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May 14, 2015

Defense Nuclear Facilities Safety Board
625 Indiana Avenue NW, Suite 700
Washington, DC 20004–2901

Subject: Comments Relating to "Safety During Recovery and Resumption of Operations; DNFSB Waste Isolation Pilot Plant Public Hearing, Carlsbad, New Mexico Wednesday April 29, 2015".

Documents may be sent to the Board's Washington, DC office.
The Board will hold the record open until May 25, 2015, for the receipt of additional materials.

Thank you for the opportunity to present several comments at the April 29 Hearing. I was encouraged by the presentations by the DNFSB staff and the open discussions by the Board. The few minutes I had to speak did not provide enough time to fully articulate a number of key, in my view, points.

Knowledge Management of waste drum loading at the Generator Sites coupled with rigorous training, and proficiency examinations for the persons loading the drums and their supervisors, can be a key element in establishing some increment of reasonable assurance that the persons loading these drums, and their supervisors, will have the requisite knowledge and awareness of a potentially hazardous situation. There are numerous examples of waste drum fires/detonations as well as interactions between nitric acid and organic materials in the DOE complex. The Nuclear Safety article I mentioned in my remarks

(Nuclear Safety, Volume 33, No. 2, April-June 1992: "An Assessment of the Flammability and Explosion Potential of Defense Transuranic Waste" by Dr. Matthew Silva) contains examples in the public record up to about 1991. I have enclosed a copy of that article for your information and use by the DNFSB staff. It really does no good if all this knowledge is spread about in various ORPs documents and site specific reports (for example, WSRC-TR-91, "Adverse Experiences with Nitric Acid at the Savannah River Site", Durant, Craig, et al, 1991). Accordingly, a robust training syllabus and a proficiency examination for waste loaders and their supervisors should provide the framework to reduce the likelihood of another WIPP drum incident.

The Accident Investigation Board Report on the February 5, 2014 Fire is replete with significant deficiencies and ineffective programs, actions, management, leadership and oversight. During the DNFSB Hearing DOE and NWP presented some of the "fixes" and promises of fixes.

"Repeat deficiencies were identified in DOE and external agencies assessments, e.g., Defense Nuclear Facility Safety Board (DNFSB) emergency management, fire protection, maintenance, CBFO oversight, and work planning and control, but were allowed to remain unresolved for extended periods of time without ensuring effective site response." (Reference: AIB Report on the February 5, 2014 Fire).

It is exceedingly important that a truly independent organization (non-DOE affiliated), with the requisite ability and qualifications, verify the efficacy of the proposed fixes, assure that there are no cross impacts of the proposed fixes, assure that the fixes are indeed implemented in a timely manner and assure that the fixes are maintained in accordance with recommendations and good practice. In addition, many portions of the WIPP infrastructure is mature (that is, was installed many years ago making the acquisition of repair parts and equipment challenging) importantly exacerbating the issue of the interface between older technologies with newer technologies.

Over the past year, members of the public have repeatedly requested the release of radiation survey data of the "contaminated" areas of the underground, by survey date, by location, identifying the instrument and the probe used. These data are obviously available, records are made (or should be made) of each survey. The requests have been stonewalled. These data are important and are directly relevant to safety during recovery and resumption of operations. It clearly is in the public interest and to the mission of the DNFSB to have the data available. Accordingly, I respectively request that the Board request these data for the Board's use and then make the data available and be updated on a regular basis as future surveys are done. A pretty coloured map of the underground in February 2015 is nearly irrelevant. The survey data are key.

The "workers" at WIPP have experienced two significant accidents: the underground fire on February 5, 2014 and the drum detonation on February 14, 2014 and a number of employees above ground received internal contamination as a result of the drum detonation. All this from a DOE facility that was to start clean, operate clean and remain clean. Worker morale in all likelihood has been degraded. Management safety leadership clearly has a significant effect on worker safety culture. There must be a direct and unambiguous linking of what leadership says and what leadership does in order to positively influence worker safety culture. When there is a departure from what leadership says and what it does, worker safety culture is degraded.

The extremely serious accidents (with one worker disabled from smoke inhalation and 22 workers with as some internal radiation exposure), the fines by the New Mexico Environment Department, the settlement of the fines by the Department of Energy, the inspection(s) by the Mine Safety and Health Administration all significantly impact worker safety culture. Accordingly, it would not be imprudent for the DNFSB to closely monitor not just worker safety culture but also management safety leadership as well.

Neither the DOE nor its contractors have been able to reproduce the event based upon the "suspect inventory" of LANL Drum 68600. Accordingly, a not unreasonable consideration is that the purported "inventory" of drum 68600 may be incorrect. Because the inventory of waste drums is critical to industrial and radiation safety both at the Generating Site and the WIPP, the Board Staff may wish to critically evaluate the mechanisms by which the Generating Sites assess the inventory of waste drums paying particular attention to chemical constituents and there is no spent fuel and no high level waste.

Thank you for the opportunity to present these comments. Safe and effective operation of defense atomic energy transuranic waste packaging and operation of the WIPP is not only important to New Mexico but to the national goal of effective and safe disposal of these materials.

I can be contacted at the letterhead address, at GAnastas5@Comcast.Net or by telephone at 505/797-5452.

Sincerely,

George Anastas
PE, CHP, FHPS, BCEE, FARPS

CC with Enclosure: Mr. Don Hancock, Southwest Research and Information Center

Enclosure as Stated: Nuclear Safety, Volume 33, No. 2, April-June 1992: "An Assessment of the Flammability and Explosion Potential of Defense Transuranic Waste" by Dr. Matthew Silva

NUCLEAR SAFETY

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TECHNICAL PROGRESS JOURNAL APR • JUN 1992

The Nuclear Operations Analysis Center (NOAC) of the Oak Ridge National Laboratory has prepared this latest member of a series of reports, whose coverage goes back to 1969, as part of its ongoing Accident Sequence Precursor Program. This program reviews licensee event reports (LERs) of operational events to identify and categorize precursors to potential severe core-damage accidents. Such precursors are infrequent initiating events or equipment failures that, had additional subsequent failures also occurred, could have resulted in a plant condition with inadequate core cooling. In other words, they are events that proceeded part-way on an identified path of multiple failures that could potentially lead to a severe core-damage accident but did not do so because the later failures did not occur. This report consists of Volumes 15 and 16 of the series; Vol. 15 contains the main report and Appendix A, and Vol. 16 contains Appendices B and C. This report is available from the National Technical Information Service, Springfield, VA 22161 or the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082.

NUREG/CR-4674
ORNL/NOAC-232
Vol. 15

Precursors to Potential Severe Core Damage Accidents: 1991 A Status Report

Main Report and Appendix A

Prepared by
J. W. Minarick, J. W. Cletcher, D. A. Copinger, B. W. Dolan

Oak Ridge National Laboratory

Prepared for
U.S. Nuclear Regulatory Commission

The Nuclear Operations Analysis Center

NOAC performs analysis tasks, as well as information gathering activities, for the Nuclear Regulatory Commission.

NOAC activities involve many aspects of nuclear power reactor operations and safety.

NOAC was established in 1981 to reflect the broadening and refocusing of the scope and activities of its predecessor, the Nuclear Safety Information Center (NSIC). It conducts a number of tasks related to the analysis of nuclear power experience, including an annual operation summary for U.S. power reactors, generic case studies, plant operating assessments, and risk assessments.

NOAC has developed and designed a number of major data bases which it operates and maintains for the Nuclear Regulatory Commission. These data bases collect diverse types of information on nuclear power reactors from the construction phase through routine and off-normal operation. These data bases make extensive use of reactor-operator-submitted reports, such as the Licensee Event Reports (LERs).

NOAC also publishes staff studies and bibliographies, disseminates monthly nuclear power plant operating event reports, and cooperates in the preparation of *Nuclear Safety*. Direct all inquiries to NOAC, P.O. Box 2009, Oak Ridge National Laboratory, Oak Ridge, TN 37831-8065. Telephone (615) 574-0393 (FTS: 624-0393).

Cover: Our cover picture this month constitutes Figure 1 of the paper "An Assessment of the Flammability and Explosion Potential of Defense Transuranic Waste," by M. Silva, appearing in this issue of *Nuclear Safety*. It shows the results of an explosion in a 55-gal drum containing mixed radioactive waste on December 2, 1976, in a truck van at Argonne National Laboratory. Please refer to the paper for more details.

Waste and Spent Fuel Management

Edited by E. G. Silver

An Assessment of the Flammability and Explosion Potential of Defense Transuranic Waste

By M. Silva[a]

Abstract: *Deep geologic disposal of transuranic (TRU) waste in a facility such as the U.S. Department of Energy's (DOE's) Waste Isolation Pilot Plant (WIPP) requires transportation and handling of the waste before emplacement. Records from the DOE's "unusual occurrence reporting system" indicate that discharge of static electricity, spontaneous ignition of pyrophoric materials, and reactions involving nitric acid have generated fires, explosions, and incidents of drum overpressurization in mixed radioactive waste. These incidents include the 1970 waste drum fire at the Idaho National Engineering Laboratory, the 1976 explosion of a waste drum at the Argonne National Laboratory-East, the 1978 incident at the Hanford site that resulted in distorted drums of transuranic waste, the 1982 fire at Hanford initiated by uranium metal dispersed in concrete, the 1983 fire at the Lawrence Livermore National Laboratory initiated by pyrophoric metals seeded in flammable waste, the 1984 fire in a container of radioactive waste at the Idaho National Engineering Laboratory, the 1985 impact ignition of discarded thorium at the Y-12 facility of the Oak Ridge National Laboratory, and the 1985 pressurization of a container and release of plutonium at the Rocky Flats Plant. Although these incidents predate Revs. 3 and 4 of the WIPP Waste Acceptance Criteria,[1,2] and not all were clearly identified as TRU waste, occurrence of these incidents is a basis for concern. An evaluation of the evidence suggests that future accidents of a similar nature must be anticipated. Workers need to be aware of the potential hazards of working with these materials, and clear and consistent procedures should be in place and enforced to ensure adequate safety to help prevent the future occurrence of such incidents before, during, or after emplacement.*

The Waste Isolation Pilot Plant (WIPP) is ultimately intended to serve as a repository for the disposal of transuranic (TRU) waste generated by the defense activities of the U.S. Government.[3] The repository is located in southeastern New Mexico, 40 km east of Carlsbad, N.M., and sited at a depth of 655 m in the lower part of a 600-m thick salt formation. The anticipated inventory includes a maximum of 176 000 m^3 (850 000 drum equivalents) of contact-handled transuranic (CH-TRU) waste and about 7 100 m^3 (8 000 canisters) of remote-handled transuranic (RH-TRU) waste. The CH-TRU waste is estimated to contain 9 million curies of activity. The activity of the RH-TRU waste is limited to 5.1 million curies.

The safe transportation and handling of TRU waste requires a realistic assessment of the flammability hazard. In calculating the probability of a fire in the waste handling building and in the underground facility, the WIPP Final Safety Analysis Report[4] identified the 1970 drum fire at the Idaho National Engineering Laboratory (INEL) as the only spontaneous ignition in a waste drum in the U.S. Department of Energy's (DOE's) operational history. Records from the DOE's "unusual occurrence reporting system," however, indicate that discharge of static electricity, spontaneous ignition of pyrophoric materials, and reactions involving nitric acid have generated other

[a]New Mexico Environmental Evaluation Group, 7007 Wyoming Blvd. NE, Suite F-2, Albuquerque, NM 87109.

fires, explosions, and incidents of drum overpressurization in various kinds of radioactive waste, at least some of which was known to be TRU waste. In general, the unusual occurrence reports are meant to inform the DOE and the DOE contractor line management of events that could adversely affect the health and safety of the public, seriously impact the intended purpose of the DOE facilities, adversely affect the environment, and endanger the health and safety of workers.

Projecting fire or explosion hazard and associated damage potential is best done from a base of related incidents. In evaluating the flammability and explosion hazard of handling TRU waste, citing the operational experience of the DOE facilities is particularly appropriate since the WIPP is a DOE facility. Hence the history of accidents at other DOE facilities involving various kinds of radioactive waste could indicate the frequency and nature of accidents that might be anticipated at the WIPP, which has yet to actually receive and handle any TRU waste.

The flammability and explosion potential of TRU waste was most recently examined in three studies.[5–7] The preliminary investigation by the Environmental Evaluation Groups focused on the volatile organic compounds (VOCs) in the waste, particularly acetone, and concluded that an explosion caused by VOCs was unlikely. Shortly after that report was issued, the Environmental Evaluation Group learned of a drum containing mixed radioactive waste that exploded in 1976 at the Argonne National Laboratory-East (ANL-E). The investigating committee at ANL-E identified two VOCs, xylene and pentane, as the most likely fuels involved in the explosion.[8] Hence the Environmental Evaluation Group, in cooperation with the DOE, initiated a search of the DOE's unusual occurrence reports for evidence of other such incidents involving mixed radioactive waste. That effort resulted in two reports, independently prepared, during roughly the same time frame—one from the DOE[6] and one from the Environmental Evaluation Group.[7]

The DOE position paper[6] evaluated each unusual occurrence report and described the regulations and requirements intended to preclude a fire or explosion during transportation and emplacement of TRU waste in the WIPP. These regulations and requirements have been formulated by different organizations, such as the U.S. Environmental Protection Agency (EPA), the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Transportation, and the DOE. The regulations and requirements include the presence of filtered vents on the waste containers, restrictions on the total amount of flammable volatile organic compounds, restrictions on the amount of flammable gases in the container headspace, restrictions on hydrogen concentration, restrictions on chemical incompatibility, restrictions on pyrophoric materials, restrictions on the amount of free liquids, and adequate waste characterization prior to shipment. In summary, the DOE position paper maintains that "adequate safety regulations exist for TRU waste to be shipped to the WIPP. With proper implementation, these regulations should minimize any hazards with flammability concerns."[6]

The most recent report from the Environmental Evaluation Group[7] also examined the unusual occurrence reports from the DOE operations and concluded that accidents, such as fires and explosions, have occurred at several facilities in the DOE complex because guidelines and procedures have been inadequate, improperly used, or not used at all. That observation suggests that future accidents of a similar nature must be anticipated, that workers need to be aware of the potential hazards of working with these materials, and that clear and consistent guidelines and procedures should be in place and enforced to ensure adequate safety.

It has been argued that the incidents discussed in these unusual occurrence reports do not pertain to the WIPP because not all of them were known to involve TRU waste and the Waste Acceptance Criteria (WAC), and other safety requirements are now in place.[6] In most cases, however, as shown in Table 1, the applicability of each incident to the WIPP remains undetermined.[9] In many cases it is unknown whether TRU waste or low-level waste was involved.[6] Hence the term *mixed radioactive waste* is used throughout this paper. The level of radioactivity is not the issue. What is important is that each incident was triggered by an ignition source and fueled by hazardous materials found in the mixed radioactive waste generated by defense activities and that each incident occurred in spite of the procedures and regulations in place at that time.

WASTE DRUM EXPLOSION AT ARGONNE NATIONAL LABORATORY

A 55-gal drum containing mixed radioactive waste exploded on Dec. 2, 1976, at ANL-E.[8] The evidence identified two volatile organic compounds, xylene and pentane, as the most likely fuels causing the explosion. The evidence also suggested that the most likely ignition source was an electrical discharge, either static electricity from the plastic bags containing the waste or electricity gener-

Table 1 Summary of Fires, Explosives, and Incidents of Drum Overpressurization[a]

Date	Site	Event	Probable cause	DOE determination		
				TRU related[b]	Applicable to WIPP[c]	Current regulation[b]
6/1/70	INEL	Burial ground fire in 55-gal drum	Pyrophorics	Likely low-level waste	Undetermined	Restriction on pyrophorics
12/3/76	ANL-E	Explosion of 55-gal drum	Flammable VOCs	No	No	Vents, restriction on flammable VOCs
8/17/78	Hanford	Distortion of 55-gal drums	Reaction between nitric acid and organic compounds	Yes	Yes	Vents, restriction on free liquids and incompatible chemicals
3/13/82	Hanford	Uranium–concrete billet fire	Pyrophorics	Likely low-level waste	Undetermined	Restrictions on pyrophorics
6/30/83	LLNL	Fire in bags of dry waste	Pyrophorics, flammable VOCs	Not known	Undetermined	Restrictions on pyrophorics, flammable VOCs, chemical incompatibility
4/20/84	INEL	Fire in a radioactive waste container	Spontaneous combustion of nitric acid	Not known	Undetermined	Restrictions on corrosives, chemical incompatibility
7/20/85	ORNL at Y-12	Fire involving thorium in a scrapped glove box	Pyrophorics	Low-level waste	Undetermined	Restrictions on pyrophorics
9/19/85	RFP	Pressurization of containers and release of plutonium	Plutonium fines, calcium, moisture	Not known	Undetermined	Restriction on chemical incompatibility, vents

[a]Acronyms used:
TRU—transuranic waste
WIPP—Waste Isolation Pilot Plant
DOE—Department of Energy
INEL—Idaho National Engineering Laboratory
ANL-E—Argonne National Laboratory-East
LLNL—Lawrence Livermore National Laboratory
RFP—Rocky Flats Plant
VOC—volatile organic compounds

[b]See Ref. 6.
[c]See Ref. 9.

ated by piezoelectric crystals from a discarded ultrasonic cleaner. Fortunately, no one was in the vicinity at the time of the explosion, there was no spread of contamination, and damage was minimal. As noted by Mueller et al.,[8] however, the consequences of that explosion could have been considerably greater.

The drum had been filled with solid radioactive waste, commonly referred to as dry active waste. The waste consisted of such items as cardboard, shredded plastic bags, broken glass, bagged out plastic pouches, hot plates, rubber hose, rubber gloves, tissue paper, etc., all of which are commonly found in solid radioactive waste. On Dec. 1, 1976, the drum was sealed, surveyed for radiation, tagged and identified, and moved to the loading dock for routine pickup. The drum was loaded into a truck, which was left parked by the waste-handling building on the afternoon of December 2. The explosion damage was discovered the next morning by an employee reporting for work.

The explosion had blasted the lid of the drum through the aluminum roof of the van either during the late hours of December 2 or the early hours of December 3. The drum showed considerable bottom deformation. That observation, coupled with an analysis of the deformed aluminum sphincter cans within the unbreached polyvinyl chloride (PVC) pouches, "characterized the incident as an explosion rather than a gradual overpressurization. . . ."[8]

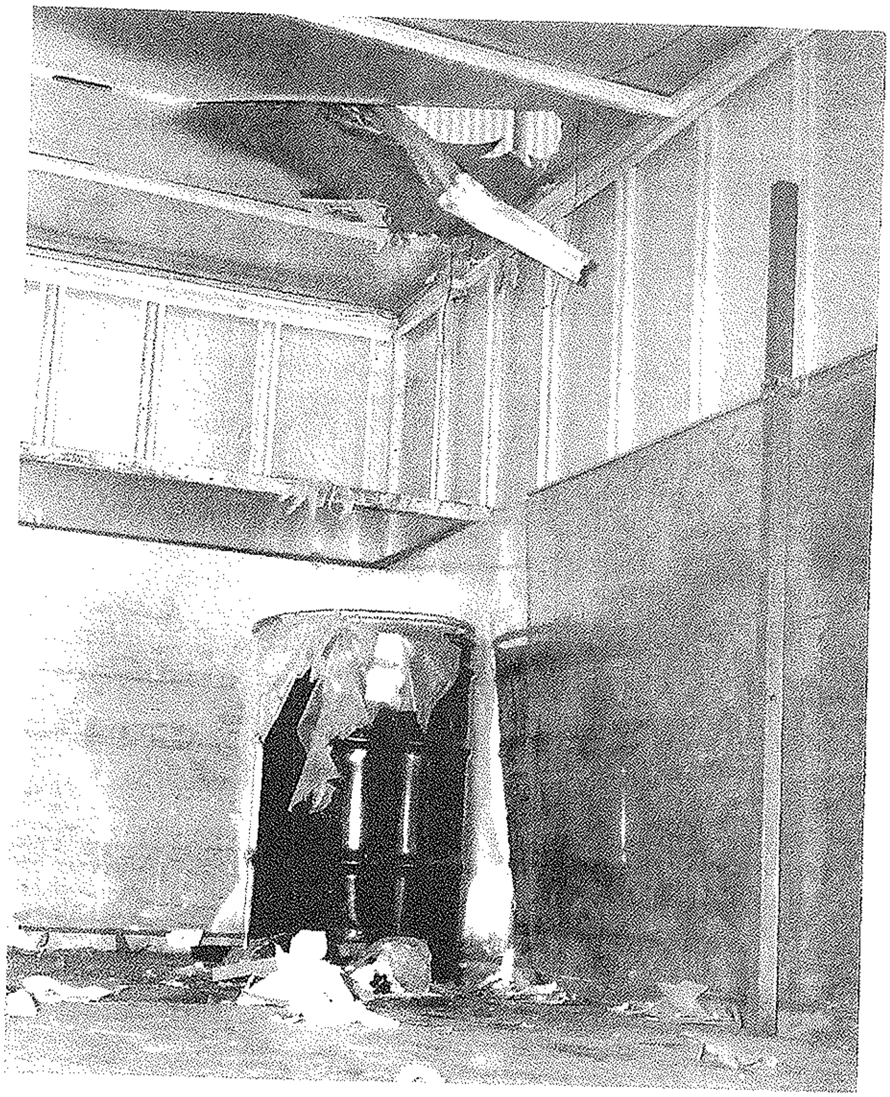

Fig. 1 Damage inside a truck at Argonne National Laboratory-East caused by the explosion of a 55-gal drum containing mixed radioactive waste. Published with permission of authors and the U.S. Department of Energy.

Figure 1[a] clearly shows the gaping hole in the metal roof of the van and the mangled reinforcing beam that had been part of the roof structure. Eight 55-gal drums and many fiber cartons of waste were in the truck at the time of the explosion. The explosion apparently occurred in the void space of one of the 55-gal drums and not within one of the bags. The drum lid was found on top of the truck.

[a]Figure 1 is the cover illustration for this issue of *Nuclear Safety*.

One PVC pouch contained two flammable organic solvents, xylene and pentane, that had been absorbed on a widely used material referred to as "Oil Dri." Apparently the solvents diffused through the PVC pouch and accumulated in the drum void space.[8]

Mueller et al.[8] concluded that an electrical discharge within the sealed drum probably initiated the explosion. They cautioned that their assumption of an electrical discharge did not preclude other mechanisms, such as spontaneous heating, chemical reactions, or radiation effects.

The committee, however, found no evidence of these or other ignition sources.

The report identified several prevailing conditions that would have enhanced the accumulation of static electricity on plastic surfaces within the drum. The drum contained polyethylene and polyvinyl chloride sheeting, bags, and pouches. The hazard of having polyethylene or polyvinyl chloride in flammable atmospheres has been well established.[7,10-12] The drum at ANL-E was loaded and sealed under the conditions of low relative humidity where charge densities persist on polyethylene surfaces.[12] The plastic packages were subjected to friction during transportation by truck between buildings.[8] Charge generation by rubbing can lead to discharges with equivalent energies up to 1 mJ, which certainly exceeds the minimum ignition energies of flammable vapors.[12] The minimum ignition energy for methane in air is 0.29 mJ, for gasoline in air is 0.24 mJ, and for hydrogen in air is only 0.02 mJ. Hord notes that "even a weak spark due to the discharge of static electricity from a human body may be sufficient to ignite any of these fuels in air. . . ."[13]

The painted interior of the drum provided a dielectric barrier, which allowed the charge to accumulate on the ungrounded plastic surfaces.[8] In such a situation static electricity has little opportunity to dissipate and can build up to potentials of several kilovolts.[12]

The waste drum was moved outdoors, which lowered the temperature of the drum dramatically. A drop in temperature can cause static charges to accumulate on the plastic surfaces. Also, solvent vapor condensation and evaporation caused by temperature fluctuations can cause static charges to accumulate. The very low outdoor temperature could have generated dimensional changes in the drum or contents and thus caused the packages to shift and accumulate a static charge.[8]

The committee cited another possible electrical discharge source, a discarded ultrasonic cleaner. The circuit from that piece of equipment consisted of two piezoelectric crystals bonded to stainless steel. As suggested, cooling effects could have generated voltage and a subsequent discharge. Mueller et al.[8] provided no further documentation nor cited references on the potential role of the discarded ultrasonic cleaner.

As noted by Mueller et al.,[8] compliance with existing procedures would have prevented this accident. Site practices at ANL-E in 1976 included evaporation of liquids before disposal of containers. In this incident, the evaporation practice was apparently initiated and then abandoned because the material was evaporating too slowly. Although there were existing regulations and site procedures that could have prevented this explosion, the procedures were not followed.

IGNITION OF PYROPHORIC RADIONUCLIDES IN MIXED RADIOACTIVE WASTE

Pyrophoric materials are inherently hazardous for two reasons. First, small amounts of pyrophoric materials represent a potential ignition source for other flammable materials present in the waste. Second, a pyrophoric material may serve as fuel for a fire.[6]

There have been several fires at generating and storage facilities which were apparently caused by the spontaneous ignition of pyrophoric radionuclides, including uranium, plutonium, thorium, and possibly cerium and neodymium. Many of the fires involved uranium metal. Although uranium is not a transuranic radionuclide, the DOE has always included it in the WIPP calculations because it is a substantial component of the waste.[4]

Small quantities of transuranic metals, in pyrophoric form, are anticipated in TRU waste.[1] Furthermore, the WIPP WAC limits the presence of pyrophoric radionuclides to less than 1 wt% rather than 3 wt% because TRU waste forms are not as uniform or homogeneous as the materials in a cited Rocky Flats study, and there is no guarantee of uniform dispersal of pyrophoric radionuclides in TRU waste.[1,2]

Although a radioactive assay, such as a passive–active neutron assay, provides an estimate of the amount of radionuclides in a drum, the technique cannot be used to determine if the material is in a pyrophoric form. Furthermore, verifying the presence of pyrophorics by visual inspection may rely on an event. For instance, in the section on identifying pyrophoric materials in waste drums, Engineering Design File RWMC-363 from the INEL states, "as it is removed from the container, the waste will be examined to determine whether or not spontaneous combustion has occurred."[14]

DRUM FIRE OF ROCKY FLATS WASTE AT INEL

In early 1970 the Atomic Energy Commission issued a directive that required segregation of all TRU waste. Although the decision to store TRU waste above ground was being made, waste transported from Rocky Flats to Idaho remained in temporary above-ground storage. On the evening of June 1, 1970, a smoldering drum at INEL was discovered by security personnel. Initial attempts by the fire department to extinguish the fire while the smoldering drum was still in the stack of waste drums failed. A crane was used to lift the burning drum from the stack. A bulldozer covered the drum with soil to extinguish the fire.

Three days later the drum was placed in a hot cell. The contents of the drum were removed and examined. Materials included broken glass, dirt, rocks, paper, plastic, glass jars, glass bottles, etc. Upon removal from the drum, one large solid object burst into flame. The blaze was extinguished. An analysis of metallic chips in the area of the burned material identified depleted uranium turnings as the most likely source of the spontaneous ignition.

In his report on the incident, McCaslin[15] suggested that radiant heat absorption by the black drum surfaces had contributed to the spontaneous ignition. That argument was used to justify periodically cooling the drums with a fine water spray and later to coat the upper surfaces of the drums with white paint.

In a Sept. 18, 1970, final report on the incident, Halls[16] noted that efforts to identify the cause of the fire, from photographs taken during drum unloading, were inconclusive. In an Oct. 7, 1970, cover memo identifying the two reports, Ginkel stated that "no other conclusions are drawn in these reports as to the cause other than spontaneous ignition of uranium."[17]

The ignition of a pyrophoric radionuclide in this drum strongly suggests that the pyrophoric radionuclides were not generally dispersed nor passivated in the waste container.

DRY WASTE FIRE AT LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL)

The refuse in waste bags at LLNL caught fire at about 1:00 p.m. on June 30, 1983. The bags of dry waste were temporarily piled up in the toxic waste holdup area awaiting the delivery of requisitioned metal drums. The unusual occurrence report identified the most likely fuel as "dry waste (primarily paper towels and rags) sparingly soaked in flammable liquids (acetone, ethanol, and laser dyes) and contained inside sealed plastic bags."[18] The report speculated that the ignition may have been caused by "pyrophoric materials (cerium, neodymium, or uranium) that might have been disposed of in the bags." The report also suggested that "the ignition might have been promoted by solar radiation" because the waste pile had been exposed to the sun for about 3 hours prior to the fire.

In responding to the emergency, the fire was treated as containing toxic and radioactive material. Hazards control and security personnel cordoned off and monitored the area for toxic and radioactive materials. After the fire was extinguished, the contents involved in the fire were identified. The amount of pyrophoric material was not specified in the report.

It is not known whether the waste was low level or transuranic.[6] Nonetheless, the incident report concluded that the dry waste fire was probably the result of having pyrophoric metals seeded in flammable waste. This fire in bags of mixed radioactive waste indicates that the radioactive pyrophorics were not sufficiently dispersed, that chemically incompatible materials were present, and that there was a sufficient concentration of flammable organic compounds to contribute to the fire.

CONTAMINATION OF FIRE FIGHTERS AT THE HANFORD SITE

During the evening of Mar. 13, 1982, an alarm beacon was activated by an exhaust duct hydrogen monitor in the 303K building at Hanford. A wooden pallet of uranium concrete billets was found burning. Uranium metal in the concrete had spontaneously ignited.[19]

The ignition was attributed to several causes. There were inadequate process specification and operating procedures, inadequate casting and curing process requirements, and a deviation from the standard casting and curing process procedures. Furthermore, the procedures had not yet been modified to reflect recent, more stringent, limitations. Finally, the concrete billets had been placed on wooden pallets rather than on metal pallets—a deviation from procedure.

The uranium fire at Hanford is germane to the WIPP for the following reasons. Air sample and radiation surveys taken in the area indicated no contamination release to the surrounding area. Yet two fire fighters had contamination on their face, hands, and clothes. The fire involved uranium that had been dispersed in concrete. As a mitigating measure, the WIPP WAC (Ref. 1) relies on the dispersal of all pyrophoric radionuclides, although the document also notes that there is no guarantee of dispersal. The incident emphasizes that untested procedures can be inadequate and guidelines can be ignored.

IGNITION OF THORIUM AT THE Y-12 PLANT (OAK RIDGE NATIONAL LABORATORY FACILITIES)

Although thorium is not a transuranic element, the account of an impact ignition of a 1-gal pail containing thorium is of interest to WIPP operational safety because over 3 tons of thorium are found in the INEL-stored CH-TRU waste.[20]

On July 20, 1985, during sorting operations in the Y-12 salvage yard, a glove box was being raised by a forklift when the glove box fell from the forks, hit the ground, and ignited a discarded 1-gal pail of thorium in the glove box. The reason for the thorium being in the glove box remains unknown. The fire was extinguished and the pail was removed from the glove box and placed in a Department of Transportation 17H drum for disposal. Thorium generators were advised not to send thorium to the salvage yard, and salvage yard personnel were requested to check all incoming items.[21]

This report strongly suggests that even a relatively mild impact, such as dropping a waste container, represents a credible ignition source. Thorium metal and its hydride, ThH_2, are extremely pyrophoric as powders. The powders ignite spontaneously as dust clouds or dust layers in air at 25 to 300 °C (Ref. 22). Again, the ignition source was thorium that had been improperly discarded.

URANIUM SCRAP FIRE AT THE Y-12 PLANT (OAK RIDGE NATIONAL LABORATORY FACILITIES)

On Nov. 7, 1985, a drum of uranium saw fines and liquid coolant ignited and exploded at the Y-12 Plant. Waste haulers were loading drums of classified parts and scrap onto a salvage truck. The drums of scrap were being handled in preparation for transport and disposal.[23]

A 30-gal drum was lifted into the bed of the disposal truck with a forklift. After loading the drum onto the truck, a wooden pallet was placed on the forks of the forklift to push the drum forward toward the cab of the truck to make room for additional drums. As the drum was being pushed, a wood slat broke, allowing the forks to push forward and penetrate two drums. Liquid, later determined to be coolant, started flowing from one of the drums. After applying absorbent material to the spilled liquid, two workers attempted to rotate the drum to stop the leak. As the workers were moving the drum, a hissing sound was produced, and a "steam" spray was observed coming from the top of the drum and the punctured area on the side of the drum. As the intensity of the hissing increased, the "steam" spray became a shower of sparks and flames. Although the workers evacuated the area, an explosion-like noise was heard as the lid blew from the top of the drum. The lid landed approximately 60 ft from the parked salvage truck.

The fire and subsequent explosion were apparently initiated while the workers were moving the drum. The exact cause of the ignition remains unclear. Nonetheless, during routine handling of a drum by waste haulers at a DOE facility, that drum was punctured with a forklift and this initiated a fire and an explosion.

PRESSURIZATION OF A CONTAINER AND RELEASE OF PLUTONIUM AT THE ROCKY FLATS PLANT

On Sept. 19, 1985, at the Rocky Flats Plant (RFP), a sealed container holding floor sweepings pressurized and released radioactive material and thus contaminated personnel and the facility. Personnel were cleaning up floor sweepings in Line 20 (Button Breakout). Some of the floor sweepings appeared wet. After 3½ hours, these sweepings looked dry. The sweepings were placed in a plastic container and removed from the line. The bag was placed in a Vollrath 8802 can and taken to the cold storage area, Room 149, to await pickup by Non-Destructive Assay personnel for plutonium assay. At approximately 2:40 p.m., selective alpha air monitors in that room sounded the alarm.[24]

Apparently an exothermic reaction pressurized the container and caused it to fail. Two possible reactions were suggested. The report summary notes that calcium metal, plutonium metal fines, and moisture were present in the container and suggests a reaction between calcium and moisture in the container. The report notes that the container may have held a sufficient amount of plutonium hydride to react with moisture or air. It is also possible that the plutonium metal reacted with air. The container was not sealed "gas tight." The package contained material in an inert atmosphere at less than atmospheric pressure. Air permeated into the container and thus allowed plutonium metal fines to spontaneously oxidize and release sufficient heat to pressurize the container. Plutonium metal fines were bagged and placed in a can without going through an oxidation process. Hence the plutonium was in a pyrophoric form.

NITRIC ACID AS AN IGNITION SOURCE

A recent report by Durant et al.[25] summarizes adverse experiences with nitric acid at the Savannah River Site including 52 incidents of spontaneous combustion—many of which occurred in mixed radioactive waste. Bulging drums of TRU waste at Hanford and a fire in a container of radioactive waste at Idaho have also been attributed to the presence of nitric acid and are discussed here.

DISTORTION OF DRUMS OF TRU WASTE AT THE HANFORD SITE

On Aug. 17, 1978, a tank farm operator at Rockwell Hanford Operations noticed a change in the physical appearance (bulging) of two 55-gal drums of TRU waste. The drums were in a staging area awaiting final stacking and recording before burial. The apparent cause of pressurization was a chemical reaction between nitric acid and organics. The first drum held 60 g of plutonium in 62 L of solution contained in Speedy dry packing material, and the second drum held 54 g of plutonium in 70 L of solution contained in Speedy dry packing material.[26]

To release the pressure, the drums were vented by remotely punching a small hole in the side. Sample analyses showed that the headspace gas contained primarily nitrogen, oxygen, carbon dioxide, nitrous oxide, and low volume percentages of hydrogen. These components are expected from a reaction between nitric acid and organic materials.

FIRE IN A RADIOACTIVE WASTE CONTAINER AT THE WESTINGHOUSE IDAHO NUCLEAR COMPANY

On Apr. 20, 1984, a chemist noticed fumes coming from a compactible radioactive waste container in Lab 103B. When the lid of the container was opened, some of the material burst into flames.[27]

Earlier a technician had used a heavy paper towel to absorb about 15 mL of undiluted fuming nitric acid that had been spilled. He discarded the towel into the container of compactible radioactive waste. The report summary indicated that the fire apparently resulted from the spontaneous combustion of this towel. Damage from the fire was limited to melting of a small part of the plastic bag used to line the waste container. No contamination was released. The accident does strongly suggest that material, such as nitric acid from laboratory projects, can find its way into radioactive waste containers.

CONCLUSIONS

The 1990 WIPP Final Safety Analysis Report elected to use the DOE's operational experience to determine the likelihood of an accidental ignition in the waste handling building. The WIPP FSAR, however, identified the 1970 waste drum fire at the INEL as the only ignition in the DOE's operational experience. Clearly, there have been other ignitions in containers of mixed radioactive waste, including the fires and explosions discussed in this report. The presence of a potential ignition source in the WIPP-bound waste, such as the discharge of static electricity or a chemical reaction, cannot be completely ruled out.

The evidence also indicates that accidents, such as fires and explosions, have occurred at several facilities in the DOE complex because guidelines and procedures have been inadequate, improperly used, or not used at all. That observation suggests that future accidents of a similar nature must be anticipated, that workers need to be aware of the potential hazards of working with these materials, and that clear and consistent guidelines and procedures should be in place and enforced to ensure maximum safety and to help prevent the future occurrence of such incidents.

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