THE EFFECTS OF CHANGES IN THE CERTIFICATES OF COMPLIANCE FOR RADWASTE SHIPPING CASKS

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ABSTRACT

In August 1984, the Nuclear Regulatory Commission (NRC) changed the certificates of compliance for at least 30 radioactive waste shipping casks. The change added new requirements for waste packages which contain materials that could generate inflammable gases, such as hydrogen, after they are sealed. This change resulted from experience at Three Mile Island with EPICOR II liners and from research performed by the Brookhaven National Laboratory.

However, these new requirements are controversial for two reasons. First, as written, they apply to wastes which historically have not demonstrated a gas generation problem during the relatively short period between packaging and shipping; second, the new requirements result in increased personnel exposure and increased disposal costs for the waste generator. After 1985, when more and more waste is placed in long term storage on site, the gas generation problem will become significant, and the personnel exposure required for container venting will be increased further.

NEW CERTIFICATE OF COMPLIANCE REQUIREMENT

During the cleanup of Three Mile Island liquid wastes, significant concentrations of hydrogen gas were detected in sealed organic ion exchange waste containers. This waste contained about 1000 curies of activity, much more than typical plant waste. However, this experience, coupled with information from two technical studies performed by Brookhaven National Laboratory, gave the Nuclear Regulatory Commission (NRC) concern about the safety of cask shipments.[1,2] Therefore, the NRC Waste Management Group was tasked with conducting research on hydrogen generation over long periods in containers loaded with more typical plant waste. The Brookhaven studies confirmed the following facts:

- When organic ion exchange resins are subjected to ionizing radiation, two gas generating processes take place. First, residual water in the resin decomposes to form hydrogen gas and oxygen. Second, the ionizing radiation present in the container acts as a catalyst to a chemical reaction between oxygen and the resin and water in the container. Finally, when all the oxygen that was present in the container air void space has reacted, the hydrogen gas buildup becomes significant enough to increase the container pressure above atmospheric pressure.
- The hydrogen gas generation rate increases in an almost linear relationship with increasing curie content in the resin.
- The oxygen/resin/water reaction depletes the oxygen in the container and generates carbon dioxide gas. This reaction actually mitigates the combustion hazard associated with the hydrogen gas generation.
- As gas pressure in the waste container increases, hydrogen may leak or diffuse from the container into the void space inside the shipping cask. The oxygen in this void space cannot react with the resin and water inside the waste container to form carbon dioxide. Therefore, the potential for combustion of the hydrogen/oxygen mixture exists.

Acting on this information and on the Waste Management Group's research, the NRC's Transportation Branch issued new requirements for secondary containers shipped inside an NRC-licensed shipping cask.

New Requirements

For any package containing water and/or organic substances which could radiolytically generate combustible gases, a determination must be made by tests and measurements of a representative package such that the following criteria are met over a period of time that is twice the expected shipment time:

- The hydrogen generated must be limited to a molar quantity that would be no more than 5 percent by volume (or equivalent limits for other inflammable gases) of the secondary container gas void if present at STP (i.e., no more than 0.063 g-moles/ft^3 at 14.7 psia and 70°F); or
- The secondary container and cask cavity must be inerted with a diluent to assure that oxygen must be limited to 5 percent by volume in those portions of the package which could have hydrogen greater than 5 percent.

For any package delivered to a carrier for transport, the secondary container must be prepared for shipment in the same manner in which determination for gas generation is made. Shipment period begins when the package is prepared (sealed) and must be completed within twice the expected shipment time.

For any package containing materials with radioactivity concentration not exceeding that for low specific activity material, and shipped within 10 days of preparation, or within 10 days after venting of drums or other secondary containers, the determination

in above item need not be made, and the time restriction above does not apply.

These requirements will affect most cask shipments made from nuclear power plants. Resins, binders, waste sludge, and wet filters contained in high integrity containers or solidified must be analyzed, filled with inert gas, or vented prior to shipping. Dry compacted or uncompacted waste and irradiated hardware are not affected by these new requirements.

NRC POSITION ABOUT THE NEW REQUIREMENT

The NRC recognizes that the Department of Transportation already prohibits the transport of packages classified as radioactive material that have combustible concentrations of gases. It is the shipper's responsibility to know what material is shipped in a container and the hazards associated with that material. The new certificate of compliance requirements were established to assist the shipper by clarifying shipment conditions related to the use of NRC-licensed casks. The new requirements are based on worst case test data which show that low specific activity (LSA) material in greater than Type A quantities and solidified in an organic-based binder could result in combustible quantities of hydrogen within 100 days. The integrity of the shipping cask could be compromised if an explosion were to occur during transit. Although the problem of hydrogen gas generation has only been seen in containers with greater than Type A quantities of waste, shippers should be alert to the fact that the same physical conditions exist in containers with Type A quantities of waste as well. However, the time needed for hazardous conditions to exist is much longer. In recognition of the fact that there has not been much research done on this subject, the NRC made the new requirements conservative. The combined research efforts of the NRC and the industry eventually may provide enough data to justify less conservative regulations.

WASTE GENERATOR POSITION ABOUT THE NEW REQUIREMENT

Initially, radioactive waste generators considered this new requirement to be overly conservative and too costly in terms of dollars and increased personnel exposure. Waste generators who ship radioactive waste in casks are affected in the following ways:

- Personnel exposure will increase. Most radioactive waste is shipped in casks because the activity of the container is too high for shipment in an unshielded vehicle. The requirement to reopen or vent these containers prior to shipping results in double personnel exposure to radiation in these containers: first, when the container is packaged and sealed; second, when it is vented prior to placement in a cask for shipping. In fact, the exposure to an individual technician could be more than double because packages are frequently stored together in one area until a cask is available for shipping. The dose rate in the general area where the technician is working to vent containers is likely to be much larger than the dose rate in the area where the container was first closed.
- Shipping costs will increase. Shipping casks are normally rented on a per day basis with a specified number of hours for loading and unloading operations before demurrage and detention charges are made. This practice is especially true for Type B casks, which are in high demand. The venting requirement or the requirement to fill the cask with inert gas will result in extra delays and, therefore, in higher shipping costs.

There is another cost factor involved: the price of the containers themselves. Some containers used now are permanently sealed and cannot be vented at all. System modifications to handle special containers may be very costly. If special containers are purchased with simple and rapid venting capabilities, the demurrage and detention charges can be reduced or eliminated. However, the price of each container will surely increase because the positive vent devices suitable for venting these containers are expensive.

Soon after the NRC placed these new requirements on secondary containers shipped in NRC-licensed casks, the Utility Nuclear Waste Transport Group and the Nuclear Waste Management Group formed a Task Force on Hydrogen Generation to study the new requirements and the basis for them. Its initial evaluation declares that the new requirement is overly conservative.

The Brookhaven National Laboratory research[1] concluded that a radionuclide loading in organic ion exchange resin must not exceed 10 Ck/ft^3 to limit the effects of radiation on organic resins. This curie loading of Cs^{137} and Sr-90 would result in hazardous container handling conditions either at the waste generator's site during loading or during unloading at the burial site. A recent Electric Power Research Institute (EPRI) survey[3] covering 34 nuclear power plants showed that routine organic resin shipments from plants are less than the 10 Ci/ft^3 limit. Sometimes shipments as high as 60 Ci/ft^3 are made. According to the EPRI survey results, this situation would be quite infrequent and, therefore, would not significantly affect normal radwaste operations. If the new NRC requirements were stated in terms of curie loading rather than hydrogen gas generation rate, the impact on plant operations would be significantly reduced because curie loading on all radwaste shipments is a routine calculation. Without performing any additional calculation, the waste generator could determine if a container would need venting prior to shipment. However, other factors such as container geometry, void space volume, isotope and physical characteristics of the waste material shipped have a significant influence on the hydrogen gas generation rate. This fact prevented the NRC from stating the new requirements in terms of curie loading alone.

However, as the task force collected more information, it found that some of the assumptions made in the initial studies on gas generation were not conservative. For example, the hydrogen generation factor varies for cation, anion, and mixed bed resins. When the worst case number is used, the quantity of hydrogen that may be present could be more than originally reported.

The task force has also recognized that the NRC's concern about combustion problems during transport of the waste to the burial site should include the waste generator's problem with long-term storage of such waste containers on site. Now, and for the rest of 1985, it will still be possible to ship a secondary container within 10 days of sealing. However, after the existing burial sites restrict their waste receipts to waste generators in a given compact, waste shipments within 10 days of sealing time would become unrealistic. There may be no site to ship to. Such containers may be stored for as long

as 2 years on site before they are shipped. Because of the high density storage, personnel assigned to vent these containers in 1988 or 1989 will be subject to when they first sealed the containers. Also, the high density storage will increase the ionizing radiation exposure and, therefore, the hydrogen generation rate in each container becasue radiation from one container will affect adjacent containers. Areas planned for long-term storage must be designed to dissipate the gases vented from containers during storage, and plans must be made for simple venting so that personnel exposure is minimized. With proper ventilation on combustion hazard in a storage facility is minimized because, unlike the cask environment, the vented gases are swept away and not confined within a small volume of air.

Also, over the next several years the hydrogen generation and personnel exposure problems are likely to compound because new ion exchange technology will surely increase the curie loading in the secondary waste containers. These new ion exchange media must be evaluated to determine whether or not hydrogen or other combustible gases will be a concern after the containers are sealed. The task force is asking EPRI to fund studies on this subject.

With these potential hazards identified, the primary goal of the task force is to collect enough background information to support methods which would accurately calculate the combustible gas generation rate in waste containers. Then the frequency of venting containers could be based on the calculated gas generation rate. Personnel exposure required to test and measure containers would be eliminated and the frequency of container venting in a long-term storage building would be minimized. The findings and methods developed by the task force would then be presented to the NRC for review.

Several organizations are working on computer programs or a series of curves which would make the gas generation rate calculation simple and accurate. The programs or curves consider parameters such as the waste form, the radioactive concentration and isotope, the container void space volume, the total mass, and the accumulated dose in the waste. One problem that has already been identified is that of proprietary information associated with ion exchange medias. Suppliers must specify what materials are present so that these calculation methods work or provide certified information about the gas generation rate in that material.

CONCLUSION

The NRC was prudent in placing new requirements on secondary containers shipped in NRC shipping casks. Since there was uncertainty in the data describing combustible gas generation in such containers, the NRC was circumspect in its requirements on the radioactive waste generators. The waste generators responded by performing studies which clarify the gas generation problem and which actually show that the NRC requirements may not be too conservative. The studies also confirm that not only shipping but long-term storage of radioactive waste will be affected by the gas generation problem.

The industry task force formed to study the gas generation problem will submit a report to the NRC in summer 1985. The report may provide sufficient information to justify a change in these NRC requirements. That information will probably support the need for special automatic venting devices on some secondary containers planned for long-term storage. Such devices have already been designed for Three Mile Island waste containers to reduce the personnel exposure assocaited with venting containers in long-term storage.

The regulatory inspired research described here is an example of how the regulatory review of nuclear industry operations works to identify problems and initiate industry solutions to those problems. Good communications between the nuclear industry operators and the regulators are necessary to ensure a continuously improving electric power generating industry.

REFERENCES

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3. "EPRI Technical Brief, "Combustible Gases in Irradiated Organic Ion Exchange Resins," RP2558.

4. USNRC IE Information Notice No. 84-72, "Clarification of Conditions for Waste Shipments Subject to Hydrogen Gas Generation".