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OPERATING EXPERIENCE WEEKLY SUMMARY

Office of Nuclear and Facility Safety

June 18 - June 24, 1999

Summary 99-25

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EVENTS

1. LEAKING RADIOACTIVE SOURCE CONTAMINATES PERSONNEL

On June 10, 1999, at Argonne National Laboratory—East, a sealed source custodian and a health physics technician (HPT) were contaminated from a leaking radioactive source while performing a leak test on three sealed cesium-137 sources. The custodian had 14,000 dpm/100 cm^2 beta/gamma contamination on his right hand and the HPT had some contamination, about 4,000 dpm/100 cm^2, on his hands and shoes. They both immediately decontaminated their hands with soap and water. A portion of the hallway they used while transporting smear samples to be counted was also contaminated to 2,000 dpm/100 cm^2. The smear taken from the leaking source indicated contamination of 500,000 dpm/100 cm^2. This event is significant because the leaking source resulted in personnel contamination and the spread of contamination in the facility. (ORPS Report CH-AA-ANLE-ANLEER-1999-0009)

The sealed source custodian and the HPT began leak testing the sources in a room where sources are stored. An instrumentation technician was also in the room with them conducting activities not related to the leak test. The custodian and the HPT opened the source containers and took smear samples of the sources. After securing the sources in the containers, they carried the smear papers (in a plastic bag) to a health physics office for counting. When the first smear was counted and indicated 500,000 dpm/100 cm^2, the HPT became concerned that a leaking source had been encountered and that he and the custodian, along with the instrument technician, may have been contaminated.

A health physics supervisor and another HPT began monitoring the contaminated individuals. The sealed source custodian had 4,500 dpm/100 cm^2 on his right shoe and 6,000 dpm/100 cm^2 on the left knee of his pants. The instrumentation technician had 6,000 dpm/100 cm^2 on both his shoes and 2,000 dpm/100 cm^2 on the thigh of his pants. The top of the shielded container that housed the leaking source had contamination of 26,000 dpm/100 cm^2. Both the custodian and the HPT had positive results on nasal blows, and they submitted bioassays to determine if there is any internal contamination.

Investigators determined that the custodian and the HPT had a beta/gamma detector with them when they were checking the integrity of the sources. The detector indicated that the source that leaked was much stronger (1 to 2 Ci) than what their records had led them to expect (about 0.2 Ci), but they could not tell by direct readings that the source was leaking. There is no obvious explanation why the source failed, other than its age. Investigators learned that nuclear activities in the facility ended in the late 1970s and that the source could have been in storage since then. The custodian took responsibility for these sealed sources two years ago, and this was the first integrity check and very possibly the first check in several years. The sealed source custodian will properly dispose of the leaking source as well as the other old sources in the inventory.

NFS has reported other events in the Weekly Summary that involved leaking or damaged sources. Some examples follow.

- Weekly Summary 96-13 reported that an employee of a manufacturer of gages containing radioactive sources was internally contaminated from a leaking source. He inhaled americium-241 oxide powder while checking a sealed, 10-mCi americium source for leaks. Bioassay results indicated a committed effective dose equivalent of between 34 and 85 rem. Investigators believe a welded plug that sealed the 1960-vintage source had fractured and released the oxide powder. (NRC Event Number 30137)

- Weekly Summary 94-08 reported three events involving leaking sources. At the Rocky Flats Process Development Laboratory, a foreman received 18,900 dpm/100 cm^2 beta contamination on his hand when an unsealed source that was taped to a cabinet fell apart while he tried to remove it. Black oxide from the source also contaminated the floor. The source was made from depleted uranium-238 and was used to source-check instruments (ORPS Report RFO--EGGR-NONPUOPS3-1994-0002). At the Portsmouth Gaseous Diffusion Plant, an HPT found a leaking 10-µCi cesium-137 source while surveying radiation monitoring instruments. A second leaking cesium-137 source was found in a storage cabinet. Investigators determined that the encapsulating material on the sources had failed (ORPS Report ORO--MMES-PORTSAFEGR-1992-0004). At the Los Alamos National Laboratory, personnel were handling a uranium-235 source when its plastic lamination separated, allowing a foil of uranium metal to fall onto a countertop. The foil spread small amounts of contamination on the countertop. Investigators determined that aging of the glue that held the plastic lamination together could have been a factor in the event as well as the failure to store and handle the source properly (ORPS Report ALO-LA-LANL-NUCSAFGRDS-1991-1579).

These events underscore the need for periodic inspections of sealed radioactive sources to verify their continued integrity and prevent the spread of contamination caused by failed sources. Inventory records should accurately reflect the number, type, and strength of sources stored within a facility. Source custodians should consider removing older and no-longer-used sources from their inventories for proper disposal before aging leads to problems.

DOE N 5400.9, *Sealed Radioactive Source Accountability and Control* (extended by DOE N 5400.10), describes how sealed radioactive sources shall be controlled and maintained and specifies requirements for receipt, inventory, storage, transfer, disposal, and integrity testing. An integrity test of an accountable sealed radioactive source shall be performed at least every 6 months and whenever the source is dropped or may have been damaged.

DOE N 441.1, *Radiological Protection for DOE Activities*, requires control of and accountability for sealed radioactive sources. The Notice establishes radiological protection program requirements that, combined with 10 CFR 835 and its associated implementation guidance, form the basis for a comprehensive radiological protection program. There are 16 top-level, performance-based requirements in this Notice. These 16 requirements supplement and enhance the requirements of 10 CFR 835 to provide critical direction in the areas of administrative controls, radiation safety training, work authorizations, posting, exposure of minors, and sealed radioactive source accountability. DOE N 441.4, *Extension of DOE N 441.1, Radiological Protection for DOE Activities,* extends DOE N 441.1 until June 30, 2000.

KEYWORDS: contamination, leakage, radiation protection, sealed source, source custodian, test

FUNCTIONAL AREAS: Radiation Protection

2. DRILL PENETRATES CONDUIT CONTAINING ENERGIZED 480-V WIRING

On June 14, 1999, at the Pantex Plant, two pipe fitters were drilling a hole through a wall when the drill penetrated an electrical conduit. The conduit contained energized 480-V wiring. The internal portion of the conduit and the wires were not damaged and there were no injuries. The pipe fitters were drilling the hole for a subcontractor. The subcontractor had marked the location of the penetration but had incorrectly measured the location of the conduit mounted on the opposite side of the wall. When the pipe fitters realized they had hit the electrical conduit they stopped work and notified their supervisor. Electricians inspected the wires, found no

damage, and sealed the conduit. Although no injuries occurred in this near-miss event, penetrating energized electrical utilities can result in serious injury, equipment damage, and disruption of facility services. (ORPS Report ALO-AO-MHSM-PANTEX-1999-0042)

The pipe fitters used a double-insulated drill with a hole-saw bit to penetrate the wall. The hole saw had a pilot bit that extended approximately 1-in. further than the teeth on the hole saw. The wall was approximately ¾ in. thick. The pipe fitter who was operating the drill did not realize that he had struck the conduit until he wondered why it was taking so long to drill through the wall. At that point he stopped drilling and noticed that the pilot bit had penetrated the conduit.

Investigators determined that the pipe fitters knew there was a conduit on the other side of the wall but relied on the mark provided by the subcontractor. The subcontractor who marked the penetration did not mark it in the correct location on both sides of the wall. Although there was a known electrical conduit on the opposite side of the wall, the only personal protective equipment required for the work (aside from a double-insulated drill) was a respirator for drilling through the cemesto wall, which contained asbestos. Facility managers are taking the following actions.

- Work requiring penetrations will be walked down with the subcontractor before it is started.
- Markings for penetration work will be physically measured to assure they match on both sides of the wall.
- Electrical power will be locked and tagged out (whenever possible) if the penetration is within 6 in. of the electrical source.

NFS has reported other events in the Weekly Summary where energized electrical service was contacted while drilling and cutting walls and floors. Some examples follow.

- Weekly Summary 99-17 reported that craftsmen at the Mound Plant penetrated a conduit containing four energized 110-V ac circuits while core drilling a concrete floor. Investigators determined that the craftsmen did not have a permit for core drilling. The permit would have required personnel with utility locating equipment to scan the area for hidden utilities. (ORPS Report OH-MB-BWO-BWO03-1999-0001)
- Weekly Summary 99-07 reported that telecommunications technicians at the Rocky Flats Environmental Technology Site drilled into two energized 120-V electrical lighting circuits while installing a telephone line in a trailer, causing two 20-amp circuit breakers to trip. Investigators determined that the integrated work control package failed to require the use of a utility locator before drilling to determine if electrical wiring was present in the trailer wall or the installation of a lockout/tagout if the technicians determined wiring was present. (ORPS Report RFO--KHLL-779OPS-1999-0007)
- Weekly Summary 99-03 reported that a subcontractor electrical crew at the Los Alamos National Laboratory cut through an exterior wall of a metal building and severed a 24-V electrical line for a manual fire alarm pull station. The crew saw the pull station mounted on the inside wall of the building but did not attempt to determine the exact location of the concealed electrical line before cutting into the wall with an electric saw. (ORPS Report ALO-LA-LANL-PHYSCOMPLX-1999-0001)

The Pantex event illustrates the importance of accurately measuring and marking not just the location of the penetration or the cut but also the location of any obstructions. Certainly the safest course of action when an electrical service is involved is to have it de-energized and locked out. As an additional precaution, workers should use double-insulated tools, rubber mats,

electrically rated gloves, and ground-fault circuit interrupt circuits for power tools. Facility managers and work planners should review the following references when planning penetration work.

Lessons Learned Report, Issue 98-02, *Penetrating Hidden Utilities,* includes lessons learned from events that involved cutting and drilling into utilities concealed behind walls, floors, and ceilings. It also provides recommendations for avoiding hidden utilities and includes useful references. Some of these recommendations include (1) checking drill holes frequently for signs of obstructions, (2) stopping to investigate if an obstruction is hit, (3) marking the location of utilities, (4) and using drills equipped with electronic drill stops. Lessons Learned Reports are available at http://www.tis.eh.doe.gov/web/oeaf/ lessons_learned/reports/.

29 CFR 1926.416(a)(3), *Protection of Employees*, states that employers shall ascertain by inquiry, direct observation, or instruments whether any part of an energized electrical circuit is located such that the performance of work may bring any person, tool, or machine into contact with it. OSHA regulations define concealed wiring as wiring rendered inaccessible by the structure or finish of the building. OSHA regulations are available at http://www.osha-slc.gov/OshStd_data.

KEYWORDS: conduit, electrical hazard, energized equipment, near miss, penetration, wire

FUNCTIONAL AREAS: Construction, Industrial Safety

3. VENDOR CONTAMINATED DURING MAINTENANCE IN HOOD

On June 17, 1999, at a Savannah River Vitrification Facility laboratory, a vendor employee was contaminated when some liquid material erupted from a sample line that he had disconnected while performing preventive maintenance on a carbon analyzer inside a radiological hood. Radiological controls personnel measured 180,000 dpm/100 cm^2 beta/gamma and 400 dpm/100 cm^2 alpha contamination on the chest area of his discarded protective clothing and 4,000 dpm/100 cm^2 beta/gamma on the same area of his personal clothing. He had no skin contamination and nasal and saliva smears were negative. Radiological controls personnel also detected 6,000 to 8,000 dpm/100 cm^2 beta/gamma and 200 dpm /100 cm^2 alpha activity on the lip of the hood and on the floor near the hood. The vendor thought that he had blocked the spilled material with his gloved hand but did not consider that some of it may have sprayed out of the hood. He also did not communicate the incident to the laboratory personnel who were assigned to assist him. Laboratory personnel believe the liquid material was waste sludge that contained strontium-90. This occurrence is significant because the vendor employee's actions were not in accordance with safe radiological work practices and resulted in the spread of contamination. (ORPS Report SR--WSRC-WVIT-1999-0013)

The facility manager convened a critique of the occurrence to determine the cause. Critique attendees identified several problems related to integrated safety management. They determined that the scope of work had not been adequately defined, that the pre-job briefing was less than adequate, and that work control was less than adequate. Laboratory personnel had little knowledge of the vendor employee's scope of work or work procedures. They had not prepared a formal work package for the maintenance and had not adequately identified associated hazards. The governing radiation work permit did not contain job-specific instructions. The vendor employee had just completed radiation worker training, but laboratory and radiological controls personnel did not provide adequate supervision to ensure safe work practices.

In response to this occurrence, the facility manager placed a hold on all work other than normal laboratory activities; directed laboratory personnel to conduct formal, documented pre-job

briefings with the operations shift manager on any work to be done in the laboratory hoods; directed radiological controls personnel to evaluate the adequacy of existing radiological work permits for hood and glovebox work; and directed briefings for workers on proper radiological work practices before they are allowed to work in gloveboxes or hoods.

This occurrence underscores the importance of pre-job planning and hazard analysis. If laboratory personnel had been aware that the vendor employee needed to disconnect a sample line, they could have specified safety measures to prevent contamination. They might have been able to prevent the occurrence if they had provided over-the-shoulder supervision of a newly trained radiation worker. While it is appropriate to exclude certain routine work from formal control, supervisors should recognize that new or non-routine jobs require work controls commensurate with potential hazards. Managers must ensure that integrated safety management systems are effectively implemented.

The objective of an integrated safety management system is to incorporate safety into management and work practices by addressing all types of work and all types of hazards to ensure safety for workers, the public, and the environment. DOE G 450.4-1, *Integrated Safety Management System Guide for Use with DOE P 450.4 Safety Management System Policy,* describes the principles and functions that must be addressed in an effective integrated safety management program. The five core functions of DOE's integrated safety management system are (1) define the scope of work, (2) identify and analyze the work hazards, (3) develop and implement hazard controls, (4) perform work within controls, and (5) provide feedback on the adequacy of controls and continuous improvement in defining and planning work.

DOE/EH-0420, Safety Notice 94-03, *Events Involving Undetected Spread of Contamination,* provides guidance, good practices, and corrective actions to prevent the spread of contamination. It also contains information on common contributing causes, including the following.

- Failure to follow applicable radiological protection procedures.
- Failure to adequately perform required surveys.
- Inadequate training for personnel involved in the handling and use of radioactive material.
- Failure of radiation protection personnel to properly identify, analyze, and respond to the event.
- Failure to exercise appropriate precautions when handling radioactive material.
- Inadequate supervision or management oversight of activities involving the handling and use of radioactive material.
- Inadequate identification of existing contamination.

Safety Notices can be found at http://www.tis.eh.doe.gov/web/oeaf/lessons_learned/ons/ons.html.

DOE/EH-0256T, *Radiological Control Manual*, states that each person involved in radiological work is expected to demonstrate responsibility and accountability through an informed, disciplined, and cautious attitude toward radiation and radioactivity. The manual presents DOE guidance on the proper course of action in the area of radiological control, including work preparation, work controls, monitoring and surveys, and training and qualifications. Section 122, "Worker Attitude," states that worker radiation exposure can be minimized only if all persons involved in radiological activities have an understanding of and the proper respect for radiation. Section 123, "Worker Responsibilities," states that trained personnel should recognize that their actions directly affect contamination control, personnel radiation exposure, and the overall radiological environment associated with their work.

KEYWORDS: contamination, hazard analysis, integrated safety management, pre-job briefing, work control

FUNCTIONAL AREAS: Radiation Protection, Work Planning

4. LOCKOUT/TAGOUT VIOLATION AT ROCKY FLATS

On June 17, 1999, at the Rocky Flats Environmental Technology Site Liquid Waste Treatment Facility, a facility manager reported that subcontractor electricians had performed work on a sludge pump without the required mechanical or electrical lockouts or tagouts installed. The electricians performed a voltage check and confirmed that no voltage was present before working on the pump. During the work, a pipe fitter questioned why the pump valves were not tagged out and were positioned incorrectly. The pipe fitter and an electrician determined that the system was not mechanically or electrically locked out or tagged out, so they requested that building personnel lock out and tag out the system. Building personnel locked out and tagged out the system without realizing that work was already in progress on it. The pipe fitter and the electrician then completed the pump removal with a lockout installed. Although there were no injuries from this incident, installing lockouts/tagouts would have provided a positive barrier to protect the workers from mechanical or electrical hazards. (ORPS Report RFO--KHLL-LIQWASTE-1999-0001)

Investigators determined that the subcontractor electricians and pipe fitters completed a pre-evolution briefing to replace the sludge pump, but no one contacted building authorities to inform them that work was beginning. Investigators also determined that a maintenance foreman saw a tag hanging from a motor control center and believed that it was for the sludge pump, so he recorded that tag number in the pump replacement procedure to document that the pump was tagged out. However, the tag was for another sludge pump that had been tagged out since 1997. Investigators determined that procedures required the subcontractors to hang their own tags and not rely on any existing tags.

The facility manager held a fact-finding meeting on the event. Meeting attendees learned that the subcontracting management firm was new to this facility and that the subcontractor managers did not recognize that a lockout/tagout violation had occurred until approximately 3 days after the event. Attendees also learned that the sludge pump power switch on the motor control center was in the off position and that the workers maintained visual control over the switch during the work. The site contractor suspended the electrician and the maintenance foreman from performing lockout/tagout activities until a formal causal analysis of this event is completed and corrective actions are developed.

NFS has reported other events involving inadequate work control programs at the Rocky Flats Environmental Technology Site in the Weekly Summary. Following is a similar event.

- Weekly Summary 98-43 reported that a building maintenance machinist and a vendor representative had performed work on a turbine generator without a lockout/tagout in place. A DOE facility representative was reviewing the work and asked a contractor technical representative engineer if a lockout/tagout had been installed before work began. The contractor technical representative engineer confirmed that no lockout/tagout had been applied. (ORPS Report RFO--KHLL-371OPS-1998-0077)

These events underscore the importance of using an integrated approach to safety that stresses clear goals and policies, individual and management accountability and ownership, implementation of requirements and procedures, and thorough and systematic management oversight. In the June 17 event, work controls, communications, and managerial oversight were

inadequate to satisfy the five core functions of DOE's integrated safety management system: (1) define the scope of work, (2) identify and analyze the work hazards, (3) develop and implement hazard controls, (4) perform work within controls, and (5) provide feedback on the adequacy of controls and on continuous improvement in defining and planning work.

The responsibility for ensuring adequate planning and control of work activities resides with line management. Managers must understand and ensure that work control processes are followed and facility practices are enforced. Safety and health hazard analyses must be included in the work control process to help prevent worker injury. The hazard analysis process should include provisions for lockouts/tagouts, job-specific walk-downs, integration of work activities, and personnel protective equipment. Pre-job briefings, facility procedures, and training programs should emphasize the dangers associated with mechanical and electrical activities. Plan-of-the-day meetings or pre-job briefings should be held so that work organization responsibilities are clearly defined and job expectations are understood.

DOE facility managers should ensure that personnel understand the basics of work control practices and work planning. Following are some documents that facility managers should review to ensure they are incorporated in current work control programs.

- DOE O 5480.19, *Conduct of Operations Requirements for DOE Facilities*, states that DOE policy is to operate DOE facilities in a manner to assure an acceptable level of safety and to ensure procedures are in place to control conduct of operations. Chapter VIII, "Control of Equipment and System Status," provides an overall perspective on control of equipment and system status. Specific applications of system control are addressed in chapter IX, "Lockout/Tagout," and chapter X, "Independent Verification."

- DOE O 4330.4B, *Maintenance Management Program*, section 8.3.1, provides guidelines on work control systems and procedures. The Order states that work control procedures help personnel understand the necessary requirements and controls. Section 3.4 identifies the elements of a maintenance management program that ensure planning, control, and documentation of maintenance.

- DOE G 450.4-1, *Integrated Safety Management Guide*, provides extensive guidance to DOE contractors for developing, describing, and implementing an integrated safety management system to comply with DOE policy and acquisition rules. The guide addresses core functions and guiding principles related to defining scope of work, analyzing hazards, developing and implementing controls, and performing work at the facility, project, or activity level.

Integrated safety management information can be found at the Safety Management website at http://tis-nt.eh.doe.gov/ism. DOE technical standards can be found at http://www.doe.gov/html/techstds/standard/standard.html.

KEYWORDS: job planning, lockout and tagout, maintenance

FUNCTIONAL AREAS: Industrial Safety, Work Control, Electrical Maintenance, Management

5. ACCELERATOR RADIATION MONITORS NOT PROPERLY CALIBRATED

On June 18, 1999, at Lawrence Livermore National Laboratory, a principal investigator discovered that the 4-MV Van de Graaff accelerator radiation monitors had not been calibrated in accordance with operational safety plan requirements. The neutron and gamma radiation monitors are interlocked with the accelerator high-voltage power supply, which automatically

shuts down the accelerator if the monitors reach an alarm setpoint. The principal investigator noticed the calibration stickers on the monitors were dated February 1998, exceeding their calibration due date. The operational safety plan requires the monitors to be calibrated semiannually. Technicians recalibrated the monitors and determined that they were within calibration criteria. The principal investigator suspended accelerator operations pending further reviews. This event is significant because failure to conduct inspections, tests, or calibrations at required intervals can violate operational safety requirements, which represent the minimum acceptable controls necessary to ensure safe operation. (ORPS Report OAK--LLNL-LLNL-1999-0021)

Investigators determined that the accelerator had been operated periodically after the calibration due dates had expired. They will continue to review this event and will determine (1) if the accelerator pre-startup procedure required verification that the calibrations were current and (2) why technicians had not performed the calibration. Program and facility managers held a meeting with the Assurance Office to discuss the situation and will decide on a course of action.

NFS has reported numerous events where calibrations, tests, or inspections were not performed as required. Some examples follow.

- Weekly Summary 98-05 reported two events in which surveillances and inspections were not conducted because of problems associated with computerized scheduling programs. At the Hanford Tank Farm, facility personnel discovered that functional tests for the high-efficiency particulate air filter differential pressure interlocks and the stack high radiation alarm were not current. Investigators determined that no one entered facility safety documentation changes into the computerized maintenance system used to schedule surveillances. At the East Tennessee Technology Park (K-25 Site), fire protection personnel reviewing inspection and test records discovered that the database contained no inspection records for five building sections. Investigators determined that because of a programming error, the computerized fire inspections management information system did not schedule several monthly fire department walk-downs, monthly sprinkler system inspections, semiannual alarm tests, main drain tests, and annual fire extinguisher inspections. (ORPS Reports RL--PHMC-TANKFARM-1998-0010 and ORO--LMES-K25GENLAN-1998-0003)

- Weekly Summaries 97-17 and 97-15 reported missed surveillances at the Oak Ridge Radiochemistry Engineering Development Center. In one event, inspectors failed to perform a semiannual efficiency test on high-efficiency particulate air filters for 18 months because a hold tag had not been removed after mechanics replaced the filters. In the other event, fire department personnel did not perform monthly inspections because inspection frequencies had not been formally established. (ORPS Reports ORO--ORNL-X10REDC-1997-0003 and 0002)

These events illustrate the importance of properly tracking, scheduling, and conducting calibration inspections and tests. Surveillance activities are designed to ensure safe shutdown capabilities; when surveillances activities are missed, the required safety envelopes cannot be ensured. Annual reviews of surveillance testing should not be relied on to ensure compliance. Computer programs and databases that track operational safety and technical safety requirements and schedule surveillances, inspections, and calibrations are effective tools. However, these computer systems can be affected by programming errors, data-entry errors, and failure to input or update facility requirements.

DOE facility managers should periodically review their calibration test procedures to ensure that scheduled tests have been performed at the frequencies specified in their safety documentation.

- DOE O 5480.22, *Technical Safety Requirements*, attachment 1, describes the purpose of surveillance requirements and states that each surveillance shall be performed within the specified interval. It also states that surveillance requirements must ensure that the quality of systems and components is maintained and the limiting conditions for operation are met. General principle 1 states: "A system is considered operable as long as there exists assurance that it is capable of performing its specified safety function(s)." Surveillance testing and calibration activities are essential in providing this assurance. DOE facilities that have Operational Safety Requirements rather then Technical Safety Requirements can use this Order to aid in determining what parameters important to safety should be specified in facility documents as surveillance requirements and what purpose surveillance requirements serve.

DOE contractors who fail to conduct required surveillances or implement corrective actions for identified deficiencies could be subject to Price-Anderson civil penalties under the work processes and quality improvement provisions of 10CFR830.120, “Quality Assurance Requirements.”

KEYWORDS: surveillance, test, communication, operational safety requirement

FUNCTIONAL AREAS: surveillance, licensing/compliance

6. DRUM LID BOLTS NOT TORQUED

On June 17, 1999, at the Hanford Site, the operations manager determined that on June 16, 1999, operations personnel did not use a torque wrench when securing drum lid bolts, as required by operating procedures. The operations manager discovered this in the course of reviewing the 55-gal low-level waste drum procedure. Inadequately torqued bolts can lead to failure of the bolted assembly. Too high a torque can result in failure of the bolt shank or threads. Too low a torque and the bolt tension can be inadequate to meet functional requirements. This event is significant because the operators’ failure to torque the drum lid bolts reduces the likelihood that the drum lid will perform properly. Proper closure of waste drums is essential to their safe movement and storage. (ORPS Report RL--PHMC-WSCF-1999-0005)

Investigators determined that operations personnel were not using a torque wrench when securing the 55-gal drum lids, as required by the Waste Sampling and Characterization Facility operating procedure for packaging low-level and mixed solid laboratory waste in 55-gal drums. The operations manager initiated a review of other facility procedures requiring containers to be secured by torquing. Operations personnel found three procedures that fit this criterion. The operations manager ordered work activities associated with these procedures to be stopped pending further review. The operations manager has not yet developed corrective actions.

NFS has reported other events in the Weekly Summary where workers failed to torque fasteners properly. Some examples follow.

- Weekly Summary 95-43 reported that a load hook from a 1-ton gantry crane came loose and fell approximately 47 ft, damaging an industrial dolly at the Hanford Site. Crane maintenance personnel had recently replaced the wire rope on the crane hoist. A dead-end clamp secured the hook to the wire rope. The work package specified the torque for the clamp nuts. A crane maintenance man tightened the nuts until they were snug but failed to tighten them to the specified value. He

signed the inspection sheet indicating that all the work was done. (ORPS Report RL--WHC-KHFAB-1995-0002)

- Weekly Summary 95-20 reported the failure of a flanged connection during a hydrostatic test of approximately 1,500 ft of 12-in. pipe at the Pantex Plant. The failure allowed water pressurized at 170 psi to spray from the pipe and strike three workers, who were transported to a nearby hospital as a precautionary measure. At the hospital, the workers were examined and released. An investigation into the event revealed that the bolts on the failed flanged connection were not properly torqued. (ORPS Report ALO-AO-MHSM-PANTEX-1995-0083)

- Weekly Summary 95-04 reported on five instances of failed welds on lid closure rings for steel 55-gal drums at the Savannah River Solid Waste Facility. The drums are used for the storage and transfer of transuranic waste. The welds failed at the lug-to-ring joint during torquing of the ring's closure bolts. Investigators determined torque requirements in the procedure were not changed to reflect a change in drum materials. (ORPS Report SR--WSRC-SLDHZD-1995-0001)

OEAF engineers reviewed the ORPS database and found 18 events involving improper torquing of fasteners. In 28 percent of these events, the result was a degradation of a safety structure, system, or component. In 44 percent of these events, the facility manager identified the direct cause as personnel error. In 28 percent of these events, the facility manager identified a procedure problem as a contributing cause.

These occurrences underscore the importance of specifying the proper torque in procedures and of properly using a torque wrench to achieve the desired torque. A single bolt, inaccurately or incorrectly tightened, can cause an entire structure, system, or component to fail. The most prevalent controlled method of tightening bolts is by use of a torque wrench. The main problem with this method is that the clamping force generated as a result of the applied torque is dependent on the design of the bolt and the prevailing frictional forces. The majority of the torque is used to overcome friction, so slight variations in the frictional conditions can lead to large changes in the actual torque applied to the bolt. This effect can be reduced by using lubricants. Despite these problems, torque wrenches are the most popular means of ensuring that a bolted joint complies with a specified torque. Job planners should ensure that torque values are clearly shown in procedures and on drawings and should state that a calibrated torque wrench must be used.

Personnel at DOE facilities that generate radioactive wastes need to ensure that the waste containers are properly assembled and that the procedures governing the assembly are appropriate for the container's design. DOE Order 5820.2A, *Radioactive Waste Management*, establishes policies, guidelines, and minimum requirements for the management of radioactive and mixed waste. This Order will soon be replaced by DOE Order 435.1, *Radioactive Waste Management,* which will reflect advances in radioactive waste management.

Additional information on applying torque to bolted connections may be found at http://boltscience.com.

KEYWORDS: bolt, drum, radioactive waste

FUNCTIONAL AREAS: Materials Handling/Storage

7. HYDROGEN FLUORIDE CYLINDER RUPTURES AT UNIVERSITY LABORATORY

On May 19, 1999, at Indiana University, students discovered a cylinder containing hydrogen fluoride (HF) that had ruptured inside a storage room next to a laboratory in the Department of Geology. The students immediately left the storage room and contacted Indiana University's office of Environmental Health and Safety (EH&S). EH&S emergency response personnel arrived shortly thereafter and learned that no university students or faculty were in the storage room at the time the cylinder ruptured and no injuries were reported. However, the force with which the cylinder burst and the subsequent release of HF would have posed a serious risk to personnel health and safety had the room been occupied. Anhydrous hydrogen fluoride (AHF) is extremely corrosive to all tissues of the body and reacts with glass, ceramics, and some metals.

Following the cylinder failure, EH&S investigators learned of a letter DuPont Fluoroproducts sent to its customers on January 29, 1997, about a HF shelf life issue. The letter discloses the potential over-pressure hazard associated with the long-term storage of AHF in carbon steel cylinders. The AHF in the cylinder reacts very slowly with the iron in the steel to form iron fluoride and hydrogen. The hydrogen collects in the cylinder's vapor space and builds pressure inside the cylinder. Air Products and Chemicals Inc. (Air Products) reprinted this information on March 12, 1997, in its bulletin *Hydrogen Fluoride Shelf Life Issue.*

The Indiana University cylinder was a lecture bottle that had been stored at the university for 22 years. EH&S personnel believe that the cylinder became overpressurized and ruptured because of the buildup of hydrogen, as described by Dupont Fluoroproducts. Following a thorough search of all of the laboratories at Indiana University, EH&S discovered three more cylinders of HF in the chemistry department. They placed all three of them in a hood in an isolated space until proper disposal can be arranged. Figure 1.1 shows a lecture bottle before and after rupturing from overpressurization when improperly filled. The ruptured Indiana University HF lecture bottle failed in a similar manner.

Figure 1.1 Lecture Bottle

DuPont Fluoroproducts and Air Products also reported about an HF lecture bottle that had been in storage for approximately 14 years and was found to be pressurized to an estimated 2,400 psig instead of the expected 5-15 psig. During subsequent cylinder venting operations, personnel analyzed the vented gas and determined the primary constituent to be hydrogen. The companies also reported that there have been several other cases worldwide of AHF cylinders failing after 15-25 years of storage as a result of overpressurization from hydrogen buildup. The Air Products bulletin on the issue of HF shelf life is available for viewing at http://www.airproducts.com/productstewardship/bulletins/ hydrogen-fluoride-shelflife.asp.

The Laboratory Chemical Safety Summary, *LCCS: Hydrogen Fluoride and Hydrofluoric Acid,* recommends that containers of HF should be stored in secondary containers made of polyethylene in areas separate from incompatible materials. This summary can be viewed at http://www.qrc.com/hhmi/science/labsafe/lcsstxt/lcsstx51.htm. The *Occupational Safety and Health Guideline for Hydrogen Fluoride* contains a special precaution that HF should be stored in containers composed of non-corrosive materials such as lead and wax, because the corrosive action of HF on metals can result in the formation of hydrogen gas. This guideline is available at http://www.osha-slc.gov/SLTC/healthguidelines/hydrogenfluoride/ recognition.html.

Facilities that have carbon steel cylinders containing AHF should not store these cylinders for extended periods of time without monitoring pressure and cylinder condition. Extreme caution should be taken when handling any AHF cylinders that have been stored for extended periods of time. Laboratory and facility managers should also consider the potential impact of using the gas from any AHF cylinder that has been stored for extended periods of time since it may contain hydrogen as well as the AHF. As with any handling of HF, proper safety procedures should always be used and first aid supplies should be available in the event of personnel exposure. Skin contact with AHF results in painful deep-seated burns that are slow to heal. Undisassociated HF readily penetrates the skin, damaging underlying tissue.

KEYWORDS: cylinder, hydrogen fluoride, rupture

FUNCTIONAL AREAS: Chemistry, Materials Handling/Storage