Operating Experience Summary

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Look Out Below — The Hazards of Falling Objects

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On November 7, 2007, at Hanford, a worker on a subcontractor survey crew dropped a metal flat bar for a laser sight instrument from a scaffolding platform. The bar, which weighed about 7 pounds, fell 17 feet and landed near a carpenter working directly below the survey crew. The carpenter was standing within 2 or 3 feet of where the bar landed and could have been seriously injured had it hit him. (ORPS Report EM-RP--BNRP-RPPWTP-2007-0020; final report issued December 19, 2007)

Workers had attached the flat bar to a stainless steel member of an elevator using magnets. (Figure 1-1 shows the scaffolding and the placement of the flat bar.) The laser sight also has a magnetic base, which is used to connect the instrument to the metal bar and hold it in place. When the crew member reached down and put the laser sight on the flat bar, the magnets holding the bar to the stainless steel member detached, and the bar fell. The worker was able to grasp the laser sight instrument and keep it from falling along with the bar. Figure 1-2 shows where the bar landed underneath the scaffolding and the location of the carpenter at the time of the incident.

Investigators determined that the surveyors failed to ensure that the flat bar was attached securely. However, they also determined that the work package documentation for both work groups was inadequate and did not provide for thorough job scoping and planning for any associated hazards. As a result of the work package deficiencies, signs for overhead work had not been posted before work began and no barrier tape or other restrictive measures were in place.

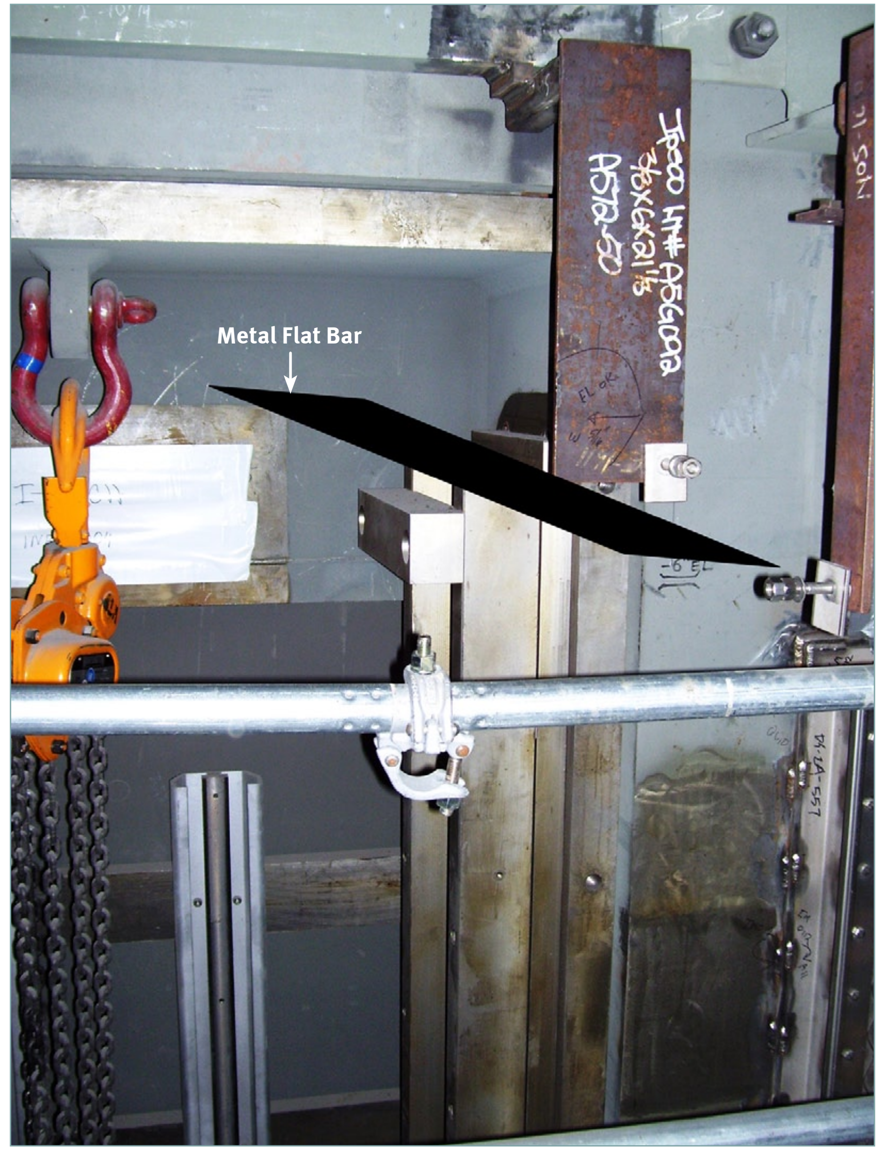

Figure 1-1. Illustration of metal piece placed on scaffolding

The investigators' review of the work packages indicated that the survey crew's work package inadequately addressed the requirements of working at heights and working outside the boundary of the scaffolding. In addition, they found that the work package did not address the possibility of having others working directly below them. The carpenters' work package addressed barricading, if required, but no barricades were used because the carpenters were not working at heights. Investigators also learned that the carpenters and the survey crew had not communicated about the work project. The carpenters knew that work was going on above them, but did not know what type of task was being performed.

Figure 1-2. Location of bar after falling and area where carpenter was standing

Two similar events occurred at Hanford earlier in 2007; one in January and one in February.

On January 29, 2007, a hot stick fell from a bucket truck and glanced off a worker below. The hot stick, which was approximately 6 feet long and weighed 3 to 5 pounds, fell approximately 12 to 15 feet from the bucket to the ground and glanced off the shoulder and hardhat of an electrician working below. Investigators determined that a spotter did not tell the electrician to leave the area before the lineman moved into position and did not let the electrician know that the bucket was moving into position above him. They also determined that the lineman did not understand the potential falling hazard presented by the hot stick and did not secure it to the bucket. (ORPS Report EM-RL--WCH-GENAREAS-2007-0001)

The second event occurred on February 19, 2007, when a 15-inch-long section of piping fell 12 feet to the floor and landed within 3 or 4 feet of a carpenter working below. Pipefitters were working from a scissor lift. As they moved a 100-foot section of pipe, it pushed the 15-inch section out of the pipe rack. When the section of pipe fell, it slid across the floor into a barricaded area the carpenters had set up and narrowly missed the carpenter. Investigators determined that the job hazard analysis did not provide sufficient guidance to address the possibility of piping falling because the spool of piping that fell was over 100 feet from where the pipefitters were working. Workers incorrectly assumed that the usual methods of securing the piping (e.g., using clamps, extending the piping over two racks) would be sufficient to keep the pipe from sliding out of the rack. To address these concerns, a new job hazard analysis, which included a requirement to use three supporting points when moving piping, was issued to address the specific hazards associated with installing piping in overhead or elevated areas. (ORPS Report EM-RP--BNRP-RPPWTP-2007-0002; final report issued March 22, 2007)

Worker injuries resulting from falling objects have also been reported to ORPS. In April 2004, a Stanford Linear Laboratory worker standing on a ladder while removing communications cables dropped a cable splice enclosure containing two cables. The enclosure hit his co-worker in the face, lacerating the area around his right eye. Investigators determined that the pre-work hazard analysis did not identify all job hazards. (ORPS Report SC-OAK--SU-SLAC-2004-0003)

A second injury event that also occurred in 2004, at Rocky Flats, resulted in a worker being hit by the handle of a sledge hammer. The sledge hammer fell from the second floor of a building, dropped through a hole, and struck the floor 16 feet below. When it hit the floor, the sledge hammer bounced, and the handle struck the worker in the back. The worker suffered minor contusions, but could have been severely injured or killed if the sledge hammer had hit him directly. (ORPS Report EM-RFO--KHLL-D&DOPS-2004-0001)

Although none of these events resulted in fatalities, both serious injuries and fatalities can result if an object falls from a height and strikes someone below. On February 12, 2008, the Mine Safety and Health Administration (MSHA) issued a Hazard Alert following two fatalities in 4 months that occurred when tools or components fell from elevated work areas and struck workers below. Figure 1-3 shows the bulletin, which cautions workers to take time to evaluate each task and provides best practices to avoid the risks of falling object accidents.


United States Department of Labor
MSHA
Mine Safety and Health Administration

HAZARD ALERT

Maintenance and Repair Work at Metal and Nonmetal Mines

In the past four months, two fatal accidents occurred because tools or components fell from elevated work areas and struck miners working below.

On 10/1/07, a miner was fatally injured when he walked under a conveyor belt being repaired. He was struck by a return roller that fell as it was being installed.

On 1/25/08, a miner was fatally injured while shoveling at the bottom of a bucket elevator. Coworkers were performing work at the top of the elevator when a pry bar fell from the overhead work area and struck him.

In 2007, there were 11 nonfatal accidents involving falling tools and parts.

Best Practices

- Stop, Look, Analyze, and Manage (SLAM) each task.
- Review maintenance procedures to ensure all possible hazards have been identified and appropriate controls are in place to protect persons.
- Establish policies to ensure that barricades, warning signs or toe boards are installed to prohibit access and protect persons from falling object hazards.

Take the time to evaluate the task

Figure 1-3. MSHA Hazard Alert, February 12, 2008

A Lawrence Livermore National Laboratory Lessons Learned document issued in April 2005 (LL-2005-LLNL-10), following two falling object accidents that occurred during roofing projects at the Laboratory, reported that an analysis of 13 events that had occurred across the Complex in the previous 17 months identified the following similarities among the events.

- Work planning, work authorization, and work deficiencies were causal factors in most of the events.
- Job hazard analyses often did not address the potential for falling objects.
- Work planners did not specify that the area below elevated work should be cleared and roped off to protect personnel from falling objects.
- Ground workers became complacent about yellow boundary tape and crossed the boundary to perform work.

To address these issues and the hazards of falling objects, the Lessons Learned Bulletin listed the following recommendations.

1. Ensure a comprehensive job hazards analysis is performed and documented when planning construction, repair, and D&D activities with elevated work areas. Emphasis should be placed on the control of falling objects and avoidance of working below other work activities.
2. Adequately secure the area below elevated work. Install barricades, post warning signs, and require all personnel to remain clear of the hazard area to protect against falling objects.
3. Wear hardhats when working in areas where falling object hazards are likely to occur.
4. Maintain control of tools and materials when working at an elevation. Use wrist straps, tool tethers, toe boards, screens, and guardrails to prevent falling objects, and use debris netting or canopies to catch falling objects.
5. Adequately secure equipment and tools before raising or lowering them.
6. Obey posted warning signs and all boundary tape and barriers.
7. Remove debris and remove or secure tools from the scaffold at the end of the shift.
8. Ensure toe boards are installed on scaffolds.

OSHA requirements in 1926.451(h), "Falling Object Protection," state that "where there is a danger of tools, materials, or equipment falling from a scaffold and striking employees below, the area below the scaffold…shall be barricaded, and employees shall not be permitted to enter the hazard area."

The requirements further state that either a guardrail system must be installed (with openings small enough to prevent passage of potential falling objects), or a canopy structure, debris net, or catch platform strong enough to withstand the impact forces of the potential falling objects must be erected over the employees below. In addition, an OSHA Construction e-tool, available at www.osha.gov/SLTC/etools/construction/struckby/falling_flying.html, provides information on protecting workers from the dangers of falling objects, including general precautions (e.g., wear a hardhat) and specific precautions (e.g., barricading hazard areas) that should be taken for overhead work.

These events illustrate the importance of ensuring that workers are protected from the hazards of falling objects and that those working on the ground are aware of work going on overhead. It is essential to identify potentially hazardous conditions before work begins and to take the appropriate precautions, such as barricading hazard areas and ensuring that workers are wearing hardhats. It is also important to ensure that workers at elevations and those working below them communicate before work begins so that both groups are aware of the potential for falling object hazards and can take appropriate actions.

KEYWORDS: Falling objects, laser sight, flat bar, scaffolding, injuries, job planning, barricades

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

Unauthorized Equipment Operation Shuts Down Facility Processes

2

On January 21, 2008, at the Savannah River Site, an on-coming shift operator altered the position of valves in a cooling water system without authorization, causing a series of low-level alarms in the H-Canyon control room and the shutdown of all H-Canyon processes. The operator noticed icing on a cooling tower and decided to bypass the cooling tower to initiate freeze protection. However, she mistakenly closed all four isolation valves to the cooling tower instead of opening the riser bypass valves. The operator's actions were performed before shift turnover and without notifying the shift operations manager as required. (ORPS Report EM-SR--WSRC-SUD-2008-0001; final report issued January 28, 2008)

The actions of the on-coming operator resulted in the loss of Normal Cooling Water, which automatically isolated on low water level in the cooling tower basin. Control room operators followed the appropriate alarm response and abnormal operating procedures to shut down facility processes. Process water operators, responding to the cooling water system upset, found all four cooling water valves closed, which resulted in dead-heading the cooling water flow. The operators reopened the valves to restore normal flow.

The on-coming operator's good intentions were based on a concern that icing on the cooling tower could result in structural damage. However, she was thinking of older, wooden cooling towers rather than the newer, metal structures, and valve configuration on the newer tower is the opposite of configuration on the old tower. This may have contributed to the operator's mistake of isolating cooling water flow and not opening the bypass valves (Figure 2-1). The operator did not have a procedure to follow and received no oral instructions from control room operators or the shift operations manager.

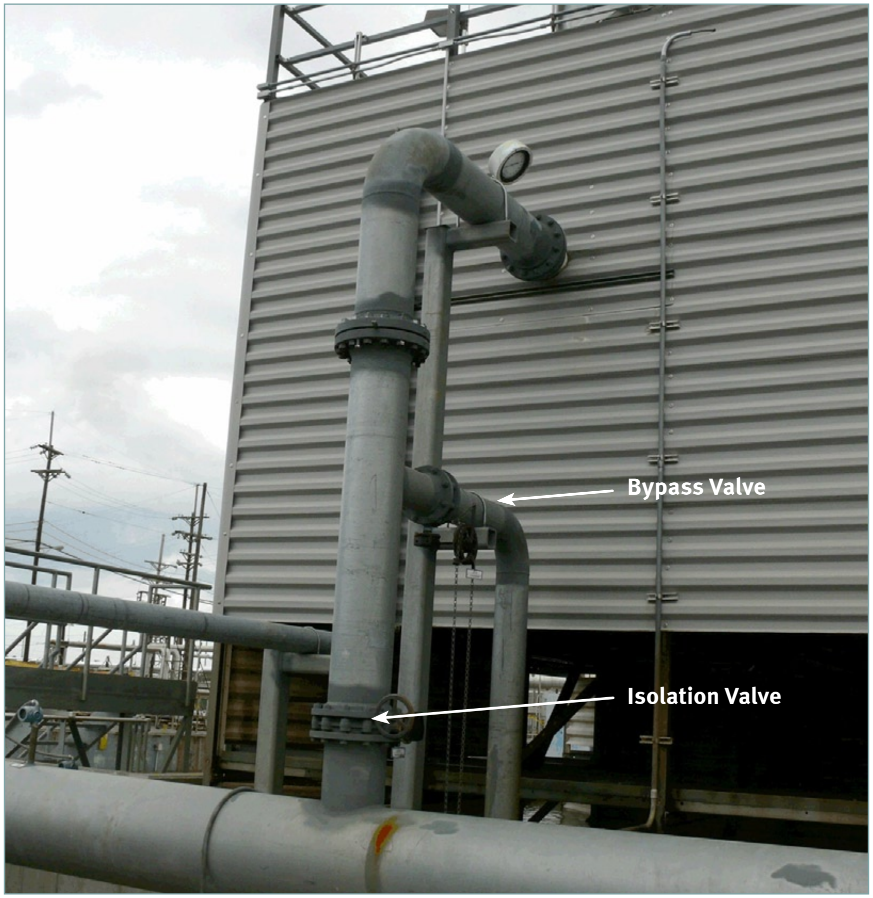

Figure 2-1. Cooling tower and piping arrangement

The operator should have contacted on-shift personnel regarding any operational concerns with facility equipment because the responsibility for the operation and configuration of the equipment rests with the on-shift crew. Any alteration of equipment could then be performed in a controlled and safe manner. As it turned out, the on-shift crew had to respond to alarms caused by an unknown condition that ultimately shut down operations.

As a result of this event, refresher training on Conduct of Operations will be provided to the cooling tower operators to ensure that each of them has full knowledge and understanding of their associated tasks.

This occurrence illustrates the consequences that can occur when failing to adhere to Conduct of Operations principles. When confronted with abnormal conditions or equipment concerns, operators should notify supervisors of the problem and take action as directed and in accordance with appropriate procedures. Performing unauthorized equipment operations can change the known configuration of facility systems, which can cause unsafe operating conditions.

KEYWORDS: Conduct of Operations, authorization, communication, configuration control, cooling tower, valve

ISM CORE FUNCTION: Perform Work within Controls

Type A Accident Investigation of the Mixed Waste Spill at Hanford Tank Farms—Part 5: Management Systems

3

On July 27, 2007, at the Hanford Tank Farms, about 85 gallons of tank waste, including suspended solids and vapors, were released from a ruptured dilution hose near a transfer pump. Because the potential for worker exposures was not fully considered, either during or shortly after the accident, a Type A accident investigation was performed. The Accident Investigation Board identified deficiencies in five program areas. Articles in previous issues of the OE Summary (2007-08 and -09; 2008-01 and -02) addressed the Board's findings and Judgments of Need (JON) in four of those areas. This article discusses management system deficiencies identified by the Board during their investigation. (ORPS Report EM-RP--CHG-TANKFARM-2007-0009)

The Board concluded that the direct cause of the spill was an overpressure of a hose connected to a dilution line on the retrieval pump system. The lack of an isolation device (i.e., a backflow preventer) between the dilution water system and the waste transfer route resulted in the overpressurization and spill. Both the Documented Safety Analysis (DSA) and the Technical Safety Requirements (TSR) required such a device. The Board identified the root cause of the event as the failure to implement the DSA requirement to provide isolation of the hose from the waste transfer route as prescribed in the TSRs. They also identified the following contributing causes to the event that resulted from deficient management controls and oversight.

- Management failed to apply lessons learned from previous contamination and vapor exposure incidents.
- Both Office of River Protection and contractor oversight and design reviews were inadequate to identify deficiencies in the pump system design, including nonconformance with TSRs.

The Board based these findings on their review of the application of lessons learned from previous events and an evaluation of applicable contractor and DOE management systems.

The Board concluded that the corrective action plans implemented following a March 5, 2005, Preliminary Notice of Violations (PNOV) and a September 2005, Potentially Inadequate Safety Analysis (PISA) were ineffective.

The PNOV, which was issued in March 2005, identified several deficiencies that were very similar to issues identified by the Board. For example, the PNOV identified a "failure to position a valve to the correct position while performing an operations procedure." During their investigation, the Board identified a "failure to position a valve to the correct position while performing an operations procedure" as one of the contributors to this event. Table 3-1 shows the correlation between the Board's findings and those identified in the PNOV.

The contractor notified DOE of the PISA in September 2005, because of an accumulation of waste material in the air line of a tank vacuum retrieval system. This was a scenario that was not bounded by the DSA. The Board concluded that the contractor did not review and evaluate the tank vacuum retrieval system PISA as a lessons learned or as an extent of condition for application to the waste retrieval system at the Tank Farms. This lack of response to the issues identified in the PISA, combined with the Board's conclusions regarding adequacy of the DSA supporting waste retrieval from the tank involved in the event, indicates that appropriate corrective action plans were not developed and implemented.

The Board also noted that none of the quality assurance audits and surveillances that were conducted identified any of the broad programmatic issues identified during the accident investigation, nor were these issues identified by the Office of River Protection quality assurance reviews.

Table 3-1. Correlation between PNOV and the Board's findings

Issues identified in The March 2005, PNOV	Issues identified by The Accident Investigation Board
Requirement that one of three backflow prevention systems be provided when non-waste transfer systems are physically connected to an active waste transfer pump.	Same condition identified now and resulted in a TSR violation.
Failure to position a valve to the correct position while performing an operations procedure.	Transfer Pump Discharge Valve left in closed position when the pump was started.
Failure to formally report equipment reliability issues.	Variable Frequency Drive, known to be unreliable, directly resulted in inability to timely operate the pump, in the reverse direction to clear waste material from the pump due to a ground fault.
Software verification and validation shall ensure that software adequately and correctly performs all intended functions. Contrary to that requirement modifications to software associated with the low flow interlock was not adequately tested nor verified. As a result automatic shutdown of the transfer pump on low flow conditions did not occur.	Recent software changes associated with low flow resulted in the transfer pump tripping on a fault with no audible or visual alarm function.
One of the operators involved in the accident had not completed the system walk down portion of the training.	One of the operators had not completed the delta change training for S-102 operations, and the millwright had not received training specific to the newly installed pump.

Some aspects of past or current management performance were not effective or were missed opportunities to identify and correct the factors that led to this accident. For example, management did not provide sufficient direction on their expectations for strict procedural compliance and for full implementation of safety requirements at all times, including during abnormal situations. The Board identified the following specific management system issues.

- Management did not provide sufficient direction about expectations for strict procedural compliance and full implementation of safety requirements, including in abnormal situations. A number of activities were performed with non-conservative application of safety requirements or did not fully comply with established controls, and some of these activities were allowed by facility management and supervisors at the Tank Farm.
- Management did not provide sufficient direction and emphasis on quality assurance or the review and evaluation of designs and equipment provided by subcontractors and vendors when the DSA was prepared or when engineering reviews of pump systems were performed. Design reviews were not sufficiently rigorous or effective to identify a significant flaw in the pump system design (i.e., the lack of a backflow preventer or alternative isolation method) or recognize the importance of evaluating off-normal pumping situations (e.g., reverse pumping operations that pressurize the supply side).
- Management did not provide sufficient direction or independent/quality assurance reviews of procedures for dealing with abnormal situations from the perspective of work control, industrial hygiene, medical response, and emergency management.

- Management was not sufficiently proactive in promoting testing pump designs in the expected environment (e.g., with a simulated slurry/sludge). Better pump testing could have resulted in fewer problems with pumping operations and less need for the reverse pumping activities that were ongoing at the time of the accident.

In interviews with the Board, senior management stated that, based on lessons learned from this accident, they were aware that oversight and engineering capabilities were not as effective as they expected, and they outlined immediate actions being taken to increase these capabilities. Senior management also stated that staff recognition of the potential for spread of radioactive contamination during retrieval activities needed to be improved and was being re-emphasized. Finally, they stated that continuous monitoring of selected hazardous chemicals during retrievals appeared appropriate and that systems to achieve this were being developed and implemented.

The Board concluded that significant improvements are needed in contractor feedback and improvement programs and in DOE oversight of contractor operations; emergency response; and environment, safety, and health programs. The Board identified the following JONs to address the management system deficiencies that contributed to this event.

1. The Office of River Protection and CH2M HILL need to review and evaluate the adequacy and implementation of corrective action plans for past events and enforcement actions to the Tank Farms and ensure that effective lessons learned processes are performed.

2. CH2M HILL and the Office of River Protections need to improve waste retrieval oversight to ensure that nuclear safety and other safety requirements are met.

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. An upcoming issue of the Summary will detail the corrective actions developed to address the Board's findings and JONs for all five program areas in which deficiencies were identified.

This event illustrates the importance of implementing effective corrective actions based on lessons learned, as well as the necessity of ensuring that in-depth quality assurance audits and surveillances are performed to identify potential issues in a timely manner. It is also important that those organizations that provide program oversight assist in identifying potential issues and ensure that contractor management addresses them appropriately.

KEYWORDS: Type A accident, hazardous waste, management systems, lessons learned, quality assurance

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

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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

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