfer the MSB loaded with spent fuel to the ventilated concrete cask, had been placed in the cask decontamination work area in the auxiliary building. Approximately 114 liters [30 gallons] of borated spent fuel pool water had been drained from the MSB to facilitate welding of the shield lid, creating an air space below the lid. The hydrogen gas ignition occurred during the initiation of the shield lid welding, approximately 11 hours after the loaded MTC had been removed from the spent fuel storage pool.

After the event, gas and water samples collected from the MSB internals showed detectable levels of hydrogen both in the air space beneath the shield lid and dissolved in the MSB water. The licensee then continuously purged the air space beneath the lid with nitrogen to prevent the accumulation of combustible gases and returned the shield lid to its original position.

The MSB was then fully flooded to eliminate the air space under the shield lid and returned to the spent fuel storage pool. On removal of the shield lid, the licensee observed a white, foam-like substance under the shield lid. Most of this substance floated to the top of the pool; however, some remained below the surface of the water. Samples of this substance were taken to Argonne National Laboratory for analysis.

The licensee unloaded the spent fuel assemblies and placed them in the spent fuel pool storage racks. A visual examination of the MSB, the MTC, and the spent fuel assemblies showed no evidence of damage as a result of the combustible gas ignition.

The unloaded MTC/MSB was subsequently moved back to the decontamination work area for further inspection as part of the licensee's investigation of the combustible gas ignition. At the decontamination work area, the MSB remained filled with borated spent fuel pool water for several days. Hydrogen continued to be generated during that time, as evidenced by the effervescence off the MSB shell and fuel grid.

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The licensee investigation determined that the source of hydrogen was oxidation of zinc in the Carbo Zinc 11 coating (used as a coating to prevent corrosion) of the MSB when in contact with the borated water in the spent fuel pool. The zinc reacted chemically with the acidic borated water from the

spent fuel storage pool to produce hydrogen, and zinc oxide and hydroxide. The foam-like substance was determined to be a mixture of a precipitate formed by the reaction, residual soap used during decontamination of the MSB, and air.

On June 3, 1996, Confirmatory Action Letters (CALs) were issued to licensees using the VSC-24 cask (i.e., Arkansas Nuclear One, Palisades Nuclear Generating Plant, and Point Beach Nuclear Plant). The CALs confirmed a commitment, made by each of the three licensees to NRC, that prior to loading or unloading a VSC-24 cask with spent fuel, or placing a VSC-24 cask into the spent fuel pool, the licensees will: (1) assess the potential for the generation and ignition of explosive gases during all phases of operation of the VSC-24 system; (2) have compensatory actions in place to minimize the potential for the generation and ignition of explosive gases; and (3) have procedures in place to respond in the event of a gas ignition and the applicable personnel trained and briefed accordingly.

Supplements to each of the June 3, 1996, CALs were subsequently issued on June 21 and June 27, 1996, to confirm a further commitment, made by each of the three licensees to NRC, that the licensees will: (1) provide the required response specified in the staff forthcoming generic communication on the Point Beach VSC-24 event (i.e., this bulletin); and (2) refrain from loading or unloading a VSC-24 cask, or placing a VSC-24 cask into the spent fuel pool, pending staff review and acceptance of the response and verification of any subsequent actions taken in response to this bulletin.

Discussion

An NRC Augmented Inspection Team (AIT) was formed and sent to the site on May 29, 1996, to examine the circumstances surrounding the event. The AIT Charter consisted of evaluations of the licensee response to the event, including the radiation protection consequences of the event to both the plant staff and the general public, the effectiveness of the licensee root-cause investigation, and determination of any potential generic implications of the event. The findings of the AIT are summarized below. Details of the AIT findings are documented in Report Nos. 50-266/96005 and 50-301/96005.

- The AIT agrees with the licensee that the hydrogen was formed by a chemical reaction among the Carbo Zinc 11 coating and the borated pool water..

- The licensee believes that its internal processes associated with the design, design review, design specifications, and the independent review of the VSC-24 cask were deficient in that they did not recognize that the chemical reaction of the Carbo Zinc 11 coating with borated water would result in the production of hydrogen.

- The licensee had several opportunities to identify the generation of gas inside the MSB during previous cask loading operations, because of several noted abnormalities. However, the abnormalities were not documented and were not viewed collectively. This is of particular concern because in at least one case the licensee had indications that the gas being produced may have been combustible.

- The generic implications of the event extend beyond the use of the VSC-24 system. The AIT recommends that the adequacy of the chemical compatibility studies conducted during design reviews for all dry cask storage designs and facility environments should be reviewed. In addition, the suitability of Carbo Zinc 11 and other similar coatings used in nuclear applications, where there is the potential for exposure to boric acid, should be reviewed.

The gas ignition caused no injuries, no radiological releases, and no apparent damage to the spent fuel, storage cask, or the reactor facility itself. However, the event has raised some generic issues pertaining to both spent fuel storage and transportation casks. These generic issues extend to spent fuel transportation casks because transportation casks have designs similar to storage casks. Also, the current trend in the industry is to pursue licensing of dual-purpose, storage/transport cask designs.

Provisions for material suitability exist in both 10 CFR Part 71 and Part 72. Notwithstanding, the event at Point Beach suggests that the VSC-24 vendor and licensees did not adequately consider material reactions, and material compatibility with possible environments, in the design and design review of the VSC-24 cask. Also, NRC did not fully consider material reactions and material compatibility in its licensing review of the VSC-24 cask and other storage and transportation casks.

Two specific concerns or issues, one short-term and one long-term, arise from the event at Point Beach. The short-term concern is that combustible gases generated by material reactions may create hazardous conditions while loading or unloading a cask. The reactions, which form the combustible gases and precipitate, would not continue after the loaded casks are drained, evacuated, and back-filled with inert helium gas. Thus, the reactions would not continue while the cask and spent fuel are in the dry storage or transportation mode. However, the reactions could resume when the cask is reflooded prior to unloading, and therefore, need to be considered in cask unloading operations.
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The long-term concern is that any remaining product of these reactions, e.g., the precipitate, may degrade the structural integrity and adversely impact the retrievability of the stored spent fuel. Degradation of the fuel structural integrity is not expected to present an immediate health or safety concern. However, the overall requirements specified in 10 CFR 72.122 for spent fuel storage casks include protection of the fuel cladding from degradation and ready retrieval of the spent fuel. The staff, based on available information, does not anticipate any impact on the continued safe confinement of spent nuclear fuel in existing dry storage installations.

Based on available information and operational experience, it appears that the VSC-24 design is the system most susceptible to hydrogen gas generation. This is due to the VSC-24 relatively large use of carbon steel and anti-corrosion coatings (i.e., Carbo Zinc 11). Other licensed or certified cask designs are primarily constructed of stainless steel, and either use no or limited quantities of anti-corrosion coatings. Over 75 non-VSC-24 storage casks have been loaded, and spent fuel transportation casks have been in use for over 20 years. Operational experience with these casks has not evidenced any problems with material reactions, material incompatibility, and combustible gas generation during loading or unloading. Nevertheless, since the licensing review did not evaluate this issue, this bulletin is intended to request information to confirm that chemical, galvanic, or other reactions are not a concern for other storage and transportation cask designs.

Requested Actions

Action addressees are requested to take the following actions:

1. Address the following items relating to the susceptibility of the spent fuel storage or transportation cask design to chemical, galvanic, or other reactions:

   (a) Review the cask materials, including coatings, lubricants, and cleaning agents, to determine whether chemical, galvanic, or other reactions among the materials, contents, and environment can occur during any phase of loading, unloading, handling, storage, and

transportation. Consideration should be given to all environments that may be encountered under normal, off-normal, or accident conditions.

(b) Evaluate the effects of any identified reactions to determine if any adverse conditions could result during cask operations, including loading and unloading. Consideration should be given, but not limited, to:

(i) generation of flammable or explosive quantities of hydrogen or other combustible gases; and

(ii) increased neutron multiplication in the fuel in a cask because of boron precipitation from a chemical reaction among the borated water and cask materials..

(c) Review current cask operating procedures to determine if adequate controls and procedures are in place to minimize hazardous conditions that may be created by any identified reactions.

(d) Evaluate the effects of any identified reactions to determine if their reaction products could reduce the overall integrity of the cask or its contents during storage or transportation. Determine if the reaction products could adversely affect the cask ability to maintain the structural integrity and retrievability of the spent fuel throughout the term of the license or to transport fuel safely. Consideration should be given, but not limited, to:

(i) changes in cask and fuel cladding thermal properties, such as emissivity;

(ii) binding of mechanical surfaces, especially fuel-to-basket clearances; and

(iii) degradation of any safety components, either caused directly by the effects of the reactions, or by the effects of the reactions combined with the effects of long-term exposure of the materials to neutron and gamma radiation, high temperatures, or other possible conditions.

2. For storage casks currently loaded with spent fuel, determine the extent, if any, of the chemical, galvanic, or other reactions that have occurred, and the effect of these reactions on the cask ability to maintain the structural integrity and retrievability of the spent fuel throughout the term of the license.

In addition to the items above, the vendor and users of the VSC-24 spent fuel storage cask (Sierra Nuclear Corporation, Arkansas Nuclear One, Palisades Nuclear Generating Plant, and Point Beach Nuclear Plant) are requested to take the following actions:

3. Evaluate the effects of the reaction among Carbo Zinc 11 (or other equivalent coating used) and the water environments the cask may encounter. Show that the ability of the cask to maintain the structural integrity and retrievability of the spent fuel over a 20-year period has not been adversely affected by the formation of precipitate, or by any other effects of the reaction. Justify the continued use of VSC-24 storage casks already loaded with spent fuel. In this evaluation, consideration should be given, but not limited, to:

(a) the effect of the precipitate on fuel cladding integrity;

(b) the effect of the precipitate on the heat transfer characteristics of the cask; and.

(c) behavior of the precipitate under long-term exposure to neutron and gamma radiation, high temperatures, and other possible conditions.

4. Evaluate the procedures for unloading the cask to consider the likely presence of hydrogen gas or precipitate inside the MSB and the possible adverse effects of the hydrogen gas or precipitate on cask handling and performance. Inform the NRC of any changes made to the unloading procedures.

Required Response

Pursuant to 10 CFR 2.204, 10 CFR 71.39, and 10 CFR 72.44(b)(3), in order to determine whether any license or certificate should be modified, suspended, or revoked, or other action taken, within 45 days of the date of this bulletin, action addressees are required to submit a written response indicating whether the addressee will implement the requested actions.

1. If the addressee intends to implement the requested actions:

(i) The 45-day response should include a report confirming completion of the actions requested in Items 1(a), 1(b), and 1(c), above, and a schedule for completing implementation of the actions requested in Items 1(d) and 2, and if applicable, Items 3 and 4, above.

(ii) Within 30 days of completion of the actions requested in Items 1(d) and 2, and if applicable, Items 3 and 4, above, provide a report confirming completion.

The reports indicated in (i) and (ii) above should provide detailed descriptions of the reviews and evaluations performed in response to the actions requested, including any compensatory measures implemented as a result of the reviews and evaluations performed.

2. If an addressee chooses not to take the requested actions, the 45-day response should provide a description of any proposed alternative course of action, the schedule for completing the alternative course of action (if applicable), and the safety basis for determining the acceptability of the planned alternative course of action.

Address the written response(s) to the U.S. Nuclear Regulatory Commission, ATTN.: Document Control Desk, Washington, D.C. 20555, under oath or affirmation under the provisions of 10 CFR 2.204, 10 CFR 71.39, and 10 CFR 72.44(b)(3). In addition, submit a copy to the appropriate regional administrator..

Related Generic Communications

IN 95-29, "Oversight of Design and Fabrication Activities for Metal Components Used in Spent Fuel Dry Storage Systems."

IN 96-34, "Hydrogen Gas Ignition during Closure Welding of a VSC-24 Multi-Assembly Sealed Basket"

Backfit Discussion

This bulletin is an information request made pursuant to 10 CFR 2.204, 10 CFR 71.39, and 10 CFR 72.44(b)(3). The objective of the actions requested in this bulletin is to verify that licensees are in compliance with existing NRC rules

and regulations pertaining to the appropriateness and adequacy of the design of spent fuel storage and transportation casks including, and without limitation, 10 CFR 71.43(d), 72.122(h), 72.122(l), 72.236(c), 72.236(f), 72.236(g), 72.40(a)(5), 72.212(b)(9), 72.236(h), 72.234(b), and 72.146(b).

Paperwork Reduction Act Statement

This bulletin contains information collections that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501, et seq.). These information collections were approved by the Office of Management and Budget (OMB), approval number 3150-0011, which expires July 31, 1997.

The public reporting burden for this collection of information is estimated to average 600 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. The U.S. Nuclear Regulatory Commission is seeking public comment on the potential impact of the collection of information contained in the bulletin and on the following issues:

1. Is the proposed collection of information necessary for the proper performance of the functions of NRC, including whether the information will have practical utility?

2. Is the estimate of burden accurate?

3. Is there a way to enhance the quality, utility, and clarity of the information to be collected?

4. How can the burden of the collection of information be minimized, including the use of automated collection techniques?

Send comments on any aspect of this collection of information, including suggestions for reducing this burden, to the Information and Records Management Branch, T-6 F33, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202 (3150-0011), Office of Management and Budget, Washington, DC 20503..

NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

Nuclear power reactor licensees with questions regarding this matter should contact the appropriate Office of Nuclear Reactor Regulation (NRR) project manager. All other addressees with questions regarding this matter should contact the technical contact listed below or the appropriate Office of Nuclear Material Safety and Safeguards (NMSS) project manager.

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