Operating Experience Summary

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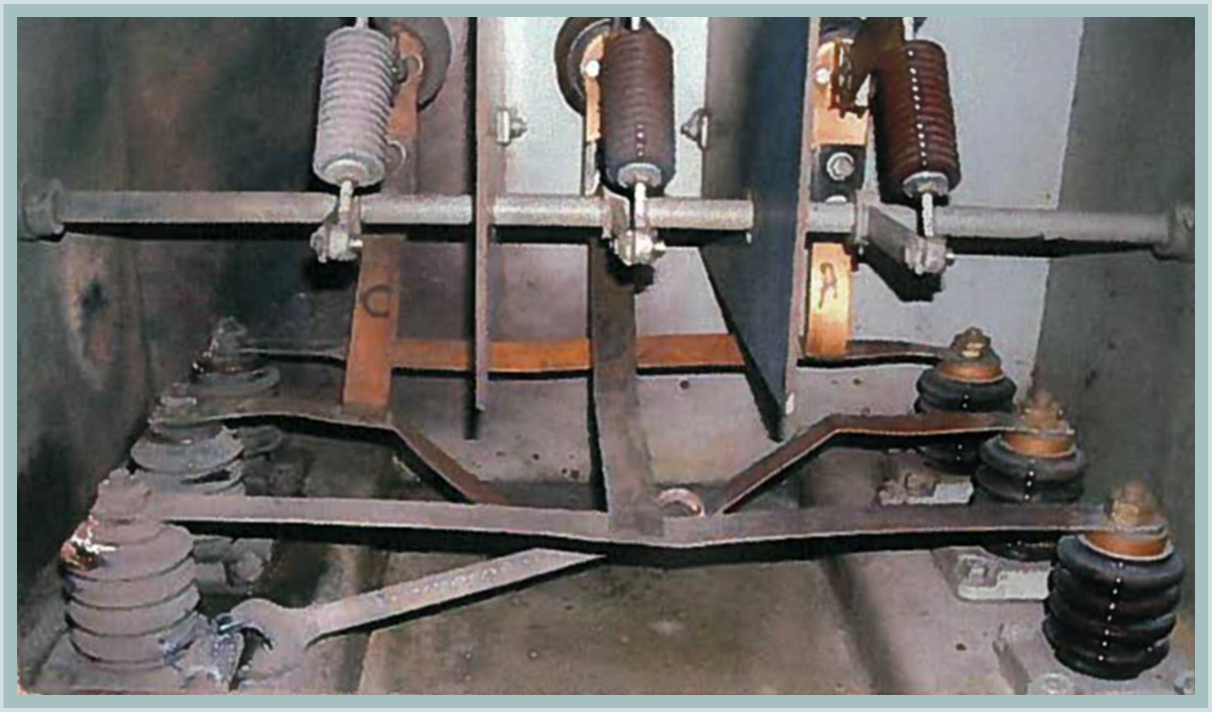

Near Miss—Work in the Wrong Electrical Cabinet Results in Arc Flash

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On March 29, 2009, at the East Tennessee Technology Park, an electrical worker (i.e., cable splicer) attempting to remove the links from the power side of a circuit interrupter placed a wrench near a bolt, heard a buzz, and felt a tingling. The worker immediately dropped the wrench, which came in contact with an energized 13.8 kV bus bar and caused an arc flash. He immediately exited the room. Although he was "shaken" by the near miss, he did not receive an electrical shock. (ORPS Report EM-ORO--BJC-K25GENLAN-2009-0001; final report issued May 19, 2009)

The worker, who was tasked with removing high-voltage bus links, mistakenly went to an energized cabinet rather than the de-energized one where he had been assigned to work. As he prepared to remove the first nut from the bus link bolts, he noticed indications that the cabinet was energized (he felt a "fuzzing" sensation), realized his mistake, turned away from the cabinet, and dropped the wrench. The ensuing arc flash welded the wrench to the cabinet (Figure 1-1). Figure 1-2 shows the damage to the cabinet.

Site management appointed an independent investigation team to investigate this near-miss event. The team learned that two electrical workers had begun work shortly before the cable splicer arrived. The cable splicer saw them working and went to an enclosure adjacent to them to begin work without realizing that he had gone to the energized cabinet by mistake. He assumed he was in the correct cabinet because he saw that the other workers had already begun to remove one of the links, and he thought that they were working on the same side of the cabinet that he was to work on. However, the other workers were

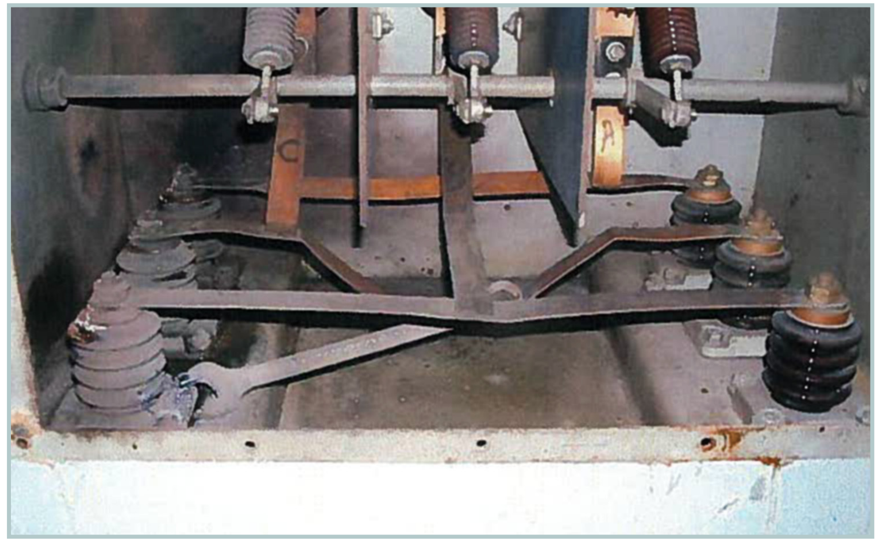

Figure 1-1. Wrench welded to bottom of cabinet

Figure 1-2. Damage to cabinet from arc flash

working on the 480-volt, secondary side, and the worker went to the energized, primary side (13.8 kV) and opened the cabinet to begin work. In addition, he did not perform a zero energy check before beginning work to ensure that he was working on a de-energized component.

Investigators determined that the procedures for electrical isolation have not been updated to reflect the current power system distribution. In addition, no project-specific procedures or work instructions were used to control the conduct of this work; instead, it was performed as minor maintenance with minimal written instructions (skill of the craft) under a Minor Maintenance Work Package (MMWP). The work package had been determined to be "Minor Maintenance Low Risk" based on the assumption that no high voltage work was to be performed on energized equipment with the exception of voltage verification. However, investigators determined that the scope of work on the MMWP did not provide sufficient detail to adequately plan the work, nor did it identify all of the hazards involved in the task. A clearly defined scope of work, rather than the more general MMWP, would have allowed workers, the planner, the supervisor, and oversight personnel to review the work activity for specific hazards.

Interviews indicated that a jobsite briefing had not been conducted. The expectation was that hazard controls would be implemented by the workers through adherence to industry codes (e.g., NFPA 70E, *Standard for Electrical Safety in the Workplace*). Some instructions were given to the other two electricians working on the task. However, there was no indication that the cable splicer received instruction regarding the work task other than what was on the MMWP, and he was not wearing the appropriate, arc-rated personal protective equipment (PPE) for the task.

The investigation team determined that the cable splicer's failure to comply with the work control step "check voltage" was the root cause of this event. Even though the system was to be worked on while de-energized, equipment is not considered de-energized until it is verified by a zero-energy voltage check. In addition, reliance on personal knowledge and experience and a lack of procedures and written controls contributed to this event, as did the following.

- The contractor's work control process did not have requirements to develop specific controls for critical steps when activities are classified as minor maintenance.
- Modification to the high-voltage power distribution system was being performed using a minor maintenance/low-risk package.
- The pre-job briefing lacked the detail and interaction needed to meet minimum safety requirements specified in 29 CFR 1910.269, did not coordinate work at the work site, and did not indicate that a voltage testing device, which was in the shop being tested, was still available for use.
- There was no supervision at the jobsite, even though it was an expectation that one supervisor would be present when the initial voltage check was performed.

Lessons to be re-learned from this event include the following.

- Do not consider electrical circuits to be de-energized until verified that they are de-energized with the use of an appropriate electrical meter.
- Always discuss potential changes in the work site during pre-job safety briefings and review all activities that are to be performed before the activity begins.
- Ensure procedures for electrical work activities are clearly defined and that requirements for the work control process are easily understood.
- Ensure procedures are kept up to date as conditions change.
- Verify that supervision is present before performing actions requiring their observation.

The investigation team also identified a number of Judgments of Need (JON) following this event, including the need to establish a written process to ensure that all electrical workers verify compliance with applicable electrical safety standards and best management practices (e.g., completing voltage checks) and the need to clearly define expectations and requirements to ensure consistent implementation of work control practices.

Other Events

A June 8, 2009, newsletter from the National Electric Code *Internet Connection* reported on an arc flash event that occurred on Good Friday 2009, in Phoenix, Arizona. While performing an annual test of a 480-volt fire pump controller, a worker and his helper were injured. With the controller door open and the fire pump running, the worker was moving his amp probe from one phase leg to another when a short circuit occurred, resulting in the arc flash. The worker was burned over 60 percent of his body and lost his eye, eyelid, part of his lower lip, and three fingers. The helper, who was standing between 10 and 15 feet away, received burns over 65 percent of his body and was blinded for some time by the flash. Fires on both workers' bodies had to be extinguished after the accident, and neither was wearing PPE. Their recovery is expected to take from 6 to 8 months.

Figure 1-3. Damage to electrical cabinet in fatal Iowa accident

A recent U.S. Department of Labor, Mine Safety and Health Administration (MSHA) Fatalgram described a fatality that occurred in Iowa on April 7, 2009, when a worker was attempting to connect a cable to load side terminals in the electrical panel and came into contact with energized 4,160-volt line side terminals. Figure 1-3 shows the aftermath of that event. The textbox above, also taken from the MSHA Fatalgram, lists best practices for performing electrical work. (http://www.msha.gov/fatals/2009/fab09m04.asp)

Before You Perform Electrical Work

- Be trained and knowledgeable in the task.
- Be trained on all the electrical test and safety equipment necessary to safely test and ground the circuit being worked on.
- Use properly rated Personal Protective Equipment including Arc Flash Protection such as a hood, gloves, shirt, and pants.
- Positively identify the circuit on which work is to be conducted.
- De-energize power and ensure that the circuit is visibly open.
- Place *your* lock and tag on the disconnecting device.
- Verify the circuit is de-energized by testing for voltage using properly rated test equipment.
- Ensure all electrical components in the cabinet are de-energized.
- Ground *all* phase conductors to the equipment grounding medium with grounding equipment that is properly rated.

Over the past few years, several issues of the OE Summary have discussed arc flash events both in industry and across the DOE Complex. Most recently, OE Summary 2009-04 discussed an arc flash event that occurred in Riyadh, Saudi Arabia, in March 2009. Like the Phoenix event, that event resulted in serious burns to workers, although there were no fatalities. OE Summary 2005-16 discusses the importance of making zero-energy checks before performing electrical work and includes a list of assumptions and mistakes that can result in an injury or fatality when working with hazardous energy. OE Summary 2006-14 discusses the importance of wearing appropriate PPE (i.e., arc-flash-rated clothing) when working on energized systems.

OSHA regulations in 29 CFR 1910 269, *Electric Power Generation, Transmission, and Distribution*, require a job briefing before workers start each job that covers the hazards associated with the job, work procedures involved, special precautions, energy source controls, and PPE requirements. The regulation also requires developing procedures that "clearly and specifically outline the scope, purpose, responsibility, authorization, rules, and techniques to be applied to the control of hazardous energy." (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table= STANDARDS&p_id=9868)

This event demonstrates the importance of detailed procedures and pre-job briefings in which all potential hazards are discussed and mitigated. Jobsite briefings are also important to identify the work site and provide an opportunity to discuss any additional hazards that may be found there. Procedures, especially for work on electrical equipment, must be detailed and precise. Workers must also take responsibility for their own safety. They should always perform zero energy checks before beginning work on electrical systems and should be alert to any signs that a system is energized, even if the expectation is that they will be working on a de-energized system. It is also important to ensure that the correct PPE for a task is worn to provide protection should an arc flash occur.

KEYWORDS: Arc flash, circuit interrupter, bus links, energized cabinet, injury, burns

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

Good Practice—Proactive Steps to Improve Safety

2

According to the National Institute for Occupational Safety and Health (NIOSH), construction workers experienced 135,350 injuries and illnesses in 2007 and had an incident rate of 190 per 10,000 workers. That Days Away, Restricted or Transferred (DART) rate of 1.9 can be compared to DOE's construction DART rate of 0.6. Within construction, contact with objects and equipment resulted in 35 percent of the injuries and illnesses. (http://www.bls.gov/news.release/pdf/osh2.pdf)

Recently, management at Thomas Jefferson National Accelerator Facility (Jefferson Lab), the Idaho National Laboratory Integrated Waste Treatment Unit (IWTU), and the Advanced Mixed Waste Treatment Plant (AMWTP) took a proactive approach to reducing the number of work-related injuries at their sites.

A June 24, 2009, submission to the DOE Lessons-Learned database described the management-initiated program at the Jefferson Lab that emphasized reporting all medically related events that occurred onsite. The intent of the program was to increase both the quality and quantity of usable site safety information to find out why injuries occur and what could be done to prevent them. (Lesson ID: JLab COE 274)

Using management meetings, site newsletters, and safety minutes at meetings with workers, management encouraged the reporting of all medically related events, regardless of their severity. The result was an almost 400 percent increase in reported events from the previous year.

Figure 2-1, taken from the Lessons-Learned submittal, shows that only 7 first-aid cases were reported between June 2007 and June 2008. However, in the year following initiation of the new reporting program (i.e., between June 2008 and June 2009), 27 such cases were reported. The information reported was a valuable tool for preventing additional (or more significant) injuries.

Figure 2-2, also taken from the Lessons-Learned submittal, shows the various types of injuries reported, with the preponderance being hand and finger injuries. The reported injuries resulted from activities such as moving equipment, pulling cable, using screwdrivers, and handling cut metal without gloves. Based on the results of this program, management provided each division with a breakdown of its individual events and appointed

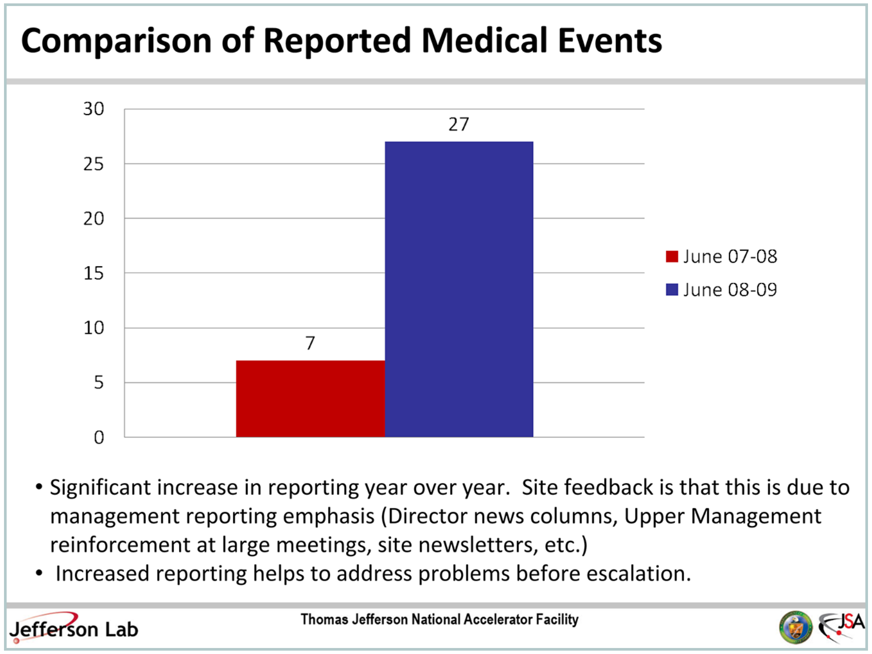

Figure 2-1. Comparison of reported hand/finger injuries before and after Jefferson Lab program implementation

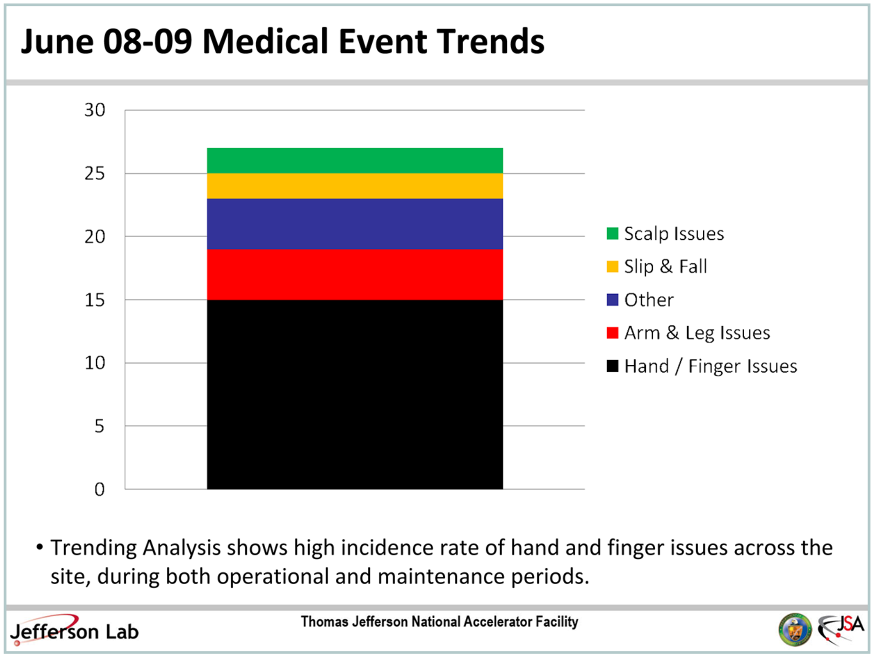

Figure 2-2. Number of reported injuries by injury type identified at the Jefferson Lab

Environment, Safety, Health and Quality (ESH&Q) liaisons to assist in determining the changes needed in work planning, task hazard analyses, and use of personal protective equipment (PPE).

Contractor management at IWTU also took a proactive approach to reversing an adverse safety trend. Based upon an adverse trend of first-aid and on-the-job injuries (non-ORPS-reportable) at the work site, the contractor called for a 24-hour safety stand-down on June 30, 2009.

About 190 craft workers (e.g., iron workers, carpenters, electricians, pipefitters) attended a 2-hour "safety pause" to discuss the adverse safety trend and provide feedback on improving safety at the job site. Work at the site was then curtailed for the remainder of the day, and workers were sent home. When they returned to work on the following day, they attended an "All Hands Meeting" followed by tool box discussions about the contractor's corrective action/safety plan to reinforce management's safety expectations. In addition, an intensive housekeeping effort was undertaken to identify and eliminate all hazards in the workplace.

AMWTP contractor management also proactively called a safety "stand-up" on July 6, 2009, to help workers regain their safety focus after the July 4th holiday weekend. This has become a routine function after major holidays at AMWTP. During the "Safety and Conduct of Operations Briefing," they discussed areas requiring additional safety focus, such as the following.

- "Big 4" Injuries — Slips/trips/falls, hand injuries, strains and sprains, and contusions
- Vehicle Safety — Speed, seat belts, fatigue, and unapproved terrain
- Heat Stress — Cell entries, sunburn, and dehydration
- Insect Stings and Snake Bites
- Lessons Learned from other DOE sites

Some threats to overall safety, along with suggested mitigating actions, were discussed at the AMWTP meeting, including the following.

- Distractions (individual focus)
- New Work Phase Startup (peer-to-peer focus)
- New Employees (ask questions)
- New Work Teams (step back if something is not understood/ does not feel right)

Good Conduct of Operations practices and Human Performance Improvement (HPI) techniques were emphasized during the stand-up, including HPI principles and tools to help anticipate and prevent active errors at the job site.

IWTU and AMWTP contractor management believe that the stand-down/stand-up and safety discussions with the various craft workers, as well as their feedback, will result in fewer accidents. In addition, taking a proactive approach to safety can result in monetary savings. For example, Jefferson Lab management estimated that at least $1,000 per year would be saved through the avoidance of lost work time and the prevention of minor, first-aid-type accidents.

Worker feedback was the topic of a 2002 Lessons Learned, *Injuries Driven to Zero when Lessons Learned Roundtable Involves Workers.* (Lessons Learned ID: 2002-NV-NTSBN-035) A manager at the Nevada Test Site found that manager-to-worker communication was not very effective in reducing worker injuries because workers did not feel part of the process when information was presented "top-down." The manager instituted a roundtable discussion of lessons learned at each weekly safety meeting. Each worker at the roundtable had an opportunity to discuss a lessons learned at home or at work that had occurred during the previous week. After including workers in these discussions, the manager saw the injury drop to zero for 8 consecutive months.

The July 22, 2009, *Safety Daily Advisor,* distributed by Business and Legal Reports (BLR), identified the following simple steps to involve employees in preventing workplace accidents.

1. **Ownership**—Give workers responsibility for such actions as planning and conducting inspections, analyzing their own data on work hazards, and developing safety checklists.
2. **Leadership**—Set an example by taking the same precautions, and wearing the same PPE, as you expect your workers to do. Be on the lookout for potential hazards and point them out to your workers.
3. **Understanding**—Explain the "why" of safety so that employees will realize that hazards put their personal health and safety at risk.
4. **Commitment**—Strive to get a commitment from every employee that safety is the number one priority.
5. **Goals**—Set clear, firm standards for workplace behavior and enforce them.
6. **Competence**—Train employees so that they will have the information and develop the skills that enable them to work safely and avoid accidents.
7. **Feedback**—Praise employees who identify and correct hazards or report problems they cannot fix.
8. **Teamwork**—Use every opportunity to encourage workers to play an active role in workplace safety and accident prevention.
9. **Responsiveness**—Respond promptly to identify hazards and take immediate steps to correct them.
10. **Persistence**—Remember, and have your workers remember, that accident prevention is an ongoing challenge that must be focused on every day—always improving, setting new safety objectives, and making steady progress toward achieving them.

An OSHA construction e-tool, *Safety and Health*, provides information on accessing a number of OSHA regulations related to construction safety. Among the regulations listed are the following related to hazard elimination and control.

1. Ensure machines and tools are in safe working order and in compliance with relevant standards [29 CFR 1926.20(b)(3), 29 CFR 1926.550(a), 29 CFR 1926.951].

2. Institute engineering and work practice controls to eliminate health hazards [29 CFR 1926.55, 29 CFR 1926.103, 29 CFR 1926 Subpart Z].
3. Perform housekeeping to remove hazards posed by scrap and debris in work areas [29 CFR 1926.25, 29 CFR 1926.852, 29 CFR 1926.152(c)(5), 29 CFR 1926.900(k)(5)].
4. Provide appropriate personal protective equipment when other controls are infeasible [29 CFR 1926.28(a), 29 CFR 1926 Subpart E].
5. Guarantee safe means of egress [29 CFR 1926.34].

The e-tool can be accessed at http://www.osha.gov/SLTC/etools/construction/shprogram.html.

Taking a proactive approach to identifying the underlying cause of worker injuries, including minor injuries that require only first-aid, can assist management in determining the changes necessary in work planning to address the causes of such injuries and reduce the potential for their occurrence. Also, a safety stand-down/stand-up, combined with meetings with workers to elicit feedback on safety issues and encourage accident prevention, is a proactive approach that can assist management in identifying causes of minor accidents and taking steps to address them.

KEYWORDS: Good practice, management, stand-up, stand-down, injuries

ISM CORE FUNCTIONS: Analyze the Hazards, Develop and Implement Hazard Controls, Provide Feedback and Continuous Improvement

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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

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