Lessons Learned
HQ-EH-2004-01

Title: Degradation and Failure of Stored Radiological Material Containers and Packages
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Summary:
The failure of an irradiated test specimen canister on December 3, 2003 and the breaching of a plutonium-238 package and resulting in worker uptake exposures on August 5, 2003 demonstrate that long-term storage of radioactive material containers and packages continue to pose hazards. Corrosion and other degradation of radioactive material packages and their contents, in combination with the buildup of pressurized flammable gases from radiolysis and decomposition, can create the potential for accidents unless such conditions are considered in design and maintenance, and for the actual storage lives of the packages.

Lesson Learned Statement: Recent events demonstrate that long-term storage of radioactive material containers and packages continue to pose hazards. Corrosion and other degradation of radioactive material packages and their contents, in combination with the buildup of pressurized flammable gases from radiolysis and decomposition, can create the potential for accidents unless such conditions are considered in design and maintenance, and for the actual storage lives of the packages.

Discussion: On December 3, 2003, at the Naval Reactors Facility on the Idaho National Engineering and Environmental Laboratory, a canister containing an irradiated non-fuel test specimen failed catastrophically while stored in a water pool. The failure made a large noise, dislodged the stainless steel canister (made from 4-inch diameter schedule 40 pipe, 18 inches long), ruptured its brass cap, and projected part of the cap 10 feet away underwater. No injuries or other damage occurred and there was no measurable release of radioactivity to the environment.

The brass cap screwed onto the canister, with two nitrile rubber o-rings providing a watertight seal. Investigators found evidence of water leakage inside the canister. Their preliminary conclusion is that during the 14 years the canister was stored in the water pool, the nitrile rubber seals degraded from exposure to high-flux gamma radiation emitted from the test specimen. Water leaked into the canister and the canister subsequently resealed tightly as a result of the brass cap's corrosion. Radiolysis caused the captured water to break down into hydrogen and oxygen gas, pressurizing the canister. (Decomposition of the nitrile rubber could also generate flammable gases.) The investigators concluded that the hydrogen detonated and caused the failure. Although the ignition source is not now clear, it could have been thermal energy from the specimen, reactions from radicals produced by the radiolysis, sparking from interaction of metallic components, or static electricity discharge.

Another recent case involving hazards from degradation of a radioactive materials container occurred on August 5, 2003, at Los Alamos National Laboratory (LANL) Technical Area 55. A package containing residues from plutonium-238 operations breached while being handled by two workers performing a pre-inventory check. The pressurized release of materials from the package gave the workers uptake doses of two or three rems CEDE. Slightly different release conditions could have increased the doses by orders of magnitude.

The plutonium-238 package had been in storage since 1996. A subsequent Type B investigation concluded that chemical, radiolytic, and thermal decomposition of the package and its contents produced significant corrosion and gas in the package. The corrosion caused "breathable" seams in the package to seal and resulted in the buildup of gas pressure. Handling the package dislodged corrosion in the package and pressurized contaminated gases vented into the room's atmosphere.

Analysis: In DOE, the causes and potential consequences from aging and degradation of radiological material packages have been well know since at least the early 1990's. Then, many packaging configurations intended for only temporary storage became subjected to much longer storage periods. The increased frequencies and mechanisms of radioactive material packaging failures were analyzed and disseminated in initiatives such as the Plutonium and Highly Enriched Uranium Vulnerability Studies. A considerable effort was made to process or repackage the stored materials. Today, however, there are still radioactive material packages poorly designed for extended storage, as evidenced by recent events.

The report of the Type B accident for the LANL occurrence noted that corrosion and degradation of similar plutonium-238 residue packages had caused multiple near miss events since 1994. In the prologue to this report, the Manager of the Los Alamos Site Office stressed that the accident could have been avoided if only the lessons learned from the near misses had been addressed.

Recommended Actions:

- The design, evaluation, and maintenance of radioactive material packages must address aging and degradation of their contents and packaging components.
- The design, evaluation, and maintenance of radioactive material packages should consider potential scenarios involving combinations of component failures, particularly aging mechanisms that open and seal containment and vents in combination with those that generate flammable and pressurized gases.

- The packaging of radioactive materials in long-term storage should be checked to see if they have design specifications compatible with currently planned storage lives and conditions.
- If such design specifications are not met, or do not exist, then the packaging needs to be evaluated for currently planned storage lives and conditions.
- Near misses from packaging failures need be recognized and addressed to prevent future accidents.
- When dealing with radioactive material packages that have not been designed to current standards (i.e., legacy materials), always assume that the package is unsafe until it is proven safe or repackaged to current standards.

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References:
ALO-LA-LANL-TA55-2003-0017, Two Employees Found Contaminated After CAM Alarmed During Work in TA-55, Building 4, Room 201B
Type B Accident Investigation of the August 5, 2003 Plutonium-238 Multiple Uptake Event at the Plutonium Facility, Los Alamos National Laboratory, New Mexico, December, 2003.
DOE/EH-0415, Plutonium Working Group Report on Environmental, Safety and Health Vulnerabilities Associated with the Department's Plutonium Storage, November 1994.
DOE/EH-0525, Highly Enriched Uranium Working Group Report on Environmental, Safety and Health Vulnerabilities Associated with the Department's Storage of Highly Enriched Uranium, December 1996.
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