Operating Experience Summary

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Near Miss — Worker Pinned Between Manlift and Overhead Pipe

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On April 23, 2008, at Hanford, a subcontractor painter working from a boom lift while cleaning pipe hangers with an electric grinder was caught between the lift and an overhead pipe when the cord of the grinder looped around a toggle switch on the control panel (Figure 1-1), causing the boom to rise. The painter was able to hit the stop switch and reach the controls to move the lift basket enough to free himself and lower the lift to the ground. He received contusions to his back, chest, and jaw; a slight cut on his chin; and scrapes on his hand, but this incident could have resulted in a life-threatening injury or a fatality. (ORPS Report EM-RP--BNRP-RPPWTP-2008-0008; final report issued June 6, 2008)

The painter was working in tight quarters (i.e., pipe supports, piping, I-beam, and ceiling) and was wearing a respirator. When the foreman asked him to stop work, he put the grinder down, but was unaware that the cord had looped around the toggle switch. He began to lower himself to the ground, and when he engaged the foot pedal and pulled the stop switch to the "on" position, the lift moved unexpectedly. The worker's left hand was pinned between the control panel guard and an I-beam; his head, neck, and back were pinned between the control panel guard and a 2-inch-diameter pipe. The worker had not removed his respirator, and investigators believe that may have impaired his ability to see the control panel as he began his descent. Figure 1-2 shows the filter on the painter's respirator, which was crushed in the accident. Figure 1-3 shows a re-enactment of the event, with the worker's back against the pipe and his chest and head pressed into the control panel.

Figure 1-1. Cord looped over the toggle switch (re-enactment)

Investigators determined that the cord wrapping around the toggle control resulted in unexpected movement when power was provided and that there were not sufficient guards on the control panel. However, several barriers were in place that helped prevent a more serious event, including a "stop" button at the base of the lift that the spotter engaged, a similar button on the control panel that the painter engaged, and a slow setting on the operating speed of the lift. The manufacturer includes some toggle-switch guards on boom manlifts, but not all toggle switches are guarded. The contractor will add toggle-switch guards to all of the toggle switches (see Figure 1-1). Control panel covers that can be lowered during work tasks to protect the control panel will also be added to all lifts.

Figure 1-2. Damage to pink filter on painter's respirator

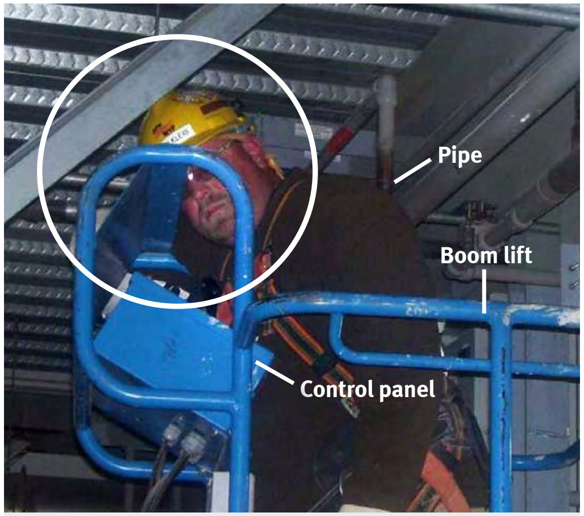

Figure 1-3. Re-enactment of the accident

Subcontractor management issued a Safety Bulletin cautioning workers to pay attention, identify hazards in the work area, establish clear communications, and be aware of co-workers and their safety. The text box on page 3 includes additional precautionary measures from the Safety Bulletin.

Another manlift event occurred at Hanford on July 30, 2007. In that event, a welder working from a scissor lift to weld two sections of stainless steel duct together was caught between the lift and the wall. The welder was having problems with the welding machine he was using, so he stopped welding, lowered the lift, and exited it to perform some test welds. When he returned to the lift, he repositioned the welding machine with the welding whip lead to the top of the lift, then repositioned his body to the left. However, he did not notice that the lead had fallen off the hand rail and onto the joystick. When the fallen lead depressed the joystick trigger, the wheels engaged and the lift moved about 3 feet, pinning the welder's leg against the wall. (ORPS Report EM-RP--BNRP-RPPWTP-2007-0014)

Investigators determined that the welder did not check to ensure that there were no objects in the travel path of the lift and that job scoping did not identify the need to ensure that equipment inside the lift was controlled to prevent it from becoming entangled in the joystick. Corrective actions included having the operator and a spotter inspect the area where a lift would be used to identify hazards, obstructions, and travel paths and requiring them to engage the emergency stop button when a lift is not in motion.

Although neither of the events at Hanford resulted in serious injuries, similar accidents in the private sector have resulted in fatalities. OE Summary 2006-12 reported on a fatality at the BP Refinery in Texas City, Texas, in July 2006. A contractor pipefitter maneuvering a manlift bucket was crushed between an I-beam structure and the control panel on the manlift. Investigators determined that he had set the speed control to the highest level, circumventing the safety interlock on the joystick, and had applied vertical force to the basket. To address the causes of this accident, revisions were made to the manlift operating procedure and to the hazard assessment form and pre-use inspection record. The OE Summary article also included an analysis of 50 manlift events at DOE that were similar to the BP event. Nearly half of those events were near misses and 14 percent resulted in injuries.

Other fatalities reported in the private sector over the last few years include the following.

- In November 2005, a firefighter was crushed between the manlift he was operating and an opening in the floor. Another firefighter found the victim near the fourth floor opening of a silo, where his self-contained breathing apparatus had become wedged between the frame of the manlift and the opening. The only instructions the firefighter had received about how to operate the manlift were from a plant employee. (NIOSH Fatality Investigation Report F-2005-34)
- In December 2005, in Alberta, Canada, a worker attaching overhead piping from a manlift died when his head was trapped between the manlift basket and an overhead beam. The worker was operating the manlift without a spotter and in limited space. (Alberta Human Resources and Employment, Workplace Safety and Health Report)
- In September 2000, in Minnesota, a painter died from injuries sustained when he was pinned between an I-beam and a manlift. The painter was moving the manlift in reverse while facing in the opposite direction and was either unaware or forgot that the I-beam was behind him. When the safety railings of the manlift passed beneath the I-beam, the victim was pinned between the beam and the control panel. The painter was working alone because a co-worker was working on another task in a different part of the building, and the co-worker found him later in the day upon his return to the work area. (NIOSH FACE Program, Minnesota Case Report 00MN044)

An OSHA study of 35 manlift fatalities between 1986 and 1990 identified the following preventative measures to address such incidents. The study is available at www.osha.gov/FatCat/fatcat.html.

1. Establishment and strict enforcement of safety standards covering good safety procedures and practices in the use of aerial devices by workers at the worksite and at critical times, through tailgate discussions and direct supervision at the work location. These include measures to prevent falls and electrocutions.
2. Improved preventive maintenance and regular maintenance procedures and frequencies to reduce equipment failure.
3. Improved efforts in training and education through the use of required work and safety procedures and better

Precautionary Measures for Work on Manlifts

- Before work begins, identify all possible obstructions that could pose a potential hazard and implement appropriate control measures.
- Ensure all controls are working properly and complete the daily inspection sheet.
- When operating lifts indoors, be sure to place speed control at the lowest possible setting.
- Think about tools in the lift that could get tangled around your feet or switches and controls. Use cordless tools when possible, and clear any debris from the lift-basket floor.
- Be aware of crush hazards when moving the lift.
- Use the emergency stop button when the lift is not in motion to prevent accidental movement.

knowledge of OSHA Safety Standards. Greater attention should be given to employees with language deficiencies.

4. Improved supervision, particularly for the new worker, in providing and requiring specific safety measures to be followed and emphasizing general safety awareness.

Manlift accidents can have tragic consequences. It is essential to ensure that all hazards are identified and addressed before a task requiring work from a manlift begins. In particular, any obstructions that could pose a hazard (e.g., items that could fall onto the joystick or cords that could tangle around feet) should be identified and controlled. In addition, the installation of engineered features (e.g., switch guards and control panel covers) should be considered to prevent inadvertent equipment operation. Workers should be properly trained in safety rules, regulations, and procedures, including how to recognize and eliminate hazards associated with tasks. Using a spotter who can help control manlift movement and can stop movement when necessary is also essential to protect the worker on the manlift from what could be a serious injury or fatality.

KEYWORDS: Near miss, manlift, joystick, control panel, pinned, piping, grinder cord, I-beam

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

Prevent an Accident — Secure That Load Before You Transport

2

On April 17, 2008, at the Hanford Site, a pump assembly loaded on a Fluor Hanford Transportation Services flatbed semi-trailer fell off the bed of the truck and landed on the ground. The pump assembly (Figure 2-1), which weighed 1,260 pounds, was being transported to an excess yard when the near-miss event occurred. No personnel were within the vicinity of the dropped load. (ORPS Report EM-RL--PHMC-FSS-2008-0004; final report issued May 28, 2008)

A storekeeper used a forklift to load the pump assembly, which was sitting on a diamond plate metal skid, onto the flatbed trailer, and the driver secured the metal skid to the trailer with a 4-inch strap rated at 12,000 pounds. The two workers believed that the pump assembly, which had been on the metal skid for approximately 19 years, was welded to the skid and painted in place. However, the two pieces were never physically attached to each other.

The loaded tractor-trailer had been driven approximately 200 feet from the loading area onto a graveled buffer area when the driver encountered a slight slope and a depression in the ground, and the pump assembly tipped over and slid off the trailer onto the ground (Figure 2-2).

The metal skid remained secured to the truck (Figure 2-3), but the pump assembly was damaged in the fall. All loading and unloading operations and all movement of material using tractor-trailers were stopped pending a review of the event with Fluor Hanford drivers, identification of methods for safely hauling unstable materials, and approval to resume work from Senior Management.

Figure 2-1. The pump assembly shown banded back together on the metal skid after the incident

Figure 2-2. Tractor-trailer and fallen pump assembly

Figure 2-3. Metal skid held down by yellow strap

Investigators determined that no one involved in the shipment of the pump assembly recognized and communicated the need for special handling to stabilize the equipment and prevent damage. Because no one knew the exact weight of the load, the fact that it was top heavy, and that the skid and pump assembly were not attached to each other, the equipment was not properly secured in accordance with Federal Motor Carrier Safety Regulations, which require at least two straps.

Investigators also determined that training for securing loads had been a one-time activity and, for some Fluor Hanford teamsters, this training had been completed in the 1980s. New training methods must be developed, and supervisors must be trained to recognize an appropriately secured load.

A review of ORPS for events involving improperly secured loads identified 16 similar events since January 2005. The following occurrences are representative of load securement problems.

On November 5, 2007, two pallets of unsecured sheet metal slid off a Fluor Hanford Transportation semi-trailer as the driver was completing a 270-degree loop at a warehouse yard. The driver was making the loop to align the trailer and was backing up to the dock when the top two pallets shifted. The pallets slid onto the ground after breaking off several of the side boards on the flatbed truck. (ORPS Report EM-RL--PHMC-FSS-2007-0015)

Investigators learned that Fluor Hanford drivers had been transporting unsecured loads around the yard for many years. Although the drivers were aware that they needed to secure loads on public roadways, they did not realize that routine yard transport could be a high-risk activity that required strapping. Management expectations for secure transport did not specifically include Fluor Hanford yard areas across the site, and it was left to the judgment of the driver to decide when to secure such loads.

On October 19, 2007, at the Idaho National Laboratory, while a truck driver was delivering empty waste boxes from an offsite warehouse to the Advanced Mixed Waste Treatment Project (AMWTP), one of the boxes fell from the flatbed when the driver turned a corner. The driver had previously delivered two of six waste boxes to another building at the AMWTP and had taken off the tie-down straps, believing that all six would be off-loaded at the first building. However, the driver was told to deliver the remaining four boxes to a different building. The driver did not re-secure the tie-down straps before driving to the other building. While making a turn that was sharper than 90 degrees, the box slid off the flatbed and landed upside down on the gravel beside the road. (ORPS Report EM-ID--BBWI-AMWTF-2007-0018)

The initial investigation determined that the flatbed had been recently oiled and it had rained that morning, which contributed to the flatbed surface being considerably more slippery than normal. Although the driver was traveling at a low speed, the lack of tie-down straps, combined with the slippery deck and the sharp corner, caused the box to slide off. A similar event occurred at the Laboratory on January 6, 2003, when an unsecured multiple-ton crane counterweight slid off a flatbed truck because of ice on the metal bed (Figure 2-4). (ORPS Report EM-ID--BBWI-CFA-2003-0001)

On May 30, 2007, at the Lawrence Livermore National Laboratory, riggers were conducting an onsite transport of equipment between two buildings when an electronics rack dislodged from the flatbed tractor trailer and dropped 5 feet to the roadway. The transport vehicle was making a left turn when the electronics rack, which weighed approximately 1,100 pounds, fell off the truck and hit the asphalt road. The electronics rack sustained significant damage. (ORPS Report NA--LSO-LLNL-LLNL-2007-0029)

Responsibility

It is always the driver's responsibility to ensure that the load is properly placed and secured with restraints before moving the vehicle.

Load Securement Practices

- Know the weight of the load and its center of gravity.
- Inspect all restraints before use, and perform a safety inspection of the vehicle.
- Use as many cargo restraints as necessary to secure the load from shifting in any direction or from falling off the truck. The load must be secured either by direct contact between the load and the restraint or by dunnage that is in contact with the load and is secured by the restraint.
- Know your coefficients of friction. On steel-decked trailers, wood softeners must be used between the load and the deck. Plastic sheeting should not be used for protective surfaces on loads unless special instructions are provided for restraints, travel routes, and speed limitations.
- Choose routes that take advantage of the best roads, and understand the forces that develop because of changes in speed or direction (i.e., acceleration, deceleration, turns, and curves).
- Understand weight distribution. Since load placement can affect vehicle handling and braking, always distribute the load over the width and length of the deck.
- Understand the principles of load securement. Improper load securement can put yourself and others in danger. Only use tie-down materials with a strength rating established and documented by the manufacturer. The principle tie-down forces should be transmitted to the vehicle frame and not the decking.

Figure 2-4. Ice on metal bed of trailer

Investigators determined that the riggers and the driver incorrectly assumed that the requirements for equipment tie-down were less strict for transporting onsite loads than for offsite transports. Investigators also determined that the load had been placed at the edge of the flatbed, which did not allow for the load straps to be equidistant and properly secured; thus, the load could shift when the driver turned corners or swerved suddenly. In addition, the length of the dunnage under the electronics rack was not adequate to properly span the load, which also may have contributed to the event. The workers assumed that the load was a typical electronics rack with a low center of gravity; but, in fact, it was a specialized piece of experimental equipment that was top heavy.

The following references provide information on securing loads for transport.

- 49 CFR 393.100, *General Rules for Protection against Shifting or Falling Cargo*
- 49 CFR 393-102, *Securement Systems*

These events underscore the importance of drivers understanding the dynamics of loads under transport and their responsibility for ensuring that all loads are properly secured before transport. The driver is responsible for safely securing the load, understanding the characteristics of the load their vehicle is carrying, and taking into account the effect of the load on the steering, cornering, and braking performance of the vehicle. Drivers must also understand and follow the rules and regulations for both onsite and offsite transportation, and supervisors and managers must ensure that they are enforced, especially with regard to onsite transports.

KEYWORDS: Truck, trailer, bed, load, cargo, securing, hauling, dropped, rigged, transportation onsite

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

Residual Flammable Vapors in PVC Pipe Cause Explosion

3

On September 13, 2007, at the Stanford Linear Accelerator Center (SLAC), a subcontractor welder was performing a hot tap into a carbon steel pipe when the heat from the acetylene torch ignited residual vapor trapped inside attached polyvinylchloride (PVC) piping and caused an explosion. The force of the explosion threw shrapnel at least 60 feet outward, and one piece was found 100 feet from the scene. Although pieces of the pipe punctured a sheet metal wall (Figure 3-1), the two workers closest to the explosion were protected by an alcove wall that separated them from the pipe. Four other workers standing about 25 feet away suffered temporary hearing loss from the concussion of the explosion. Following the explosion, the facility manager evacuated the accelerator tunnel below the work area as a precaution, and the area was barricaded. (ORPS Report SC--SSO-SU-SLAC-2007-0011; final report issued October 26, 2007)

Subcontractor workers had used PVC cement and primer when installing new PVC piping that connected to a steel pipe, which extended into the alcove. The workers then blanked off (i.e., capped) the new pipe to prepare it for pressure testing. On the following day, the welder began to cut a hole in the steel pipe section to install a "threadlet" for pressure testing, and the vapor that had been trapped inside the blanked pipe ignited from the heat of the torch, rapidly increasing the pressure in the pipe and resulting in the explosion. Figure 3-2 shows the hole in the PVC piping after the explosion.

The Laboratory Director convened an Incident Analysis Board (IAB) to investigate the accident. The IAB estimated that the force of the explosion was equivalent to the force of 2 pounds of TNT. They reviewed the MSDS for the PVC cement and determined that, although a subsection states that the cement is a fire hazard because of its low flash point and that "vapors… may travel to sources of ignition at or near ground or lower levels and may flash back," there was no mention of an explosion hazard if gasses were trapped in a closed pipe and a torch was applied.

During interviews, the IAB learned that many workers were not aware of the explosion hazard. The welder, for example, told them that he was not familiar with the dangers and hazards associated with the steel/PVC pipe configuration because he normally worked only with carbon steel pipe. The IAB also learned that detailed information about the hazards of using PVC pipe and cement was not included in the project safety documents; specifically, there was no warning that PVC cement fumes trapped in a closed pipe could explode if an ignition source was introduced during cutting operations. When reviewing the safety documents for this task, the IAB

Figure 3-1. Shrapnel penetration

Figure 3-2. Hole in PVC pipe following the explosion

determined that the hot work permit did not include details about what would be cut or welded, the location for the work was not accurate, and the JSA did not detail work steps properly to ensure that the problem of fumes inside the closed pipe would be detected.

Importantly, the pressure gauge was not installed during preassembly work, which resulted in the need for the welder to cut into the new steel pipe after it had been attached to the PVC piping. In addition, the cement fumes were not allowed to dissipate to the atmosphere after the piping was assembled and before the new pipe sections were blanked off. The need to install the pressure tap constituted a change in job scope, which should have led to a re-evaluation of the hazards, but the potential for an explosion was never discussed. Also, the lack of a pressure test plan and a sequence of tasks that included installing the pressure gauge before capping the pipe, left it to the welder to decide how to proceed.

A similar event occurred at Hanford in 1995, when a contractor was installing a new pipe line. About 3 weeks before the accident occurred, one end of a 6-inch PVC pipe was connected to a steel pipe with PVC cement; the other end of the pipe was capped. On the day of the accident, when a contractor used a torch to cut a hole in the steel pipe to attach a sensor, the entire section of PVC pipe exploded and shrapnel spread throughout a 400-foot by 220-foot building. Although about 40 people were standing under the pipe when the explosion occurred, only 2 workers were injured, neither seriously. Investigators determined that the adhesive used when assembling the pipe contained volatile solvents that were trapped in the joint and caused an explosive mixture in the sealed pipe. The recommended actions developed following this event stated that newly fabricated PVC pipes should be ventilated before performing any spark-producing activity around them. (Richland Operations Office Lessons Learned Identifier 1995-RL-WHC-0044)

Another accident related to PVC cement fumes occurred in Philadelphia, Pennsylvania, on April 22, 1997, where there was an explosion in the pit of a Montgomery-KONE elevator during modernization of a post office. Two workers were injured when a welding torch ignited flammable vapors from PVC cement that had been used a week earlier. To accommodate the piston for one elevator, a 72-foot deep shaft was drilled into the base of the pit and the shaft was lined with PVC pipe sections glued together with PVC primer and liquid cement. Both contained flammable solvents that were 2.5 times heavier than air. A week later, a welding torch set off an explosion that blew the PVC pipe out of the shaft and strewed PVC shrapnel around the pit, causing multiple leg injuries to one worker. The second worker lost hearing in one ear as a result of the explosion.

OSHA investigated this accident and determined that the welding arc ignited heavier-than-air vapors from the primer and PVC cement. OSHA investigators believe that the vapors settled into the bottom of the PVC liner, even though the Montgomery-KONE workers had made efforts to remove them, including using an exhaust fan to suck out the air in the elevator pit and blowing compressed air into the PVC cylinder to purge it. Unfortunately, because of the weight of the flammable vapors, these efforts were inadequate, and, when the jack cylinder was lowered into the PVC liner, it partially displaced these vapors from the PVC liner into the elevator pit. The employee holding the welding torch was standing several feet from the liner. When he lit the welding torch, the flame ignited the vapors in the elevator pit and carried the reaction to the vapors that remained in the PVC liner. The resulting explosion shattered the PVC liner and strewed pieces of PVC shrapnel around the pit. OSHA issued three citations to Montgomery-KONE, including one for a serious violation of the construction safety standard with regard to confined spaces [i.e., 29 CFR 1926.21(b)(6)(i)].

OSHA requirements in 1926.21(b)(2) state that the employer "shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work environment to control or eliminate any hazards or other exposure to illness or injury."

The IAB investigation of the accident at SLAC identified problems with project safety documents that did not identify the hazard of PVC cement fumes being trapped in a closed pipe; thus, many workers, including the welder, considered the work to be a routine, low hazard activity. The IAB concluded that applying ISM principles (i.e., defining work scope, identifying hazards, developing barriers to hazards, and implementing barriers) potentially would have ensured that the hazards would have been identified and the accident would not have occurred.

This event demonstrates the need to ensure that all potential hazards are identified and addressed before work begins. Job planners should consider searching other DOE databases and industry lessons-learned sources and trade databases to assess whether hazards from past experiences are present in the planned work. All work control documents should clearly identify hazards associated with work tasks and provide explicit details on planning and job sequencing to ensure that new hazards are not introduced. In addition, any potential hazards should be discussed and planned for in the pre-job briefings. It is also important that workers avoid making assumptions about work tasks on the basis of previous experience with similar tasks, as such experience may not be applicable to the task at hand.

KEYWORDS: Explosion, PVC piping, cement vapors, welder, acetylene torch

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

The Office of Health, Safety and Security (HSS), Office of Analysis publishes the Operating Experience Summary to promote safety throughout the Department of Energy (DOE) complex by encouraging the exchange of lessons-learned information among DOE facilities.

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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