

INTER-OFFICE MEMORANDUM

DATE : July 1, 1996

TO : Eric J. Leeds, Frederick C. Sturz
U.S. Nuclear Regulatory Commission

FROM : John R. Stokley, Joseph D. Price ⁹⁰⁷
Science Applications International Corporation

SUBJECT : Maximum over-pressure achievable on burning of
hydrogen-air mixtures

BACKGROUND

Burning of hydrogen gas has occurred during weld closure of spent fuel storage casks. The gas accumulated in a headspace between the cask lid and water covering the spent fuel assemblies. The gas is believed to have been generated during degradation of a coating used to protect cask internals. While the confirmed burn event caused no damage to the cask or spent fuel assemblies, more energetic events are possible. This memorandum provides estimates of the maximum over-pressures expected for burning of confined mixtures of hydrogen and air.

ANALYSIS

Combustion of hydrogen-air mixtures may occur at a range of rates. If the flame proceeds from the point of ignition through the mixture at a rate on the order of meters per second, the event is termed a deflagration and mixture pressure may be represented as uniform throughout the burnable volume (Ref 1, p 2-95). If the flame moves at a rate on the order of thousands of meters per second, the event is termed a detonation and a shock wave coalesces with a combustion wave producing a discontinuity in pressure which propagates through the mixture (Ref 2, p 52). Detonation over-pressures generally exceed deflagration over-pressures. For either deflagration or detonation to occur, the hydrogen concentration must be between the lower (4 vol %) and upper (76 vol %) flammability limits. Stoichiometric conditions correspond to hydrogen concentration of approximately 30 vol per cent.

Final conditions for confined deflagrations are estimated by representing the process as adiabatic and the system as well-mixed and of constant volume. An energy balance and an assumed equation of state are then applied to calculate final system temperature and pressure. The analysis resembles a standard flame temperature calculation with the exception of imposition of a constant volume rather than constant pressure constraint. Although the system volume appears in the governing equations, the estimated final temperatures and pressures are nearly independent of system volume.

EA No. 96-215

Mr. Robert Link
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Milwaukee, WI 53201

SUBJECT: NRC REGION III AUGMENTED INSPECTION TEAM REVIEW OF THE MAY 28, 1996, HYDROGEN GAS IGNITION DURING DRY CASK STORAGE WELDING OPERATIONS REPORTS NO. 50-266/96005; 50-301/96005

Dear Mr. Link:

On May 30 through June 7, 1996, an NRC Augmented Inspection Team (AIT) conducted an inspection at your Point Beach 1 & 2 Nuclear Plants. The inspection focused on the circumstances surrounding an unanticipated hydrogen gas ignition which occurred on May 28, 1996, during welding of the shield lid on the multi-assembly sealed basket of a VSC-24 spent fuel cask. Specifically, the AIT focused on the radiological significance of the event, your response to the event, your root cause investigation and generic implications related to the event.

The AIT was composed of Messrs. R. Caniano (Team Leader), T. Kobetz, and R. Paul, of this office; C. Withee and P. Narbut of the Office of Nuclear Materials Safety and Safeguards (NMSS); and J. Davis of the Office of Nuclear Reactor Regulation (NRR). A separate inspection was conducted by several other NRC inspectors at Sierra Nuclear Corporation. A copy of that inspection report will be forwarded to you when it is issued.

The enclosed copy of our AIT report identifies areas examined during the inspection. At the conclusion of the inspection the AIT discussed its findings and conclusion with you and others of your staff during a public meeting on June 7, 1996.

The AIT concluded that there were no offsite radiological consequences as a result of this event. The AIT further concluded that there were no measured releases of radioactivity from the cask and no unanticipated exposure to your staff.

Your management and staff response during and following the event was good. However, the inspectors identified the following weaknesses associated with this event:

Unloading procedures had not been adequately updated.

A Safety evaluation for a change to the Safety Analysis Report was not thorough.

Robert Link

INTER-OFFICE MEMORANDUM

Estimated final conditions for the lower flammability limit (LFL), stoichiometric, and upper flammability (UFL) concentrations of hydrogen are:

H ₂ Concentration (vol %)	Final Temperature (°F)	Final Pressure (atm)
LFL	717	2.10
stoichiometric	4457	7.65
UFL	1697	3.75

where the ideal gas law was used to estimate final pressure. Maximum over-pressure for an adiabatic, constant pressure process are reported is 6.9 atm (Ref 1, p 2-93).

Over-pressures for confined hydrogen detonations may be estimated using mass, momentum, and energy balances (Chapman-Jouguet relations) but have also been experimentally determined. Results for systems initially at 64 °F and 1 atm (Ref 3) are:

System	Detonation Temperature (°F)	Detonation Pressure (atm)
2H ₂ + O ₂	5989	18.0
2H ₂ + O ₂ + 3N ₂	4945	15.6
2H ₂ + O ₂ + 5N ₂	4373	14.4

Thus for stoichiometric conditions, final temperature and pressure would be approximately 4600 °F and 15 atm, respectively. The results indicate that detonations produce over-pressures considerably in excess of deflagration over-pressures.

Because of the large difference in potential effects, differentiation between deflagration and detonation is desirable. Two conditions, minimum energy for ignition and system length scale relative to detonation cell width, provide guidance. However, in the case of hydrogen, the minimum energy for ignition and the detonation cell width are small relative to expected system conditions. Thus, a conservative approach would assume that detonation can occur.

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EXECUTIVE SUMMARY

On May 28, 1996, after loading a VSC-24 ventilated storage cask with spent fuel, an unanticipated hydrogen gas ignition occurred inside the cask during welding of the shield lid. The gas ignition, which was heard by plant technicians, displaced the shield lid in the upward direction approximately 3 inches, and cocked it at a slight angle. The shield lid is approximately 9 inches thick, 5 feet in diameter and weighs slightly less than 6,400 pounds. There was no evidence of damage to the spent fuel in the cask as a result of the gaseous ignition. The Augmented Inspection Team (AIT) concluded that there were no offsite radiological consequences as a result of this event. During this event, all possible station release pathways to the public were monitored with no indication of abnormal releases. The AIT further concluded that there were no measured releases of radioactivity from the cask and no unanticipated radiation exposure to the staff. There were no personnel injuries.

The licensee's actions during and following the event including management oversight were good. However, the inspectors identified weaknesses in unloading procedures, safety evaluations, corrective actions and rigging practices.

The licensee has concluded and the AIT agrees, that the source of the hydrogen was an electrochemical reaction of zinc in the Carbo Zinc 11 coating when in contact with the borated water in the spent fuel pool (SFP). The coating is used to prevent corrosion of the multi-assembly sealed basket (MSB). At the conclusion of the AIT inspection the licensee had not fully completed their root cause investigation. However, the licensee believes that opportunities were missed during the design, design review, design specifications, and the independent review of the design of the VSC-24 cask to recognize that the electrochemical reaction of the coating, when in contact with borated water, would result in the production of hydrogen.

In addition, the licensee had several opportunities to identify the generation of gas inside of the MSB during previous cask loading operations due to several noted abnormalities. However, the abnormalities were not documented and were not viewed collectively. This is of particular concern because the licensee had direct indications that combustible gas was being produced.

The AIT determined that the potential generic implications of the event extend beyond the use of the VSC-24 system. Consideration should be given to review the adequacy of the chemical compatibility evaluations conducted during design reviews for all dry cask storage designs and facility environments. In addition, consideration should also be given to determine the suitability of Carbo Zinc 11 and other similar coatings used in nuclear applications, where there is the potential to expose them to boric acid.

U.S. NUCLEAR REGULATORY COMMISSION

REGION III

AUGMENTED INSPECTION TEAM

Docket No: 50-266, 50-301, 72-005
License No: DPR-24; DPR-27

Report No: 50-266/301-96005

Licensee: Wisconsin Electric Power Company
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Facility: Point Beach Nuclear Plant Units 1 and 2

Dates: May 30 through June 7, 1996

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REPORT DETAILS

1.0 Purpose of the Augmented Team Inspection

Following initial review of the May 28, 1996, incident involving the unanticipated ignition of a combustible gas during welding of a shield lid on a VSC-24 spent fuel cask, an NRC Augmented Inspection Team (AIT) was formed to examine the circumstances surrounding the event. The AIT Charter (Attachment 1) consisted of evaluations of the licensee's response to the event including the radiation protection consequences of the event to both the plant staff and the general public, the effective-ness of the licensee's root cause investigation, and determination of any potential generic implications of the event.

2.0 Background and Summary of the Event

2.1 Background

Point Beach Nuclear Plant (PBNP) began storing spent nuclear fuel at an Independent Spent Fuel Storage Installation (ISFSI) in December 1995. PBNP utilizes the VSC-24 ventilated storage cask system which it operates under a general license in accordance with 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-level Radioactive Waste" and Certificate of Compliance 1007.

PBNP completed loading its first VSC-24 on December 19, 1995. The second cask load was completed on May 26, 1996. PBNP began loading its third cask on May 26, 1996, following completion of the second cask.

The VSC-24 cask was loaded with spent fuel, removed from the spent fuel storage pool about 4:10 p.m. on May 27, and placed in the cask decontamination area in the auxiliary building. The cask remained mostly filled with water; about 30 gallons had previously been removed to create an air space under the shield lid to facilitate welding. A welding machine was then installed to weld the shield lid in place.

On May 28 at 2:45 a.m., hydrogen gas ignited unexpectedly inside the cask during initiation of welding the shield lid. The gas ignition, which was heard by plant technicians, displaced the shield lid in the upward direction approximately 3 inches and cocked it at a slight angle. The shield lid is approximately 9 inches thick, 5 feet in diameter and weighs slightly less than 6,400 pounds.

Immediately following the event the licensee performed radiation surveys and determined there was no evidence of damage to the spent fuel in the cask. In addition, based on the normal radiation levels and visual

inspections, the licensee determined the fuel was still adequately contained inside of the MSB. Continuous air measurements in the cask decontamination area showed no measurable radioactivity indicating there was no threat to the plant staff or general public. There were no

personnel injuries. Upon removal from the cask, more extensive visual inspections of the fuel were performed, confirming that no damage had occurred to it.

To alert other utilities of the event, on May 31, 1996, the NRC issued Information Notice 96-34, "Hydrogen Gas Ignition During Closure Welding of a VSC-24 Multi-Assembly Sealed Basket." In addition, on June 3, 1996, the NRC issued Confirmatory Action Letters (CALs) to all licensees either currently using or preparing to use the VSC-24 system. The purpose of the CALs was to ensure that the applicable licensees were aware of the event and document their agreement to; assess the potential for the event at their site; and taking compensatory measures to minimize the potential of a similar event at their site including the development of response procedures. The CAL indicated that once these actions had been completed, the licensee must notify the appropriate NRC Regional office, 14 days prior to loading or unloading a VSC-24 cask.

2.2 Licensee Response to the Event [Charter Item No. 3]

The inspectors assessed the licensee's actions during and following the event, including their immediate response to the event, implementation of emergency plans and procedures, event reporting, followup actions, and management response. These assessments were based on the following information:

- Interviews with staff and management directly involved in the loading of all three casks at PBNP and the recovery from the event.

- Observations by onsite NRC inspectors during the recovery from the event.

- A review of licensee loading and unloading procedures.

Overall, licensee response to and recovery from the event was good. Specifically:

- Health Physics was quick to respond and evaluate the radiological consequences of the event. Radiation and airborne contamination levels were monitored with no increases noted.

- Operations, Engineering and Maintenance supervision were also quick to respond to the event. Their immediate focus was to ensure that the cask was in a safe condition and make preparations to safely return it to the spent fuel pool.

- For this particular cask load the licensee was allowed 55 hours, after it is removed from the SFP, to completely drain down the MSB. The time limit is calculated for each cask load in accordance with the Certificate of Compliance. The purpose of the time limit

is to prevent boiling in the MSB and is based on the heat output of the fuel being stored in each cask. If the MSB

cannot be completely drained during this period, it must be returned to the SFP within the allowed time.

To preclude further ignitions, the licensee suspended all hot work in the area and continuously monitored the gap between the shield lid and the MSB for hydrogen.

The duty shift supervisor was quickly notified of the circumstances. He then promptly notified Senior Point Beach Management and the NRC Senior Resident Inspector. A review of the licensee's evaluation of event classification and NRC notification indicate that they properly classified the event in accordance with their procedures and NRC requirements.

On May 28, 1996, Point Beach Management promptly began to develop an action plan for the following activities:

- Determine the source and type of the gas.

- Recover the shims and restore the lid to the correct position.

- Update unloading procedures to take into account the post-event conditions so that the cask could be safely returned to the spent fuel pool before the time limit expired.

Senior licensee managers provided around-the-clock coverage until the cask was returned to the SFP. The cask was successfully returned to the SFP at 8:23 p.m. on Wednesday, May 29, approximately 52 hours after being removed from the pool. The licensee consciously proceeded slowly to ensure they did not experience any further unanticipated conditions. However, delays were encountered when the licensee determined that the shield lid actually weighed more than previously calculated (see Section 2.3).

Following the return of the cask to the SFP, the AIT observed unloading of 16 of the 24 fuel assemblies. A visual inspection of the fuel assemblies, by the licensee, did not show any signs of damage. Once all visual inspections were complete the licensee confirmed that no physical damage had occurred to any of the 24 assemblies.

2.3 Weaknesses Identified During Licensee Response to the Event

The inspectors identified the following weaknesses in the licensee's preparations for loading the cask and subsequent recovery from the event:

2.3.1 Inadequate Design Change Process

Prior to returning the cask to the spent fuel pool, the licensee determined that it had miscalculated the weight of the shield lid. PBNP VSC-24 loading and unloading procedures noted the weight of the shield lid as 4,429 pounds when it actually weighed 6390 pounds (determined during a subsequent weight test by the licensee). This indicates a weakness in the engineering evaluations and design change process for dry cask storage activities.

2.3.2 Inappropriately Sized Rigging

As a result of the shield lid weight discrepancy, the licensee identified an additional concern. Since the weight of the shield lid had been underestimated, the rigging used to move the lid over the spent fuel pool for all previous lifts, had been undersized. The safety factor of the rigging was slightly greater than 10-to-1, therefore the safety significance was minimal. However, PBNP did not meet commitments to the NRC that require a safety margin of 11-to-1 to take in to account the dynamic loading of the crane.

During the investigation of the above issue, the AIT identified another rigging weakness. The rigging used to lower the cask into the ventilated concrete cask for the first two cask loads was also undersized when taking into account the possibility that in an uncontrolled crane lift the cask could actually lift the MSB transfer cask (MTC) as discussed in the Safety Analysis Report. The weight of the MTC had not been taken into account when sizing the lifting slings.

These two weaknesses coupled with the load test discrepancies associated with the MTC as noted in Inspection Reports 50-266/301-95015 and 50266/301-96002, indicated a trend in non-adherence to lifting requirements of the Certificate of Compliance for the VSC-24 cask.

2.3.3 Insufficient Safety Evaluation in Accordance with 10 CFR 72.48

The Management Supervisory Staff verbally approved a safety evaluation in which the shield lid was to be weighed in place on the cask. This was required to determine the actual weight of the lid to ensure that future movements utilized appropriately sized rigging. The method was to use the primary auxiliary building crane to lift the lid during weighing. This method involved administrative controls that relied on worker communication to ensure that the lid was not inadvertently removed from the cask by an uncontrolled crane lift. However, the safety evaluation did not fully address all of the requirements of 10 CFR Part 72.48.

The method proposed may have been acceptable; however, there was insufficient information to support the licensee's conclusion. Specifically, the safety evaluation did not include supporting information, based on experience or dry runs, that communications between workers would be

sufficient to ensure the shield lid would not be inadvertently removed from the MSB and expose the workers to the spent fuel; or that the dose consequence of removing the shield lid from the MSB was not an unreviewed safety question. The inspectors concluded that the safety evaluation did not fully address the following two conditions, as required by 10 CFR Part 72.48.

"If the probability of occurrence or consequences of an accident or malfunction of equipment important to safety previously evaluated in the Safety Analysis Report may be increased" or

"If a possibility for an accident or malfunction of a different type than any evaluated previously in the Safety Analysis Report may be created,"

After the inspectors raised concerns with this issue, the licensee reevaluated their methods to weigh the lid and developed a new approach which did not require the crane to be energized. This prevented the possibility of crane failure from inadvertently removing the shield lid from the cask.

2.3.4 Unloading Procedures not Properly Updated

The inspectors noted cases in which the licensee had not updated unloading procedures in a timely manner. Before the licensee began loading operations for the second cask on May 20, 1996, the resident inspectors expressed concerns that the licensee had not completed updating the unloading procedures with information obtained during the first cask load in December of 1995. The AIT expressed the same concern on May 29, prior to the licensee's returning the cask to the spent fuel pool. Specifically, the AIT raised the concern that the unloading procedures had not been updated to reflect the fact that the shield lid would have to be placed on the spent fuel pool divider wall to install shorter lifting slings to manipulate the lid outside of the pool. The change and updated safety evaluation were not performed prior to removal of the shield lid. This resulted in a delay in which the shield lid had to remain suspended above the spent fuel pool while engineering staff re-evaluated the increased weight of the shield lid on the spent fuel pool divider wall.

2.3.5 Conclusions

None of these weaknesses by themselves pose a significant safety concern. However, collectively they indicate weaknesses in the licensee's evaluation of conditions which could result in circumstances not bounded by the VSC-24, Safety Analysis Report.

3.0 Root Cause Investigation [Charter Item No. 4]

The inspectors assessed the licensee's root cause investigation including potential source(s) of hydrogen generation, and the initial evaluation of the licensee's corrective actions. These assessments were based on the following information:

- Interviews with staff and management directly involved in the root cause investigation of the event at *Point Beach*.

- Participation in the technical discussions between the licensee and design and fabrication vendors.

- Independent NRC research of *the materials* involved.

The licensee's root cause investigation was being performed in two phases. PBNP contacted and obtained onsite support from the VSC-24 vendor, Sierra Nuclear Corporation, and the two other NRC licensed users of the cask, Palisades and Arkansas Nuclear One. All three organizations participated in the PBNPs root cause investigation. Phase I, was nearing completion at the end of the AIT investigation and included:

- Determining of the root cause of the event.

- Identifying of the source of the combustible gas.

- Reviewing of welding procedures, processes and work practices, including purging during welding as is the normal practice for primary side welding activities, positioning of the person performing the welding and sampling for combustible gases.

- Evaluating of operating experience at other utilities using the VSC-24 MSB and Carbo Zinc 11 coating.

- Review of precursors to this event.

Phase II, which was also in progress at the conclusion of AIT included:

- Performing a detailed investigation into the source of hydrogen.

- Performing a detailed inspection of fuel removed from the MSB effected by the event.

- Justifying for the continued use of the MSB affected by the event and the two MSBs which were previously loaded and stored at the ISFSI. This includes further inspection of the MSB effected by the event.

- Reviewing the procedure change process for loading and unloading.

- Reviewing of the VSC-24 Safety Analysis Report.

Reviewing of the VSC-24 component weights and rigging methods.

Reviewing of existing safety evaluations performed in accordance with 10 CFR Part 72.48.

The AIT concluded that the licensee investigation scope was thorough and encompassed the appropriate safety related issues.

3.1 Identification of the Source of Hydrogen

The licensee's investigated several possible causes for the presence of gas that ignited during the tack welding of the lid on the third MSB.

The licensee concluded that the primary source of hydrogen in the cask was the electrochemical reaction of the zinc in the Carbo Zinc 11 coating when in contact with the borated water in the SFP. The licensee proposed that none of the other sources of hydrogen considered could produce sufficient hydrogen to account for the amount of hydrogen present in the cask. The AIT agreed with the licensee's conclusion.

The following is a breakdown, by possible cause, considered by the licensee and the reason the cause was accepted or rejected:

Generation of hydrogen from the Carbo Zinc 11 primer in the cask

Preliminary calculations and measurements by the licensee indicate that the primary source of hydrogen was corrosion of the Carbo Zinc 11 primer. The gas coming from the Carbo Zinc 11 primer was confirmed to be hydrogen, both in the cask and in laboratory experiments where Carbo Zinc 11 coated coupons were immersed in borated water. Gas generation from the laboratory samples was readily apparent and was analyzed and confirmed to be hydrogen by the licensee. Calculations conducted by the licensee predicted hydrogen concentrations in the range of the concentrations measured at the space between the shield lid and the borated water.

Corrosion of the Zircalloy cladding

Preliminary calculations of the quantity of hydrogen produced from corrosion of the fuel cladding indicate that the amount of hydrogen generated would be an order of magnitude lower than the amount observed.

Radiolytic production of hydrogen from the water in the cask

Preliminary calculations indicate that radiolysis of water would not produce hydrogen in the concentrations observed. As further

evidence that radiolysis of water was not responsible for the generation of hydrogen, the hydrogen content in the spent fuel pool was 0.1 cc/kg as compared to 16 cc/kg in the storage cask. Since there was fuel with higher heat output in the spent fuel pool, the concentration of hydrogen should be higher in the spent fuel pool if radiolysis is the primary source of hydrogen. Furthermore, the licensee demonstrated that hydrogen could be generated even when fuel had been removed from the cask unloading.

Defective Carbo Zinc 11 paint

No coating defects were identified that could cause a release of hydrogen. The certified material test report (CMTR), the coating application procedures and the coating check-off lists were reviewed and no unusual occurrences were identified.

Contamination of the Carbo Zinc 11 paint

No contaminants were identified that could cause the release of hydrogen during the review of the CMTR or the check-off list.

Improper application of the Carbo Zinc paint

No evidence could be found that the Carbo Zinc 11 was improperly applied based on the review of the application procedures and the coating check-off list.

Inadvertent introduction of combustible gas during the loading process

No evidence was uncovered that any combustible gas was inadvertently introduced to the cask during the loading process.

3.2 Production of Precipitates

Once the MSB had been returned to the SFP, a white precipitate was observed under the shield lid when it was removed from the MSB. Most of the precipitate floated to the top of the SFP; however, some remained below the surface of the water. The precipitate was foam-like in the water but quickly dried and formed a powder when removed from the water. Samples were analyzed, by Argonne National Laboratory for the licensee, to determine the source of the precipitate. The initial analysis, using X-ray diffraction, identified boric oxide and silicate. Additional chemical analysis indicated that the following elements were the most prevalent:

<u>Element</u>	<u>Concentration</u>
Boron	4.01%
Iron	2.08%

Silica	1.16%
Zinc	14.9%
Aluminum	0.02%

The licensee and NRC discussed this precipitate with Carboline, the manufacturer of Carbo Zinc 11. Carboline indicated that precipitates of zinc are common due to the reactivity of the zinc. The common reactions result in the formation of zinc hydroxide or zinc oxide.

An unanticipated constituent of the precipitate included zinc silicate which would not normally be expected since all of the silicate would be chemically bound in the coating. However, silicate is present in the spent fuel pool from the Boroflex in the fuel racks and was available to react with the zinc. Additional discussions with the PBNP Chemistry Department showed that the silicate level in the cask increased with time. Palisades' representatives indicated that they also noted an increase in silicate levels in the SFP during cask loading. In addition, the boron level in the cask did not decrease with time. Therefore, the boron identified in the precipitate is thought to be the result of borated water and not from a reaction with the zinc.

Carboline stated that the precipitate would not normally float. Additional testing revealed that soap was present in the precipitate. The soap was used during the MSB decontamination process. This appears to be the reason the precipitate floated to the surface of the SFP.

Carboline conducted a study to determine if hydrogen would be generated during dry cask storage. The study indicated that there is almost no hydrogen generation from the coating when the coating is dry. This is a preliminary indication that hydrogen should not develop after an MSB has been drained of water, vacuum dried, and filled with helium in preparation for storage at the independent spent fuel storage installation.

3.3 Conclusions

The occurrence of the hydrogen ignition event made it clear that appropriate attention had not been given to the chemical compatibility of the basket's zinc coating and the spent fuel pool's boric acid conditions. Neither the designer nor the licensee considered the potential for the chemical reaction in their reviews. Several indications that might have alerted the involved parties were available.

The root causes being considered by the licensee are deficiencies in the design, the design review, the design specifications, and the independent review of the design. The licensee has concluded and the AIT agrees, that during one or more of the design steps, the fact that hydrogen would be generated from the electrochemical reaction of the Carbo Zinc 11 coating and spent fuel pool water should have been identified.

4.0 Event Description and Comparison to Previous Cask Loading Activities [Charter Items No. 1 and No. 2]

The event description and sequence of events for all three casks loaded by Point Beach were independently developed and validated by the inspectors. These events were then compared by the inspectors in an effort to identify any differences between the first two cask loads and the third load. Any differences were then reviewed to see if they identified precursors to the event or identified potential root causes of the event. The following information was used by the inspectors during these tasks:

- A review of the licensee's formal and informal logs.

- Interviews with staff and management directly involved in the loading of all three casks at Point Beach including recovery from the event.

- Observations by onsite NRC inspectors during the recovery from the event.

- A review of licensee loading and unloading procedures.

The sequence of events studied consisted of those operations determined to be relevant to the root cause of the event. This comparison identified some anomalies which, in retrospect, are indicative of the conditions thought to have contributed to the hydrogen ignition.

The tasks associated with cask loading which were relevant to this inspection were:

- Filling the cask with borated water.

- Placing the cask into the SFP.

- Loading 24 spent fuel assemblies into the MSB.

- Placing the shield lid on the MSB.

- Removing the MTC and MSB from the SFP

- Draining 30 gallons of water from below the shield lid of the MSB.

- Decontaminating the MTC and MSB.

- Welding the shield and structural lids on the MSB.

- Completing drain down of the MSB.

The actual time-sequence of events for all three cask loading operations was taken mainly from entries in informal logs supplemented by some

events being recorded in the control room log and the procedures check-off list. The informal logs were kept by the project managers to aid in identifying procedure changes to improve future loading operations. The time and date chronology of the relevant events for all three loading operations is given in Attachment 2, Table 1. Attachment 2, Table 2, gives the elapsed time of the relevant loading operations.

4.1 Possible Indications of Hydrogen During Previous Cask Loads

The following sections highlight the differences and abnormalities noted during the three cask loads at PBNP. In addition, although not part of the AIT Charter, several team members did have discussions with the representatives from both Palisades and Arkansas Nuclear One, the other licensees using the VSC-24 cask. Both indicated that, in retrospect, there may have been similar, minor, indications of gas being generated inside the MSB during loading operations.

4.1.1 First Cask Load

Prior to actually loading spent fuel into the first cask, it was used in two pre-operational test "dry run" operations to satisfy Certificate of Compliance requirements. In each of these two evolutions, the cask was flooded with borated water. The cask was flooded a third time when the actual loading operation began. It is likely that the reaction rate of the boric acid and zinc decreased during each of these evolutions resulting in a reduced hydrogen production rate during the actual loading operation. However, the licensee did not observe any gas production in the MSB during these activities.

One event of note during the loading of the first cask was the presence of a small amount of moisture around the vent port which was removed with rags. Although not considered at the time, this moisture may have been the first indication of potential gas

pressure buildup in the cask forcing water out of the vent. The other loading operations associated with the first cask were uneventful.

4.1.2 Second Cask Load

During the welding operations for the second cask load, the week of May 20, 1996, there were also possible indications of gas buildup in the cask but the significance was not recognized by the licensee. The root pass on the shield lid weld was stopped about 3 inches from closure because of the possibility of porosity at the start of the weld caused by an initial high welding machine current. The welders began to grind the area in question to smooth the two weld ends for the final closure weld. The time

between ending the weld and grinding was 2 to 3 minutes. During the grinding operation the welder noticed a small blue flame that burned for 30 to 40 seconds. The intensity of flame was light and as such was not noticeable unless one put a glove or other item behind the flame. When the flame was noticed, the licensee staff present rationalized that it was probably the result of residual cleaner or solvents left from the decontamination or other cleaning procedures. The weld was finished successfully. It was later determined; however, that no flammable solvents or cleaners were used in the decontamination area.

During the subsequent welding operations on the structural lid of the second cask, it was noticed that water was seeping up past the drain port foreign material exclusion plug. The licensee suspected that thermal expansion of the water during cask warm up was pushing up the drain tube and causing this seepage. The engineering staff made a rough calculation and it was concluded that thermal expansion of the water could be the cause of the seepage. This moisture caused the initial seal weld to fail examination. The area was vacuum dried and the weld was successfully completed. In addition, the gas pressure in the cask was vented at least twice to relieve the potential pressure for forcing water up the drain tube.

4.1.3 Third Cask Load

In the third cask loading operation, the shield lid had a tighter fit than for the first two casks. This fit could have retained more hydrogen inside the MSB. It is possible that this overall set of conditions created a hydrogen concentration distribution that supported the hydrogen ignition. The welder, who was kneeling on the shield lid at the time of the hydrogen ignition, jumped off of the lid when he heard the sound. However, he did not feel anything or notice any flash, heat, smoke or odor of a burn which supports the hypothesis that the combustible gas was hydrogen.

The licensee and inspectors also noted a white foamy precipitate that was discovered on the underside of the shield lid when the third cask was unloaded. This effect was not observed when the shield lid was removed after either of the dry runs (see Section 5.2 for further discussions on the precipitate).

4.1.4 Time Available for Gas Generation

A final consideration in the differences between the three cask loading operations was the time available for gas to generate and collect. Two starting points were considered as possible times for gas collection to begin. These were when the shield lid was placed on the cask and when the cask had 30 gallons of water pumped out. The time interval between

the shield lid placement and the beginning of the tack welds was 17.5 hours, 14.25 hours and 11.9 hours for loads one, two and three, respectively. The corresponding time interval from the 30 gallon pump down to tack weld was 13.25 hours, 10.3 hours and 10.4 hours. The third cask was loaded more quickly than the first two operations and thus may have provided less time to generate and collect hydrogen.

The AIT could not conclude if these time differences contributed to the collection and concentration of hydrogen within the MSB.

4.1.5 Condition Reporting System not Always Utilized

The inspectors noted a weakness in the licensee's use of their condition reporting system. Condition reports were not initiated for either of the following issues:

During completion of the root weld of the shield lid during loading of the second cask on May 22, 1996, the welders noted a small blue flame while grinding a portion of the weld. The flame appeared over one of the shims in an area that had not yet been welded. The welders brought this to the attention of their supervisors and Engineering. However, those involved rationalized that the flame was the result of igniting residual cleaning fluid or other solvent from the surface of the cask and/or lid.

In addition, later, during welding of the structural lid on the second cask, the licensee's staff observed water seepage from the cask drain line onto the top of the shield lid. The staff rationalized that the leakage was due to a pressure build-up under the lid from water expansion due to heat generated by the fuel. However, this also could be an indication that some type of gas was collecting underneath the shield lid.

Although these appear to be separate issues, they do, in hindsight, appear to be indications of gas build-up inside of the cask. However, since no condition reports were issued, no further staff or management evaluation of the conditions was conducted.

4.2 Conclusions

When viewed collectively, these abnormalities appear to indicate that a combustible gas was being generated. However, the abnormalities were not aggressively pursued by the licensee either individually or collectively. Had the licensee further evaluated the conditions, it may have been able to identify the generation of hydrogen and prevented the ignition from taking place.

5.0 Determination of Whether Appropriate Attention was given to the Condition of Systems and Components Associated with Dry Cask Evolutions,

Including Compatibility of the Dry Cask with Spent Fuel Pool Conditions.
[Charter Item No. 5]

The inspectors' assessment of the appropriateness of the attention given to the systems and components was based on the following:

Reviewing fabrication and receipt inspection records.

Reviewing inspection procedures.

Interviewing licensee personnel involved in fabrication oversight.

5.1 Oversight of MSB Fabrication

The inspectors examined the licensee's overview and control of the MSB during the entire fabrication and receipt inspection. The inspectors concluded that the licensee had given appropriate attention to the oversight of their fabricators throughout the MSB fabrication process. The licensee had essentially full-time Quality Assurance representation at the fabrication sites and documented its oversight through the use of hold points in the construction documents. Licensee representatives independently verified important parameters such as cleanliness, weld size, and material certifications. Their verifications included detailed parameters such as coating thickness. The licensee's receipt inspection process also independently verified that the casks received on site had been maintained in a quality condition.

5.2 Compatibility of the MSB with the Spent Fuel Pool

As stated earlier, the occurrence of the hydrogen ignition event made it clear that appropriate attention had not been given to the chemical compatibility of the basket's zinc coating and the spent fuel pool's boric acid conditions. Neither the designer nor the licensee considered the potential for the chemical reaction in their reviews. Several indications that might have alerted the involved parties, were available.

First, the coating manufacturer's specification sheet stated that the paint was not recommended for immersion in acids. Secondly, the licensee studied the incompatibility of the coating and the spent fuel pool boric acid in a study it conducted in July 1995. The study noted the potential for the introduction of dissolved zinc and a zinc borate precipitate. Hydrogen generation was not addressed. Since hydrogen is routinely used to maintain reactor coolant chemistry, chemistry personnel only focussed on the effect that zinc would have on the reactor coolant system and did not consider the production of hydrogen during dry cask storage activities. The study was a result of the licensee's policy of having the Chemistry Department review any new item that might introduce chemical contaminants into the spent fuel pool. Unfortunately, the study focused only on potential reactor plant effects and not on the

potential effects on dry cask storage operations.

Review of the Safety Analysis Report for the Ventilated Storage Cask System showed that considerable attention was given to corrosion considerations for long term dry storage, but consideration of the temporary condition of the cask being immersed in borated water was, likewise, not assessed.

The inspectors concluded that insufficient attention was given to the chemical compatibility of the dry cask with spent fuel pool conditions.

6.0 Determination of the Potential Generic Implications of the Event.
[Charter Item No. 6]

The inspectors' assessment of the potential generic implications of the event was based on the following:

Review of the circumstances of the event as described in this report.

Discussions with AIT team members, licensee personnel and management, and NRC staff and management.

The team identified the following potential generic issues. It was noted that other generic issues might be identified as the NRC continued to assess the event subsequent to the AIT inspection.

6.1 Chemical Compatibility Studies for all Currently Licensed Dry Cask Systems

Consideration should be given to review the adequacy of the chemical compatibility evaluations conducted during design reviews for all cask designs. Appropriate focus should be given to the cask interaction with facility environment. Items to consider are:

The amount and acceptable limits of zinc, silica and other unanticipated materials introduced into the spent fuel pool.

Identify materials that may migrate to the reactor coolant system after being introduced into the spent fuel pools.

Examples of oversights identified from this event included the generation of hydrogen from a zinc coating and borated water reaction, and the possibility of water intrusion in the shield lid's shielding material in some shield lid designs. The shield lid design used at Point Beach is seal welded such that water cannot intrude into the shielding material. This is not the case for the shield lid design used by the other two user utilities.

6.2 The Suitability of Carbo Zinc 11 and Similar Products for Use in Nuclear Applications

Consideration should be given to review the suitability of this coating in other nuclear applications, where there is a potential for exposure to boric acid.

6.3 The Adequacy of Cleanliness Controls During Cask Fabrication and Use

Consideration should be given to generically define cask cleanliness controls for all cask designs. This should include the potential for the presence of chemical reaction of residues and other foreign material on fuel and storage cask components. The term "potential" for the presence of material is used because the PBNP casks have some residue; however, it is not clear whether other cask systems would have unanticipated materials.

At PBNP, the casks were not cleaned with water before immersion. In addition, soap was knowingly introduced into the cask during the decontamination process. Neither licensee or the AIT determined what affect these conditions had on the formation of precipitate in the cask.

6.4 The Adequacy of Foreign Material Exclusion (FME) Controls During Cask Loading and Unloading Operations

Consideration should be given to assess what potential hazards exist from the introduction of foreign material into the cask during loading and unloading operations. Determination of specific FME controls should be made.

7.0 Evaluation of the Technical Support by the Vendor for the Prevention of Similar Events. [Charter Item No. 6]

The inspectors' assessment of the technical support by the vendor for the prevention of similar events was based on the following:

Interviews with site personnel including the vendor representative.

Discussions with the NRC team leader conducting an independent inspection at Sierra Nuclear Corporation on June 3-5, 1996.

After the event, the cask designer, Sierra Nuclear Corporation, dispatched an operations engineer to provide technical expertise and assist in the unloading of the cask. Additionally, frequent telephone conference calls were held between the Wisconsin Electric staff and Sierra Nuclear Corporation designers to discuss technical issues pertinent to the analysis of the event. Staff from two other nuclear plants (Palisades and Arkansas Nuclear One) using the cask design also participated in the telephone conferences. An NRC inspection team at Sierra Nuclear noted

that Sierra Nuclear had developed a detailed investigation and action plan in response to the event.

Overall, the inspectors considered the technical support provided by Sierra Nuclear for this event to be adequate. The adequacy of the vendor's support to prevent similar events will be determined by an NRC assessment of its review conducted in response to this event.

8.0 Dry Cask Loading Activities and Radiological Protection Performance As Result of Dry Cask Hydrogen Ignition. [Charter Item Nos. 7 and 8]

The inspectors' assessment concerning radiation protection and precautions taken as part of the dry cask loading and unloading activities and the radiological consequences to the public and staff from the hydrogen ignition event were based on the following reviews:

- Radiological surveys.
- Air sample results (inplant and vent effluent).
- Chemistry sample results.
- Radiation Protection (RP) and Chemistry personnel Interviews
- Direct field observations.

The inspectors concluded that as a result of this event there were no offsite radiological consequences. The assessment indicated that during cask loading operations and the unloading of the third cask good radiological controls were implemented. These controls were part of the radiological protection and chemistry programs developed for those evolutions. The program included appropriate radiation protection and emergency procedures, sound work practices, employee training, monitoring techniques, and ALARA initiatives.

The inspectors further determined that as a result of the May 28, 1996 event, there were no measurable releases of radioactivity from the cask, and radiation exposure to the staff was equivalent to normal work activities associated with the evolution. For this event, all possible station release pathways to the public were monitored with no indication of abnormal releases. In addition, radiation protection and chemistry technicians responded to the event in a timely manner and implemented good radiological controls and measurements. Following the event it was noted that increased radiological surveys were routinely performed as were increased collections of gas and cask samples.

One weakness was identified concerning poor contamination controls around the cask decontamination (decon) area. Specifically, following the transfer of the cask to the decon area on June 4, 1996, surveys on the MSB, on the lid of the MTC, and on the floor of the decon area indicated some increased loose levels of mixed fission and corrosion products. Because of the nature of the area, it was also likely to have radioactive

"hot" particles on and around the cask. For work in that area (chemistry samples, inspection, etc) only booties, gloves, and one set of protective clothing (PC) coveralls were required. When exiting the area, the coveralls were not required to be removed. Given the nature of the work, and the possibility of hot particles, the practice of using only one set of PCs and allowing the PCs to be worn after exiting the area increased the probability of transporting particles and loose contamination. In addition, it was also noted that a fan used to dilute hydrogen produced in the MSB was set up near the top of the MSB and was installed without the knowledge of radiation protection personnel. Although no contamination was identified, the fan had the potential to blow some of the loose contamination off the lid into the decon area. These practices may have contributed to a hot particle shoe contamination on a person who was located outside of the contaminated area. Although there was very little dose from the hot particle, the licensee did not maintain sufficient controls to ensure particles of this type remain in controlled areas.

9.0 Exit Meeting

The team met with licensee representatives (identified below) during a public meeting on June 7, 1996, and summarized the purpose of the AIT, AIT charter items, and inspection findings. The team discussed the likely informational content of the inspection report with regard to documents or processes reviewed by the team during the inspection.

PERSONNEL PARTICIPATING IN THE EXIT MEETING

Wisconsin Electric Power Company

R. Link, Vice President, Nuclear Power
G. Krieser, Manager, Industry and Regulatory Services Section
G. Maxfield, Plant Manager, Point Beach
F. Cayia, Production Manager, Point Beach
A. Riemer, Manager, Nuclear Engineering

U. S. Nuclear Regulatory Commission

C. Paperiello, Director, Office of Nuclear Materials Safety and
Safeguards
J. Grobe, Deputy Director, Division of Reactor Safety, Region III
R. Caniano, Chief, Plant Support Branch 2, Division of Reactor Safety
T. Kobetz, Senior Resident Inspector, Point Beach
R. Paul, Senior Radiation Specialist
J. Davis, Materials Engineer, NRR
C. Withee, Senior Criticality and Shielding Engineer, SFPO, NMSS
P. Narbut, Senior Nuclear Safety Inspector, SFPO, NMSS

Augmented Inspection Team Charter - Point Beach Nuclear Plant

Examine the circumstances surrounding the dry cask ignition event at the Point Beach Nuclear Plant on May 28, 1996, including but not limited to the following:

1. Develop and validate a chronological sequence of events and activities for the dry cask evolution, detailing events just prior to and immediately after the gas ignition.
2. Compare this sequence of events to other dry cask loading evolutions at Point Beach to identify any anomalies associated with this particular load.
3. Evaluate the licensee's actions during and following the event; including their immediate response to the event, implementation of emergency plans and procedures, event reporting, followup actions, and management response.
4. Evaluate the extent of the licensee's analysis and determination of the root cause for the event, including potential source(s) of hydrogen generation, and the initial evaluation of appropriate corrective actions.
5. Determine if appropriate attention was given to the condition of systems and components associated with dry cask evolutions, including compatibility of the dry cask with spent fuel pool conditions.
6. Determine any potential generic implications of the event. Evaluate the technical support by the vendor for the prevention of similar events.
7. Evaluate the adequacy and appropriateness of radiation protection precautions taken by the licensee as part of the dry cask loading activity.
8. Evaluate the radiation protection consequences of the event to both the plant staff and the general public.

Table 1

CHRONOLOGY OF RELEVANT DRY CASK OPERATIONS
(TIME : DATE)

EVENT	LOAD #1	LOAD #2	LOAD #3
(Serial #)	(MSB-01)	(MSB-03)	(MSB-02)
Start MSB fill	0911; 12/11/95	1800e; 5/20/96	2145; 5/26/96
MSB into SFP	1030	2215	2300e
Load fuel	1235-0030; 12/12	0100-1330; 5/21	0100e-1142; 5/27
Shield lid in place	0415	1645	1450
MSB breaks SFP surface	0820	2035	1610
30 gal. Pump down	0830e	2041	1620e
MSB out of SFP	0900	2100	1645
Tack welds begin	2145	0700e; 5/22	0245; 5/28
Shield weld complete	0330 : 12/13	1230	*
Weld structural lid	0900-1530	2300-1100e; 5/23	*
Structural lid seal weld	1640-1715	0405e1; 5/25	*
Drain MSB	2145-2230	1600e-1641; 5/23	*

e - Time of event not recorded; estimate based on adjacent recorded events.

* - Not performed

1 - Drained down prior to completing structural lid seal weld

MSB - Multi-Assembly Sealed Basket

SFP - Spent Fuel Pool removed from the spent fuel pool.

Table 2

CHRONOLOGY OF RELEVANT DRY CASK OPERATIONS
ELAPSED TIME (HRS:MINS)

EVENT	LOAD #1	LOAD #2	LOAD #3
(Serial #)	(MSB-01)	(MSB-03)	(MSB-02)
Start MSB fill	0	0	0
MSB into SFP	1:19	4:15	1:15
Load fuel	15:19; 12 hr	19:30; 12.5 hr	13:57; 10.7 hr
Shield lid in place	19:04	22:45	17:05
MSB breaks SFP surface	23:09	26:35	18:25
30 gal. Pump down	23:19	26:41	18:35
MSB out of SFP	23:49	27:00	19:00
Tack welds begin	36:34	37:00	29:00
Shield weld complete	42:19	42:30	*
Weld structural lid	54:19; 6.5 hr	65:00; 12 hr	*
Structural lid seal weld	56:04	106:00 ¹	*
Drain MSB	61:19	70:00	*

* - Not performed

MSB - Multi-Assembly Sealed Basket

SFP - Spent Fuel Pool

1 - Drained down prior to completing structural lid seal weld

EA No. 96-215

Mr. Robert Link
Vice President, Nuclear Power
Wisconsin Electric Power Company
231 West Michigan Street - P379
Milwaukee, WI 53201

SUBJECT: NRC REGION III AUGMENTED INSPECTION TEAM REVIEW OF THE MAY 28, 1996, HYDROGEN GAS IGNITION DURING DRY CASK STORAGE WELDING OPERATIONS REPORTS NO. 50-266/96005; 50-301/96005

Dear Mr. Link:

On May 30 through June 7, 1996, an NRC Augmented Inspection Team (AIT) conducted an inspection at your Point Beach 1 & 2 Nuclear Plants. The inspection focused on the circumstances surrounding an unanticipated hydrogen gas ignition which occurred on May 28, 1996, during welding of the shield lid on the multi-assembly sealed basket of a VSC-24 spent fuel cask. Specifically, the AIT focused on the radiological significance of the event, your response to the event, your root cause investigation and generic implications related to the event.

The AIT was composed of Messrs. R. Caniano (Team Leader), T. Kobetz, and R. Paul, of this office; C. Withee and P. Narbut of the Office of Nuclear Materials Safety and Safeguards (NMSS); and J. Davis of the Office of Nuclear Reactor Regulation (NRR). A separate inspection was conducted by several other NRC inspectors at Sierra Nuclear Corporation. A copy of that inspection report will be forwarded to you when it is issued.

The enclosed copy of our AIT report identifies areas examined during the inspection. At the conclusion of the inspection the AIT discussed its findings and conclusion with you and others of your staff during a public meeting on June 7, 1996.

The AIT concluded that there were no offsite radiological consequences as a result of this event. The AIT further concluded that there were no measured releases of radioactivity from the cask and no unanticipated exposure to your staff.

Your management and staff response during and following the event was good. However, the inspectors identified the following weaknesses associated with this event:

Unloading procedures had not been adequately updated.

A Safety evaluation for a change to the Safety Analysis Report was not thorough.

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Your staff did not always generate condition reports of unusual occurrences during previous cask loading operations.

Your design change process failed to identify the increased shield lid weight resulting in the use of undersized rigging.

While none of these weaknesses by themselves pose a significant safety concern, collectively they indicate a weakness in your staff's ability to evaluate conditions which may not be bounded by the VSC-24, Safety Analysis Report.

Even though the safety consequences of this event were minimal, we are concerned that your staff had missed opportunities to identify that combustible gas was being generated during cask loading operations. It is disappointing that these opportunities had not been properly documented in accordance with your condition reporting system. Had they been documented, a common root cause may have been identified and this event may have been prevented.

It is not the responsibility of an AIT to determine compliance with NRC rules and regulations or to recommend enforcement actions. These aspects will be reviewed during subsequent inspections.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter, its enclosures and your response to this letter will be placed in the NRC Public Document Room (PDR).

We will gladly discuss any questions you have concerning this inspection. Your cooperation with us is appreciated.

Sincerely,

Hubert J. Miller
Regional Administrator, Region III

Docket Nos. 50-266; 50-301; 72-005

Enclosure: Inspection Reports
No. 50-266/96005(DRS);
No. 50-301/96005(DRS)

See Attached Distribution

Robert Link

-3-

cc w/encl: G. J. Maxfield, Plant Manager
Virgil Kanable, Chief
Boiler Section
Cheryl L. Parrino, Chairman,
Wisconsin Public Service
Commission
State Liaison Officer

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Sincerely,

Hubert J. Miller
Regional Administrator, Region III

Docket Nos. 50-266; 50-301; 72-005

Enclosure: Inspection Reports
No. 50-266/96005(DRS);
No. 50-301/96005(DRS)

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Robert Link

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cc w/encl: G. J. Maxfield, Plant Manager
 Virgil Kanable, Chief
 Boiler Section
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T. P. Gwynn, RIV	S. R. Stein, SRS
J. Lieberman, OE	J. R. Goldberg, OGC

May 29, 1996

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE PNO-III-96-033A

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by Region III staff (Lisle, Illinois) on this date.

Facility

Wisconsin Electric Power Co.
Point Beach 1 2
Two Rivers, Wisconsin
Dockets: 50-266, 50-301

Licensee Emergency Classification

Notification of Unusual Event
Alert
Site Area Emergency
General Emergency
X Not Applicable

Subject: UNIDENTIFIED GAS IGNITED DURING SPENT FUEL CASK WELDING

An NRC Augmented Inspection Team (AIT) has been formed to review the combustible gas ignition which occurred on May 28 during welding of a shield lid on a VSC-24 spent fuel cask. The team is led by a Region III Branch Chief and includes the Senior Resident Inspector, a region-based inspector, and three specialists from the NRC Headquarters Offices of Nuclear Reactor Regulation and of Nuclear Material Safety and Safeguards. The region-based team members arrived on May 28 and the headquarters specialists are due to arrive on May 29.

The licensee has collected gas and water samples from the cask. The samples collected showed detectable levels of a combustible gas (hydrogen) in the air space beneath the shield lid and dissolved in the water in the cask.

The licensee continuously purged the air space inside the cask to prevent any accumulation of combustible gases, while licensee technicians moved the shield lid back into its original position. Shims, which were previously installed to position the lid during welding, were removed. Several shims had been dislodged during the event, falling to the floor of the work area.

The licensee is currently reviewing procedures for returning the cask to the spent fuel storage pool and plans to move the cask later today (May 29). The cask will be fully flooded, eliminating the air space under the shield lid and any potential accumulation of combustible gases in the cask. The licensee plans to remove and inspect the fuel assemblies, placing them in the pool storage racks.

The licensee's investigation of the source of the combustible gas is continuing.

The licensee issued a news announcement on May 28, and NRC Region III issued a news announcement on May 29. There has been area news media interest.

The State of Wisconsin will be informed of this updated information. State officials have been briefed periodically on the status of the event. The information in this Preliminary Notification has been reviewed with licensee management.

This information is current as of 12 noon (CDT) on May 29, 1996.

Contact: MARTIN FARBER
(708)829-9605

ROY CANIANO
(708)829-9904

May 31, 1996

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE PNO-III-96-033B

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by Region III staff (Lisle, Illinois) on this date.

Facility

Wisconsin Electric Power Co.
Point Beach 1 2
Two Rivers, Wisconsin
Dockets: 50-266,50-301

Licensee Emergency Classification

Notification of Unusual Event
Alert
Site Area Emergency
General Emergency
X Not Applicable

Subject: UNIDENTIFIED GAS IGNITED DURING SPENT FUEL CASK WELDING

At 8:20 p.m. on May 29, 1996, the licensee transferred the spent fuel storage cask from the decontamination work area in the auxiliary building to the spent fuel storage pool. At 3 a.m. on May 30 the licensee began unloading the fuel assemblies and placing them in the storage racks in the pool. The unloading was completed by 12 noon on May 30. A visual examination of the fuel assemblies showed no evidence of damage.

Prior to returning the cask to the spent fuel storage pool, the licensee determined that the weight of the shield lid was 6,390 pounds. (The weight was previously reported to be 4,400 pounds.) Although the weight was greater than anticipated, the licensee had used lifting straps rated at 66,000 pounds for moving the lid, providing a substantial margin of safety.

Following unloading of the cask, the cask was moved back to the decontamination work area for further inspection as part of the licensee's investigation of the combustible gas burn. One possible source of the hydrogen being considered by the licensee is a zinc-based coating applied to internal surfaces of the cask. The zinc may have reacted chemically with the acidic water from the spent fuel storage pool, producing hydrogen. (Boric acid is added to the spent fuel pool water for additional criticality control.)

NRC staff members have been continuously at the Point Beach site since the event, monitoring the licensee's response and recovery activities. The Augmented Inspection Team (AIT) has been interviewing plant personnel associated with the cask loading activities and gathering other information associated with the incident.

All nuclear power plants currently using dry cask spent fuel storage systems have been advised of the incident. The NRC Office of Nuclear Material Safety and Safeguards is planning to issue a generic communication to nuclear power plants informing them of the incident and ongoing assessments.

The State of Wisconsin will be informed of this updated information.

There has been continuing news media coverage in the plant vicinity and the Milwaukee area.

This information is current as of 9 a.m. on May 30, 1996.

Contact: ROY CANIANO
(708)829-9904

JACK GROBE
(708)829-9701

June 7, 1996

PRELIMINARY NOTIFICATION OF EVENT OR UNUSUAL OCCURRENCE PNO-III-96-033C

This preliminary notification constitutes EARLY notice of events of POSSIBLE safety or public interest significance. The information is as initially received without verification or evaluation, and is basically all that is known by Region III staff (Lisle, Illinois) on this date.

Facility

Wisconsin Electric Power Co.
Point Beach 1 2
Two Rivers, Wisconsin
Dockets: 50-266, 50-301

Licensee Emergency Classification

Notification of Unusual Event
Alert
Site Area Emergency
General Emergency
X Not Applicable

Subject: UNIDENTIFIED GAS IGNITED DURING SPENT FUEL CASK WELDING
(THIRD UPDATE)

The NRC Augmented Inspection Team (AIT) has completed its onsite review of the ignition of hydrogen gas during welding of a shield lid on a VSC-24 spent fuel storage cask on May 28, 1996. The team held an exit meeting June 7, 1996, with the licensee. The meeting was open to public observation.

Following the event, the VSC-24 cask was returned to the spent fuel storage pool and the fuel assemblies were unloaded. The cask was then moved back to the adjacent decontamination area. There was no apparent damage to the cask components or the spent fuel.

Among the findings of the AIT, which were presented at the exit meeting: The source of the hydrogen gas was a chemical reaction between boric acid in the spent fuel pool water and zinc in a coating on the carbon steel interior of the cask. Hydrogen accumulated in an air space under the shield lid and ignited when technicians began welding the lid in place.

There were possible precursor events at Point Beach during the welding of another cask on May 20, including a minor combustible gas burn. Most of the weld had been completed, and welders were grinding a portion of the weld before finishing the weld. During the grinding, the welders observed a small blue flame at the unwelded portion of the gap between the cask wall and the shield lid. This flame lasted about 30 seconds. The welders incorrectly attributed the flame to residue of a cleaning solvent, and the incident was not documented.

A review of video tapes of the cask loading process at Point Beach and also at the Palisades Nuclear Plant, which also uses the VSC-24 cask, showed visible bubbles rising from the grid portion of the casks. The significance of these bubbles, apparently hydrogen, was not recognized at either facility.

The licensee's response to the event was thorough, and appropriate precautions were taken.

In addition to the AIT inspection at the Point Beach site, the NRC Office of Nuclear Materials Safety and Safeguards conducted an inspection at Sierra Nuclear Co., the cask designer. The separate inspection at the

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Sierra Nuclear facility determined that the potential reaction between the zinc-based coating and the water in the spent fuel pool had not been recognized by the cask designers.

Confirmatory Action Letters were issued by NRC regional offices on May 31, 1996, to the three utilities using or preparing to use the VSC-24 casks. The letter confirms that, prior to any cask loading or unloading, the utilities will assess the potential for generation of combustible gases and take steps to minimize the potential generation and ignition, and have procedures to respond to a gas ignition.

There has been news media interest in the event and the exit meeting. The State of Wisconsin will be provided with this updated information.

This information is current as of 10 a.m. on June 7, 1996.

Contact: ROY CANIANO
(708)829-9904

JACK GROBE
(708)829-9701

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

May 31, 1996

NRC INFORMATION NOTICE 96-34: HYDROGEN GAS IGNITION DURING CLOSURE WELDING OF
A VSC-24 MULTI-ASSEMBLY SEALED BASKET

Addressees

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

Independent spent fuel storage installation designers and fabricators.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to 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. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

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 [6,390 pounds]), leaving it in place but tipped at a slight angle, with one edge about 7.6 centimeters [3 inches] higher than normal.

The 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 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.

Discussion

Following 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.

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The MSB was then fully flooded to eliminate the air space under the shield lid and returned to the spent fuel storage pool. The licensee unloaded the spent fuel assemblies and placed them in the spent fuel pool storage racks.

The 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. 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.

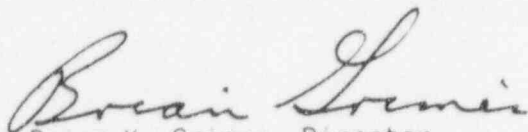
The investigation into the possible sources of hydrogen is focusing on a zinc-based coating applied to the internal surfaces of the MSB. The zinc may have reacted chemically with the acidic borated water from the spent fuel storage pool to produce hydrogen. Borated water is used for criticality control in the spent fuel storage pool water at plants with pressurized water reactors and during fuel loading operations with this cask design.

An NRC Augmented Inspection Team (AIT) has been formed and is on site to investigate the event. The objectives of the AIT are to identify and communicate both the facts of the event and any generic safety concerns and to document the findings and conclusions of the on site inspection.

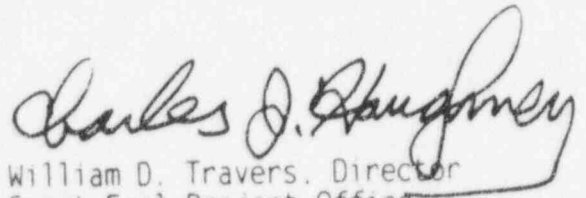
Related Generic Communications

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

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact the technical contact listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.



Brian K. Grimes, Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation



for William D. Travers, Director
Spent Fuel Project Office
Office of Nuclear Material
Safety and Safeguards

Technical contact: A. Hansen, NRR
(301) 415-1390
Internet: agh@nrc.gov

Attachment: List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
96-33	Erroneous Data From Defective Thermocouple Results in a Fire	05/24/96	All material and fuel cycle licensees
96-32	Implementation of 10 CFR 50.55a(g)(6)(ii)(A). "Augmented Examination of Reactor Vessel"	06/05/96	All holders of OLs or CPs for nuclear power reactors
96-31	Cross-Tied Safety Injection Accumulators	05/22/96	All holders of OLs or CPs for pressurized water reactors
96-30	Inaccuracy of Diagnostic Equipment for Motor-Operated Butterfly Valves	05/21/96	All holders of OLs or CPs for nuclear power reactors
96-29	Requirements in 10 CFR Part 21 for Reporting and Evaluating Software Errors	05/20/96	All holders of OLs or CPs for nuclear power reactors
96-28	Suggested Guidance Relating to Development and Implementation of Corrective Action	05/01/96	All material and fuel cycle licensees
96-27	Potential Clogging of High Pressure Safety Injection Throttle Valves During Recirculation	05/01/96	All holders of OLs or CPs for pressurized water reactors
96-26	Recent Problems with Overhead Cranes	04/30/96	All holders of OLs or CPs for nuclear power reactors
96-25	Transversing In-Core Probe Overwithdrawn at LaSalle County Station, Unit 1	04/30/96	All holders of OLs or CPs for nuclear power reactors
96-24	Preconditioning of Molded-Case Circuit Breakers Before Surveillance Testing	04/25/96	All holders of OLs or CPs for nuclear power reactors

United States Nuclear Regulatory Commission
Office of Public Affairs
Washington, DC 20555
Phone 301-415-8200 Fax 301-415-2234
Internet:opa@nrc.gov

No. 96-78

FOR IMMEDIATE RELEASE
(Tuesday, June 4, 1996)

NRC SENDS LETTERS TO THREE UTILITIES
ON SPENT FUEL STORAGE CASKS

The Nuclear Regulatory Commission has issued Confirmatory Action Letters to utilities operating nuclear power plants in Wisconsin, Michigan and Arkansas that use or plan to use spent nuclear fuel storage casks similar to one that experienced a problem last week.

Hydrogen gas unexpectedly ignited during the welding of a lid on a spent fuel storage cask on May 28 at the Point Beach plant, located near Two Rivers, Wisconsin, and operated by Wisconsin Electric Power Company. The storage cask had been loaded with 24 spent fuel assemblies and moved from the spent fuel storage pool at the plant to an adjacent work area--preparatory to placing it on an outdoor concrete pad at the plant. The gas ignition displaced the lid, leaving it in place but tipped at a slight angle. The event caused no injuries nor releases of radioactive material and no apparent damage to the spent fuel or the storage cask.

The cask in use was the VSC-24, designed by Sierra Nuclear Corporation, Scotts Valley, California.

The NRC's letters are directed to Wisconsin Electric and to Consumers Power Co., operator of the Palisades Nuclear Power Plant near South Haven, Michigan, which has loaded 13 casks of the same type and plans to load others, and Entergy Operations, Inc., operator of the Arkansas nuclear power plant near Russellville, which plans to load spent fuel into VSC-24 casks some time after June 18.

The letters confirm NRC's understanding that the utilities will take the following actions:

- Assess the potential for the generation and ignition of hydrogen or other explosive gases during all phases of operation of the VSC-24 system.

U.S. NUCLEAR REGULATORY COMMISSION
Region III Office of Public Affairs
801 Warrenville Road, Lisle IL 60532-4351

NEWS ANNOUNCEMENT: RIII-96-23

June 4, 1996

CONTACT: Jan Strasma 708/829-9663
Angela Dauginas 708/829-9662
E-mail: opa3@nrc.gov

NRC SPECIAL INSPECTION TEAM TO PRESENT ITS FINDINGS
ON GAS BURN IN SPENT FUEL CASK AT POINT BEACH NUCLEAR PLANT

A Nuclear Regulatory Commission Augmented Inspection Team will meet Friday (June 7) with Wisconsin Electric Power Company officials to discuss the findings of its review of a hydrogen gas burn in a spent fuel storage container May 28 at the Point Beach Nuclear Power Station. The Station is near Two Rivers, Wisconsin.

The meeting will be at 10 a.m. in the Two Creeks Town Hall, located at State Highway 42 and Tapawingo Road north of Two Rivers, Wisconsin.

The six-person inspection team is headed by Roy Caniano, a Branch Chief from the NRC's Region III Office. Dr. Carl Paperiello, Director of the NRC's Office of Nuclear Material Safety and Safeguards, and other NRC staff members will also attend the meeting.

The hydrogen gas burn occurred as technicians were beginning to weld a shield lid on the spent fuel storage container after it was loaded with 24 fuel assemblies. There was no evidence of damage to the storage container or to the fuel assemblies as a result of the gas burn.

The spent fuel assemblies were subsequently placed back in the spent fuel storage pool.

The investigation into the cause of the incident is focussing on a zinc-based coating used on internal surfaces of the container. The coating may have reacted chemically with the acidic water from the spent fuel storage pool to produce hydrogen.

The meeting between the NRC staff and Wisconsin Electric officials will be open to public observation. At the close of the meeting there will be an opportunity for questions and comments from members of the public.

The team will issue a written report in several weeks.

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- Have compensatory actions in place to minimize the potential for the generation and ignition of such gases.
- Have in place procedures to respond in the event of a gas ignition and have appropriate personnel trained in these procedures.
- Two weeks before loading or unloading a VSC-24 cask with spent fuel, or placing a VSC-24 cask in the spent fuel pool, contact the NRC.

The letters require the utilities to notify the NRC when they have completed these actions.

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FROM : Panasonic PPF



UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
801 WARRENVILLE ROAD
Lisle, Illinois 60532-4351

June 3, 1996

CAL No. RIII-96-0005

Mr. Robert Link
Vice President, Nuclear Power
Wisconsin Electric Power Company
231 West Michigan Street - P379
Milwaukee, WI 53201

SUBJECT: CONFIRMATORY ACTION LETTER

Dear Mr. Link:

On May 28, 1996, an event occurred involving a VSC-24 spent fuel storage cask at your facility. During that event, a hydrogen gas ignition occurred during the welding of the shield lid on a VSC-24 multi-assembly sealed basket (MSB). The gas ignition displaced the shield lid, leaving it in place but tipped at a slight angle.

The VSC-24 multi-assembly transfer cask (MTC), a shielded lifting device used to transfer the MSB loaded with spent fuel for storage, had been placed in the cask decontamination work area in the auxiliary building. Approximately 30 gallons of spent fuel pool water had been drained to facilitate welding of the shield lid by 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.

Although the gas ignition caused no injuries, no radiological releases, and no apparent damage to the spent fuel or to the storage cask, the staff is concerned that such an event has not been evaluated and could potentially result in more severe consequences. Therefore, on May 29, 1996, an NRC Augmented Inspection Team (AIT) was formed and sent to Point Beach to investigate the event. The objectives of the AIT are to identify and communicate both the facts of the event and any potential generic safety concerns and to document the findings and conclusions of the onsite inspection.

FROM : Panasonic PPF

Robert Link

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Pursuant to a telephone conversation between Fred Cayia, Production Manager, and Jack Grobe, Deputy Director, Division of Reactor Safety, and other members of my staff on June 3, 1996, it is our understanding that you have taken or will take the following actions prior to loading or unloading a VSC-24 cask with spent fuel or placing a VSC-24 cask into the spent fuel pool:

- (1) You will assess the potential for the generation and ignition of explosive gases during all phases of operation of the VSC-24 system;
- (2) You will have compensatory actions in place to minimize the potential for the generation and ignition of explosive gases;
- (3) You will have procedures in place to respond in the event of a gas ignition and the applicable personnel trained and briefed accordingly; and
- (4) Upon completion of the above actions, and 14 days prior to loading or unloading a VSC-24 cask with spent fuel or placing a VSC-24 cask into the spent fuel pool, you will contact William L. Axelson, Director, Division of Reactor Projects, at (708) 829-9600.

Pursuant to Section 182 of the Atomic Energy Act, 42 U.S.C. 2232, you are required to:

- 1) Notify me immediately if your understanding differs from that set forth above;
- 2) Notify me if for any reason you cannot complete the actions within the specified schedule and advise me in writing of your modified schedule in advance of the change; and
- 3) Notify me in writing when you have completed the actions addressed in this Confirmatory Action Letter.

Issuance of this Confirmatory Action Letter does not preclude issuance of an order formalizing the above commitments or requiring other actions on the part of the licensee; nor does it preclude the NRC from taking enforcement action for violations of NRC requirements that may have prompted the issuance of this letter. In addition, failure to take the actions addressed in this Confirmatory Action Letter may result in enforcement action.

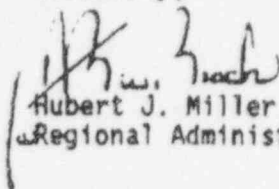
The responses directed by this letter are not subject to the clearance procedures of the Office of Management and Budget as required by the Paperwork Reduction Act of 1980, Pub. L. No. 96-511.

Robert Link

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In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and your response will be placed in the NRC Public Document Room (PDR). To the extent possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be placed in the PDR without redaction. However, if you find it necessary to include such information, you should clearly indicate the specific information that you desire not to be placed in the PDR, and provide the legal basis to support your request for withholding the information from the public.

Sincerely,



Hubert J. Miller
Regional Administrator

Docket No. 50-266

Docket No. 50-301

cc: G. J. Maxfield, Plant Manager
Virgil Kanable, Chief, Boiler Section
Cheryl L. Parrino, Chairman,
Wisconsin Public Service Commission
State Liaison Officer

BACKFIT CONSIDERATIONS

Part 71.43(d): "A package must be made of materials and construction that assure that there will be no significant chemical, galvanic, or other reaction among the packaging components, among package contents, or between the packaging components and the package contents, including possible reaction resulting from leakage of water, to the maximum credible extent. Account must be taken of the behavior of materials under irradiation." ADDRESSEES REQUESTED ACTIONS 1(a), 1(b) & 1(c)

Part 72 Subpart F: General Design Criteria

- § 72.122(h) [Confinement Barriers and Systems]; "The spent fuel cladding must be protected during storage against degradation that leads to gross ruptures ... such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage." ADDRESSEES REQUESTED ACTION 1(c); VSC-24 VENDORS & USERS ACTIONS 1(a), 1(b) & 1(c)
- § 72.122(i) [Retrievability]; "Storage systems must be designed to allow ready retrieval of spent fuel ... for further processing or disposal." ADDRESSEES REQUESTED ACTIONS 1(c)(ii) & 2

Part 72 Subparts K & L: General License and Approval of Spent Fuel Casks

- § 72.236(c) [Subcriticality Requirement]; "The cask must be designed and fabricated so that the spent fuel is maintained in a subcritical condition ...". ADDRESSEES REQUESTED ACTION 1(b)(ii)
- § 72.236(f) [Adequate Passive Heat Removal Capacity]; "The cask must be designed to provide adequate heat removal capacity without active cooling systems". ADDRESSEES REQUESTED ACTION 1(c)(i); VSC-24 VENDORS AND USERS REQUESTED ACTION 1(b)
- § 72.236(g) [Twenty Year Safe Storage]; "The cask must be designed to store the spent fuel safely for a minimum of 20 years and permit maintenance as required". VSC-24 VENDORS AND USERS REQUESTED ACTIONS 1 & 2
- § 72.212(b)(9) & 72.40(a)(5) [Written Operating Procedures]; "Conduct activities related to storage of spent fuel under this general license only in accordance with written procedures" and "The applicant's proposed operating procedures to protect health and to minimize danger to life or property are adequate". ADDRESSES REQUESTED ACTION 1(d) & VSC-24 VENDORS AND USERS REQUESTED ACTION 2
- § 72.236(h) [Compatibility with Loading and Unloading Facilities]; "The cask must be compatible with wet or dry spent fuel loading and unloading facilities". VSC-24 VENDORS AND USERS REQUESTED ACTION 1
- § 72.234(b) [Conditions of Approval]; "Design, fabrication, testing and maintenance of spent fuel storage casks must be conducted under a quality assurance program that meets the requirements of Subpart G ...". ADDRESSEES REQUESTED ACTION 1(a)

Part 72 Subpart G: Quality Assurance

- § 72.146(b) [Design Control]; "... The licensee shall apply design control measures to items such as the following ...compatibility of materials ...". ADDRESSEES REQUESTED ACTION 1(a)