Operating Experience Summary

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Near Miss — Shelving Units Collapse 1

On July 19, 2007, at Hanford, a storekeeper placed a box of soil samples on the top shelf of a shelving unit, and the entire unit collapsed. As the unit collapsed, it fell into another shelving unit, which also collapsed. The storekeeper was able to move out of the path of the falling shelves and was not injured, but the shelving and some soil samples were damaged. (ORPS Report EM-RL--PHMC-General-2007-0004; final report issued July 26, 2007)

The storekeeper was relocating boxes of soil samples from a pallet to the free-standing shelving where they were stored. As he was pushing a box from the front of a shelf to the rear of it, the bottom part of the shelf wall gave way, and the entire unit began to collapse and fall. Figure 1-1 shows the box of soil samples that the storekeeper was shelving, as well as the fallen shelving units. Figure 1-2 shows the aftermath of the collapse and the fallen second unit. Had the shelving fallen in the opposite direction, the storekeeper could have been badly injured.

Investigators determined that when the shelves were assembled the manufacturer's instructions were not followed. They also determined that the shelves were poorly braced. In addition, the fasteners used to connect individual sections of shelving were not checked after assembly to ensure that all of them were installed and had been properly tightened.

Shelving in other site facilities had cross-bracing installed between the shelves and the wall, but cross-bracing had not been installed on these units because it would have to be positioned too low to allow a fork truck to move between the

Figure 1-1. Box of soil samples and collapsed shelves

Figure 1-2. Aftermath of shelving collapse

units. More manual labor would have been required to load the heavy soil samples on the shelves without the fork truck, so the decision was made to install the cross-bracing after the shelves were loaded. Because neither the bottom nor top tier of shelves was cross-braced, the shelving was vulnerable to failure when it was carrying a normal vertical load.

On November 1, 2007, Fluor Hanford issued an Information Bulletin on the shelving collapse at Hanford (2007-RL-HNF-0042). The bulletin includes the following recommended actions to prevent similar incidents.

1. Always obtain and use manufacturer's assembly instructions.
2. Never make modifications which may degrade structural integrity without an engineering analysis and approval.
3. Inspect and verify that free-standing shelving fasteners used to connect sections are present and tightened; ensure adequate cross-bracing is present in each section and that it is adequate for the loads they contain and is attached to the facility structure in some fashion (bolted to the floor, fastened directly to the wall, or uses a grid system of bracing to fasten one section to another).

On June 29, 2006, at the Nevada Test Site (NTS), wall-mounted cabinets in an office fell to the floor. The shelving had been mounted to drywall with self-drilling drywall anchors and weighed about 250 to 350 pounds. No one was in the room when the shelving fell, but as can be seen in Figure 1-3, the employee who worked in the office could have been injured, perhaps seriously. (ORPS Report NA--NVSO-BOPNV-2006-0001)

The cabinets, which were installed 3 days before the incident, were designed to store notebooks, books, and paper and were hung from two rails. The building manager noticed signs of stress on the mounting rails and asked that the material on the cabinets be removed so that rail attachments to the wall could be strengthened; however, the shelving fell before repairs could be made. Investigators determined that only 7 of the 12 manufacturer-required anchors had been installed. When several anchors pulled through the drywall, the remaining anchors could not support the weight of the cabinet and shelves. A Lessons Learned Bulletin (2006-LANL-NTS-001) on the event states that "not following manufacturer's instructions for wall-mounted cabinets can result in catastrophic failure."

A shelf in a flammable materials cabinet collapsed at Lawrence Berkley National Laboratory in 2006. As a result, a bottle of toluene fell, broke, and splashed a researcher's legs and

Figure 1-3. Fallen office shelving (anchors are circled)

feet. Because the researcher quickly removed his clothing and washed his legs and feet in an emergency eyewash/shower, he was not injured, but the room was evacuated until firefighters and hazardous waste technicians cleaned up the spill. Post-incident inspection indicated that there were several deficiencies in the cabinet shelving. A Lessons Learned bulletin on the event (LL-2006-03) states that equipment should always be inspected upon receipt to ensure that it meets all requirements for its intended use and that all equipment should be thoroughly assessed to ensure that it is safe to use.

It is important to install shelving according to manufacturers' instructions, and all components should be used only as instructed. In addition, shelving and components should only be installed or rearranged by trained personnel who have read and understand the instructions and warnings. Shelving that is used to store heavy material (such as the soil samples) should be anchored to a suitable building wall, to the floor, or otherwise braced to prevent overturning or collapse. Never alter, modify, or otherwise structurally change the shelving or any of its component parts. Modification or alteration may cause the shelving or component parts to become structurally unsafe, resulting in tipping, collapse, or other failure of the fixture.

It is important to understand the impact of even subtle changes in configuration, design, or assembly, especially when dealing with structural components. Equipment, such as shelving, is designed to be installed and used in a specific manner and in accordance with manufacturers' instructions. It is also important to ensure that shelving is properly braced, adequate for the load it will hold, and attached to the facility structure or a bracing system to ensure that it does not collapse under load. Shelving should also be inspected regularly to ensure that it is still in good condition and that all fasteners are properly installed and intact.

KEYWORDS: *Shelving, collapse, modification, installation*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls*

Type A Accident Investigation of the Mixed Waste Spill at Hanford Tank Farms — Part 2: Work Control Factors

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On July 27, 2007, at the Hanford Tank Farms, a spill of about 85 gallons of tank waste from a ruptured dilution hose resulted in high radiation levels in an area surrounding a transfer pump. A Type A Accident Investigation Board conducted an independent accident investigation of the event and determined that, although the cause of the spill was overpressure of the hose due to the lack of a required backflow device, deficiencies in five program areas contributed to the accident. OE Summary 2007-08 reported on deficiencies in engineering design that contributed to the spill. The focus of this article is on deficient work control factors that contributed to the event. (ORPS Report EM-RP--CHG-TANKFARM-2007-0009)

The Accident Investigation Board evaluated work control processes in three areas (operations, maintenance, and radiation protection activities) and reviewed them against core Integrated Safety Management (ISM) functions. The Board reviewed activities that were important to the accident and sampled the performance of other activities supporting waste retrieval. Among the activities the Board reviewed were troubleshooting, operations and maintenance activities to free the clogged pump (manual pump rotation combined with electrical pump bumping), waste retrieval pumping operations, and radiological controls associated with retrieval operations and during event response.

The Board determined that some aspects of operations and maintenance activities were performed in accordance with procedures and ISM core values; however, they also identified numerous deficiencies in the procedures and in conformance with procedures. For example, although the operations procedure defined the scope of work for normal operations adequately, it did not address off-normal activities, such as reverse pumping or recovering from a clogged pump, and there were errors and ambiguities in the procedure (e.g., a valve re-opening step was omitted).

The Board found that there was no operating or maintenance procedure defining the scope, hazards, controls, and coordination required to rotate the waste retrieval pump manually and "bump" it electrically. Troubleshooting the stalled pump and clearing the clog were performed in accordance with a standing minor maintenance instruction, and the requirements were not consistent with the facility-level work control procedure. The Board also learned that procedures were not always followed, some logs were not properly maintained, some controls were informally communicated (e.g., via email) and were not passed on to workers, and some operating instructions were not incorporated into the operations procedure.

The Board identified a number of deficiencies in processes and performance in the area of radiation protection controls. The waste retrieval pumping procedures, the abnormal operating procedures, and the radiation work permits did not adequately define the scope of radiological work conducted during the event, and there were weaknesses in radiological hazard analysis. The Board reviewed the retrieval pumping procedure and found that it lacked a documented technical basis associated with the radiological criteria of 75 mrem and 100 mrem, which

were used as the trigger/action level. They also determined that an informal entry plan, rather than a formal procedure, was used when entry was made into the high radiation area to conduct a survey to investigate the high radiation condition. This approach resulted in incomplete hazard analysis, lack of required work reviews, and potentially deficient controls.

Several controls for ensuring proper recognition of waste transfer leaks were in place, but incomplete procedural guidance for radiological surveys, radiological criteria, and response actions, as well as weak implementation of survey protocols, rendered them ineffective. Also, using Abnormal Operating Procedures as standalone procedures without regard to other procedures and protocols resulted in potentially unsafe working conditions, a delay in recognizing the leak, and unclear specification of personal protective equipment needed during the response.

The supervisor, operating crew, and responders all incorrectly believed that an above-ground waste leak that was not detected by the Transfer Leak Detection System was not credible, so they did not aggressively investigate that possibility when they investigated the high radiation level condition. The Board reviewed operations and radiation survey actions and identified a number of opportunities to identify the spill condition, including the following.

- The Health Physics Technician did not follow the operating instructions for performing both open and closed window dose rate measurements. (Open window readings, which are sensitive to beta radiation, might have detected the leak earlier because high levels of beta radiation would indicate the waste was not contained in the piping.) Review of tank farm radiological survey reports indicated that this is a common practice, accepted by management.
- Members of the operating crew noticed that background radiation doubled in a short period of time and that there were simultaneous updates of the portal monitor because of changes in ground radiation levels, but they did not consider that those conditions were related to a waste spill.
- The supervisor and operating crew inappropriately used Material Balance Discrepancy data to conclude that a spill had not occurred. These data are intended to detect large volume waste leaks rather than the relatively small volume leaked in this spill.
- Poor lighting conditions (a previously identified deficiency) slowed visual observation of the spill and resulted in the inability to survey the entire spill area with a remotely controlled camera.

The Board reviewed the work control processes associated with this accident against ISM core functions. Their analysis of work control processes in regard to operations, maintenance, and radiological control indicated that many ISM areas require attention. Importantly, lessons learned from previous damage to the original pump, including procurement of an air motor to turn a stopped pump versus turning it by hand and special tools and torque limits for turning the pump by hand if needed, were not implemented effectively. In addition, several of the deficiencies identified by the Board during the accident investigation are very similar to noncompliant conditions included in a Price-Anderson Enforcement Action issued on March 10, 2005.

The contributing work control causes identified by the Board during the accident investigation are shown in the text box. The following Judgments of Need (JON) address these issues.

1. Management needs to define and implement an effective method for identifying Tank Farm small quantity waste leaks.
2. Management needs to clarify Technical Safety Requirements with regards to radiological measurements as indicators of waste transfer leaks.
3. Management needs to address radiological conduct of operations deficiencies that were evident during the response to abnormal operating conditions.
4. Workers, supervisors and management need to improve implementation of the required Conduct of Operations Program.

The detailed two-volume Accident Board report is available on the DOE Office of Health, Safety and Security website at http://www.hss.energy.gov/csa/csp/aip/HanfordTankFarm.html. The Board's conclusions and JONs in the area of Emergency Management will be the topic of an upcoming article in the *OE Summary*.

This event illustrates the importance of developing accurate procedures, communicating them properly, and following them precisely. The event also shows the importance of not making assumptions about equipment or data, but rather investigating all possibilities to accurately identify the source of any problems. It is also essential to effectively implement previous lessons learned to avoid similar, future occurrences.

KEYWORDS: *Type A accident, hazardous waste, spill, work control, procedures, radiological controls, lighting, ISM*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls, Provide Feedback and Improvement*

Contributing Factors — Work Control

The Accident Investigation Board identified the following work control conditions as contributing causes to the event.

- Supervisors and workers did not rigorously implement event-related, S-Tank Farm normal and abnormal procedures before or during the spill event. For example, efforts to unclog the retrieval pump were not covered by the retrieval operating procedure and supporting maintenance efforts were outside the scope allowed by the verbal-directed work provisions.
- Management and supervisors did not fully ensure work activities and radiation protection measures were conducted within S-Tank Farm approved procedures.
- Work control hazard analysis and implementing controls were not fully effective during the various re-entry activities during the event.
- Many event-related portions of S-Tank Farm procedures were inadequate. For example, the retrieval procedure was inadequate in defining the requirements for conducting radiological surveys and leak detection activities and for defining correct actions upon discovery of high radiation caused by a waste leak.

Issue 2007-01	Article Title	Event	Lessons Learned
	Excavator Accidents Can Be Deadly	Natural gas pipeline explosion killed a private contractor excavator driver. (N/A)	*Perform pre-job analyses that include task-specific, "what-if" scenarios.*
	Electrical Short Circuit in Cafeteria Oven Results in Fire	Fire ignited inside the back panel of a portable warming oven at NTS. (ORPS Report NA--NVSO-NST-NTS-2006-0006)	*Follow site emergency action plans, and be cautious when determining whether a fire can be extinguished using a fire extinguisher.*
	SafetyXChange Reports on Best Practices of 2006	Links to best worker safety practices in 2006. (N/A)	*Share best practices across the Complex.*

Issue 2007-02	Article Title	Event	Lessons Learned
	Operating Vehicles or Equipment While Fatigued Can Be Fatal	Employee fell asleep at the wheel, collided with a tractor-trailer, and was killed. (ORPS Report NA--LASO-LLNL-LLNL-2006-0035)	*Avoid driving or operating equipment when fatigued.*
	Ladders: What Goes Up Must Come Down — Safely	Electrician fell from a ladder and was badly injured. (ORPS Report NA--LSO-LLNL-LLNL-2006-0037)	*Take safety precautions when using ladders.*
	Valley Fever Cases Reported at Lawrence Livermore National Laboratory	Four cases of occupational Valley Fever reported at LLNL in 2006. (ORPS Report NA--LSO-LLNL-LLNL-2006-0066)	*Minimize exposure to dust that may carry the spores that cause Valley Fever.*

Issue 2007-03	Article Title	Event	Lessons Learned
	PPE and Engineered Controls Can Prevent Welding Exposure to Hexavalent Chromium	Welder exposed to hexavalent chromium in excess of OSHA PEL. (ORPS Report EM-RL--PHMC-GPP-2007-0001)	*Use controls to prevent exposures to hexavalent chromium.*
	Failure to Verify Voltage Results in Electrical Near Miss	Wireman used a 1,000-volt-rated multimeter without verifying actual voltage (480 volts). (ORPS Report NA--NVSO-NST-NTS-2007-0003)	*Ensure that hazards are correctly identified and do not perform work based on assumptions.*
	Aerosol Can Explodes Inside a Hot Truck and Damages Windshield	Aerosol can left in truck overheated and exploded. (ORPS Report NA--SS-SNL-NMFAC-2007-0003)	*Ensure aerosol cans are handled, stored, and disposed of properly.*

Issue 2007-04	Article Title	Event	Lessons Learned
	Inadequate Industrial Job Planning Can Result in Unintended Consequences	Muriatic acid used in floor cleaning caused employee health impacts and work interruptions. (ORPS Report SC--BHSO-BNL-BNL 2007-0004)	*Perform detailed job hazard analyses and pre-work planning; provide proper notification before beginning work with hazardous materials.*
	Always Consider Potential Electrical Hazards in Non-Electrical Work	Worker received an electrical shock when metal on a caulking gun contacted an energized buss bar. (ORPS Report NA--KCSO-AS-KCP-2007-0001)	*Plan non-electrical work carefully where there is even a remote possibility of electrical interaction.*
	Is There a Fire Hazard Underneath Your Desk?	Electrical arc from a damaged power cord burned a metal footrest. (ORPS Report NA-SS-SNL-10000-2007-0001)	*Properly inspect and manage office power cords and power strips.*

Issue 2007-05	Article Title	Event	Lessons Learned
	Preventing Heat-Related Illness	Heat-related illnesses can lead to serious complications, even death. (N/A)	*Train workers in the prevention of heat-related illness and make them aware of the signs of heat stress.*
	Poor Job Planning Results in Electrical Worker Fatality	Lineman electrocuted by touching a truck that became energized when the boom contacted an overhead power line. (N/A)	*Plan adequately and assign adequate resources when work will be performed near overhead electrical hazards.*
	Lessons Learned from Leak at British Reprocessing Plant	Report on investigation of internal leak of highly radioactive liquid at Britain's THORP plant. (N/A)	*Believe indications, maintain a questioning attitude, thoroughly investigate abnormal conditions, and foster a safety culture.*

Issue 2007-06	Article Title	Event	Lessons Learned
	NRC Identifies Recurring Operability Issues with Emergency Diesel Generators	Results of an NRC evaluation that identified recurring events involving the operability of emergency diesel generators. (N/A)	*Conduct periodic diesel generator startup/load tests and perform preventive maintenance in accordance with manufacturer's recommendations.*
	Damaged Powered Air Purifying Respirator Hoses	Cut in a breathing air tube for a powered air purifying respirator identified. (Lesson Learned 2007-RL-HNF-0029)	*Inspect respirator equipment and verify its integrity before issuing it to the user.*
	Safe Use and Installation of Fall Protection Anchors	Members of a roofing crew attached fall protection lanyards to anchor points that were not bolted down. (ORPS Report NA--SS-SNL-NMFAC-2007-0006)	*Carefully plan and engineer installation of fall protection anchors and calculate the amount of load the anchor needs to support.*

Issue 2007-07	Article Title	Event	Lessons Learned
	OSHA Issues New Instruction on Combustible Dusts	New safety and health instruction issued for inspecting workplaces where there are combustible dusts. (N/A)	*Implement good housekeeping measures as an effective method of identifying and removing potential hazards.*
	Near Miss—Roll Bar on Riding Mower Knocks Down Window Air Conditioner	Lawn mower roll bar struck a window air conditioning unit and knocked it to the ground. (ORPS Report SC--BHSO-BNL-PE-2007-0004)	*Ensure that mowing equipment operators are trained on equipment, familiar with potential hazards, and focused on the task.*
	Are Proper Cold Weather Protection Measures in Place at Your Site?	Annual reminder of freeze protection measures. (N/A)	*Ensure that freeze protection plans are in place before the onset of winter weather and that protective measures are communicated to employees.*

Issue 2007-08	Article Title	Event	Lessons Learned
	Near Miss—Excavator Windshield Broken By Flying Debris	Entangled rebar dislodged, sprang backwards toward the excavator, and struck the windshield. (ORPS Report EM-RP--BNRP-RPPWTP-2007-0017)	*Ensure that equipment operators wear appropriate PPE and that enhanced cab protection is properly used.*
	Type A Accident Investigation of the Mixed Waste Spill at Hanford Tank Farms—Part 1: Engineering Design Factors	Accident Board identified deficient engineering design features that resulted in the overpressure of a hose connected to a dilution line. (ORPS Report EM-RP--CHG-TANKFARM-2007-0009)	*Conduct detailed design reviews and engineering analyses of equipment and systems to guarantee that their design, installation, and function meet all documented safety requirements.*
	NRC Operating Experience on Electrical Circuit Breaker Problems	Information Notice issued about problems associated with maintenance and operation of low-, medium-, and high-voltage circuit breakers. (N/A)	*Maintain a strong circuit breaker maintenance program to identify and resolve electrical circuit breaker problems.*

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Commonly Used Acronyms and Initialisms

Agencies/Organizations	
ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
CPSC	Consumer Product Safety Commission
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
INPO	Institute for Nuclear Power Operations
NIOSH	National Institute for Occupational Safety and Health
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
SELLS	Society for Effective Lessons Learned Sharing

Units of Measure	
AC	alternating current
DC	direct current
mg	milligram (1/1000th of a gram)
kg	kilogram (1000 grams)
psi (a)(d)(g)	pounds per square inch (absolute) (differential) (gauge)
RAD	Radiation Absorbed Dose
REM	Roentgen Equivalent Man
TWA	Time Weighted Average
v/kv	volt/kilovolt

Job Titles/Positions	
RCT	Radiological Control Technician

Authorization Basis/Documents	
JHA	Job Hazards Analysis
JSA	Job Safety Analysis
NOV	Notice of Violation
SAR	Safety Analysis Report
TSR	Technical Safety Requirement
USQ	Unreviewed Safety Question

Regulations/Acts	
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
D&D	Decontamination and Decommissioning
DD&D	Decontamination, Decommissioning, and Dismantlement
RCRA	Resource Conservation and Recovery Act
TSCA	Toxic Substances Control Act

Miscellaneous	
ALARA	As low as reasonably achievable
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
ISM	Integrated Safety Management
MSDS	Material Safety Data Sheet
ORPS	Occurrence Reporting and Processing System
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
SME	Subject Matter Expert