U.S. Department of Energy
Office of Fossil Energy

Accident Investigation Report

Scissor Lift Accident in the West Hackberry Brine Tank-14 Resulting in Injury on February 7, 2013

June 2013

Strategic Petroleum Reserve
West Hackberry Storage Site
Cameron Parish, Louisiana

Disclaimer

This report is an independent product of the Accident Investigation Board appointed by Christopher A. Smith, Acting Assistant Secretary, Office of Fossil Energy. The Board was appointed to perform an Accident Investigation and to prepare an investigation report in accordance with Department of Energy (DOE) Order 225.1B, *Accident Investigations.*
The discussion of the facts as determined by the Board and the views expressed in the report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

Release Authorization

On February 15, 2013, an Accident Investigation Board (the Board) was appointed to investigate an accident that resulted in serious injuries caused when a scissor lift tipped over in Brine Tank-14 (WHT-14) at the Strategic Petroleum Reserve, West Hackberry, Louisiana, site on February 7, 2013. The Board's responsibilities have been completed with respect to this investigation. The analysis and the identification of the direct cause, root causes, contributing causes, and judgments of need resulting from this investigation were performed in accordance with the Department of Energy (DOE) Order 225.1B, *Accident Investigations*.

The report of the Accident Investigation Board has been accepted and the authorization to release this report for general distribution has been granted.

Christopher A. Smith
Acting Assistant Secretary
Office of Fossil Energy

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Legend of Personnel

AGSC SCS	AGSC Site Construction Specialist
CRO	Control Room Operator
DOE Eng	Department of Energy Engineer
DOE SSR	DOE Senior Site Representative
PBC Blaster	PBC Abrasive Blaster
PBC FSS	PBC Facility Safety Supervisor
PBC HSE Director	PBC Health, Safety and Environment Director
PBC Hole Watch	PBC Tank Entry Watch (Confined Space Watch)
PBC NACE Insp	PBC NACE Inspector (NACE International, originally National Association of Corrosion Engineers)
PBC Pot Tender	PBC Pot Tender
PBC SSR	PBC Site Safety Representative
PBC Site Sup	PBC Site Supervisor
DM EMS/ERT Lead	DM Fire Protection and Emergency Management Specialist/ERT Lead
ERT	Emergency Response Team
EMT	Emergency Medical Technician

Acronyms

A&E	Architectural and Engineering
AGSC	ASRC Gulf States Constructors, LLC
APM	Accident Prevention Manual
CON	Conclusion
CRO	Control Room Operator
CST	Central Standard Time
DM	DM Petroleum Operations Company
DOE	Department of Energy
ERT	Emergency Response Team
ES&H	Environment, Safety and Health
FE	Office of Fossil Energy
ISM	Integrated Safety Management
JON	Judgment of Need
JHA	Job Hazard Analysis
JSA	Job Safety Analysis
NACE	NACE International, originally National Association of Corrosion Engineers
OSHA	Occupational Safety and Health Administration
PBC	Performance Blasting and Coating, LP
PHR	Preliminary Hazards Review
PPE	Personal Protective Equipment
RFO	Request for Offer
SEP	Safety Execution Plan
SOW	Statement of Work
SPR	Strategic Petroleum Reserve
SPR-HQ	Strategic Petroleum Reserve Headquarters
SPRPMO	Strategic Petroleum Reserve Project Management Office
SWP	Safe Work Permit
WHT-14	West Hackberry Brine Tank-14

Executive Summary

Introduction

On February 15, 2013, an Accident Investigation Board (the Board) was appointed to investigate an accident that resulted in serious injuries caused when a scissor lift tipped over in Brine Tank-14 (WHT-14) at the Strategic Petroleum Reserve, West Hackberry, Louisiana, site on February 7, 2013. The Board's responsibilities have been completed with respect to this investigation. The analysis and the identification of the direct cause, root causes, contributing causes, and judgments of need resulting from this investigation were performed in accordance with the Department of Energy (DOE) Order 225.1B, *Accident Investigations*.

Accident Description

On February 7, 2013, a Performance Blasting & Coating, LP, (PBC) employee was seriously injured at the West Hackberry Strategic Petroleum Reserve (SPR) when a fully extended scissor lift tipped over during an abrasive blasting operation.

After arriving at the West Hackberry SPR site early on the morning of February 7, 2013, PBC and DM Petroleum Operations Company (DM) updated the Safe Work Permit (SWP) for conducting abrasive blasting operations in Brine Tank 14 (WHT-14). The PBC Site Superintendant (PBC Site Sup) conducted a morning safety meeting with the crew involved in the abrasive blasting operation, which included a review of the work to be performed and certification of scissor lift training for selected employees. Blaster 1 was assigned to work from Skyjack scissor lift Model SJIII 3226, and he completed the PBC Aerial Man Lift Preventive Maintenance Checklist for the assigned scissor lift and did not note any unsatisfactory conditions. At approximately 9:54 a.m. Central Standard Time (CST), Blaster 1 and Blaster 2 entered WHT-14 to perform elevated abrasive blasting operations.

PBC Blaster 1 and PBC Blaster 2 were connected by separate blast hoses to a common sand pot and began blasting the upper four feet (the 28 to 32 foot level above the floor of the tank) of the interior tank wall. PBC Blaster 1 was working, in a counterclockwise direction with the scissor lift fully extended, and was visible from the location where the PBC Tank Entry Watch (PBC Hole Watch) was monitoring the activity. The PBC Hole Watch reported that PBC Blaster 1 was making good progress and that he had experienced few problems with his equipment.

At approximately 10:42 a.m., the PBC Hole Watch felt the blast hose supplying air and grit to Blaster 1 pulse, an indication that the nozzle had been opened to begin blasting, looked up, and observed the scissor lift and PBC Blaster 1 falling toward the center of the tank. PBC Blaster 1 and the scissor lift came to rest on the floor of the tank with PBC Blaster 1 lying partially out of the work platform, still connected to the work platform by a lanyard attached to his fall protection harness.

The PBC Hole Watch immediately sounded an air horn, which was PBC's designated emergency signal, to alert others in the area that a problem had occurred. The accident was not immediately reported to the Control Room Operator (CRO) as required, and as a result activation of the

Emergency Response Team (ERT) was delayed until 10:56 a.m. and the call to 911 was delayed until 11:00 a.m.

The Cameron Ambulance arrived at 11:08 a.m.; PBC Blaster 1 was placed in the ambulance at 11:34 a.m.; and the ambulance departed the West Hackberry SPR site at 11:44 a.m. to transport the injured employee to a local hospital.

Direct, Root, and Contributing Causes

Direct Cause - the immediate events or conditions that caused the accident. The Board concluded the direct cause of this accident was lateral forces exceeded the capability of the scissor lift to remain upright.

Root causes are the causal factor(s) that, if corrected, would prevent recurrence of the same (local) or similar (systemic) accidents. The Board determined that:

The **local root cause** was that SPRPMO, DM, AGSC, and PBC failed to recognize, understand, and manage operating conditions within the safe operating limits specified by the equipment manufacturer.

The **systemic root cause** of this accident was that SPRPMO, DM, and AGSC failed to adequately implement several of the guiding principles of Integrated Safety Management: Clear Roles and Responsibilities; Competence Commensurate with Responsibilities; Identification of Safety Standards and Requirements; and Hazard Controls Tailored to Work Being Performed. Examples of specific deficiencies included:

- Unclear responsibilities of the PBC site supervisor and site safety representative for supervising and overseeing the work;
- Unclear responsibilities of the DM and PBC employees regarding emergency response operations;
- Unclear responsibilities at the SPRPMO for review of field site plans and work documents;
- Inexperience of AGSC and PBC employees for overseeing and conducting blasting work inside a tank using scissor lifts;
- Failure by PBC to evaluate and designate, in writing, who the OSHA competent person was for the project; and
- Job specific safety documents developed by PBC, approved by AGSC, and reviewed by DM and the SPRPMO did not include detailed lateral force restriction hazard information (0 mph wind / 90 lb side) as provided by the manufacturer.

Contributing Causes - events or conditions that collectively with other causes increased the likelihood of an accident but that individually did not cause the accident. The Board identified eight contributing causes to the accident:

- Safety documents such as the Job Hazard Analysis were generic and did not identify and analyze lateral force as a hazard;

- Supervisors and safety personnel were not aware of the lateral force hazard;
- Scissor lift operators were not trained to be aware of the lateral force hazard;
- Scissor lift operators were allowed to operate the scissor lift without regard to the lateral force hazard;
- Oversight organizations were not technically knowledgeable in the operational limitations and specific safety requirements for scissor lift operations;
- Work planning depended on skill of the craft due to a lack of adequate safe work procedures and competent supervision;
- The length of the blast hose was not sufficient to prevent excessive lateral loading of the elevated work platform; and
- The operators were inexperienced in using scissor lifts for blasting jobs inside tanks.

Conclusions and Judgments of Need

Based upon the findings of this accident investigation, the Accident Investigation Board (the Board) concluded that this accident and the resulting injury were preventable.

Table ES-1 summarizes the Conclusions (CONs) and Judgments of Need (JONs) determined by the Board.

The conclusions are those that the Board considered significant and are based on the facts and pertinent analytical results. Judgments of Need are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the probability or severity of a recurrence of this type of accident resulting in an injury or fatality. Judgments of Need are derived from the conclusions and causal factors and are intended to assist managers in developing corrective actions and fostering continuous improvement.

Table ES-1: Conclusions and Judgments of Need

Conclusion	Judgment of Need
Selection of scissor lifts by PBC and acceptance by AGSC to perform the blasting job were poor decisions because scissor lifts have significant operating restrictions concerning lateral force including the attachment of blast hose and air hose to the work platform.	**JON 1**: The SPRPMO must develop a written process that requires all (powered) equipment used for SPR work to undergo a review before being allowed onto any SPR site. The review should identify the manufacturers name, make and model, serial number, and current inspection date, and it should ensure that equipment specific hazards and operational limitations, as identified in current/up-to-date operational manuals are analyzed for incorporation into work safety-planning documents.
AGSC allowed work to commence without ensuring all contract required submittals from PBC were adequate and complete.	**JON 2**: Contractors must strengthen their contract submittal review process to ensure subcontractor required submittals are adequate and complete before allowing work to commence.
Job specific safety documents, developed by PBC, approved by AGSC, reviewed by DM and the SPRPMO, were deficient because they did not include manufacturer information regarding lateral force hazards that were specific to the scissor lift equipment or the operating restrictions in the applicable ANSI standard.	**JON 3:** Contractors must strengthen their safety document review process to ensure that subcontractor safety document submittals are reviewed by individuals with sufficient technical competence to determine the adequacy of submitted documents. **JON 4:** The SPRPMO must formalize and document their safety document review process. When implemented, the process needs to ensure that submittals are reviewed by individuals with sufficient technical competence to determine the adequacy of those submittals and it needs to include documented authorization or non-authorization of the completed review. The process should include a hold point(s) and sufficient review windows. Clear roles and responsibilities should be clarified and should include the Contracting Officer, CORs, onsite Federal line staff, and SPRPMO staff.

Conclusion	Judgment of Need
The Job Safety Analysis did not identify hazards associated with abrasive blasting work from a scissor lift, specifically the lateral force restriction.	**JON 5**: Subcontractors must ensure that equipment specific operator manual and label requirements are appropriately reviewed, understood, and incorporated into work control documents and practices. **JON 6**: Contractors must ensure that subcontractors review, understand, and incorporate equipment-specific operator manual and label requirements into work control documents and practices.
Information regarding the lateral force restrictions that were specific to the scissor lift was available in the operating manual located in a holder on the scissor lift and on a warning label attached to the scissor lift, but that restriction was not incorporated into work controls.	**JON 5**: Subcontractors must ensure that equipment specific operator manuals and label requirements are appropriately reviewed, understood, and incorporated into work control documents and practices. **JON 6**: Contractors must ensure that subcontractors review, understand, and incorporate equipment-specific operator manual and label requirements into work control documents and practices.

Conclusion	Judgment of Need
SPRPMO, DM, AGSC, and PBC failed to recognize, understand, and manage the lateral force restrictions of the scissor lift.	**JON 7:** Work planning must include the analysis of the hazards associated with the operation of all power equipment and machinery required to perform the job. Contract language shall require the selected vendor to list the equipment in their Work Plan proposal and address, at a minimum, all manufacturer precautions and limitations identified in the operations manuals. Precautions and limitations must be discussed during hazard identification and work planning sessions so that appropriate mitigating factors can be established, approved and monitored. The competency of those reviewing, approving and monitoring shall be commensurate with the identified hazards. Precautions and limitations requiring engineering analysis to mitigate a hazard shall require review and approval by a qualified individual or group. **JON 8**: Subcontractors must ensure that equipment operating restrictions and precautions are adequately identified and incorporated into work documents and practices. **JON 9**: Subcontractor supervisors, safety personnel, and workers must be properly trained and made aware of equipment operating restrictions and precautions. **JON 10**: Contractor supervisors, safety personnel, and other workers who oversee subcontractor work must be aware of equipment operating restrictions and precautions. **JON 11:** SPRPMO Federal supervisors, safety personnel, and other workers who oversee contractor and subcontractor work must be aware of equipment operating restrictions and precautions.

Conclusion	Judgment of Need
Scissor lift operator training that was conducted by PBC was deficient because it was not conducted by a qualified person as defined by OSHA, and it did not include the lateral force restriction that was specific to the scissor lift.	**JON 12**: Subcontractor equipment specific training must meet OSHA/ANSI minimum requirements. **JON 13**: Contractors must ensure that training conducted by a subcontractor for work to be performed on the SPR site meets OSHA/ANSI minimum requirements.
The PBC person identified as the on-site scissor lift competent person was not qualified to perform the functions of a competent person as defined by 29 CFR 1926 for scissor lifts and scaffolding.	**JON 14**: Subcontractors must ensure that individuals assigned to perform competent person responsibilities meet the requirements of a competent person as defined by OSHA. **JON 15**: Contractors must ensure that subcontractors who assign individuals to perform competent person responsibilities meet the requirements of a competent person as defined by OSHA.
Various supervisory functions were specified and required (including job supervision, OSHA competent person, site safety supervision, and OSHA confined space entry supervisor). However the persons assigned to those functions were not always available or able to oversee the work inside the tank and they were unable to effectively perform a supervisory function.	**JON 16:** The roles and responsibilities of subcontractor personnel, including supervisory functions, and the competencies required of those roles, should be clearly identified in work planning and assurance must be given that assigned personnel have the knowledge, competence and opportunity to carry out their functions. Specific required supervisory functions should be specified in contract documents.
None of the workers were familiar with using scissor lifts during blasting operations inside tanks.	**JON 17**: During the selection phase of the contract procurement process, contractors must require subcontractors to provide a summary of their experience that is associated with operating specific equipment and with performing specific task activities. That experience level should be utilized to assess the risk of the contractor to perform the operation/work task and to qualify the contractor by its acceptability to management.

Conclusion	Judgment of Need
There are additional weaknesses in hazard identification, hazard control, and performance of work within controls.	**JON 18:** SPRPMO and its contractors and subcontractors must strengthen the identification and communication processes for classifying and reclassifying confined spaces when work activities change the hazards present within those spaces. **JON 19:** SPRPMO and its contractors and subcontractors must ensure that safety documents that require the use of respiratory protection identify the atmospheric hazard(s) of concern, the anticipated levels, the methods to be used to evaluate those levels, and proper respirator use procedures. The criteria for when respirators shall be required shall be specified.
There was confusion regarding the responsibilities for emergency response actions.	**JON 20**: Emergency response procedures/plans must be implemented and used by all organizations and individuals performing work at SPR sites. Potential emergency response procedures, roles and responsibilities should be documented, reviewed and agreed upon and all involved parties should be trained prior to the start of work.
A PBC subcontractor employee had questioned the use of scissor lifts to perform blasting operations inside the tank, but took no further action.	**JON 21**: SPRPMO should require contractors and subcontractors performing work at SPR sites to implement a process for resolving safety related questions in instances that do not meet "Stop Work" levels.
The SPRPMO and its contractors' corrective action processes need improvement regarding oversight, training, stop work, and lessons-learned.	**JON 22:** SPRPMO and its contractors need to conduct independent corrective action effectiveness reviews of all corrective actions from previous accident/incident reports to measure their current effectiveness regarding oversight, training, stop work, and lessons-learned. **JON 23:** SPRPMO should develop a matrix of OSHA-required training that displays the expected proficiencies that employees must have upon completion of that training, for each

Conclusion	Judgment of Need
	requirement. This matrix should be made specific to types of equipment or tasks. It should be distributed to each DOE employee who is assigned oversight responsibilities and made available to contractors to use as a benchmark. The matrix should be used to identify training requirements for oversight personnel. Oversight validation of contractor personnel training should include requiring copies of relevant training certificates, curriculum topics, and trainer qualifications. Failure to document this training would be indicative of an OSHA violation and possibly a contract violation.
PBC employees who witnessed the accident and initial responders from DOE and DM did not immediately contact the Control Room Operator to initiate emergency response.	**JON 24:** Contractors must reinforce the SPR West Hackberry emergency notification procedures to ensure that all events requiring emergency or medical response are promptly reported to the proper contact/location. **JON 25**: Contractors must ensure that the SPR West Hackberry emergency notification procedures are transmitted as a requirement to subcontractors.
The Board determined the scene was preserved, photographed and the witness statements completed in a timely manner.	None.

1.0 Introduction

1.1 Appointment of the Board

On February 15, 2013, an Accident Investigation Board (the Board) was appointed to investigate an accident that resulted in serious injuries caused when a scissor lift tipped over in Brine Tank-14 (WHT-14) at the Strategic Petroleum Reserve, West Hackberry, Louisiana, site on February 7, 2013. The Board's responsibilities have been completed with respect to this investigation. The analysis and the identification of the direct cause, root causes, contributing causes, and judgments of need resulting from this investigation were performed in accordance with the Department of Energy (DOE) Order 225.1B, *Accident Investigations*.

1.2 Facility and Organization

1.2.1. Strategic Petroleum Reserve

The Strategic Petroleum Reserve (SPR) is the world's largest supply of emergency crude oil. The Federally-owned oil stocks are stored in large underground salt caverns along the coastline of the Gulf of Mexico. SPR currently operates and maintains four major oil storage facilities in the Gulf Coast regions of the United States. Bayou Choctaw, West Hackberry, Big Hill, and Bryan Mound, are located along the Gulf Coast of Louisiana and Texas and have a combined oil storage capacity of 727 million barrels and a drawdown capability of 4.4 million barrels per day.

All oil stored in SPR's oil storage facilities is in large underground storage caverns which have been developed in salt dome formations. Salt dome storage technology provides maximum security and safety for the Nation's stockpile of crude oil.

1.2.2. West Hackberry Site

The SPR West Hackberry storage site is located in Cameron Parish, Louisiana, approximately 25 miles southwest of Lake Charles, Louisiana. The site has 22 storage caverns with a combined storage capacity of 228 million barrels, and a cavern inventory of 215.8 million barrels.

The West Hackberry site was completed in 1988. SPR annually performs a number of major maintenance projects to maintain the site's operational capabilities. One of these activities is maintenance of two tanks that are used to store brine water that is needed to displace stored crude oil when oil is withdrawn from underground storage caverns. The brine tanks must be repaired and repainted every three to five years to protect them from corrosion.

Figure 1: West Hackberry Site, Cameron Parish, Louisiana

1.2.3. Office of Fossil Energy

The Department of Energy Office of Fossil Energy (FE) organization is made up of about 1,000 scientists, engineers, technicians and administrative staff. Its headquarters offices are in downtown Washington, DC, and in Germantown, Maryland. The organization also includes the National Energy Technology Laboratory with offices in Morgantown, WV, Pittsburgh, PA, Sugar Land, TX, Albany, OR, and Anchorage, AK; the Strategic Petroleum Reserve based in New Orleans, LA; and the Rocky Mountain Oilfield Testing Center in Casper, WY.

FE is responsible for several high-priority initiatives including implementation of the $2 billion, 10-year Clean Coal Power Initiative to develop a new generation of environmentally sound clean coal technologies; the FE elements of the American Recovery and Reinvestment Act of 2009; and the nation's SPR and Northeast Home Heating Oil Reserve, both key emergency response tools available to the President to protect Americans from energy supply disruptions.

1.2.4. SPR Project Management Office in New Orleans, LA

The SPR Project Management Office (SPRPMO), based in New Orleans, LA, is responsible for carrying out the operational aspects of SPR's mission. The SPRPMO oversees the day-to-day operations of the major crude oil storage sites and logistical facilities for the nation's emergency oil stockpile. The SPRPMO is managed by the Office of Petroleum Reserves, FE-40, located at the DOE Headquarters in Washington, D.C. (SPR-HQ)

Because there are two prime contractors at the SPR, including DM Petroleum Operations Company (DM) and ASRC Gulf States Constructors, LLC (AGSC), SPRPMO has the responsibility for ensuring that the various contractors' activities and safety programs are effectively coordinated.

1.2.5. Operating Contractor Organization

DM Petroleum Operations Company (DM) is the current Management and Operations contractor required to implement actions and programs necessary for the SPR to fulfill its mission; to create and maintain a crude oil reserve capable of meeting national requirements in the event of crude oil import reduction or cessation; to maintain the ability to expeditiously draw upon this resource when directed by national authority; and to provide "cradle-to-grave" oversight of projects related to implementation of upgrades at the SPR through the Readiness Review Board process.

DM also has the responsibility for security and emergency response, including facilitating access of offsite emergency response. As a subcontractor to DM, Wackenhut Services, Inc. has responsibility for security.

1.2.6. Construction Contractor Organization

ASRC Gulf States Constructors, LLC (AGSC) is a minority owned 8(a) company based in Anchorage, Alaska. Specializing in construction and industrial building projects, AGSC is currently the construction management services contractor for the SPR and, as such, is responsible for procurement and construction management of all major capital improvement projects.

1.2.7. Subcontractor Organization

Performance Blasting & Coating (PBC) is based in Port Author, TX and specializes in the pipeline, chemical, petrochemical, utility, and marine aspects of the coatings industry. PBC offers a variety of services including industrial surface preparations, corrosion inspection and analysis, paint/coatings and paint coating removal, grit recycling and fireproofing. PBC is a subcontractor to AGSC.

1.3 Scope, Purpose and Methodology of the Accident Investigation

The Board began its onsite investigation on Monday, February 25, 2013; completed onsite activities on March 1, 2013; completed the analysis and a factual accuracy review; and submitted the final report for acceptance to the Appointing Official.

The Board conducted its investigation using the following methodology:

- Facts relevant to the accident were gathered through interviews, document and evidence reviews, and examination of physical evidence;
- Event and causal factor analysis, barrier analysis, and change analysis techniques were used to analyze the facts and identify the cause(s) of the accident; and
- Based on the analysis of information gathered, judgments of need were developed for corrective actions to prevent recurrence.

Figure 2 describes the accident investigation terminology used throughout this report.

Accident Investigation Terminology
A **causal factor** is an event or condition in the accident sequence that contributes to the unwanted result. There are three types of causal factors: direct cause(s), which is the immediate event(s) or condition(s) that caused the accident; root causes(s), which is the causal factor that, if corrected, would prevent recurrence of the accident; and the contributing causal factors, which are the causal factors that collectively with the other causes increase the likelihood of an accident, but which did not cause the accident. The **direct cause** of an accident is the immediate event(s) or condition(s) that caused the accident. **Root causes** are the causal factors that, if corrected, would prevent recurrence of the same or similar accidents. Root causes may be derived from or encompass several contributing causes. They are higher-order, fundamental causal factors that address classes of deficiencies, rather than single problems or faults. **Contributing causes** are events or conditions that collectively with other causes increased the likelihood of an accident but that individually did not cause the accident. Contributing causes may be longstanding conditions or a series of prior events that, alone, were not sufficient to cause the accident, but were necessary for it to occur. Contributing causes are the events and conditions that “set the stage” for the event and, if allowed to persist or re-occur, increase the probability of future events or accidents. **Event and causal factors analysis** includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the accident to occur), and the use of deductive reasoning to determine the events or conditions that contributed to the accident. **Barrier analysis** reviews the hazards, the targets (people or objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or administrative. **Change analysis** is a systematic approach that examines planned or unplanned changes in a system that caused the undesirable results related to the accident.

Figure 2: Accident Investigation Terminology

2.0 Facts and Analysis

2.1 Description of Work Activity

On August 3, 2012, DOE prime operating contractor DM issued a Statement of Work (SOW) for Task Numbers WH-MM-818B and WH-MM-819B to repair brine tanks WHT-14 and WHT-15 at the West Hackberry SPR. DM had previously submitted the technical specifications for this work for DOE review. Following the review and approval of the SOW, DOE incorporated it into a tank repair task order request that was issued to prime construction contractor, AGSC.

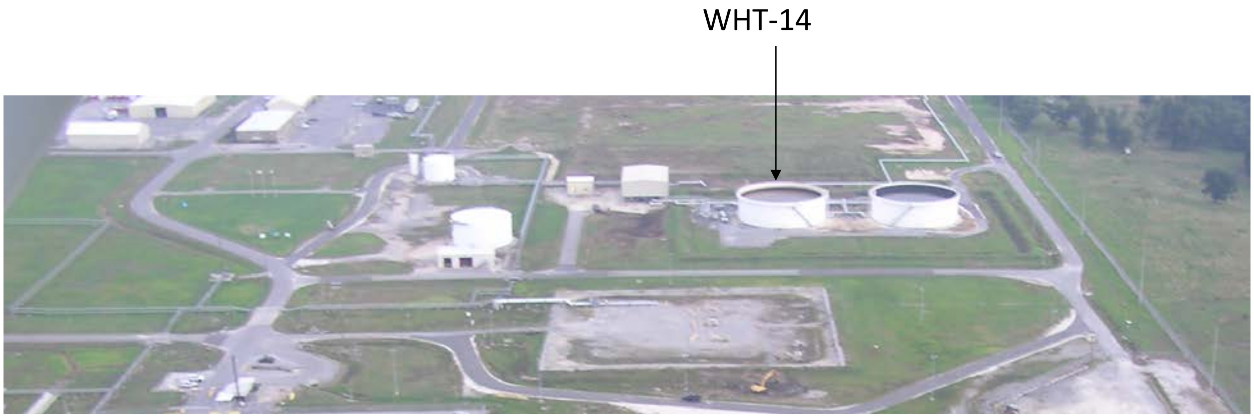


Figure 3: WHT-14 at the SPR West Hackberry Site

On August 9, 2012, DOE construction management services contractor AGSC, issued a Request for Offer (RFO) to repair the two open-topped brine tanks, 32 feet in height and 110 feet in diameter (WHT-14 and WHT-15) at the West Hackberry SPR. See Figure 3. The RFO did not specify equipment to be used, but did require that if scaffolding or electric scissor lifts were to be used they would be provided with soft rubber tires to protect the tank floor. The RFO specified that the tank would be provided to the subcontractor in a state of cleanliness where non-permitted confined space entry was possible. The Government provided lockout/tagout of electrical/mechanical equipment so that the task could be completed. Once the subcontractor's confined space plan was approved; the designation of entry requirements was the responsibility of the subcontractor.

On August 30, 2012, PBC submitted a bid to AGSC in response to the RFO. The bid specified blasting a six inch band on the exterior tank rim to six inches below; a four foot band on the interior tank wall to one specification; and the tank floor and the remaining lower 28 feet of the interior tank wall to a different specification. A qualification statement in the bid indicated that the bid price was based on utilizing scissor lifts for access to the interior of the tank.

On October 4, 2012, AGSC contracted with PBC to complete the work under contract AGSC-SPR-2012-113.

On October 31, 2012, Environmental Measurements Corporation provided a certified industrial hygienist review and comment on PBC safety documents under basic ordering agreement AGSC-BOA-2011-001. No comments were made relevant to use of scissor lifts.

On November 19, 2012, PBC issued a *Safety Execution Plan* for the work to be completed, which was approved by AGSC on December 20, 2012.

PBC procured scissor lifts to perform work inside the tank in accordance with qualifications stipulated in their contract with ASRC. The rented scissor lifts included a JLG Model 2646ES and a Skyjack Model SJIII 3226, Serial Number 27000317. See Figures 4 and 5 for an illustration and the specifications of the Skyjack SJIII scissor lift. The lifts were delivered to the West Hackberry SPR site on January 28, 2013, and were inspected and accepted by PBC. A crane was used to move each scissor lift into the tank. PBC mobilized and performed preliminary work during that week.

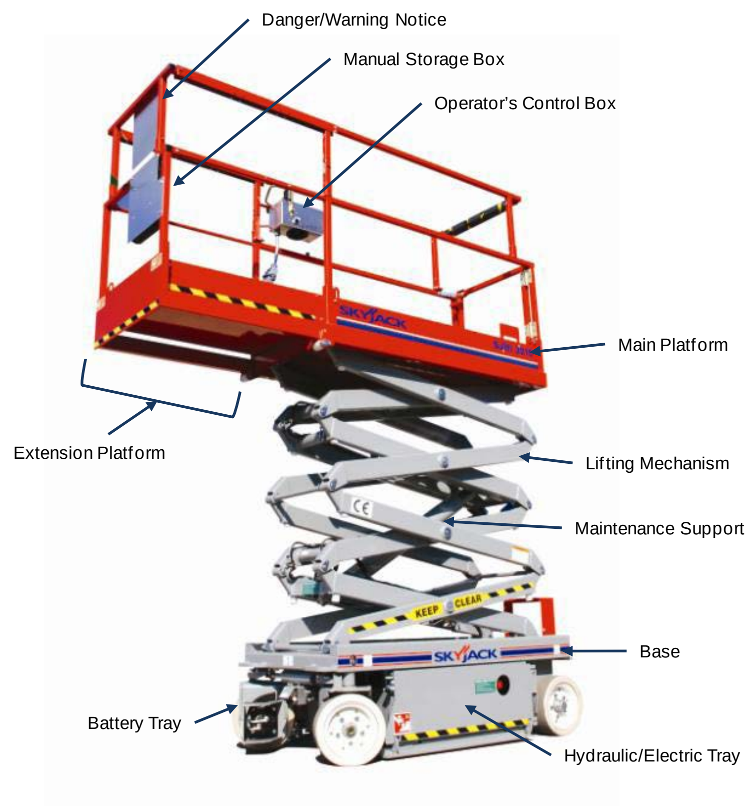
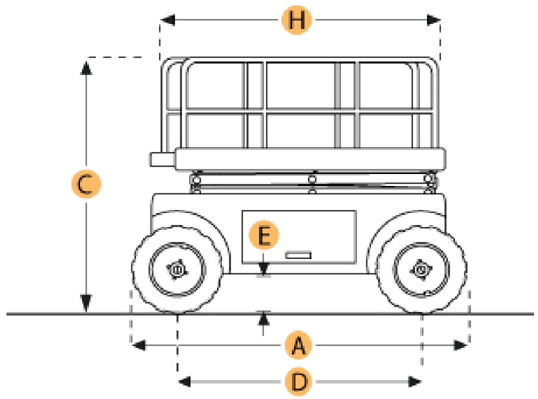


Figure 4: Skyjack SJIII 3226 Scissor Lift

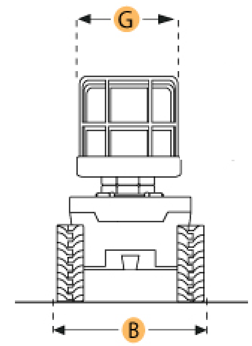
On the morning of Monday, February 4, 2013, Safe Work Permit (SWP) 356174 was initiated by the PBC Site Safety Representative (PBC SSR) and issued by DM to blast and recoat WHT-14. Conditions of the permit required flammable/combustibles removed; lock out/tag out for control of electrical energy; and reclassification of the tank as a non-permit required confined space with continuous atmospheric testing and the condition that respirators must be worn while inside the tank blasting or painting. DM conducted an inspection of the tank, performed atmospheric testing, and reclassified the tank as required by the SWP.

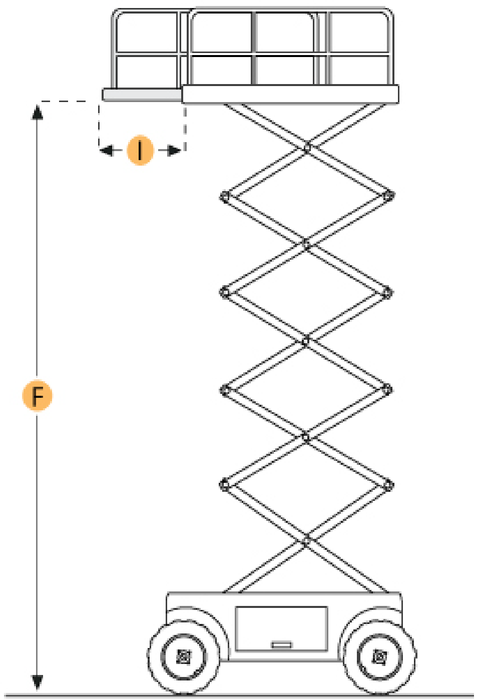
Beginning on February 5, 2013, blasting work was performed in WHT-14, and a job specific surveillance was conducted by the AGSC Site Construction Specialist (AGSC SCS). No work was performed on February 6, 2013, because of rain.

On February 7, 2013, PBC workers arrived at the West Hackberry SPR site to continue blasting and recoating activities on WHT-14. The PBC work crew consisted of the PBC SSR, a PBC site supervisor (PBC Site Sup), three blasters (PBC Blaster 1, PBC Blaster 2, and PBC Blaster 3), a confined space watch (PBC Hole Watch), a Pot Tender (PBC Pot Tender) and a NACE inspector (PBC NACE Insp). Other PBC employees, including the Facility Safety Supervisor (PBC FSS), were on the West Hackberry SPR site, but were assigned to another job.



A.	Overall Length	91.5 in
B.	Overall Width	32 in
C.	Height w/rails	84.7 in
D.	Wheelbase	71 in
E.	Ground Clearance	3.5 in
G	Platform Width	28 in
H.	Platform Length	84 in





F. Max Platform Height	20 ft
I. Deck Extension	2.9 ft
Maximum Working Height	20 ft
Weight	4,135 to 4,610 lb
Total Capacity	500 lb

Figure 5: Dimensional Specifications and Dimensions of the Skyjack SJIII 3226[1]

[1] Skyjack Operating Manual ANSI & OSA, April 2006

At 6:55 a.m., the PBC SSR and DM updated SWP 356174, which consisted of performing specific atmospheric tests. The SWP was reissued even though the form was not complete because the lower explosive level test did not indicate completion and the time the test was completed was not entered on the form.

A morning safety meeting was conducted, and a pre-job briefing and worker qualification form was completed by PBC Site Sup. The completed form indicated that the PBC Site Sup, PBC Blasters 1, 2, and 3, the PBC Pot Tender, PBC Hole Watch, and PBC NACE Insp were present. The PBC Site Sup also verified the special qualification that he and PBC Blasters 1 and 2 were scissor lift certified and qualified to perform the assigned task.

At 9:54 a.m., PBC Blaster 1 and PBC Blaster 2 entered WHT-14 to continue blasting the top four feet (28 to 32 feet) of the inside of the tank. PBC Blaster 1 was working from the smaller Skyjack Model SJIII 3226 scissor lift and PBC Blaster 2 was working from the larger JLG Model 2646ES scissor lift.

2.2 Accident Description

On February 7, 2013, at 9:54 a.m., PBC Blaster 1 and PBC Blaster 2 entered WHT-14. PBC Blaster 1 was to work from Skyjack scissor lift Model SJIII 3226. PBC Blaster 1 completed a PBC Aerial Man Lift Preventive Maintenance Checklist for the assigned scissor lift and did not note any material conditions that were not satisfactory.

Figure 6: Overturned Scissor Lift in Tank

PBC Blaster 1 and PBC Blaster 2 were connected by separate blast hoses to a common abrasive pot, and began blasting the upper four feet (at the 28 to 32 foot level above the floor of the tank) of the interior tank wall. PBC Blaster 1 was working the scissor lift in a fully extended position, in a counterclockwise direction, and was visible from the location where the PBC Hole Watch was monitoring the activity. The PBC Hole Watch reported that PBC Blaster 1 was making good progress, and that he had experienced few problems with his equipment.

PBC Blaster 2 was working from a different scissor lift on the opposite side of the tank, just to the left of the opening where the PBC Hole Watch was stationed. The PBC Hole Watch monitored PBC Blaster 2 with a mirror because he was not allowed to place his head inside the tank. The PBC Hole Watch communicated with PBC Blasters 1 and 2 using hand signals, and relayed their requests to the PBC Pot Tender.

PBC Blaster 3 was working from the catwalk between PBC Blaster 1 and PBC Blaster 2, and was blasting the tank rim and the top six inches of the tank exterior. PBC Blaster 3 was on a separate pot and communicated directly with the PBC Pot Tender using hand signals.

At approximately 10:42 a.m., the PBC Hole Watch felt the hose supplying air and abrasive to PBC Blaster 1 "pulse", an indication that the nozzle had been opened to begin blasting, and he looked up to observe the scissor lift and PBC Blaster 1 falling toward the center of the tank. Figure 6 shows the location of the fallen scissor lift. The PBC Hole Watch immediately sounded an air horn, which was PBC's designated emergency signal, to alert others in the area that a problem had occurred.

PBC Blaster 3 had just completed clearing the blast nozzle of his equipment by pointing it inside the tank and pulling the trigger. He did not observe the initiation of the accident, but observed PBC Blaster 1 and the scissor lift as they were falling. PBC Blaster 2 was not aware of a problem until he heard the scissor lift hit the floor of the tank.

PBC Blaster 1 and the scissor lift came to rest on the floor of the tank with PBC Blaster 1 lying partially out of the work platform guardrails, still connected to the work platform by a lanyard that was attached to his fall protection harness.

2.2.1. Accident Scene Analysis and Reconstruction

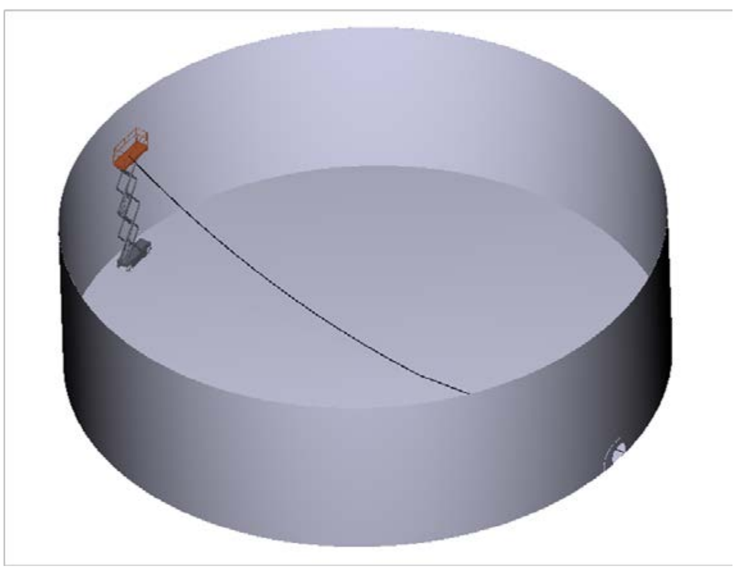


Figure 7: 3-D Rendering of Scissor Lift and Hose Prior to the Accident

Of crucial importance to the analysis was the determination of the length of hose that was suspended above the tank floor. The Board suspected that a significant portion of the hose was in the air and was being supported by the work platform in the upright position just prior to the accident, resulting in significant lateral forces on the work platform guardrails.

The base of the scissor lift (right wheel) was found by the Board to be 105 feet from the service entrance. The middle work platform guardrails, where the blast hose was attached to the lift, was found to be 26 feet from the base of the wheels. Using simple trigonometry the straight line distance from the service entrance to the middle work platform guardrails, when the lift was in the upright position, was calculated to be 108 feet 2 inches (Appendix E). Using a formula for a circle, this distance then represented a chord and, assuming the 111 feet 0 inches of blast hose formed a perfect arc between its ends, the radius was derived. The Board employed an architectural and engineering (A&E) firm to assist in the re-creation of the position of the hose and work platform during blasting. Computer aided design was then utilized to determine that 43 feet 7 inches of that arc lay below the horizontal line (representing the tank floor) leaving 67 feet 5 inches suspended from the lift. The A&E firm was then able to develop a three dimensional mockup of the lift and blast hose configuration prior to the lift toppling (Appendix E, Attachment E.3). These findings support the Board's theory that a significant portion of the blast hose was suspended above the tank floor. See Figure 7.

2.2.1.1. Force Analysis

The lateral force on the work platform guardrails, imposed by the weight of the 67 feet 5 inches length of suspended hose, was evaluated by the A&E firm through the use of a cable tension formula and standard mechanical force diagrams and calculations. An example calculation is shown in Table 1 and Appendix E (note this example does not take into account the weight of the supplied air breathing hose). The Board determined, through worker interviews, that the injured employee had just depressed the "deadman" switch at the blast nozzle when the lift toppled. This implies that blast material and air were flowing through the hose at the time the accident occurred; adding to the amount of suspended weight. Additionally, a 0.75 inch outer diameter supplied air breathing hose was taped to the blast hose.

It was determined by the Board that the copper slag blast material can add appreciable weight to the hose; however, the amount present in the internal void of the hose is highly dependent on the job. The Board was not able to accurately determine the percent of hose void occupied by the blast media, although an internet search found it to be nominally 10 percent for most applications. It was therefore decided that the following table be developed to show the variation in lateral force on the work platform guardrails with respect to the percent of internal void of the blast hose occupied:

Table 1: Variation in Lateral Force on the Work Platform Guardrails

Lateral Force at Hose Attachment Point to Scissor Lift Mid Rail		
<u>Calculation Input:</u>		
Blast Hose Weight	1.36	lbs/ft
Blast Hose Inner Diameter	1.50	inches
Length of Suspended Blast Hose	67.42	ft

Lateral Force at Hose Attachment Point to Scissor Lift Mid Rail		
Air Hose Weight	0.19	lbs/ft
Blast Material Density	0.12	lbs/cubic inch
Hose Deflection	4.44	ft
Angle of Force (from horizontal)	22.94	degrees

Calculation:

% Void Occupied by Blast Material	Weight Added by Blast Material (lbs/ft)	Total Weight of all Hoses and Contents (lbs/ft)	Force (Tension) of all Hoses and Contents (lbf)[2]	Lateral Force on the Work Platform Mid Rail Guardrail (lbf)
0	0.00	1.55	194.04	171.73
10	0.25	1.80	225.88	199.91
20	0.51	2.05	257.73	228.09
30	0.76	2.31	289.57	256.28
40	1.01	2.56	321.41	284.46
50	1.27	2.81	353.26	312.64
60	1.52	3.07	385.10	340.83
70	1.78	3.32	416.95	369.01
80	2.03	3.58	448.79	397.19
90	2.28	3.83	480.64	425.38
100	2.54	4.08	512.48	453.56

The force exerted on the worker, and ultimately the work platform, by the pressure at the nozzle when the “deadman” switch is depressed must be added to the values presented in the table in order to understand the total lateral force. The blast workers indicated, during interviews, that the typical working pressure for their blast operation is 80 to 100 psi. Follow-on investigation by the Board, using internet searches, substantiated these statements. Standard force calculations then indicate that the resultant lateral load imposed by the pressurized air flowing from the nozzle is 12.82 to 16.75 pounds assuming the use of a standard 0.50 inch nozzle.

The lateral force on the scissor lift work platform guardrails resulting from securing the blast and supplied air supply hoses to the work platform guardrails, and the blasting

[2] Lbf = pounds of force

operation, ranges from 184.55 pounds (no media present) to 470.32 pounds (hose 100 percent full of media).

2.2.2. Chronology of Events

The times listed in various logs and testimony varied by as much as four minutes for the same event. Times listed in this report have been adjusted to coincide with the time an employee obtained from their cellular telephone the moment the alarm horn was sounded. Table 2 is the Board's determination of the chronology of the events of this accident.

Table 2: Chronology of Events

Date and Time (hours)(CST)	Event
08/06/2012	DOE prime contractor DM issued a Statement of Work (SOW) for Task Numbers WH-MM-818B and WH-MM-819B, to repair Brine Tanks WHT-14 and WHT-15 at the West Hackberry SPR. The completed package was stamped by a professional engineer and approved for construction by DM.
08/09/2012	AGSC issued a Request for Offer (RFO) to repair WHT-14 and WHT-15.
08/10/2012	AGSC issued the solicitation on indicating that all sealed bids were due September 10, 2012.
08/30/2012	Performance Blasting & Coating (PBC) submitted their bid, number 2012-681-I-RC.
09/10/2012	Sealed bids were due for the AGSC RFO to repair WHT-14 and WHT-15.
10/04/2012	AGSC awarded Contract #AGSC-SPR-2012-113 to PBC.
10/31/2012	Environmental Measurements Corporation provided a certified industrial hygienist review and comment on PBC safety documents under basic ordering agreement AGSC-BOA-011-001 on October 31, 2012.
11/19/2012	PBC issued a Safety Execution Plan to AGSC for the repair of WHT-14 and WHT-15.
12/20/2012	AGSC approved the PBC Safety Execution Plan.

Date and Time (hours)(CST)	Event
01/28/2013	The scissor lifts delivered to the site staging area included a JLG Model 2646ES and a Skyjack Model SJIII 3226, Serial Number 27000317. Lifts were inspected and accepted by PBC.
01/28/2013	SWP 356227 Contractor mobilized tools and equipment at brine tank area: set up mats, abrasive pot, air compressor, etc.
01/30/2013	SWP 356181 issued to remove anodes from inside WHT-14. Began to pull hoses in preparation for blasting & coating.
01/30/2013	DM Permit – Required Confined Space Reclassification Form for WHT-14-Brine Tank. **Purpose of Entry**: to stage manlifts for repair of tank.
01/30/2013	JHA and Job Safety Plan for blasting and coating completed by PBC.
01/31/2013	DM Permit – Required Confined Space Reclassification Form for WHT-14-Brine Tank. **Purpose of Entry**: remove anodes in preparation of blasting & coating.
02/04/2013	DM Permit – Required Confined Space Reclassification Form for WHT-14-Brine Tank. **Purpose of Entry**: Blasting & Coating WHT-14.
02/04/2013	SWP 356174 was initiated by PBC and issued by DM to blast and recoat WHT-14.
02/05/2013	DM Permit – Required Confined Space Reclassification Form for WHT-14-Brine Tank. **Purpose of Entry**: Blasting & Coating WHT-14.
02/05/2013	PBC began blasting work along the top sections of WHT-14.
02/06/2013	No work performed because of rain.
02/07/2013	PBC workers arrived at WHT-14 to continue blasting WHT-14.
02/07/2013 6:55 a.m.	SWP 356174 was updated by PBC SSR and DM, including specific atmospheric tests.
02/07/2013	A morning safety meeting was conducted and qualification form completed by PBC Site Sup.

Date and Time (hours)(CST)	Event
02/07/2013 9:54 a.m.	PBC Blaster 1 and PBC Blaster 2 entered WHT-14.
02/07/2013 ~10:42 a.m.	PBC Hole Watch felt hose supplying air and abrasive to PBC Blaster 1 pulse and saw scissor lift with PBC Blaster 1 falling toward center of the tank.
02/07/2013 ~10:42 a.m.	When PBC Hole Watch noticed PBC Blaster 1 and scissor lift falling toward center of WHT-14, he immediately sounded an air horn to alert others that a problem had occurred.
02/07/2013 ~10:42 a.m.	A Skyjack SJIII 3226 scissor lift tipped over resulting in a serious injury to PBC Blaster 1.
02/07/2013 ~10:42 a.m.	DOE SSR heard the air horn and called DOE Engineer (DOE Eng) by cell to ask her to investigate the situation.
02/07/2013 ~10:42 a.m.	Protective Force Officer heard air horn from Main Gate but returned to normal duties.
02/07/2013 ~10:43 a.m.	PBC Site Safety Representative (PBC SSR) heard the air horn warning and responded to the tank entrance.
02/07/2013 ~10:43 a.m.	PBC SSR immediately donned his fall protection harness and entered the tank.
02/07/2013 ~10:43 a.m.	In response to the air horn sounding, PBC Blaster 3 came down from the tank and the PBC Pot Tender began securing the air compressors and other equipment.
02/07/2013 ~10:45 a.m.	DOE Eng arrived at WHT-14, noted an injury had occurred and the The Control Room Operator (CRO) had not been contacted.
02/07/2013 ~10:45 a.m.	DOE Eng contacted DOE Senior Site Representative (DOE SSR) to tell her to get to WHT-14 now.
02/07/2013 ~10:45 a.m.	DOE Eng contacted DM Fire Protection and Emergency Management Specialist and ERT Lead (DM EMS/ERT Lead) and requested he come to WHT-14.
02/07/2013 ~10:48 a.m.	DOE Eng briefed DOE SSR about situation upon arrival of DOE SSR at WHT-14.

Date and Time (hours)(CST)	Event
02/07/2013 ~10:48 a.m.	DOE SSR questioned the PBC Hole Watch and PBC NACE Insp for information about the accident and the status of notifications.
02/07/2013 ~10:48 a.m.	DOE SSR observed the PBC safety person inside the tank attempting a rescue of some type.
02/07/2013 ~10:48 a.m.	DOE SSR attempted to call DM Fire Protection and Emergency Management Specialist and ERT Lead (DM EMS/ERT Lead).
02/07/2013 ~10:48 a.m.	DOE SSR then attempted to contact West Hackberry Site Director.
02/07/2013 ~10:49 a.m.	PBC Site Supervisor (PBC Site Sup) arrived at the scene and entered the tank to evaluate the situation.
02/07/2013 ~10:54 a.m.	PBC FSS arrived at WHT-14, donned a safety harness and entered the tank.
02/07/2013 ~10:55 a.m.	DOE SSR contacted the CRO and requested the ERT be activated and an ambulance to be called to the scene.
02/07/2013 ~10:55 a.m.	DM EMS/ERT Lead arrived at WHT-15 and called the CRO and asked for an ambulance.
02/07/2013 ~10:56 a.m.	CRO activated the ERT response.
02/07/2013 ~10:59 a.m.	ERT fire truck left the bay.
02/07/2013 ~11:00 a.m.	CRO called for an ambulance.
02/07/2013 ~11:00 a.m.	West Hackberry Site Security Captain, having heard radio traffic, directed two security rovers to respond to accident to support ERT.
02/07/2013 ~11:00 a.m.	Two security rovers responded and upon arrival set a traffic control point on road to escort anticipated ambulance.
02/07/2013 ~11:04 a.m.	DM ERT-1 and DM EMT-1 arrived and entered tank.
02/07/2013 ~11:08 a.m.	Cameron Ambulance arrived with the Sherriff's Department and was escorted to WHT-14 by two security rovers.

Date and Time (hours)(CST)	Event
02/07/2013 ~11:08 a.m.	The two ambulance EMTs entered the tank to provide assistance to the injured worker.
02/07/2013 ~11:34 a.m.	PBC Blaster 1 was removed from WHT-14 and moved to the ambulance.
02/07/2013 ~11:44 a.m.	The Cameron ambulance departed the site.

2.3 Implementation of Integrated Safety Management System

2.3.1. Define the Scope of Work

The RFO issued by AGSC, under contract to the DOE SPRPMO, required the selected subcontractor to furnish all materials, tools, equipment, supplies, transportation, facilities, labor, supervision and services needed to perform work in connection with the repairs of tanks 14 (WHT-14) and 15 (WHT-15) at the West Hackberry Strategic Petroleum Reserve site in southwest Louisiana. The SPR West Hackberry DOE SSR stated that the tanks undergo a "required inspection" approximately every five years. This particular task was to replace the coating type, in its entirety, while also providing the necessary repairs. The DOE SSR estimated that WHT-14 had last been repaired over five years ago.

Line item details relevant to the repairs included blasting rust scale and damaged coatings from all surfaces including tank walls and penetrations.

WHT-14 is described in the SOW as 32 feet high, opened top and 110 feet in diameter. Entry into the tank is limited to two routes:

1) A single access panel located on the south side of the tank too small to allow passage of large equipment such as man lifts or scaffolding, and

2) The open top, 110 foot diameter, portion of the tank.

Because of this, WHT-14 is normally considered a confined space; however, it was provided to the subcontractor in a “state of cleanliness where non-permitted confined space entry is possible.”

The SOW, included by AGSC in the solicitation for the tank repairs, was developed by SPRPMO prime contractor, DM. DM manages and operates the SPR oil storage facilities located in Louisiana and Texas under performance based service contract #DE-AC96-03PO92207. Under that contract, DM is required to perform all necessary technical, operational and management functions to manage and operate the site/facility and perform the DOE missions assigned to the site/facility including, but not limited to: expansion of the SPR; all infrastructure management and maintenance; human resources management; environmental management; health, safety, and security; and purchasing, financial and other administrative systems. Within the scope of that contract, SPRPMO tasked DM with the development of the "Repair Brine Tanks WHT-14 & WHT-15" task package. The deliverable included a work summary, surface cleaner application instructions, material safety data sheets, tank design calculations, tank drawings and photos. It did not include the type of equipment the vendor was to use to perform the repairs. The task package was then contractually transferred by SPR to the SPRPMO prime contractor, AGSC.

AGSC performs construction management services under performance-based service contract #DE-AC96-08PO92954. Under that contract, AGSC provides services for major maintenance and capital projects budgeted for action by the DOE on a fiscal year basis and assigned to AGSC for management and execution. AGSC is assigned task orders to manage work designed by a third-party, and task orders that require AGSC and its contractors to perform design/build functions. In order to meet their contractual obligations, AGSC solicits and evaluates contractors, and awards general contracts on a best value basis. Within the scope of the contract, SPRPMO tasked AGSC with procuring the necessary services to repair WHT-14 (Task #WH-MM-818B). Solicitation #2012-CEL-020 was then issued by AGSC. Within the clauses of that procurement action, notably Attachment J-10: *Preliminary Hazard Review*, various types of walking/working surfaces such as scissor lifts are mentioned; however, none of the clauses expressly require the use of a scissor lift for any of the specified work activities. The selected vendor, PBC, chose to utilize electric powered scissor lifts in order to blast the elevated portions of the interior walls of WHT-14. The decision to use a scissor lift for this type work is questionable given the fact that manufacturer specifications severely limit the amount of lateral force that can be imposed on the work platform guardrails while it is elevated. Determining, minimizing, and controlling these critical loads requires specialized design capability, safety planning and oversight by qualified individuals.

Selection of scissor lifts by PBC and acceptance by AGSC to perform the blasting job were poor decisions because scissor lifts have significant operating restrictions concerning lateral force including the attachment of blast hose and air hose, to the work platform. **(JON 1)**

As the construction management services contractor, AGSC was responsible for developing processes and work instructions to ensure that AGSC personnel and subcontractors followed applicable regulations and site-specific safety requirements. AGSC was also responsible for ensuring that site safety requirements flow down to its contractors and subcontractors. As a subcontractor to AGSC, PBC was responsible for ensuring that its workers and subcontractors understood and followed established controls. Attachment J-2: *Safety and Health Requirements, Construction Contracts*, of the solicitation required the selected vendor to submit pertinent safety and health documents for review and approval by AGSC prior to allowing work to commence. Although multiple safety plans were submitted, reviewed and approved, the Board concluded that none of them sufficiently documented the inherent hazards of blasting from an elevated scissor lift work platform. Because of this, neither contractor implemented the necessary contractual controls to adequately identify the risks and hazards associated with the job the result of which was an inability to effectively communicate approved mitigation techniques to the workforce.

AGSC allowed work to commence without ensuring all contract required submittals from PBC were adequate and complete. **(JON 2)**

The Board is aware that qualification language included by the vendor in the winning bid is written into the contract that governs the performance and cost of the work. Consequently, each decision made in the bid preparation process limits the flexibility to make changes during the project performance. PBC selected scissor lifts as the elevating means to perform blasting work within the tank, as shown in the bid letter submitted with their original bid and in a cover letter with a revised bid submitted on September 7, 2012. Board interviews with the PBC Health Safety and Environment Director (PBC HSE Director) and each member of the work crew confirmed that none of them provided input to the scissor lift selection process. Scissor lifts were selected, budgeted, and were made part of the bid for the tank repair job. Early involvement of safety specialists and employees in work planning decisions is a work control to help ensure that the feasibility and any associated hazards are addressed before the equipment decision is made. Job scoping was an opportunity to consider operational restrictions on the use of scissor lifts and in particular, warnings to limit lateral forces and prohibitions on securing attachments to the platform or guardrail systems. These warnings are found in the ANSI/SIA A92.6-2006 standard, *Self-Propelled Elevating Work Platforms*, which applies to motorized scissor lifts, and in manufacturers' manuals that can be searched on the Internet.

Scissor lifts, while relatively inexpensive, present unique hazards that must be addressed in order to ensure the equipment is operated in a manner that heeds the manufacturers' warnings. Other elevating means with different operational restrictions could have been selected, or various manufacturers could have been contacted to explore approved modifications would have allowed blasting and breathing air hoses to be supported by the scissor lift platform. This was the first time that the PBC HSE Director and the crew had used a scissor lift for blasting inside a tank. PBC management failed to recognize changed conditions in their selection of scissor lifts. PCB had successfully used scissor lifts in previous painting and coating jobs, but not to perform abrasive blasting inside a tank that would require externally supplied hoses to deliver blasting media and breathing air. PBC did not own the scissor lifts that would be used in the job and proposed to rent them. This created two unfamiliar situations: use of scissor lifts for blasting inside a tank and use of equipment not owned by PBC. In selecting scissor lifts for the bid, PBC did not use the work control of early involvement of safety specialists and affected employees.

Selection of a scissor lift for blasting was not challenged when the PBC HSE Director and PBC Site Sup performed the hazard analysis. Both of them told the Board that the selection had been made and neither had questioned this selection or made a recommendation to use a different piece of equipment to accomplish the task. The work control of a questioning attitude was not effective.

2.3.2. Identify and Analyze Hazards Associated with the Work

A thorough hazard analysis is the basis of safe work performance. It begins with defining the work scope and the means of performing the work; and continues through preparation of work plans and site safety plans and Job Safety Analysis (JSA); and into the field where the work is actually set up and done. Hazard analysis requires knowledge of occupational safety and health; knowledge of the work site environment; the tasks to perform the job; and the equipment, tools and materials to be used in the job.

In its RFO package, AGSC prepared a Preliminary Hazards Review (PHR) to inform bidders of potential hazards associated with the tasks and to outline the requirements that the successful bidder must fulfill.[3] The PHR contained a disclaimer regarding its completeness and stated that the subcontractor would be responsible for completing its own hazard analysis and preparation of safety and health submittals. It also stated that the PHR assumed methods of construction that would be used but that the subcontractor may have selected and used construction methods that were materially different from those assumed by AGSC. AGSC characterized the work as “high hazard” work and listed eye injury; hearing loss; bodily injury; falls; skin irritation; abrasions; inhalation of toxic vapors, dust and fumes; fires; burns; and heat stress. This PHR identified the use of scissor lifts and required the use of an air compressor with in-line filtration and carbon monoxide monitoring for supplied breathing air during blasting. The RFO required that the successful bidder prepare an activity hazard analysis and a project safety and health plan that contained a hazard review and methods to mitigate the hazards. Additionally, written programs were required for ten safety issues, including fall protection. Section J-2: *Safety and Health Requirements, Construction Contracts*, Revision May 2012, of the contract between AGSC and PBC, required PBC to complete and submit an activity hazard analysis for AGSC approval. It further specified that PBC use *www.jsabuilder.com* to perform the activity hazard analysis, or an equivalent method that is approved by AGSC. Section J-2 further suggested that AGSC would reject incomplete activity hazard analyses. Overall, the PHR provided to PBC by AGSC contained sufficiently detailed work requirements and identification of potential hazards necessary to aid in the development of an effective hazard analysis and job safety plan.

PBC submitted multiple safety documents in response to the solicitation requirements. There was no evidence that PBC examined or calculated the lateral forces that would be exerted on the scissor lift during blasting operations or considered the performance characteristics in the scissor lift’s ability to withstand those forces without tipping over. Most of the safety documents submitted by PBC did not mention scissor lifts, but referred to aerial lifts or elevated work platforms.

[3] AGSC Request for Offer (RFO) 2012-CEL-020, Section J, Attachment J-10, *PHR*

PBC prepared a document titled *Safety Execution Plan* (SEP), dated November 19, 2012, that was identified as the overarching document to be used to meet the requirements for PBC to conduct a written hazard analysis and develop a safety and health plan. The hazard analysis was to include an assessment determining what hazards may be present or were likely to be present, which would then necessitate the use of personal protective equipment (PPE). If such hazards were present, or were likely to be present, then PBC was to clearly identify the hazards and the types of PPE that would protect employees from those hazards. The PBC work safety planning submittals, specifically hazard analysis and the SEP, contained insufficient detail to be used in identifying the specific hazards associated with the work to be completed. The SEP had only two clearly identifiable sections that attempted to identify and mitigate the hazards related to analysis, Section 20: *Hazard Assessment* and Section 23: *Risk Assessment and Hazard Analysis*. Neither of the two sections mentioned the use of scissor lifts, or identified the hazards associated with abrasive blasting. Many of the hazards listed were not clearly hazards and in many cases the hazard control or mitigation simply stated, "Will be addressed by JHA/Safe Work Permit." Overall the Risk Assessment and Hazard Analysis was generic and failed to specifically address the hazards associated with the work being performed such as abrasive blasting from scissor lifts.

AGSC conducted an initial review of the submittal package and then forwarded only the specific sections of the package that dealt with safety to the SPRPMO safety specialist, who in turn, forwarded these sections to DM for review and comment.

- ASGC failed to complete an effective comparative review of the SEP and hazard analysis utilizing the AGSC PHR and contract submittal requirements.
- AGSC failed to recognize that the work safety planning submittals lacked sufficient detail necessary to properly identify and mitigate the hazards associated with the work being done, specifically in the area of scissor lift use and abrasive blasting.
- AGSC failed to include its PHR and other relevant documents in its review request for DOE and DM review. This documentation would have assisted the reviewers in determining what the work and associated hazards were.

DM reviewed and DOE approved the submittals with only minor comments. DOE and DM failed to recognize that the submittals specific to the SEP and hazard analysis did not include enough detail to properly identify the type of work being completed. The specific hazards associated with the use of scissor lifts and abrasive blasting in a confined space could not have been effectively analyzed since they were not specifically identified in the SEP and hazard analysis.

To be effective, the analysts must consider each step of each task, and for each, consider how the task performance, conditions, and equipment will impact safety and health. Applicable standards, procedures and company policies must be identified, as well as prior experience and lessons learned from other organizations that performed similar work.

Although the safety submitted review process was documented, it consisted of little more than a check list identifying that the submittals were received.

- There was no clearly defined process to ensure the contractor safety submittals appropriately identified and addressed the hazards associated with the work.
- Work-specific planning and hazard analysis were deficient.
- Although there were multiple reviews, safety specialists missed the opportunities to identify deficiencies.
- Reviewers assumed that additional hazard analysis would take place at a lower level through the use of an activity hazard analysis also known as a JSA[4].
- There was no apparent follow up by anyone to determine whether or not the JSA appropriately identified the hazards and included appropriate mitigation factors associated with use of a scissor lift in sandblasting operations inside a confined space.

Although the contract required a formal hazard analysis and specific work safety plan, it was PBC's policy to address specific hazards associated with work being performed at the lowest level through the use of a daily Job Safety Analysis. A JSA, also known as job hazard analysis (JHA) or activity hazard analysis, is a safety management tool in which the risks or hazards of a specific job in the workplace are identified, and then measures to eliminate or control those hazards are determined and implemented. More specifically, a job safety analysis is a process of systematically evaluating certain jobs, tasks, processes or procedures and eliminating or reducing the risks or hazards to as low as reasonably practical in order to protect workers from injury or illness. The JSA process is documented and the JSA document is used in the workplace or at the job site to guide workers in safe job performance. The JSA document is also a living document that is adjusted as conditions warrant.

The JSA process begins with identifying the potential hazards or risks associated with a particular job task. Once the hazards are understood, the consequences of those hazards are then identified, followed by control measures to eliminate or mitigate the hazards. A detailed JSA can be performed by breaking the job into specific steps or tasks and identifying specific hazards and control measures for each job step/task, providing the worker with a documented set of safe job procedures. Some JSA processes also include some form of risk assessment that lists the probability of each hazard occurring and the severity of the consequences; additionally some JSAs evaluate the effectiveness of the control measures. The end result of a JSA is an easy to understand document that can be shared with workers as part of pre-job and safety meetings, and/or included as part of worker job descriptions. The JSA process can be used to help refine safe work procedures described in safety manuals or standard operating procedures, and the JSA document can serve as a useful tool in training new employees. Both workers and management must clearly understand the risks and hazards associated with the job.

[4] Although PBC utilizes the term job hazard analysis in its *Job Safety Analysis Policy*, the document developed and used by PBC was titled Job Safety Analysis (JSA), the term JSA is being utilized in the report.

PBC's *Job Safety Analysis Policy* states:

> *JSAs are very effective in anticipating, identifying and controlling the incidents related to process, i.e. permits, condition of tools, equipment, etc. However, unless the supervisor and employee craft person goes beyond the tradition of the JSA to include the anticipation, identification, recognition and control of the ways/methods, body positions, skills that they apply to perform the tasks, injuries cannot effectively be controlled or minimized.*

PBC normally utilized a hand-written JSA form that was prepared at the work site. In this case, PBC utilized an on-line tool identified at *www.jsabuilder.com* to prepare JSAs for this work. This was identified in the SOW as the preferred method and it was a change in how they normally had completed JSAs. The PBC HSE Director indicated that the new process was not one that he would choose to use on his own jobs, but felt it was adequate. The work level JSAs were developed away from the actual work site due to the inability to connect to the internet. (Normally the JSAs would have been developed by the crews in the field.) The use of new software which consists of a menu driven process that allows the person developing the JSA to select one of several pre-developed items may have limited the critical thinking process needed for a comprehensive hazard analysis. Task steps were not sufficiently detailed, resulting in hazards, particularly those of lateral forces, and controls being overlooked.

Hazard analysis also involves identifying operational parameters and warnings provided by manufacturers regarding their equipment. It is essential to investigate and identify all of the vulnerabilities associated with equipment and evaluate the risks of those hazards to workers who will be performing the task. The hazard analysis process needs to translate all of these warnings, restrictions, instructions, and operating standards to the JSA so that workers are informed. In the case of the PBC JSA for blasting from a scissor lift, the only hazard warning to the work crew was:

> *Only certified personnel to operate equipment (aerial lift, etc.) and must comply with the manufacturers' operating procedures.*

This statement may have been sufficient if the two operators had read and recognized the significant operational limitation found on page 13 of the Operating Manual which states:

> *DO NOT exert side forces on aerial platform while elevated.*

If recognized this single significant operational limitation, should have identified the hazard of applying side forces and precluded the use of the scissor lift when side forces are exerted.

The JSA also contained a risk assessment section and the scissor lift was identified as a physical hazard with a severity of outcome for physical injuries categorized as *medium* (S-2) and a *high* probability of occurrence (P-1). Of all the physical hazards listed, the JSA showed that aerial work equipment was the only category of hazards with a *high* probability. Overturning of equipment was cited as one of many consequences.

Although the scissor lift was identified as the highest hazard on the worksite it was given little attention.

The Board concluded that the job specific safety documents, developed by PBC, approved by AGSC, reviewed by DM and the SPRPMO, were deficient because they did not include manufacturer information regarding lateral force hazards that were specific to the scissor lift equipment or the operating restrictions in the applicable ANSI standard. **(JON 3) (JON 4)**

The Board concluded that the Job Safety Analysis did not identify hazards associated with abrasive blasting work from a scissor lift, specifically the side force restrictions. **(JON 5) (JON 6)**

Additionally ANSI A92.2-2006, in Section 7.10(33) and again in 8.10(33), warns that the user (aka the employer of the operator) shall direct the operator not to exceed the manufacturer's rated horizontal force. A label entitled, "Side Force/Outdoor" is identified in the Skyjack Operating Manual,[5] Section 2, as being manufacturer-placed on the platform of the Model 3226 and specifies restrictions on the side force and on wind. The manual itself does not specify a side force or wind velocity limit for the Skyjack 3226 model used in this accident. However, the manufacturer-applied label attached to the platform states that wind speed is to be limited to 0 mph and the side force is to be limited to 90 pounds. (See Figure 8.) This label is located in the platform underneath the black box that held the manuals. This side force warning was not considered in selecting the particular scissor lift and in configuring the job. PBC did not adhere to the warnings to limit side forces as specified by the manufacturer when workers failed to recognize the hazards of lateral forces and secured the blast hose to the work platform.

The Board concluded that the information regarding the lateral force restriction specific to the scissor lift was available in the Operating Manual located in a holder on the scissor lift and on a warning label attached to the scissor lift, but that restriction was not incorporated into work controls. **(JON 5) (JON 6)**

[5] Skyjack Operating Manual ANSI & CSA, April 2006, Section 2- Operation.

Figure 8: Manufacturer-Applied Label shows 0 wind and 90 lb side force

Ultimately the most significant hazard analysis failure was not recognizing that the work to be performed would place significant lateral forces on the scissor lift. These forces were not identified or estimated and were not considered in selecting the scissor lifts for the job. Also, the hazards of inexperience with scissor lifts while conducting abrasive blasting were not recognized. This inexperience extended from corporate inexperience to crew member inexperience.

In the accident on February 7, 2013, there were a number of hazards which were poorly analyzed or not identified. PBC failed to adhere to the tenets of its own policy:

- It did not sufficiently break down the specific tasks being performed into logical steps;
- It failed to identify the specific hazards in enough detail; and
- It ultimately failed to identify and implement the necessary work controls to prevent the accident from happening.

The work specific safety planning did not effectively identify hazards associated with abrasive blasting work from a scissor lift, specifically the side force restrictions. If the hazards associated with use of a scissor lift had been properly identified and analyzed in sufficient detail and properly mitigated, the accidental overturning of the scissor lift could have been prevented.

The Board concluded that SPRPMO, DM, AGSC, and PBC failed to recognize, understand, and manage the lateral force restrictions of the scissor lift. **(JON 7) (JON 8) (JON 9) (JON 10) (JON 11)**

2.3.3. Develop and Implement Hazard Controls

Controlling exposures to occupational hazards is the fundamental method of protecting workers. Traditionally, a hierarchy of controls is used as a means of determining how to implement feasible and effective controls. One representation of this hierarchy can be summarized as follows:

- Elimination
- Substitution
- Engineering controls
- Administrative controls
- Personal protective equipment

The idea behind this hierarchy is that the control methods at the top of the list are potentially more effective and protective than those at the bottom. Following the hierarchy normally leads to the implementation of inherently safer systems, ones where the risk of illness or injury has been substantially reduced. The hazards of the work to be performed must be recognized and identified before they can be mitigated with hazard controls.

Performance of the blasting job in WHT-14 by PBC required work at elevated heights and scissor lifts had been selected as the means to achieve this elevation. PBC determined the primary hazard was fall from the scissor lift. Falls from the scissor lift were recognized by PBC as demonstrated by their mandatory fall protection harnesses and tie off requirement for the scissor lift operators. Tip-over of the scissor lift itself had been identified as a hazard; however, there was no attempt to control this hazard with substitution or elimination. Other elevation means, such as scaffolds or aerial lifts, could have been a safer way to elevate workers blasting inside the tank. PBC also identified hazards related to the blast work itself such as eye/face/skin protection from abrasive blast particles and respiratory hazards related to the blast dust.

Scissor lifts are designed and warranted for specific workloads. In making the decision to select scissor lifts as the equipment to elevate workers, there should have been an effort to specify the required capabilities of the scissor lift to be used.

- Height capability: A 26-foot height requirement was specified and this height was appropriate for blasting up to the tank heights of 32 feet.
- Load capacity: PBC did not specify a load capacity for the lifts, but assumed that only one worker would be on each lift. The weight of the worker plus the weight of

any materials on the elevated scissor work platform was less than 500 pounds, which is the minimum capacity of most manufactured scissor lifts. Therefore, although not specified as an engineering limit, the load would be within the capacity of any available scissor lift.

- Lateral forces: PBC failed to recognize the lateral force loads that the blasting work would create. No calculations were made of the lateral forces exerted by the vertical segment of hose supported by the work platform or of the force expelled from the blast nozzle when activated. This hazard was not addressed in the equipment selection or safety planning.

As a result of these deficiencies in identifying requirements, the rental company had no instructions for the selection of the scissor lifts except for the working height and required delivery date. PBC provided the field crew with no specifications for the scissor lifts they were to use for blasting inside the tank, other than the working height of the lifts.

The job planning and hazard identification did not address the issue of how to support the weight of the hoses that would be used by the blasters. When the blaster is elevated to 26 feet, the weight of the blast hose and its contained blast media plus the weight of the breathing air hose cannot be supported on the shoulders of the blaster. PBC failed to address the control of this weight in any written work instructions. Selection of this work control was left to the skill of the crew performing the work.

Elimination and substitution, while most effective at reducing hazards, also tends to be the most difficult to implement in an existing process. If the process is still in the design or development stage, elimination and substitution of hazards may be inexpensive and simple to implement. For an existing process, major changes in equipment and procedures may be required to eliminate or substitute for a hazard.

Performance of the blasting required work at elevated heights. Since there was no practical way to bring the work down to ground level, a scissor lift was chosen to elevate the worker to the task. The scissor lift could have been substituted by another method of elevating the worker and equipment to the task but there is no evidence that a risk assessment was performed on the use of scissor lifts or other equipment.

Falls from the scissor lift were recognized by PBC as demonstrated by their mandatory fall protection harnesses and tie off requirement for the scissor lift operators. Falls or potential falls of the scissor lift itself were not considered in the job planning hazard mitigation documentation even though they were recognized as a hazard. Other elevation means, such as scaffolds or aerial lifts, could have been feasible as a safer means of elevating workers blasting inside the tank. Factors influencing the selection of scissor lifts included:

- The PBC bid package that had specified and budgeted costs for scissor lifts;
- Knowledge that scissor lifts had been used by other contractors in previous blasting jobs inside WHT-14; and

- Prior PBC experience using scissor lifts in other jobs.

An inadequate hazard analysis of the impact of lateral forces associated with blasting impeded the hazard control process. Without adequate hazard recognition, there was little reason to recommend a substitute for the use of scissor lifts. Board interviews with the HSE Director and the PBC SSR revealed that neither of them questioned the selection of scissor lifts for this job during their hazard control planning. Both accepted the selection as a given and did not consider the use of substitutes, despite their personal and corporate lack of knowledge and experience regarding scissor lift use for abrasive blasting inside tanks. The PBC controls identification and selection process accepted the use of scissor lifts for elevating workers despite the limitations of scissor lifts and the lack of prior PBC experience in using scissor lifts for blasting work. Equipment substitution was not selected as a control.

The Board concluded that the selection of scissor lifts by PBC and acceptance by AGSC to perform the blasting job were poor decisions because scissor lifts have significant operating restrictions concerning lateral force including the attachment of blast hose and air hose, to the work platform. **(JON 1)**

Because blasting was the essential task to be performed for the job, its inherent hazards could not be eliminated. Copper slag was substituted for silica dioxide as a blast media although it still created a respiratory hazard and required PPE.

Engineering controls are used to remove a hazard or place a barrier between the worker and the hazard. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions to provide this high level of protection. Protecting the scissor lift operators from falls was addressed by the scissor lift manufacturer's incorporation of standard guardrails around the work platform. With properly designed and installed guardrails, Occupational Safety and Health Administration (OSHA) does not require workers on a scissor lift to wear personal fall protection equipment be worn by workers on the scissor lift. The PBC blast workers did wear fall protection harnesses attached by lanyard to the scissor lifts; however, the attachment point of the lanyard to the scissor lift involved in the accident was not load rated for fall protection use.

Administrative controls and PPE are frequently used with existing processes where hazards are not particularly well controlled. These methods for protecting workers have also proven to be less effective than other measures, requiring significant effort by the affected workers. The controls PBC placed on the blasting work and scissor lift operation were largely administrative and were incomplete, sometimes ignored and ineffective. Administrative controls include policies, procedures, JSAs, training, pre-job briefs, lessons learned, manufacturer's instructions, labels, safety inspections, selection of qualified personnel, roles and responsibilities, supervision, and oversight.

With respect to scissor lifts, no PBC policy or written procedures address scissor lifts use or operation. There is no evidence that PBC reviewed or incorporated the ANSI standard, ANSI/SIA A92.6-2006, *American National Standard for Self-Propelled Elevating Work Platforms* in its work control planning or OSHA requirements covered under 29 CFR 1926 Part L. Most of the work conducted at SPR sites is regulated by the DM *Accident Prevention Manual* (APM); however, the APM did not contain procedures or policies concerning the use of scissor lifts and therefore was not consulted as a hazard control. The OSHA construction standard for scaffolds, 29 CFR 1926 Part L, includes scissor lifts and contains requirements for their safe use. Various OSHA letters of interpretation clarified that scissor lifts are classified with mobile scaffolds under this standard and are not regulated as aerial lifts.

The JSA for the blasting job on the day of this accident inadequately addressed the hazard of a scissor lift tipping over and provided only a training work control to prevent this from occurring. This control was for the operators to be certified to operate a scissor lift and to read and follow the manufacturers' operating manuals for the rented scissor lifts. PBC provided an opportunity at the tank site for the Blasters to read and review the operating manuals. However, the many warnings contained in these manuals were not discussed and the operators were not required to demonstrate their comprehension of the warnings. As discussed in the Section 2.3.4 on performing work within controls, there is ample evidence that the operators did not recognize the manufacturers' warnings. PBC trained and certified its scissor lift operators, but as also discussed in the section on work within controls, this training was inadequate. The PBC SSR was not trained in scissor lifts.

Pre-job briefs were conducted daily and attended by the PBC crew members assigned to WHT-14. There is no evidence that the control of scissor lift lateral forces was discussed. Lessons learned can provide memorable safety information, but there is no evidence that any scissor lift lessons learned, or the lessons learned from the final incident report for the man lift incident that occurred at the West Hackberry site involving PBC in November 2012, was communicated to PBC employees associated with this job.

Manufacturers' instructions were provided with each scissor lift and PBC operators were provided an opportunity to read them. The manufacturers' manuals were not consulted during the development of the hazard controls. This omission is partially explained by the fact that the specific makes and models were not known until the lifts were delivered to the site by the rental company. However, many scissor lift operating manuals are available on the Internet and review of a few different manuals could have alerted PBC to the types of hazard controls that scissor lift operations would require. Lateral force limitations and warnings against placing materials on the guardrails should have stimulated a more thorough analysis of hazard controls. Manufacturer-placed labels on the scissor lift provided operational limitations for its use and provided warnings for prohibited actions. These labels were not recognized by the work crew and supervision. Initial and daily inspections were performed but were not effective in drawing attention to warning labels.

Selection of qualified personnel is a key element in planning hazard controls. Experienced workers are able to recognize hazards, know how to correct problems, and may have confidence to stop work until their concerns about potentially unsafe conditions are resolved. In contrast, an inexperienced crew may be unaware of hazards and overly confident that conditions are safe to proceed. Based on information obtained from interviews conducted with the PBC employees, not a single member of the crew selected for this job had ever performed blasting on a scissor lift inside a tank. The PBC HSE Director had never been involved in a job where blasting was performed on a scissor lift inside a tank. This inexperience should have signaled a need to bring in personnel with more experience or to perform greater diligence in identifying and selecting the hazard controls.

A significant omission in hazard control was the failure to designate, in writing, who was the scaffold competent person for this job. The contract required this designation and OSHA provides specific standards for the knowledge and authority of the scaffold competent person. As part of hazard control, PBC was responsible to evaluate and name a competent person who met the OSHA requirements. This step was not taken. Job planning documents and the JSA failed to specify the name of the competent person for scaffolds or even the requirement to have a competent person. Evidence indicates the PBC SSR was recognized as and performed the duties of a scaffold competent person; however, he was not qualified. The PBC Site Sup deferred to the PBC SSR's role and performed other work away from the tank site, leaving the scissor lift operations unsupervised by a scaffold competent person.

Effective supervision of blasting work was not addressed in hazard control planning. Neither the PBC SSR nor the PBC Site Sup could directly observe blasting work in progress. Nobody could enter the tank or climb up to the top catwalk without respiratory protection because the blasting created airborne particulates inside the tank. The PBC Hole Watch had a seat at the small tank portal and used a mirror to observe one of the blasters who was working above the portal, but the PBC Hole Watch could not leave his post for someone else to look inside from his vantage point. In order to peer through the portal and up to the blasters working near the top rim, it was necessary to squat down and look up without entering the tank. No work control was provided to allow the supervisors to observe blasting work for longer than a minute or two which created a situation where unsafe conditions or work practices would not

Figure 9: Breathing Air Filtration System

be seen or corrected by supervisors. This limitation also prevented any effective third party oversight of the work in progress.

Personal Protective Equipment PBC selected the personal protective equipment (PPE) to be used for blasting on scissor lifts. Although the PPE appears to be appropriate for the job, the Board is concerned that the selection of a supplied air breathing system that utilized an on-site air compressor was contrary to the PBC respiratory protection procedure that requires breathing air to be supplied from breathing air cylinders obtained from a reliable source. See Figure 9. PBC did not have procedures for the use of an air compressor for breathing air. The PBC SSR told the Board that he relied on instructions provided by the air filtration module that PBC acquired for use with the air compressor. PBC did not identify adequate controls be to warn the crew of breathing air quality problems, should they develop. The filter system's audible alarm would not be heard by the crew due to the loud blasting noise. In addition, the warning light would not be visible because the crew worked with their backs to the unit and bright sunlight would interfere with the ability to perceive the warning light if it was triggered and although the PBC SSR was responsible for the safe operation of the breathing air system, however he was not able to monitor its use from outside the tank.

The Board concluded that the scissor lift operator training that was conducted by PBC was deficient because it was not conducted by a qualified person as defined by OSHA, and it did not include the lateral force restriction that was specific to the scissor lift. **(JON 12) (JON 13)**

2.3.4. Perform Work within Controls

2.3.4.1. PBC

PBC's work performance was governed by the contract with AGSC; OSHA standards; PBC *Safety Procedures Manual*; site-specific work plans and JHAs; safe work permits; manufacturer's instructions and warnings for equipment selected and used; ANSI standards for equipment performance and use; assignment of role and responsibilities; training; supervision; and the skills and experience of its work crew. The Board examined how compliance with these work controls contributed to the scissor lift tip over at West Hackberry. The work processes analyzed in this section include:

- Ordering the rented scissor lifts;
- Assigning of a scaffold competent person;
- Training;
- Experience of the work crew;
- Inspecting and accepting of the scissor lift upon delivery;
- Securing hoses to the guard rails of the scissor lift;

- Recognizing and controlling the hazard of lateral forces;
- Planning and verifying of hose length; and
- Supervising of work within the tank.

Ordering the rented scissor lifts: Because the hazard analysis failed to recognize and calculate anticipated lateral forces that the blasting task would place on the scissor lift, PBC prepared a rental order that did not specify the performance requirements for the scissor lift. The only specification identified was that it be rated for an elevated height of 26 feet. It did not specify that the lift must have a lateral side rating capable of supporting the lateral forces that should have been calculated for the blasting job. The rental company supplied two scissor lifts, one rated for 1,000 pounds and one rated for 500 pounds; both lifts elevated to 26 feet. The one rated for 500 pounds was the one that tipped over and was rated for 0 mph wind and for a maximum of 90 pounds of lateral force. The scissor lifts provided by the rental company met the requirements stated in the rental order.

Assigning the scaffold competent person: Critical to the safe performance of work is the assignment of the scaffold competent person. The AGSC solicitation documents specified the requirement for a competent person for scaffolds. OSHA also requires a competent person for scaffolds. The OSHA standard for scaffolds does not specifically address scissor lifts, but OSHA letters of interpretation have been published stating that scissor lifts are regulated as mobile scaffolds and must meet both the general requirements for scaffolds and those for mobile scaffolds. The scaffold competent person, according to OSHA, must be designated by the employer and have the authority to take prompt corrective measures to eliminate hazards. Additionally, the competent person must have specific training in and be knowledgeable about the structural integrity of scaffolds and their maintenance, and of the OSHA scaffold requirements. Technical skills are required of the competent person to assess how loads imposed by persons, materials, and wind can affect the structural integrity.

PBC recognized this duty to have a scaffold competent person in its scaffold procedure, dated October 11, 2012, which was submitted to AGSC as an attachment to its *Safety Execution Plan,*[6] Additionally, PBC has a process to designate competent persons that requires the signatures of the competent person and PBC HSE Director. The form lists various competencies and provides check boxes for the PBC HSE Director to check and sign. The competencies checked for the PBC SSR did not include scaffolds or aerial lifts and this form was signed by the PBC HSE Director on December 17, 2012. PBC failed to follow its own procedures when it authorized the PBC SSR to be the competent person for scissor lifts. The Board was provided no documentation that this authorization formally occurred, but in an interview with the PBC HSE Director, the Board was told that the scissor lift competent person was the PBC SSR. Also, the PBC Site Sup told the Board that he deferred to the PBC SSR in matters of safety. PBC did not provide the PBC SSR any scissor lift training; he was not authorized by PBC to operate a scissor lift;

[6] PBC *Safety Execution Plan, Repair WHT-14 & WHT-15 Brine Tanks SPR Hackberry, LA*, dated November 19, 2012

and in his own words in an interview with the Board, he stated that he was "no expert in scissor lifts." Although PBC SSR had operated scissor lifts occasionally during his 15-year construction career, he had never operated one as a PBC employee. Throughout the performance of the blasting job, he demonstrated a lack of knowledge of scissor lift hazard recognition and safe operation by allowing work practices that did not conform to applicable OSHA, the ANSI standards, and the scissor lift manufacturer's warnings. He overlooked the manufacturer's warnings on safe use practices and failed to recognize that excessive lateral forces were being applied, and that contrary to explicit manufacturer's warnings, allowed hoses to be tied to the guardrails. He failed to verify that the length of PBC Blaster 1's hose within the tank would be sufficient when elevated to a height of 27 to 28 feet. He failed to observe that a significant length of hose was off the ground and supported by the guardrail.

The PBC person identified as the on-site scissor lift competent person was not qualified to perform the functions of a competent person as defined by 29 CFR 1926 for scissor lifts and scaffolding. **(JON 14) (JON 15)**

The Board concluded that the various supervisory functions were specified and required (including job supervision, OSHA competent person, site safety supervision, and OSHA confined space entry supervisor). However the persons assigned to those functions were not always available or able to oversee the work inside the tank and they were unable to effectively perform a supervisory function. **(JON 16)**

Training: The scissor lift operators were trained and authorized by PBC. This is noted on the Pre-Job Briefing and Worker Qualification form completed on February 7, 2013, and signed by Blaster 1, Blaster 2, and the PBC Site Sup. Training was documented with a training certificate and both PBC Blaster 1 and PBC Blaster 2 were trained and authorized as scissor lift operators, as were the PBC Site Sup and the PBC FSS. Training was provided in-house by PBC. The fact that scissor lift training was provided and documented appeared to influence the PBC work crew and their management that they knew how to work safely on scissor lifts. Similarly, oversight and review personnel from AGSC, DM and DOE accepted the fact that scissor lift training had been provided. The certificates and/or wallet cards were made available and any discussion with the PBC team members would have confirmed that the training actually occurred.

OSHA requires that scaffold operator training be provided by a qualified person and that it includes:

- Recognition of hazards associated with the type of scaffold being used;
- Procedures to control or minimize these hazards;
- The proper handling of material on the scaffold;
- The maximum intended load and load-carrying capacity of the scaffolds used; and

- The applicable OSHA requirements.

The training consisted of classroom instruction and hands-on operation and demonstration of skills. Not only did the written examination administered at the conclusion of the scissor lift training fail to contain any questions specific to scissor lifts, it was identical to the written examination used for their aerial lift training.

Experience of the work crew: Although some PBC employees had performed work from a scissor lift, none of the supervisors or work crew assigned to this tank blasting job had ever performed blasting using a scissor lift inside a tank. The guidance contained in their JSA was to read and obey the operating manuals. A scissor lift training review at the tank site consisted of the blasters having the opportunity to read the manufacturer's operating manuals at the jobsite. The manuals had not been made available to the blasters or crew before delivery of the rented scissor lifts on January 28, 2013. It should be noted that the two scissor lifts rented for this job were made by different manufacturers and had different load ratings. Each of the blasters worked on both of the scissor lifts. The operating manuals each contained numerous specific safety precautions and warnings. The Skyjack manual was 52 pages long and the JLG manual was over 100 pages long. Having the training and prior experience in using scissor lifts on other jobs gave the work crew confidence that they knew how to operate them safely and little or no discussion of scissor lift hazards and controls were reviewed in pre-job briefs. Work performance by the blasters demonstrated a lack of knowledge of required scissor lift safety topics, starting with the use instructions printed on the labels on the lifts. Warnings contained in the Skyjack manual that were not recognized include:

- "Do not exert side forces on aerial platform while elevated." (The hoses and the force of the blast nozzle exerted side forces.)
- "Do not place materials on the guard rails or materials that exceed the confines of the guardrails unless approved by Skyjack." (Hoses were secured to the guardrails.)
- "Do not drive or elevate the aerial platform if it is not on a firm level surface." (The scissor lift was driven over and parked on a layer of spent blast media and rain water.)
- "An operator should not use any aerial platform that…has alterations or modifications not approved by Skyjack." (Holes had been drilled into the guardrail without Skyjack approval.)

None of these warnings was identified in the PBC JSA on the day of the accident. Also, these warnings were not addressed in the operator training written examination. The only way that the operators were informed of these warnings was by reading the manual. No one verified their comprehension of this reading despite a warning in the manual that states, "…the operator MUST understand and be familiar with this operating manual, its warnings and instructions, manual of responsibilities, and ALL warnings and instructions on the aerial platform." The work control of training failed. The work control of assigning personnel with competencies commensurate with their assigned responsibilities also failed because no one recognized that the conditions of use were different from their prior experience with scissor lifts.

The Board concluded that none of the workers were familiar with using scissor lifts during blasting operations inside tanks. **(JON 17)**

<u>Accepting the scissor lift upon delivery</u>: OSHA requires that "Scaffolds and scaffold components shall be inspected for visible defects by a competent person before each work shift, and after any occurrence which could affect a scaffold's structural integrity." (29 CFR 1926.451) The PBC SSR performed the acceptance inspection of the scissor lifts when they were delivered by the rental company. PBC SSR was not a competent person for scissor lifts. The scissor lift that tipped over showed readily observable signs of age and heavy usage. The PBC SSR accepted this lift after performing a visual inspection, and after observing an operator testing the functions, he checked off each box on the rental company's acceptance inspection form. He marked the worn out tires as "N/A." The PBC SSR did not make note of the holes drilled into the guardrails. PBC SSR did not examine any annual inspection reports of the lift and when the Board asked him about the lift's annual inspection, he stated he was unaware of this requirement and consequently had not looked for or requested these reports. He told the Board that he assumed that the rental company had performed all required maintenance. Most critically, he failed to take notice of the restrictions posted on the scissor lift for wind speed and lateral forces and accepted the scissor lift as adequate for the blasting job. The work control of inspection was deficient.

A label near the inner base of the work platform displayed a side load limit of 90 pounds. It was a pictograph label in the scissor lift work platform, located beneath the black box that housed the Operating Manual. See Figure 10. The failure of the PBC hazard analysis to identify and estimate lateral forces that would be made against the lift during blasting resulted in no controls for this hazard and as a result, the PBC SSR had no frame of reference to evaluate this posted limitation. A scaffold competent person is expected to know how to assess loads imposed by persons, materials and winds, but PBC SSR had never been trained to do this. The PBC SSR did not seek guidance regarding the suitability of this model for the planned work, by calling either the PBC safety office or the manufacturer.

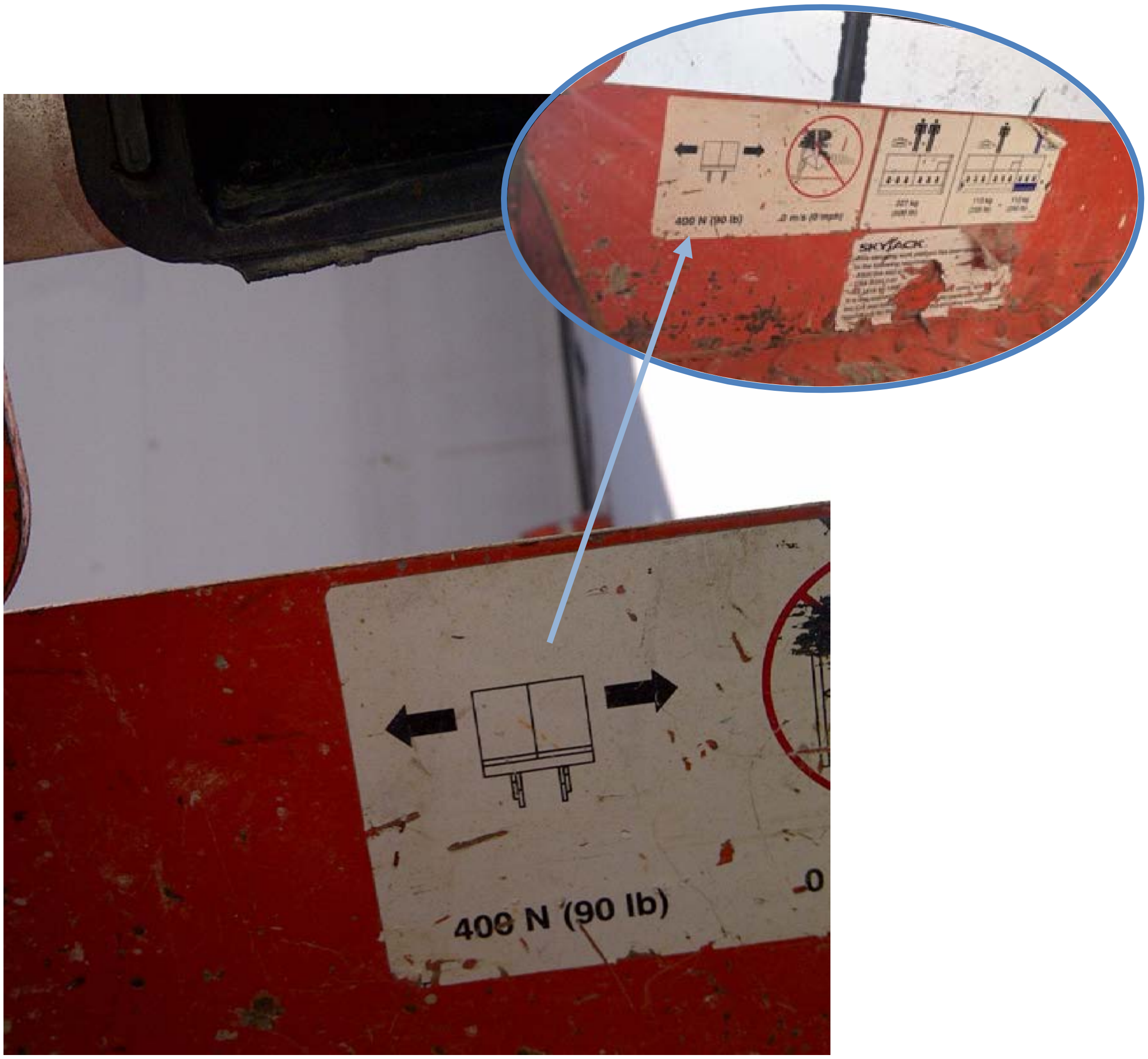


Figure 10: Warning Label inside Scissor Lift Identifying Side Force Limitations

Additionally, there was an adjacent label that displayed a warning that wind must not exceed 0 miles per hour. Because WHT-14 was open topped and ambient winds blew through this large enclosed space, the scissor lift would be subject to winds greater than 0 mph during use inside the tank. The PBC SSR failed to observe or failed to recognize this warning during his acceptance inspection of the scissor lift. PBC Blaster 1 inspected and operated this lift despite the warning label. The Operating Manual states: "Do not raise the aerial platform in windy or gusty conditions."[7] The Board has no reason to believe that wind conditions were windy or gusty, but the local weather report for the day of the accident showed gusts up to 9 mph. This exceeds the limit established by the manufacturer. It should be noted that these small labels are the only quantitative limits for lateral forces provided by the manufacturer. The manufacturer's posted control was not heeded. The work control of equipment inspection was performed deficiently.

[7] Skyjack Operating Manual ANSI & CSA, SJIII Series, April 2006, Page 12

Securing hoses to the guardrails of the scissor lift: According to the Skyjack Operating Manual ANSI & CSA, SJIII Series, April 2006, page 14, "Do not place materials on the guardrails or materials that exceed the confines of the guardrails unless approved by Skyjack." ANSI /SIA A92.6-2006, the applicable ANSI standard that was included with the Operating Manual in the document holder on the scissor lift, provides operator warnings and instructions. No evidence of any approvals from Skyjack was provided to the Board.

OSHA 1926.451(g)(4)(ix) states that:

> *Midrails, screens, mesh, intermediate vertical members, solid panels, and equivalent structural members of a guardrail system shall be capable of withstanding, without failure, a force applied in any downward or horizontal direction at any point along the midrail or other member of at least 75 pounds (333 n) for guardrail systems with a minimum 100 pound toprail capacity, and at least 150 pounds (666 n) for guardrail systems with a minimum 200 pound toprail capacity*.
>
> In order to determine if attaching hoses to the work platform guardrails would compromise this specification, PBC would have to obtain a professional engineer's written opinion or permission from the manufacturer stating that the performance of the guardrails on the work platform would not be compromised. This was not obtained. Attaching the hoses to the work platform guardrails of the scissor lift was not authorized by the manufacturer or by a professional engineer.

For this blasting task, the blasting hoses and breathing air hoses were tied to the guardrails with rope and secured with duct tape on the two scissor lifts used inside the tank. There were no work procedures or steps in the JSA that directed the crew as to the method to support the weight of the hoses to prevent the entire weight of the elevated hoses to be carried by each blaster. It was left to the skill of the craft to devise a makeshift support and they used the available means, which was the guardrail system of the work platform. The guardrail warnings were not heeded and the scaffold competent person allowed the hoses to be attached to the guardrails. The hoses were attached externally to the confines of the guardrails. Failure to comply with this restriction placed a lateral force on the scissor lift that contributed to the tip over.

Recognizing and controlling the hazard of lateral forces: ANSI A92.2-2006, in Section 7.10(33) and again in Section 8.10(33), warns that the user (the employer of the operator) shall direct the operator not to exceed the manufacturer's rated horizontal force. A label entitled, "Side Force/Outdoor" is identified in the Skyjack manual[8] as being manufacturer-placed on the work platform of the Model SJIII 3226 and that specifies restrictions on the side force and on wind. The manual itself does not specify a side force or wind velocity limit for the Skyjack SJIII 3226 model used in this accident. However, the manufacturer-applied label attached to the work platform states that wind speed is to

[8] Skyjack Operating Manual ANSI & CSA, April 2006; Section 2- Operation

be limited to 0 mph and the side force is to be limited to 90 pounds. This label is located in the work platform underneath the black box that held the manuals. The hoses tied to the guard mid rail and the blasting from the nozzle exerted side forces. At the location where the scissor lift overturned, the blast hose was fully extended and pulled on the side of the work platform. When the hose was pressurized and the nozzle activated, the side force from the hose and blasting media, plus the pressure expelled from the hose exceeded the posted 90 pound limit of side force. The Board performed measurements and calculations to estimate the side force at the time of the tip over. The findings from engineering calculations show a lateral force of approximately 217 to 470 pounds. See Appendix E, Force Calculations of Scissor Lift.

In an interview with the Board, one PBC blaster demonstrated the stance taken when blasting and it involves a braced position with feet apart, knees slightly bent, shoulders hunched, and both hands on the nozzle. He stated that it was necessary to hold the nozzle "firm and tight." None of the PBC employees interviewed by the Board could state the pressure from the nozzle, but a few commented that the pressure varied, depending on the compressor; if one or both hoses were being pressurized; and other factors. A witness who saw the scissor lift tip over stated that it fell over as soon as the PBC Blaster 1's hose was pressurized and PBC Blaster 1 began blasting. Board research found that blast forces are typically 12 to16 pounds, as described in Appendix E. This was added to the lateral forces of the hose.

The side force warning was not considered in selecting the particular scissor lift and in configuring the job. Operators were unaware of the amount of side forces on their scissor lifts. PBC did not adhere to the warnings to limit side forces as specified by the manufacturer. The blasters were not provided with any work controls to maintain the side forces within the limits of the scissor lift specifications. In fact, PBC created side forces on the scissor lift by allowing the hoses to be tied and taped to the guardrails of both scissor lifts inside the tank.

The Board concluded the information regarding the lateral force restrictions that were specific to the scissor lift was available in the operating manual located in a holder on the scissor lift and on a warning label attached to the scissor lift, but that restriction was not incorporated into work controls. **(JON 5) (JON 6)**

The Board concluded that the Job Safety Analysis did not identify hazards associated with abrasive blasting work from a scissor lift, specifically the side force restrictions. **(JON 5) (JON 6)**

<u>Jobsite planning and verifying hose length</u>: Each blaster was responsible for checking his own hose and making sure it was long enough. The hose needed to be kept clear of the scissor lift mechanism. So, the blaster was careful not have excessive hose inside the tank.

PBC Blaster 1 did not provide a sufficient length of blast hose from the hole to the positions his scissor lift would take. The control for this activity was skill of the craft because there were no written guidelines or calculations provided for him to determine the length of hose needed and no one double-checked his hose to be sure that the length was adequate. The PBC Pot Tender and PBC Hole Watch remained outside the tank. The PBC SSR did not enter the tank that morning, but observed set-up from outside the tank. What PBC Blaster 1 failed to take into account was the additional hose length that would be needed to reach the work platform when elevated. As a result, he laid out 111 feet of hose length, a length that was more than adequate to reach the scissor lift at its farthest distance from the hole when extended across the floor of the tank. However, when the hose was required to be lifted 27 to 28 feet above the floor, this length was not adequate. The only work control for this critical task of pulling the hose was the operator's skill. There were no written instructions as to the minimum hose length needed and there was no buddy or supervisor to double check his hose line. Failure to provide an adequate length of hose placed excessive lateral force on the scissor lift and contributed to its tip over.

Supervising work within the tank: The contract with AGSC required PBC to have a dedicated safety person for this tank job. PBC provided this person, but failed to plan for effective supervision during blasting because of limited visibility to observe work performance. The tank had one small portal at ground level and was open topped with a catwalk. However, during blasting, airborne dust levels may have exceeded OSHA limits and consequently, access into the tank or up upon the catwalk required wearing PPE, including a supplied air respirator. No work control documents addressed this constraint on direct supervision of blasting. Neither the PBC SSR nor the PBC Site Sup were able to supervise the blasters, except by squatting down and looking into the tank without making an entry, or by suiting up and entering the tank. They provided work instructions and allowed the PBC Blaster 1 and PBC Blaster 2 to perform the work. Deficiencies in planning effective safety supervision controls prevented the supervisors from any opportunity to observe and correct the inadequate hose length. As noted above, the PBC SSR who was recognized as the competent person would likely not have stopped the unsafe act of securing the hoses to the guardrails, since he had been present during set up when the hoses would have been tied and taped to the guardrails. There was a double deficiency in supervision: ability to see the work as it was being performed because of limited visibility and competence to recognize the hazards.

No eyewitnesses observed PBC Blaster 1 move his scissor lift to a new work location adjacent to the section that he had just completed. PBC directed operators of the scissor lift not to drive in the elevated position. The Board requested but was not provided with this in writing, but both the PBC Site Sup and another blaster told the Board that their procedure for moving a scissor lift was to lower it, drive it and then raise the work platform. The evidence suggests that PBC Blaster 1 drove the scissor lift to its new position immediately prior to the tip-over, based on the position of the lift after it fell. Photographs of the scene and the visual inspection by the Board confirm that the tipped over lift was directly beneath a section of tank that had not been blasted clean. See Figure 10.

Figure 11 indicates the section immediately to the right of the lift was blasted clean. The Board determined that PBC Blaster 1 had completed that section and had moved the lift to begin work on the next section.

Figure 11: Position of the scissor lift in relation to work completed.

The Board, based on the evidence and interviews, believes that the scissor lift was completely stopped when it toppled over. That is, it was not being driven when it fell. The Skyjack engineer who inspected the tipped over scissor lift confirmed that the wheels were in a locked position and the pothole protection bar was lowered. These conditions are automatically activated when the scissor lift is stopped. Figure 12 shows the toggle switch in the drive position; however, the locked wheels and lowered pothole protection bar indicates that the scissor lift was stopped. The Board was not able to interview PBC Blaster 1, but the PBC SSR told the Board that he asked PBC Blaster 1 what happened when he responded to the tip over. Blaster 1 told him that he had turned his blast hose on and the next thing he knew, he was falling over backwards. Had a supervisor been in position to watch PBC Blaster 1 re-position the scissor lift and to also observe the attached hoses being uplifted along a significant length of the hose, that observer would likely have stopped the action and directed PBC Blaster 1 to pull more hose into the tank.

Figure 12: Control Box with three-way switch pointing to the drive position

Work controls during emergency response: The first responder, the PBC SSR, and the second responders, the PBC Site Sup and PBC FSS, followed the PBC procedure for confined space entry in donning a harness prior to entry. None of them wore a retrieval line and no mechanical device was provided for life rescue. This does not conform to the PBC procedure. None of them donned any respiratory protection. Failure to consider exposure to harmful particulate levels inside the tank was not considered during rescue planning or by the responders as they rushed to provide assistance. The PBC SSR was not currently certified in first aid but performed injury assessment and removed the injured blaster's blast hood, glove, and lanyard attachment to the lift work platform. In removing the helmet and its attached vest, PBC SSR would have needed to move the injured person's head, neck, and back to pull the tight-fitting respirator neck collar and attached vest over his head. Moving the injured blaster's head or spine after a serious fall could have resulted in serious, long-term damage. The Board does not know if these movements had any impact on the extent of PBC Blaster 1's injuries.

The first responder, PBC SSR, did not activate the SPR emergency response system and directed the PBC Hole Watch not to call for help. Instead, PBC SSR called the PBC FSS, who was a paramedic, and the PBC Site Sup. This delayed the arrival of the Emergency Medical Technicians (EMTs).

By immediately calling the PBC FSS, the first responder was following the procedures established in the PBC Safety Execution Plan for this task, dated November 19, 2012, that had been approved by AGSC. This plan required that any emergency first aid and cardiopulmonary resuscitation was be given by trained PBC employees. Under this plan, emergency services were to be requested if immediate medical care was required.

Medical emergencies were to be reported to AGSC and also, the SPR Control Room was to be notified. The Safety Execution Plan did not follow the SPR requirements for reporting and responding to medical emergencies. It also did not follow the PBC Confined Space Procedure that states that the Client (SPR) will serve as the emergency services provider. Failure to follow work controls delayed the arrival of medical help for the injured worker.

Other work performance factors: The Board considered other potential work performance factors, such as scissor lift defects that might have contributed to instability; sloping or instability of the tank floor; or failure of PBC Blaster 1's respiratory protection to deliver an adequate supply of safe breathing air that could have resulted in dizziness and loss of balance. These factors were determined not to be direct causes of the tip over. However, the Board's analysis found deficiencies in the implementation of the controls designed to prevent such occurrences and these are summarized briefly below.

Scissor lift structure deficiencies: The Board invited the Skyjack product safety engineer to examine the tipped over scissor lift. He inspected the scissor lift and documented some damage, but was unable to determine if the damage was caused by the tip over or was present before the accident. His inspection was necessarily incomplete because the scissor lift was not upright and he was unable to test the various drive and elevate functions. The Board had also commissioned a professional architectural and engineering firm (A&E) to calculate the side forces exerted on the scissor lift, based on measurements made by the Board of the hose length and tank dimensions. The engineering analysis demonstrated that the side forces were so overwhelming that the question of structural integrity of the lift was a moot point and not a direct cause of the tip over.

Sloping or instability of the tank floor: The Board measured the slope of the tank floor with an inclinometer and determined that the slope was approximately one degree near the scissor lift wheels. This slope is within the 3-degree slope limit set by the scissor lift manufacturer. The tank floor stability was qualitatively assessed and found to be stable and able to support the weight of the scissor lift. Neither the tank floor slope nor tank floor instability contributed to this tip over. Any reduction in traction of the wheels with the tank floor due to spent media grit and rain water accumulation or due to the worn tire conditions had a minimal impact, compared with the overwhelming side forces exerted.

Respiratory, head, and eye protection: The Board was particularly concerned with respiratory protection for the blasters because two and a half years prior to this accident, there was a fatality in an SPR tank that was associated with respiratory protection. The Board examined the possible role of breathing air-related dizziness or loss of consciousness in the sudden scissor lift overturn. The supplied breathing air and its delivery to each blaster via a blaster helmet were determined not to be causal factors in the scissor lift tip over. The blasters experienced no problems with the respirators. PBC Blasters 2 and 3 were on the same supplied air system as PBC Blaster 1, and they did not experience any problems with the air quality delivered to their blast helmets. PBC Blaster 1 was conscious and coherent immediately after the tip over. The Board found some problems with the controls implemented in the set-up of the supplied air system, but concluded that these deficiencies had no causal relationship with the tip over.

The blast hood had an integral hard hat to protect the user from overhead hazards. When the Board examined PBC Blaster 1's hood, the hard hat suspension assembly was missing. This suspension is designed to absorb some of the impact of a direct contact in order to protect the head from striking the helmet. It is not known if the suspension assembly would have decreased any head injury to PBC Blaster 1 when he fell. He was conscious and able to answer questions after the tip over, but it is unknown if there was any head injury.

The Board concluded that there are additional weaknesses in hazard identification, hazard control, and performance of work within controls. **(JON 18) (JON 19)**

2.3.4.2. AGSC

AGSC performed several oversight work controls for this tank job. In selecting PBC as their subcontractor, they evaluated PBC's approach to the work and prior experience. The PBC bid met the Request for Offer requirements and their injury/illness rate experience was exemplary, as was their workers' compensation experience modification rate. These rates were a positive indicator that PBC would be able to perform the tank repair job safely. One area that AGSC did not closely evaluate was if PBC had prior experience in using scissor lifts for blasting inside tanks. PBC had experience with blasting, with operating scissor lifts, and working inside tanks, but not the combination of all three in a single job. AGSC knew that prior tank repair jobs at the SPR site had been uneventfully accomplished with use of scissor lifts and did not recognize that PBC lacked this experience. The work control of selecting a subcontractor with direct relevant experience was not effective.

AGSC performed a review and approval of PBC's *Safety Execution Plan* prior to authorizing start up. If AGSC had recognized that PBC lacked experience in blasting with a scissor lift inside a tank, a more rigorous review may have been conducted. AGSC used a check list to guide their review and also engaged a certified industrial hygienist to review those aspects of the plan related to respiratory protection and chemical hazard communication. The industrial hygiene review was a precaution taken in light of a confined space fatality at SPR a few years prior. On the surface, the PBC plan appeared to match the requirements provided by AGSC to guide PBC's submission. A more in-depth review would have revealed that the use of scissor lifts was not addressed and that the emergency response plan was not specific to the site. Elevated work was identified, but was not made specific to the use of scissor lifts. The hazards were generic and the controls were use of personal fall protection systems. This oversight work control failed to detect these PBC plan deficiencies. Had the AGSC process been effective, it would have required PBC to demonstrate better work control planning.

AGSC required documentation of training and of various competencies. However, AGSC did not follow up on its requirement for a scaffold competent person by requiring

PBC to submit a competent person authorization. Either they failed to recognize that scissor lifts were scaffolds and therefore required a scaffold competent person, or they overlooked submission of the written scaffold competent person authorization. Had they required submission of a scaffold competent person authorization, PBC might have realized that their SSR was not a competent person for scaffolds and either provided the PBC SSR specialized training or designated a more qualified person to be the competent person.

AGSC performed weekly *Job Specific Safety Surveillance*, but did not recognize the unsafe condition caused by tying the blasting and breathing air hoses to the guardrails of the scissor lifts. On the afternoon of February 5, 2013, the AGSC SCS completed an inspection checklist of the PBC work being performed at WHT-14. The checklist does not state what work was in progress, but in an interview with the Board, the SCS reported that he had observed PBC employees blasting from scissor lifts. At no time did he sense that conditions were unsafe. All items on the checklist were marked as accepted. This checklist contained no items relative to the scissor lift or of any work being conducted at heights.

During the prior week on January 31, 2013, the AGSC SCS had completed the weekly surveillance checklist and added a note that he had observed and stopped a PBC subcontractor employee who was tasked with removing anodes from the tank wall and who was getting into a scissor lift without tying off. The PBC subcontractor employee did not have lanyards on his fall protection harness. The AGSC SCS reminded the work crew of the importance of "being tied off and about safety in general." The AGSC SCS submitted a *Safety Intervention* report of the accident, using the AGSC Safety S.H.I.E.L.D. report form. This discrepancy was also noted on the AGSC *Daily Construction Management Report* for January 31, 2013. This report was jointly signed by the AGSC SCS and the AGSC Site Construction Coordinator. Clearly, AGSC had stop work authority and provided periodic safety inspections of the work. The AGSC SCS was at the tank on the morning of the accident, but the crew was setting up their hoses outside the tank and the blasting had not yet begun because damp conditions were not suitable for blasting. In an interview, the AGSC SCS explained that his role was to monitor PBC's compliance with their safety plans. He had previous experience observing scissor lift work and had never taken scissor lift training. He had limited experience with blasting. He assumed that PBC knew what they were doing, in part because he had examined their training certifications and work authorizations and confirmed their safety briefings. His role was to monitor for any deviations from their work plan. From his perspective, PBC was performing work within the controls established by the JSA. The work control of periodic work inspection was performed, but was not fully effective.

The Board concluded that the Job Safety Analysis did not identify hazards associated with abrasive blasting work from a scissor lift, specifically the lateral force restriction. **(JON 5) (JON 6)**

2.3.4.3. DM

DOE Environment, Safety and Health (ES&H) had tasked DM to perform a safety review of the PBC *Safety Execution Plan* on their behalf. DM performed this review without having all of the work plan documents. This was a failure to work within controls. It is not clear if they knew that the blasting work would be performed from scissor lifts. They failed to comment on the lack of specificity in the analysis of hazards related to scissor lift use. DM provided comments to DOE on the PBC emergency response plan, noting that DM would not be responsible for responding to emergencies involving PBC personnel.

DM issued the work authorization permit for PBC to perform blasting, based on a review of their work plan submittals. DM reclassified the tank as a non-permit confined space each day, by performing a checklist inspection of the lockouts and tag-outs outside the tank and an entry with air monitoring equipment to verify safe atmospheric conditions inside the tank.

After the accident, the DOE SSR called the DM Emergency Management Specialist/ERT Lead (DM EMS/ERT Lead). The DM EMS/ERT Lead responded within minutes and initiated a first response. There were no procedures to guide DM in making the determination if the space was or was not hazardous due to air contaminants from abrasive blasting. DM relied on the gas detection monitors that showed safe gas levels -- but the monitor did not measure particulate levels. Rescue planning in the event of an emergency was not well coordinated or practiced with PBC, contrary to DM policies and procedures.

The Board concluded that there was confusion regarding the responsibilities for emergency response actions. **(JON 20)**

Despite EMT observations that the injured employee was bleeding, the potential exposure to blood borne pathogens was not communicated to the responders who assisted in removing the injured employee from the tank and into the ambulance nor was PPE required by response supervisors on-scene. Two responders got blood on their hands and following departure of the ambulance, were referred to the medical clinic for follow up evaluation. The work control of proper PPE was not followed.

2.3.4.4. DOE

DOE reviewed the PBC *Safety Execution Plan*. This was accomplished by tasking DM to perform the review and to provide comments to DOE. DOE lacked the resources to perform its review in house. DOE failed to communicate the discrepancies in the emergency response plan as noted by DM nor did DOE ask AGSC to re-submit a revised emergency response plan.

DOE on-site staff performs formal monthly observations of contractor work and frequently visit various work sites. They have stop work authority and have used that authority at West Hackberry. This tank work was considered a recurring task that has been performed approximately every five years ever since the tanks were constructed. DOE had authorized the job, based on DM's review of PBC's submittals and documents provided to DM. Sufficient evidence was not provided to the Board to determine if DOE staff members had specific scissor lift training and experience.

When PBC activated the air horn after the scissor lift fell, the DOE SSR called the DOE Eng to investigate. Contrary to SPR emergency response plans, the DOE Eng failed to immediately call the Control Room and this error was repeated by the DOE SSR, who called the DM EMS/ERT Lead. DOE personnel did not comply with the SPR emergency response plan.

2.3.5. Provide Feedback and Continue to Improve Safety Management

Feedback and continuous improvement is the fifth Core Function of ISM and provides a vital feedback link to the other Core Functions to improve overall safety performance. Feedback is accomplished by collecting information on the adequacy of controls, identifying opportunities for improving how work is defined and planned, reviewing the results of line and independent oversight, and then applying that feedback to the work control process. During this investigation the Board reviewed reports associated with two previous SPR accidents to evaluate the effectiveness of corrective actions that resulted from those accidents. This evaluation was conducted after the majority of analysis had been completed and the conclusions had been determined. The reports included in the evaluation were:

- *The Strategic Petroleum Reserve BMT2 Incident Analysis Review Team Report*, by a DOE and contractor team appointed by the SPRPMO Project Director, dated August 31, 2010.
- *Independent Review of the Fatality at the Strategic Petroleum Reserve Bryan Mound Site*, by the U.S. Department of Energy Office of Health, Safety and Security, dated September 2010.
- The *DOE Federal Accident Investigation Report for the Fatality at the Strategic Petroleum Reserve at Bryan Mound Site*, conducted by U.S. Department of Energy Office of Health, Safety and Security, dated September 13, 2011.

The following is a summary of JONs that were identified in those 2010 and 2011 reports, and for which corrective actions were developed and reported as complete:

<u>Oversight</u>

- Ensure that the safety representative assigned to support activities has the requisite knowledge of applicable health and safety requirements to effectively monitor and control the safe execution of the work.
- Identify Hazards and Safety Requirements.

- The subcontractor needs to prepare and provide a safety plan specific to that task, and not a generic safety plan.
- Each applicable hazard and control is specifically identified in work control documents and that the crew members understand these hazards and controls.
- DOE establish a process for assessing and prioritizing health and safety risks at SPR sites, and maintain a cadre of safety specialists that can be temporarily located at sites, commensurate with these risks.
- The contractor needs to ensure that hazards listed in equipment manufacturer operator's manuals and other relevant references are included in the JHAs.
- The contractor needs to revise daily equipment operating checklists to ensure consistency with the equipment operator's manual for such equipment.
- The contractor needs to revise the SWP process to specifically include a review of the JHAs for the work to be performed and to confirm adequate controls are in place.
- The contractor needs to develop a pre-job briefing process that establishes a minimum set of requirements to be addressed at each pre-job briefing commensurate with the hazards and complexities of the work.
- The Office of Petroleum Reserves, FE-40 (SPR-HQ) needs to evaluate the contractor's effectiveness in implementing improvements in JHA, SWP, and pre-job briefing processes.

Training

- The contractor needs to revise its OJT and qualification program so that the OJT is specific to equipment and processes that are significantly unique.
- The contractor needs to provide sufficient guidance in the OJT materials to ensure that consistent, task specific training is conducted and documented.
- The contractor OJT program needs to ensure relevant work documents such as equipment operator's manuals, JHAs, and equipment warnings are addressed and documented in the OJT record.
- The contractor needs to ensure the necessary OJT and other required training are properly completed and documented before assigning an employee to perform a particular task.
- SPR-HQ needs to evaluate the contractor's effectiveness in implementing training improvements for OJT, and the contractor's process for verifying that training is complete before employees are assigned tasks.

Low Threshold Stop Work Policy

- The contractor needs to augment its current stop work policy by incorporating a graded approach to stop work that encourages workers to initiate a "stop when unsure" "pause" or "timeout" process.

- The contractor needs to develop and implement stop work training that includes situations and scenarios that will help workers identify when to stop work at lower thresholds.

Lessons Learned

- Procedures and practices are modified to ensure that DOE lessons learned are considered during the planning of work to be performed by subcontractors.
- SPR-HQ and the contractor need to ensure that DOE operating experience programs and reporting systems are used to continuously improve operations.
- SPR-HQ needs to provide oversight of the resolution of corrective actions related to this [2011] accident and the corrective actions associated with the prior 2010 fatality at the SPR-BM site to ensure effective implementation and to prevent recurrence.

Although a different contractor and subcontractor, and different work tasks were involved with the 2013 SPR WHT-14 accident, successful resolution of previously identified judgments of need could have prevented the accident. Several JONs developed by this Board are very similar, if not word-for-word, to previous JONs. It was evident to the Board that the SPRPMO and contractors' corrective action processes were not effective in implementing the corrective actions necessary to resolve problems in the work control process. The Board identified that some corrective actions were narrowly focused on a particular work activity (tank cleaning, for example) rather than control of subcontractor work in general. Others were directed at a single SPR prime contractor rather than at both SPR prime contractors that accomplish similar work through subcontracts. Expanding corrective actions as lessons learned to the contractor not directly involved in a particular accident, but who performs similar work, is a best management practice.

Identifying and controlling hazards were major contributing factors to this accident and if previously identified corrective actions had been adequately implemented, this accident could have been prevented. Additionally, SPRPMO and its contractors have not implemented sufficient oversight controls to identify safety issues early on during the work-planning, design, and procurement phases of a job.

The Board concluded that a PBC subcontractor employee had questioned the use of scissor lifts to perform blasting operations inside the tank, but took no further action. **(JON 21)**

The Board concluded that the SPRPMO and its contractors' corrective action processes need improvement regarding oversight, training, stop work, and lessons-learned. **(JON 22) (JON 23)**

2.4 Emergency Response

When the scissor lift initially fell, the PBC Hole Watch used his air horn to get attention, indicating an emergency/evacuation situation was present according to PBC procedures; however, the use of the horn was not necessarily universally understood by other site personnel. There is nothing in the PBC procedures to indicate that the Control Room should be called in the case of an emergency; however, it is listed on the safe work permits and statements indicate it was briefed to PBC personnel as site procedure.

The PBC SSR was sitting in a truck near the tank completing paperwork when he heard the air horn warning and immediately responded to the tank entrance. After learning of the accident from the PBC Hole Watch, the PBC SSR immediately donned his fall protection harness, according to PBC procedures, and entered the tank at 10:43 a.m. While the PBC SSR was donning his harness, the PBC Hole Watch asked if he should call the Control Room to report the accident, which is the required action to initiate a DM ERT response, but the PBC SSR indicated to the PBC Hole Watch that he would handle the notifications. This action delayed 911 notification and arrival of an ambulance. PBC had no rescue/retrieval equipment set up by the tank nor was it clear who the PBC rescue team was.

The PBC SSR called the PBC Shift Sup and PBC FSS (a licensed paramedic) by cell phone requesting them to come to tank WHT-14. By immediately calling the PBC FSS, the PBC SSR was following the procedures established in the PBC Safety Execution Plan for this task, dated November 19, 2012, that had been approved by AGSC. This plan required that any emergency first aid and cardiopulmonary resuscitation was be given by trained PBC employees. Under this plan, emergency services were to be requested if immediate medical care was required. The PBC SSR, who was not currently certified in first aid, performed injury assessment while waiting for the PBC FSS and PBC Site Sup to arrive. PBC Blaster 1 was conscious and asked the PBC SSR to remove his blast hood and gloves and lanyard attachment to the work platform. The PBC SSR did remove the blast hood, gloves and disconnected the lanyard from the work platform; however, the Board does not know if these movements had any impact on the extent of injury to PBC Blaster 1.

At 10:48 a.m., the PBC Site Sup arrived at the scene and entered the tank to evaluate the situation, after putting on his retrieval harness. At 10:54 a.m., the PBC FSS arrived at the tank and after entering, found PBC Blaster 1 to be in pain in several locations on the right side of his body, and noted that PBC Blaster 1 was alert and oriented. Moments later, DM ERT personnel arrived and entered the tank and the PBC personnel ceded control to them.

The PBC *Safety Execution Plan* did not follow the SPR requirements for reporting and responding to medical emergencies. PBC's failure to follow SPR emergency response procedures work controls delayed the arrival of medical help for the injured worker. PBC personnel did not follow their own plan. None of the PBC responders wore a retrieval line with their harnesses and no mechanical device was provided for life rescue. This is not in conformance with the PBC procedure. None of them donned any respiratory protection. Failure to consider exposure to harmful particulate levels inside the tank was not considered during rescue planning or by the responders as they rushed to provide assistance.

2.4.1. DOE and DM Responses

The DOE SSR was conducting business at a cavern outside the West Hackberry site main fence line, but heard the air horn and noticed several people moving quickly near the tank. The DOE SSR noted the time as 10:42 a.m. and called the DOE Eng by cell phone and asked her to investigate the situation since it would take time to re-enter the site through the security portal and the DOE Eng was closer to WHT-14. At the same time a Protective Force Officer at the main gate also heard the air horn and observed activity around the tank. Not knowing what the air horn meant, the Protective Force Officer returned to his normal duties. There is nothing in the West Hackberry site procedures to indicate the meaning of an air horn. In response to the accident and air horn, PBC Blaster 3 came down from the tank, PBC Blaster 2 exited the tank, and the PBC Pot Tender began securing the air compressors and other equipment.

The DOE Eng arrived at the scene a few minutes later and determined that an accident had occurred and that the Control Room had not been notified. She called the DOE SSR via cell phone and instructed her to "get back over here now." The DOE Eng then called the DM EMS/ERT Lead by cell phone and requested that he come to the scene. Upon the DOE SSR's arrival, she was briefed by the DOE Eng on the situation. The DOE SSR questioned the PBC Hole Watch and PBC NACE Insp for information about the accident and the status of notifications. At this time, the DOE SSR observed the PBC SSR inside the tank attempting a rescue of some type. The DOE SSR then tried calling the DM EMS/ERT Lead, a DM confined space expert, knowing they would need him there. She asked the DOE Eng if the Control Room had been called and was told yes, but there still had not been an ERT page issued at this point. The DOE SSR tried calling the West Hackberry Site Director by phone and had to leave a message. The Site Director had been notified and was proceeding to the incident scene. The Site Director called the DOE SSR while proceeding to the scene. At 10:55 a.m., the DOE SSR finally contacted the Control Room directly, briefed the situation, and requested the ERT be activated and an ambulance called to the scene.

The DM EMS/ERT Lead stated he was notified by the DOE Eng to proceed to the tank. Upon DM EMS/ERT Lead's arrival at the tank, the PBC Hole Watch stated the injured employee had been down approximately 30 minutes.

The DM EMS/ERT Lead stated he immediately called the Control Room and asked for an ambulance. The control room log states the DOE SSR called at 10:55 a.m. The DM EMS/ERT Lead stated that as he was getting out of his vehicle he heard a call over the radio for the ERT to respond. The DM EMS/ERT Lead took charge of the response and considered the tank a "non-permit required" space. At 10:56 a.m., the Control Room Operator called for the ERT to respond. The West Hackberry site ERT fire truck left the fire bay at 10:59 a.m., en route to the accident scene. At 11:00 a.m., the Control Room Operator called for an ambulance, almost 20 minutes from the initial accident.

At 11:00 a.m., the West Hackberry Site Security Captain, having heard the radio traffic calling for the ERT at WHT-14, directed two security rovers, over the radio, to respond to the accident and support the ERT. The two rovers responded as security personnel rather than medical support and set up a traffic control point on Black Lake Road in front of well pad 112 in anticipation of escorting the ambulance upon the pending arrival. At 11:04 a.m., DM employees DM ERT-1 and DM EMT-1 arrived and entered the tank. About this same time an announcement was made over the public address system for the ERT to respond. DM EMT-1 was not a member of the site ERT but was allowed to respond into a confined space. Once in the tank, DM ERT-1 and DM EMT-1 continued to evaluate the patient until relieved of their duties by the ambulance crew.

At 11:08 a.m., the Cameron Ambulance and the local sheriff's department arrived and were escorted to WHT-14 by the two security rovers. The two ambulance EMTs were allowed to enter the tank to provide assistance to the injured worker. In the interest of time, the DM EMS/ERT Lead allowed the ambulance personnel into the tank rather than the ERT bringing the injured employee out to the ambulance.

As the injured employee was being removed from the tank, an ambulance crew member requested assistance in removing the injured employee from the tank at the man-way. The DM EMS/ERT Lead directed six personnel that were outside of the tank: site ERT, EMT and Security personnel, to assist with the removal of the injured employee from the tank. At 11:34 a.m., the injured employee was removed from the tank and placed into the ambulance. Since the injured employee showed evidence of bleeding from his wounds, the DM EMS/ERT Lead had the ERT, Security and EMT supporters check themselves for blood exposure. Two persons, a security rover and an ERT member discovered they had been in direct contact with blood. The ambulance departed the site at 11:44 a.m., approximately one hour after the accident occurred.

The control room log does not indicate that security was ever formally notified to respond in a coordinated effort with the site ERT. The security officers who responded did so in a mental framework of responding as protective force responders rather than as medical responders. The West Hackberry security officers carry blood borne pathogen protective gloves on their person but did not don them in this instance.

The Board concluded that the PBC employees who witnessed the accident and initial responders from DOE and DM did not immediately contact the Control Room Operator to initiate emergency response. **(JON 24) (JON 25)**

2.4.2. Investigative Readiness and Scene Preservation

2.4.2.1. Scene Preservation

From testimony and review of the records, the Board learned that the West Hackberry site took control of the accident scene immediately after the injured employee was transported off-site on February 7, 2013. West Hackberry personnel collected written witness statements and preserved the accident scene to the maximum extent possible. Some of the initial photographs of the accident scene that were compiled by the site were extremely useful in the conduct of the accident investigation because wind effects in the open top tank caused equipment and materials in the tank to migrate over time. West Hackberry site security was posted outside the tank entrance 24/7 from the time the ambulance left the scene until the accident scene was released by the Board over two months later.

On February 15, 2013, the Acting Assistant Secretary for Fossil Energy appointed an Accident Investigation Board to investigate the scissor lift tip over and injury in West Hackberry WHT-14 and tasked the Board members with conducting a thorough investigation of the scissor lift tip over and injury; determining root causes; and developing corrective and preventive actions to preclude recurrence. Subsequent actions taken by the West Hackberry site immediately following the accident and over the next several weeks in support of the Board included collection and sharing of a large amount of data/documentation; coordination of interviews; hosting of the Board and Board members with SMEs on numerous site visits; and providing constant security of the scene and of evidence removed from the scene until the Board released the accident scene to site operations on April 9, 2013. All physical evidence removed from the scene by the Board was fully documented and placed in a secure locked area.

All evidence collected through this effort was shared with the Board once it was established on February 15, 2013. On February 25, 2013, the Board arrived at West Hackberry and the site operations released control of the accident scene to the Board. As can be best determined, West Hackberry took all necessary actions to ensure preservation of the accident scene and for the collection of evidence for transitioning to the DOE accident investigation.

The Board determined the scene was preserved, photographed and the witness statements completed in a timely manner.

2.5 Barrier Analysis

An analytical technique the Board used was Barrier Analysis, which identifies management (administrative) and physical barriers/systems to isolate and avoid workplace hazards. In this particular accident scenario, the target was PBC Blaster 1 and the hazard was an unmitigated fall from height due to scissor lift tipping over. The Board identified eight barriers for this work activity and they were:

- Equipment Selection;
- Subcontractor Selection Process;
- Scissor Lift Operating Restrictions, including Job Hazard Analysis;
- Personal Protective Equipment;

- Training;
- Competent Person;
- Safety Feature;
- Safety Oversight to Ensure Work was Performed Safely;
- Supervision; and
- Questioning Attitude.

The result of the Barrier Analysis is presented in Appendix B.

2.6 Change Analysis

To further support the development of causal factors, the Board performed a Change Analysis of the accident. The Board examined the planned and unplanned changes that caused the undesired results or outcomes related to the event. The changes that related to this accident were:

- Blasting was performed from scissor lift;
- Workers, supervisors, and safety oversight not aware of scissor lift operating restrictions;
- Job Safety Analysis did not include specific scissor lift operating restrictions;
- Job Safety Analysis development process changed to an on-line, pick list and menu driven format;
- Training did not include scissor lift operating restrictions concerning lateral force;
- Scissor lift was located farther away from the man-way location where hose was secured;
- Blasting started with scissor lift in an unstable condition due to lateral force from blast hose;
- Blasting hose was secured/attached to side of scissor lift work platform; and
- An insufficient length of blasting hose was used in this job.

The Change Analysis is presented in Appendix C.

2.7 Event and Causal Factors Analysis

After performing the barrier, change, and error precursor analyses, the Board assigned results from each analysis to events on the chronology of events. This involved assigning analysis results as conditions that were related to or caused the events on the chronology. Once conditions were assigned, the Board examined the events and causal factors to determine which events were significant (i.e., which events played a role in causing the accident).

The Board then assessed the significant events (and the conditions of each) to determine the causal factors of the accident. The causal factors that resulted were:

The **direct caus**e of this accident is lateral forces exceeded the capability of the scissor lift to remain upright.

Root causes are the causal factor(s) that, if corrected, would prevent recurrence of the same (local) or similar (systemic) accidents. The Board determined that:

The **local root cause** was that SPRPMO, DM, AGSC, and PBC failed to recognize, understand, and manage operating conditions within the safe operating limits specified by the equipment manufacturer.

The **systemic root cause** of this accident was that SPRPMO, DM, and AGSC failed to adequately implement several of the guiding principles of Integrated Safety Management: Clear Roles and Responsibilities; Competence Commensurate with Responsibilities; Identification of Safety Standards and Requirements; and Hazard Controls Tailored to Work Being Performed. Examples of specific deficiencies included:

- Unclear responsibilities of the PBC site supervisor and site safety representative for supervising and overseeing the work;
- Unclear responsibilities of the DM and PBC employees regarding emergency response operations;
- Unclear responsibilities at the SPRPMO for review of field site plans and work documents;
- Inexperience of AGSC and PBC employees for overseeing and conducting blasting work inside a tank using scissor lifts;
- Failure by PBC to evaluate and designate, in writing, who the OSHA competent person was for the project; and
- Job specific safety documents developed by PBC, approved by AGSC, and reviewed by DM and the SPRPMO did not include detailed lateral force restriction hazard information (0 mph wind / 90 lb side) as provided by the manufacturer.

The **contributing causes** were:

- Safety documents such as the Job Hazard Analysis were generic and did not address lateral force as a hazard;
- Supervisors and safety personnel were not aware of the lateral force hazard;
- Scissor lift operators were not trained to be aware of the lateral force hazard;
- Scissor lift operators were allowed to operate the scissor lift without regard to the lateral force hazard;
- Oversight organizations were not technically knowledgeable in the operational limitations and specific safety requirements for scissor lift operations.;

- Work planning depended on skill of the craft due to a lack of adequate safe work procedures and competent supervision;
- The length of the blast hose was not sufficient to prevent excessive lateral loading of the elevated work platform; and
- The operators were inexperienced in using scissor lifts for blasting jobs inside tanks.

The Event and Causal Factor Analysis is presented in Appendix D.

3.0 Conclusions and Judgments of Need

Judgments of Need are the managerial controls and safety measures determined by the Board to be necessary to prevent or minimize the probability or severity of a recurrence. These JONs are linked directly to the causal factors which are derived from the facts and analysis. They form the basis for corrective action plans which must be developed by line management. The Board's conclusions and JONs are listed below in Table 3.

Table 3: Conclusions and Judgments of Need

Conclusion	Judgment of Need
Selection of scissor lifts by PBC and acceptance by AGSC to perform the blasting job were poor decisions because scissor lifts have significant operating restrictions concerning lateral force including the attachment of blast hose and air hose to the work platform.	**JON 1**: The SPRPMO must develop a written process that requires all (powered) equipment used for SPR work to undergo a review before being allowed onto any SPR site. The review should identify the manufacturers name, make and model, serial number, and current inspection date, and it should ensure that equipment specific hazards and operational limitations, as identified in current/up-to-date operational manuals are analyzed for incorporation into work safety-planning documents.
AGSC allowed work to commence without ensuring all contract required submittals from PBC were adequate and complete.	**JON 2**: Contractors must strengthen their contract submittal review process to ensure subcontractor required submittals are adequate and complete before allowing work to commence.
Job specific safety documents, developed by PBC, approved by AGSC, reviewed by DM and the SPRPMO, were deficient because they did not include manufacturer information regarding lateral force hazards that were specific to the scissor lift equipment or the operating restrictions in the applicable ANSI standard.	**JON 3:** Contractors must strengthen their safety document review process to ensure that subcontractor safety document submittals are reviewed by individuals with sufficient technical competence to determine the adequacy of submitted documents. **JON 4: The** SPRPMO must formalize and document their safety document review process. When implemented, the process needs to ensure that submittals are reviewed by individuals with sufficient technical competence to determine the adequacy of those submittals and it needs to include documented authorization or non-authorization of the completed review. The process should include a hold point(s) and sufficient review windows. Clear roles and responsibilities should be clarified and should include the Contracting Officer, CORs, onsite Federal line staff, and SPRPMO staff.

Conclusion	Judgment of Need
The Job Safety Analysis did not identify hazards associated with abrasive blasting work from a scissor lift, specifically the lateral force restriction.	**JON 5**: Subcontractors must ensure that equipment specific operator manual and label requirements are appropriately reviewed, understood, and incorporated into work control documents and practices. **JON 6**: Contractors must ensure that subcontractors review, understand, and incorporate equipment-specific operator manual and label requirements into work control documents and practices.
Information regarding the lateral force restrictions that were specific to the scissor lift was available in the operating manual located in a holder on the scissor lift and on a warning label attached to the scissor lift, but that restriction was not incorporated into work controls.	**JON 5**: Subcontractors must ensure that equipment specific operator manuals and label requirements are appropriately reviewed, understood, and incorporated into work control documents and practices. **JON 6**: Contractors must ensure that subcontractors review, understand, and incorporate equipment-specific operator manual and label requirements into work control documents and practices.
SPRPMO, DM, AGSC, and PBC failed to recognize, understand, and manage the lateral force restrictions of the scissor lift.	**JON 7:** Work planning must include the analysis of the hazards associated with the operation of all power equipment and machinery required to perform the job. Contract language shall require the selected vendor to list the equipment in their Work Plan proposal and address, at a minimum, all manufacturer precautions and limitations identified in the operations manuals. Precautions and limitations must be discussed during hazard identification and work planning sessions so that appropriate mitigating factors can be established, approved and monitored. The competency of those reviewing, approving and monitoring shall be commensurate with the identified hazards. Precautions and limitations requiring engineering analysis to

Conclusion	Judgment of Need
	mitigate a hazard shall require review and approval by a qualified individual or group. **JON 8**: Subcontractors must ensure that equipment operating restrictions and precautions are adequately identified and incorporated into work documents and practices. **JON 9**: Subcontractor supervisors, safety personnel, and workers must be properly trained and made aware of equipment operating restrictions and precautions. **JON 10**: Contractor supervisors, safety personnel, and other workers who oversee subcontractor work must be aware of equipment operating restrictions and precautions. **JON 11:** SPRPMO Federal supervisors, safety personnel, and other workers who oversee contractor and subcontractor work must be aware of equipment operating restrictions and precautions.
Scissor lift operator training that was conducted by PBC was deficient because it was not conducted by a qualified person as defined by OSHA, and it did not include the lateral force restriction that was specific to the scissor lift.	**JON 12**: Subcontractor equipment specific training must meet OSHA/ANSI minimum requirements. **JON 13**: Contractors must ensure that training conducted by a subcontractor for work to be performed on the SPR site meets OSHA/ANSI minimum requirements.
The PBC person identified as the on-site scissor lift competent person was not qualified to perform the functions of a competent person as defined by 29 CFR 1926 for scissor lifts and scaffolding.	**JON 14**: Subcontractors must ensure that individuals assigned to perform competent person responsibilities meet the requirements of a competent person as defined by OSHA. **JON 15**: Contractors must ensure that subcontractors who assign individuals to perform competent person responsibilities meet the requirements of a competent person as defined by OSHA.

Conclusion	Judgment of Need
Various supervisory functions were specified and required (including job supervision, OSHA competent person, site safety supervision, and OSHA confined space entry supervisor). However the persons assigned to those functions were not always available or able to oversee the work inside the tank and they were unable to effectively perform a supervisory function.	**JON 16:** The roles and responsibilities of subcontractor personnel, including supervisory functions, and the competencies required of those roles, should be clearly identified in work planning and assurance must be given that assigned personnel have the knowledge, competence and opportunity to carry out their functions. Specific required supervisory functions should be specified in contract documents.
None of the workers were familiar with using scissor lifts during blasting operations inside tanks.	**JON 17**: During the selection phase of the contract procurement process, contractors must require subcontractors to provide a summary of their experience that is associated with operating specific equipment and with performing specific task activities. That experience level should be utilized to assess the risk of the contractor to perform the operation/work task and to qualify the contractor by its acceptability to management.
There are additional weaknesses in hazard identification, hazard control, and performance of work within controls.	**JON 18:** SPRPMO and its contractors and subcontractors must strengthen the identification and communication processes for classifying and reclassifying confined spaces when work activities change the hazards present within those spaces. **JON 19:** SPRPMO and its contractors and subcontractors must ensure that safety documents that require the use of respiratory protection identify the atmospheric hazard(s) of concern, the anticipated levels, the methods to be used to evaluate those levels, and proper respirator use procedures. The criteria for when respirators shall be required shall be specified.

Conclusion	Judgment of Need
There was confusion regarding the responsibilities for emergency response actions.	**JON 20**: Emergency response procedures/plans must be implemented and used by all organizations and individuals performing work at SPR sites. Potential emergency response procedures, roles and responsibilities should be documented, reviewed and agreed upon and all involved parties should be trained prior to the start of work.
A PBC subcontractor employee had questioned the use of scissor lifts to perform blasting operations inside the tank, but took no further action.	**JON 21**: SPRPMO should require contractors and subcontractors performing work at SPR sites to implement a process for resolving safety related questions in instances that do not meet "Stop Work" levels.
The SPRPMO and its contractors' corrective action processes need improvement regarding oversight, training, stop work, and lessons-learned.	**JON 22:** SPRPMO and its contractors need to conduct independent corrective action effectiveness reviews of all corrective actions from previous accident/incident reports to measure their current effectiveness regarding oversight, training, stop work, and lessons-learned. **JON 23:** SPRPMO should develop a matrix of OSHA-required training that displays the expected proficiencies that employees must have upon completion of that training, for each requirement. This matrix should be made specific to types of equipment or tasks. It should be distributed to each DOE employee who is assigned oversight responsibilities and made available to contractors to use as a benchmark. The matrix should be used to identify training requirements for oversight personnel. Oversight validation of contractor personnel training should include requiring copies of relevant training certificates, curriculum topics, and trainer qualifications. Failure to document this training would be indicative of an OSHA violation and possibly a contract violation.

Conclusion	Judgment of Need
PBC employees who witnessed the accident and initial responders from DOE and DM did not immediately contact the Control Room Operator to initiate emergency response.	**JON 24:** Contractors must reinforce the SPR West Hackberry emergency notification procedures to ensure that all events requiring emergency or medical response are promptly reported to the proper contact/location. **JON 25**: Contractors must ensure that the SPR West Hackberry emergency notification procedures are transmitted as a requirement to subcontractors.
The Board determined the scene was preserved, photographed and the witness statements completed in a timely manner.	None.

Scissor Lift Accident in the West Hackberry Brine Tank-14 Resulting in Injury

4.0 Board Signatures

Mark J. Matarrese
DOE Accident Investigation Board Chairman
U.S. Department of Energy, Office of Fossil Energy
Director, Office of Environment, Security, Safety and Health

James B. Wallace
DOE Accident Investigator and Board Member
U.S Department of Energy, Strategic Petroleum Reserve Project Management Office
Director, Environment, Safety and Health Division

Michael J. Monahan
DOE Accident Investigator and Board Member
U.S Department of Energy, National Energy Technology Laboratory
Director, Environment, Safety, Security and Health Division

Michael J. Taylor
DOE Accident Investigator and Board Member
U.S Department of Energy, Rocky Mountain Oilfield Testing Center
Director, Technical Assurance

James M. Gruber, PE
DOE Accident Investigator and Board Member
U.S. Department of Energy, Strategic Petroleum Reserve
Petroleum Engineer

5.0 Board Members, Advisors and Consultants

Board Members

Chairman	Mark J. Matarrese, FE-7
Member	James B. Wallace, SPRPMO, FE-4442
Member	Michael Monahan, NETL
Member	Michael J. Taylor, RMOTC
Member	James M. Gruber, PE, FE-42

Advisor/Team Coordinator

Consultant/Advisor	Chad Bourgoin, FE-7
Consultant/Advisor	Robert C. Seal, MAS Consultants, Inc.
Accident Analyst/ Consultant/Advisor	Mary Anne Chillingworth, MSPH, CIH, CSP Project Enhancement Corporation
Consultant/Advisor	Leslie Bermudez, CSP, REM U.S. Department of Energy Office of Enforcement and Oversight (HS-40) Office of Health, Safety and Security

Administrative Coordinator

Consultant/ Technical Editor	Susan M. Keffer, Project Enhancement Corporation

5.1 Biographies of Accident Investigation Board Members and Support

Mark J. Matarrese
DOE Accident Investigation Board Chairman
U.S. Department of Energy, Office of Fossil Energy
Director, Office of Environment, Security, Safety and Health

Mark J. Matarrese is the Director for the DOE Fossil Energy (FE) Office of Environment, Security, Safety and Health (FE-7). He also serves as the FE Headquarters Security Officer, NEPA Compliance Officer, and Emergency Response Manager. He previously served as the Environmental Compliance Manager, Quality Assurance Officer, and Safety Officer.

Mr. Matarrese holds a Bachelor of Science degree with major coursework in chemistry/microbiology from the University of Central Florida. He also completed postgraduate coursework in computer programming. Mr. Matarrese has 32 years of experience in the environment, security, safety and health (ESS&H) and emergency management fields. Previous positions included ESS&H and emergency response manager for Naval Petroleum and Oil Shale Reserves; Physical scientist with DOE Defense Programs in the Office of Nuclear Self-Assessment and Emergency Management; and Compliance Officer in the DOE Office of Environment, Safety and Health, Military Applications Division.

Mr. Matarrese initially began working with Orange County Pollution Control (Florida) and spent the next six years of his career in private industry as a supervisory analytical chemist and laboratory safety officer. He later served as a Laboratory Director for the U.S. Marine Corps at Naval Air Rework Facility, Marine Corps Air Station (MCAS) Cherry Point. After a follow-on job as a senior physical scientist at DoD's Defense Technical Information Center, Cameron Station, he joined the DOE in 1989.

Mr. Matarrese is a senior fellow with the Council for Excellence in Government, and a graduate of the USDA Graduate School's Executive Potential Program. He served on a formal detail at the National Transportation Safety Board to establish their Federal Employee Occupational Safety and Health program, as well as at the FBI Academy's Forensic Science Research Unit on Marine Corps Base Quantico, Virginia.

Other credentials include DOE Certified Accident Investigator and Board Chairman; Top graduate of Gas-Free Engineering class for confined space entry conducted by Naval Sea Systems Command Safety School; and 28-year member of the American Chemical Society. Examples of inspections and assessments conducted include:

- Operational Readiness Review for K-Reactor Restart at Savannah River Site;
- Radioactive Waste Management Assessment at Sandia National Laboratory;
- Occurrence Reporting Assessment at Lawrence Livermore National Laboratory;
- Operations Security Inspection at DOE Headquarters;
- Integrated Safety Management (ISM) Verification at the Strategic Petroleum Reserve (SPR);
- ISM Verification at Naval Petroleum Reserve (NPR);
- ISM Verification at National Energy Technology Laboratory (NETL);
- Pollution Prevention Opportunity Assessment at the SPR.

James B. Wallace
DOE Accident Investigator and Board Member
U.S. Department of Energy, Strategic Petroleum Reserve
Director, Environment, Safety and Health Division

Brad Wallace is currently the Director of the Environmental, Safety & Health Division of the U. S. Strategic Petroleum Reserve, Project Management Office, in New Orleans, Louisiana. He previously served as the Emergency Program Manager for the Petroleum Reserve, and has been working for DOE since 2004. Mr. Wallace also serves as the SPR Aviation Safety Officer.

Mr. Wallace earned a Bachelor of Science degree in Environmental Health from the University of Georgia and a Master of Science degree in Occupational Safety & Health from East Carolina University. Mr. Wallace has over 32 years of ESH experience in a variety of settings including government, military, industry and consulting with diverse specialties including safety, industrial hygiene, environmental, emergency management, and security. Mr. Wallace is trained, certified and experienced in a variety of accident investigation areas including industrial, agricultural, aviation, marine, pollution, and transportation related. Mr. Wallace has worked for the U.S. Environmental Protection Agency and the U.S. Coast Guard as an enforcement officer, as an ESH professional for several petroleum companies (to include offshore/pipelines/terminals and refining), and as a consulting expert in ESH, emergency management and maritime security with several consulting organizations. Mr. Wallace is also a U.S. Coast Guard Reserve Commander, currently serving as Commanding Officer of Port Security Unit 307 in Clearwater, Florida.

Mr. Wallace is a professional member of the American Society of Safety Engineers, a full member of the American Industrial Hygiene Association. Mr. Wallace holds credentials as a Certified Safety Professional (CSP), a licensed Commercial Pilot (fixed-wing/rotary-wing/instrument) and a licensed commercial vehicle operator.

Michael J. Taylor
DOE Accident Investigator and Board Member
U.S. Department of Energy, Rocky Mountain Oilfield Testing Center
Director, Technical Assurance

Michael Taylor's current position is Director, Technical Assurance with DOE RMOTC in Casper, Wyoming. He is responsible for DOE's Environmental, Safety, Security, Occupational Health, Emergency Management, and Quality Assurance Programs.

In addition, Mr. Taylor's Federal Government Collateral Responsibilities include NEPA Compliance Officer, Site Security Officer, and Contracting Officer Technical Representative.

Mr. Taylor's education is comprised of a B.S. in Engineering with continuing education in Environmental, Safety, Security and Health, Facilities Operations, and Industrial Construction. Mr. Taylor is a Certified NREP Certified Registered Environmental Manager.

Michael J. Monahan
DOE Accident Investigator and Board Member
Environment, Safety, Security & Health Director
U.S. Department of Energy, National Energy Technology Laboratory

Mike Monahan graduated from West Virginia University in 1987 with a Bachelors of Science degree in Chemical Engineering. He has spent his entire professional career, 24 years and counting, as a dedicated federal government employee. Many job opportunities have allowed him to build a well rounded portfolio in the chemical and mechanical engineering, safety and health, environment, and facility maintenance disciplines.

Immediately upon graduating from WVU, Mr. Monahan began his life long career as a federal government employee at the Naval Ordinance Station in Indian Head, Maryland. While there, he worked mainly on explosives facility design and maintenance and assisted with ordinance production for the U.S. Navy fleet. In December of 1990, he returned to Morgantown, West Virginia to begin his current career with the Department of Energy's National Energy Technology Laboratory (NETL). He spent his first sixteen years with NETL in the research and development group, designing and operating fossil energy projects that ranged in size from tabletop systems to multi-acre demonstration units. In 2006 he stepped into the management arena and began supervising the engineering and safety programs associated with the full NETL R&D portfolio. After 16 years of working for the same group, he decided to expand his horizons, so in 2009; he moved to the facility operations side of NETL and began managing the site operations programs. After a 2010 NETL reorganization, he became the Director of Environment, Safety, Security and Health.

James M. Gruber
DOE Accident Investigation Board Member
U.S. Department of Energy, Strategic Petroleum Reserve
Petroleum Engineer

James Gruber has worked for the federal government for over 25 years. He began his career as a facilities engineer for the Department of the Army's Petroleum Center in New Cumberland, Pennsylvania. While there, he provided guidance and assistance in the construction, modification and upgrades to Army fuel facilities throughout the US and the world. Mr. Gruber also trained and assisted fuel handlers in the field on all aspects of fueling operations and management. Mr. Gruber served as the Army's lead in all matters relating to underground storage tank operations and maintenance.

In 1992, Mr. Gruber took on the responsibilities as the headquarters facilities engineer for the Naval Petroleum and Oil Shale Reserves in Washington, DC. He oversaw and assisted in many oilfield construction projects as well as maintenance and operations. After the sale of the Elk Hills Oil field in Bakersfield, California, Mr. Gruber was an active member of the Equity Finalization Team for the Department of Energy in the equity redetermination with Chevron USA.

Mr. Gruber came to the Strategic Petroleum Reserve in 2001 as part of the Planning and Engineering Office. He assumed the duties as the lead engineer for refinery operations. In that position, he took over the customer service program, and continues to maintain contact with all of the SPR's refinery customers. During emergencies, such as hurricanes, Mr. Gruber is the primary contact for refiners within the SPR. Currently, Mr. Gruber serves as the headquarters cavern engineer.

Mr. Gruber graduated in 1984 with a B.S. in Petroleum and Natural Gas Engineering from Pennsylvania State University. Mr. Gruber became a Registered Professional Engineer in the Commonwealth of Pennsylvania and earned his Professional Engineering license in 1997.

Chad Bourgoin
Federal Accident Investigation Consultant
Department of Energy, Office of Fossil Energy
FE-7, Office of Environment, Security, Safety and Health

Chad Bourgoin is the Environmental Manager for the U.S. Department of Energy's (DOE) Fossil Energy (FE) Office of Environment, Security, Safety and Health. He holds a Bachelor of Science Degree in Environmental Studies from the University of Maine. He is a nationally registered Environmental Manager and has training and experience in the areas of safety management, hazardous materials management, emergency response, explosive ordnance disposal, CERCLA remediation technologies, asbestos management, facilities management, industrial hygiene, Lean Six Sigma, project management, accident investigation, and firefighting.

Mr. Bourgoin has nearly 20 years of Environmental, Health, Safety and Emergency Management Experience as well as over 10 years of construction project management experience as a Federal Contracting Officers Representative (COR). During the base realignment and closure process at Loring Air Force Base, he served as the environmental compliance manager for site caretaker operations. He served as the sole environmental protection specialist as well as a construction COR for the Bureau of Indian Affairs Office of Indian Education Facilities Management Program. He was employed by Raytheon Missile Systems as the Senior Environmental, Health and Safety Engineer at the NAPI Production Facility. Mr. Bourgoin began his DOE career as an Environmental Protection Specialist with DOE Western Area Power Administration where he was responsible for environmental compliance related to the operation of Federal high voltage transmission systems.

Robert C. Seal
Accident Investigation Consultant
MAS Consultants, Inc., Senior Principal Consultant

As a Senior Principal Consultant with MAS Consultants, Inc, Robert Seal provides services to clients that included developing, implementing, and conducting operational and safety oversight; leading and participating on accident and event investigations; lead instructor for DOE accident investigation training; developing, implementing, and evaluating conduct of operations programs; leading and participating on operational readiness reviews and readiness assessments; and developing, implementing and evaluating effective Contractor Assurance Programs.

As a Facility Representative and supervisor at the Idaho Operations Office for 20 years, Mr. Seal was responsible for managing, supervising, and implementing improvements for the DOE Idaho Facility Representative Program. He supervised extensive oversight and evaluation of facility operations and operational safety, served as a Steering Committee Member of the DOE Facility Representative Program, and participated as a member of two DOE Technical Standard Writing Teams. He participated as a member of the DOE Order Writing Team that revised the DOE accident investigation process Order and is currently active as a consultant to accident investigation boards and is a trainer for the Accident Investigation Program.

Mr. Seal served as an Accident Investigation Board Member, Chairperson, or advisor for numerous significant accidents within the DOE complex, and was a Team Member and Senior Technical Advisor for several Operational Readiness Reviews and site assessments.

As a qualified Facility Representative, Mr. Seal was responsible for oversight of all facilities within the Advanced Test Reactor Complex, the Material and Fuels Complex, and the Specific Manufacturing Capability facility. Mr. Seal participated as a Team Member on Phase-II Integrated Safety Management System Reviews the Oak Ridge National Laboratory and the Idaho National Laboratory and served as the DOE Idaho Conduct of Operations Program Manager where he facilitated initial implementation of conduct of operations at the Idaho National Laboratory. He served as an Operational Readiness Review Team Member for the Advanced Mixed Waste Treatment Project Treatment Facility Operations, the Defueling of Power Burst Facility Canal, and was the Team Leader for the Startup of the High Level Liquid Waste Evaporator at the New Waste Calcining Facility.

Mr. Seal served in the Navy's Nuclear Power Program for twenty-three years as an operator, operations supervisor (including Engineering Officer of the Watch), instructor, and evaluator onboard nuclear powered ships and at shore installations. During his military service, Mr. Seal demonstrated in-depth knowledge and understanding of the principles and practices associated with conduct of operations and operational safety while serving in the U.S. Navy Nuclear Propulsion Program and retired as a Master Chief Petty Officer.

Mr. Seal's education includes: Master of Science, Industrial Technology Education, University of Idaho; Bachelor of Science in Technology, Industrial Technology, University of Idaho, Summa Cum Laude; Executive Leadership Program, United States Department of Agriculture Graduate School; and the United States Navy Senior Enlisted Academy.

Mary Anne Chillingworth, MSPH, CIH, CSP
Accident Investigation Analyst/Consultant
Project Enhancement Corporation

Mary Anne Chillingworth has over 35 years experience in occupational safety and industrial hygiene. She developed and implemented safety programs for several environmental and engineering firms, including PEC, and has supported Federal clients in improving their safety programs, including DOE, DHS, OSHA, NASA, and Navy. She is also an Adjunct Associate Professor at University of Maryland University College, teaching online courses in occupational safety and health within the Department of Environmental Management.

Ms. Chillingworth has provided contract support to DOE since 1993, including analyses of safety and health performance and preparing draft policies for health and safety initiatives. She prepared white papers on DOE motor vehicle and forklift injuries that analyzed causal factors and made recommendations for improvement. She supported a safety perception survey of one DOE Office and worked with that Office to support an employee task group to develop recommendations based on the survey. For fiscal years 2006-2011, she drafted and edited the DOE annual reports to OSHA, analyzing self-evaluations submitted by Offices and sites, as well as workers' compensation data and DOE databases. She co-presented a paper at the 2009 National Safety Congress on her work to improve the quality of electronic injury/illness reports in DOE electronic data systems. She recommended learning objectives and provided content for the DOE initial and refresher safety and health online awareness training and developed a supervisor course on workers' compensation. Ms. Chillingworth was a DOE VPP Recertification Team member for two sites: a GOCO fabricated metal products manufacturing plant and a contractor security force. During the 1990's, she managed the DOE Response Line to provide expert interpretations of OSHA, DOE, and national consensus standards for DOE and contractor employees. She was also a member of the DOE highly enriched uranium vulnerability study.

Recent contract work for Department of Homeland Security included field evaluations of safety and health programs of each DHS component and a redesign of the DHS OSH Program Self-Assessment Worksheet. She developed the content of the first DHS-wide online safety awareness course for DHS. Ms. Chillingworth recently provided technical analyses for OSHA in support of a new health standard. For the NASA Goddard Space Flight Center, she has performed qualitative industrial hygiene surveys, personal protective equipment assessments, and risk assessments of laboratories, machine shops, security operations, and pilot plants at, as well as an asbestos survey of ten buildings. She worked onsite as a contractor for the Navy Safety Liaison Office, analyzing Navy safety performance; drafting directives; preparing briefing memos; supporting work groups for VPP, fall protection and ergonomics; teaching a course on CBRN respirators, and championing a study to reduce noise levels on Navy ships.

She is a certified industrial hygienist and a certified safety professional and has a Bachelor of Science degree in biology from Tufts University and a Master of Science in Public Health degree in environmental sciences and engineering from the University of North Carolina School of Public Health. She is an active member of the American Industrial Hygiene Association and the American Society of Safety Engineers.

Susan M. Keffer
Investigation Administrative Coordinator
and Technical Editor
Project Enhancement Corporation

Susan Keffer has more than 30 years of professional experience as a detail-oriented manager of analysis and research; personnel issues; providing and meeting milestones and deliverables; and budget process. She has over twelve years in all aspects of corporate business development through research of opportunities, proposal development, including graphics, technical writing, and marketing.

As a Project Manager at Project Enhancement Corporation (PEC) since 2006, Ms. Keffer:

- Provides support to the Department of Energy (DOE) Office of Health, Safety and Security, the Office of Environmental Management, and the National Nuclear Security Administration (NNSA) in their mission with such programs as Federal Employees Occupational Safety and Health (FEOSH) and Accident Investigation. This requires research and analysis of safety statistics; serving as point of contact for the field representatives; performing data analysis on Department safety and health issues; and research for and preparation of management studies as well as budget analysis for programs. Provides document editing, graphics, and format expertise for annual reports and other documents. Develops presentations for annual meetings and the annual training modules, and provides support for the DOE Directives Initiative to update all DOE orders, manuals and guides.
- Trained and actively serves as an Administrative Coordinator for the DOE Accident Investigation Program and has been certified as a DOE Accident Investigator. Since 2006, has responded to fourteen accident investigations in support of the Board. Demonstrates ability to respond on short notice to the accident site; handle the logistics for the Board; coordinate interviews, request documentation from the site, and maintain evidence files. Maintains document control and serves as technical editor of the report and provides the final report for approval.
- Assisted Federal budget personnel in the DOE National Nuclear Security Administration (NNSA) Office of International Coordination in all aspects of financial management and the budget process including maintenance of financial data, preparation of financial execution documents, and analysis of budget execution. In support of the upcoming years' budget submission to Congress, prepared ad hoc financial analysis for determining impacts on the projects during continuing resolutions and other requests from senior management; and interfaced with the NNSA Service Center to obtain current guidance pertaining to funds.
- Provided administrative, document preparation, coordination of focus groups and other support to the Department of Homeland Security (DHS) and Office of the Architect of the Capital (AOC) contracts. Assisted with the Department of Labor Occupational Safety and Health (OSHA) contract by supporting the 6th Joint Conference of the United States/European Union on the Occupational Safety and Health by preparing documents for distribution, coordinating conference details, and providing on-site support for the conference.

Appendix A: Appointment of an Accident Investigation Board

Department of Energy
Washington, DC 20585

MEMORANDUM

February 15, 2013

TO: Mark J. Matarrese
Director, Office of Environment, Security, Safety and Health
Office of Fossil Energy

FROM: Christopher A. Smith
Acting Assistant Secretary
Office of Fossil Energy

SUBJECT: Appointment of Accident Investigation Board to investigate the February 7, 2013 injury at West Hackberry

I hereby establish an Accident Investigation Board to investigate the injury that occurred on February 7, 2013, at the West Hackberry Strategic Petroleum Reserve. You are hereby appointed Chairman of the Investigative Board to investigate the subject accident. You are to perform a Type B Accident Investigation of this accident as defined in Department of Energy (DOE) Order 225.1B, Accident Investigations, and DOE-HDBK-1208-2013, DOE Handbook Accident and Operational Safety Analysis. The Board will be comprised of the following members:

Brad Wallace, SPRPMO
Michael Monahan, NETL
Mike Taylor, RMOTC
James Gruber, SPR - FE-42

Steven A. Porter, Office of Chief Counsel, GC-76, will serve as the legal liaison for the Board. The Board will be assisted by advisors, consultants, and other support personnel as determined by you. If additional resources are required to assist you in implementing this task, please let me know and it will be provided.

The scope of the Board's investigation is to include, but is not limited to, identifying all relevant facts; analyzing the facts to determine the direct, contributing, and root causes of the accident; developing conclusions; and determining judgments of need that, when implemented, should prevent the recurrence of the accident. The Board will focus on and specifically address the roll of DOE and contractor organizations and Integrated Safety Management Systems, including human performance elements, as they may have contributed to the overall incident. The scope will also include an analysis of the application of lessons learned from similar incidents within the Department.

The Board will provide the West Hackberry site office, the Strategic Petroleum Reserve Project Management Office (SPRPMO) and the headquarters Program Office with weekly reports on the status of the investigation. Draft copies of the factual portion of the investigation report will be submitted to the West Hackberry site office, SPRPMO, and the contractor for factual accuracy prior to report finalization.

The final investigation report should be provided to me by May 1, 2013. Any delay in this date shall be justified and forwarded to SPRPMO. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report. If you have any questions, please contact me at (202) 586-6660.

cc: R. Corbin, FE-40, FORS
W. Elias, FE-42, FORS
W. Gibson, FE-44, SPRPMO
S. Porter, GC-76, FORS
G. Podonsky, HS-1, FORS
D. Pegram, HS-23, GTN
S. Domotor, HS-23, GTN
C. Turner, RMOTC
S. Klara, NETL

Appendix B: Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all tasks. A barrier is any means used to control, prevent, or impede a hazard from reaching a target, thereby reducing the severity of the resultant accident or adverse consequence. A hazard is the potential for an unwanted condition to result in an accident or other adverse consequence. A target is a person or object that a hazard may damage, injure, or fatally harm. Barrier analysis determines how a hazard overcomes the barriers, comes into contact with a target (e.g., from the barriers or controls not being in place, not being used properly, or failing), and leads to an accident or adverse consequence. The results of the barrier analysis are used to support the development of causal factors.

Table B-1: Barrier Analysis

<table>
<tr><th colspan="3">Hazard:
Fall from height due to scissor lift tipping over</th><th colspan="2">Target:
PBC Blaster 1</th></tr>
<tr><th>Barrier</th><th>Location of Barrier</th><th>How did barrier perform?</th><th>Why did the barrier fail?</th><th>How did the barrier affect the accident?
Context: ISM</th></tr>
<tr><td rowspan="3">Equipment Selection
(CF1 – Define the Scope of Work)</td><td>DOE SPRPMO contract review process.</td><td rowspan="3">Not effective</td><td rowspan="3">The contract review and approval process as performed was not adequate because it did not include evaluation of the proposed method for performing abrasive blasting.</td><td rowspan="3">The use of scissor lifts to perform abrasive blasting was not clearly identified, and therefore the subcontractor was not asked to justify the use of scissor lifts.
GP1, GP2, GP3, GP5</td></tr>
<tr><td>DOE West Hackberry Site contract review process.</td></tr>
<tr><td>DM contract review process.</td></tr>
</table>

Hazard: **Fall from height due to scissor lift tipping over**			**Target:** **PBC Blaster 1**	
Barrier	**Location of Barrier**	**How did barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?** Context: ISM
	AGSC solicitation package allowed for the use of a scissor lift with added disclaimers that equipment selection was the responsibility of the subcontractor.	Partial failure	Scissor lifts have severe operating restrictions leaving little room for error.	AGSC did not identify, understand, or manage the severe operating limitations. GP3, GP5
	PBC response to the AGSC solicitation identified scissor lift as equipment to be used but did not specify minimum operational specifications.	Failed	PBC did not understand the limiting operational parameters associated with the particular scissor lift and did not specify minimum capability requirements.	The scissor lift was undersized to perform the work and had very limited operating parameters. GP3, GP4, GP5
Subcontractor Selection Process (CF1 Define the Scope of Work)	Subcontractor selection criteria regarding experience specific to the intended methods for performing work.	Failed	The subcontractor did not have any previous experience performing abrasive blasting operations from a scissor lift.	The inexperienced subcontractor was not knowledgeable of the lateral force restriction associated with scissor lifts and failed to conduct work safely, resulting in a serious accident within the first few hours of the new work activity.

Hazard: Fall from height due to scissor lift tipping over			Target: PBC Blaster 1	
Barrier	**Location of Barrier**	**How did barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?** Context: ISM
Scissor Lift Operating Restrictions (CF2 Analyze the Hazards)	ANSI Standard, Z92.6 (Safety rules for scissor lifts)	Failed	Restrictions were not identified and incorporated into work practices by PBC.	The scissor lift was operated without regard to 90 pound lateral force limit during blasting operation. GP1, GP3, GP5, GP6
	Scissor Lift Operating Manual	Failed	Restrictions were not identified and incorporated into work practices. “DO NOT exert side forces on aerial platform while elevated.	
	Scissor Lift Warning Label	Failed	Restrictions were not identified and incorporated into work practices.	
	Job Safety Analysis (JSA)	Failed	Restrictions were not identified and incorporated into work practices.	
	Safe Work Permit (SWP)	Failed	Restrictions were not incorporated into work practices.	
	Pre-Job Briefing / Worker Qualification Form	Failed	Restrictions were not identified and incorporated into work practices.	

Hazard: **Fall from height due to scissor lift tipping over**			**Target:** **PBC Blaster 1**	
Barrier	**Location of Barrier**	**How did barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?** Context: ISM
Personal Protective Equipment (CF3 - Develop and Implement Hazard Controls)	Blasting Hood Helmet	Partially Failed	Blasting Hood Helmet suspension system was missing.	The injured employee had inadequate head protection that could have contributed to a head injury. GP5, GP6
Training (CF4 - Perform Work Within Controls)	Scissor Lift Training / Certification	Failed	Scissor lift training conducted by PBC was not adequate to instruct employees in the hazards of lateral force.	Supervisors and workers failed to recognize the hazards of lateral forces and secured hoses to the guard rails. GP1, GP3, GP4, GP5
Competent Person (CF4 - Perform Work Within Controls)	OSHA competent person for Scissor Lift inspection and recognition, and correction of hazards.	Failed	PBC did not provide an OSHA competent person.	PBC authorized securing hoses to the scissor lift work platform and failed to observe that the blast hose was too short. GP1, GP2, GP3, GP5, GP6

Hazard: Fall from height due to scissor lift tipping over			Target: PBC Blaster 1	
Barrier	**Location of Barrier**	**How did barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?** Context: ISM
Safety Oversight to Ensure Work was Performed Safely (CF4 - Perform Work Within Controls and CF5 – Provide Feedback and Continuous Improvement)	Safety Oversight - DOE	Ineffective	Periodic spot checks are effective for identifying long-term programmatic issues, but not for rapidly changing conditions.	Unsafe work was allowed to continue until the accident occurred. GP1, GP2, GP3, GP4, GP5, GP6, GP7
	Safety Oversight – DM	Failed	Inspected to determine compliance with work documents but failed to detect unsafe conditions.	
	Safety Oversight - AGSC	Failed	Did not identify the JSA was inadequate. Although daily inspections were conducted, the unsafe conditions were not observed or recognized.	
	Safety Oversight - PBC	Failed	Did not identify and stop unsafe work conditions.	

Hazard: **Fall from height due to scissor lift tipping over**			**Target:** **PBC Blaster 1**	
Barrier	**Location of Barrier**	**How did barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?** Context: ISM
Supervision (CF4 Perform Work Within Controls and CF5 Provide Feedback and Continuous Improvement)	PBC Site Sup and PBC SSR	Failed	Did not identify and stop unsafe work conditions. Not a dedicated position, performing more than one function.	Was not available to effectively perform the supervisory function. GP1, GP3, GP4, GP5
Questioning Attitude (CF5 - Provide Feedback and Continuous Improvement)	PBC NACE Inspector	Ineffective	Although the use of the scissor lift was questioned, it was not raised to a level of concern.	The question was not brought to management attention for resolution. GP1, GP2
	PBC HSE Director	Ineffective	Accepted the original decision to use a scissor lift for blasting despite operational restrictions and inexperience of the work crew in using a scissor lift for blasting.	Use of a scissor lift was accepted instead of a more stable scaffold or aerial lift. GP1, GP2, GP3, GP4, GP6

The seven guiding principles of ISM are intended to guide Department and contractor actions from development of safety directives to the performance of work. These principles are:

GP1 - *Line Management Responsibility for Safety*. Line management is directly responsible for the protection of the public, the workers, and the environment.

GP2 - *Clear Roles and Responsibilities*. Clear and unambiguous lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels within the Department and its contractors.

GP3 - *Competence Commensurate with Responsibilities*. Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.

GP4 - *Balanced Priorities*. Resources shall be effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment shall be a priority whenever activities are planned and performed.

GP5 - *Identification of Safety Standards and Requirements*. Before work is performed, the associated hazards shall be evaluated and an agreed-upon set of safety standards and requirements shall be established which, if properly implemented, will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.

GP6 - *Hazard Controls Tailored to Work Being Performed*. Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work being performed and associated hazards.

GP7 - *Operations Authorization*. The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed upon.

Scissor Lift Accident in the West Hackberry Brine Tank-14 Resulting in Injury

Appendix C: Change Analysis

Change is anything that disturbs the "balance" of a system from operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Change analysis examines the planned or unplanned disturbances or deviations that caused the undesired results or outcomes related to the accident. This process analyzes the difference between what is normal (or "ideal") and what actually occurred. The results of the change analysis are used to support the development of causal factors.

Table C-1: Change Analysis

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
Blasting was performed from scissor lift.	Blasting was normally performed from aerial lift, scaffolding, or spider.	Blasting was performed from a less stable work platform.	The scissor lift was an inherently less stable work platform to perform blasting operations that required observing specific restrictions and left little room for error.
Workers, supervisors, and safety oversight not aware of scissor lift operating restrictions.	Workers, supervisors, and safety oversight aware of scissor lift operating restrictions.	Lateral force and "do not attach anything outside the work platform" restrictions were not followed.	Workers, supervisors, and safety oversight were not aware of scissor lift operating restrictions regarding the lateral forces created by insufficient length of blast hose and effect of blast nozzle pressure.

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
Job Safety Analysis did not include specific scissor lift operating restrictions.	Job Safety Analysis did include specific scissor lift operating restrictions.	Workers, supervisors, and safety oversight would be aware of scissor lift operating restrictions.	Workers, supervisors, and safety oversight were not aware of scissor lift operating restrictions regarding the lateral forces created by insufficient length of blast hose and effect of blast nozzle pressure.
Job Safety Analysis development process changed to an on-line, pick list and menu driven format.	Job Safety Analysis was hand-written by personnel involved in work, requiring knowledge of work to be performed.	Job Safety Analysis development procedure deviated from existing policy and training.	The resulting Job Safety Analysis did not identify specific tasks or equipment limitations/restrictions.
Training did not include scissor lift operating restrictions concerning lateral force.	Training did include scissor lift operating restrictions concerning lateral force.	Workers and supervisors would be aware of scissor lift operating restrictions concerning lateral force.	Workers, supervisors, and safety oversight were not aware of scissor lift operating restrictions regarding the lateral forces created by insufficient length of blast hose and effect of blast nozzle pressure.
Scissor lift located farther away from the man-way location where hose was secured.	Scissor lift was located closer to man-way location where the hose was secured.	Blast hose exerted additional lateral force to the work platform.	At the point where the work was performed, the blast hose was too short and greater lateral force was exerted on the work platform.

Accident Situation	Prior, Ideal or Accident-Free Situation	Difference	Evaluation of Effect
Blasting started with scissor lift in an unstable condition due to lateral force from blast hose.	Scissor lift in a stable condition.	Blasting created additional lateral force.	With the scissor lift in an unstable condition, additional lateral force created by the blast nozzle pressure caused the scissor lift to tip over.
Blasting hose secured/attached to side of scissor lift work platform.	Nothing attached/connected to side of lift work platform.	Attaching the hose added extra lateral force to the scissor lift.	By attaching the blasting hose to the work platform of the scissor lift, additional lateral force was placed on the lift.
An insufficient length of blasting hose was used in this job.	Adequate lengths of blast hose would be used.	By not using enough blasting hose, there was additional lateral force placed upon the scissor lift.	Lack of enough blasting hose placed significant lateral force on the work platform.

Appendix D: Event and Causal Factor Analysis

An events and causal factors analysis was performed in accordance with the DOE Workbook, *Conducting Accident Investigations*. The events and causal factors analysis requires deductive reasoning to determine those events and/or conditions that contributed to the accident. Causal factors are the events or conditions that produced or contributed to the accident, and they consist of direct, contributing, and root causes. The direct cause is the immediate event(s) or condition(s) that caused the accident. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the accident, but which did not solely cause the accident. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar accidents. The causal factors are identified in Table D-1: Events and Causal Factors Analysis.

Table D-1: Event and Causal Factors Analysis

Date and Time (hours)	Event	Causal Factors
08/06/2012	SPR tasked DM with the development of the “Repair Brine Tanks WHT-14 & WHT-15” task package.	The completed package was stamped by a professional engineer and approved for construction by DM.
08/09/2012	AGSC issues a Request for Offer (RFO) to repair WHT-14 and WHT-15.	Bids are due September 10, 2012
08/10/2012	AGSC issued the solicitation indicating that all sealed bids were due September 10, 2012.	
08/30/2012	Performance Blasting & Coating (PBC) submitted their bid, number 2012-681-I-RC.	
10/04/2012	AGSC awarded Contract # AGSC-SPR-2012-113 to PBC.	
10/31/2012	Environmental Measurements Corporation provided a certified industrial hygienist review and comment on PBC safety documents.	Basic Ordering Agreement AGSC-BOA-011-001
11/19/2012	PBC issued a Safety Execution Plan to AGSC for the repair of WHT-14 and WHT-15.	
01/28/2013	SWP 356227 Contractor to mobilize tools and equipment at brine tank area. Set up mats, sand pot, air compressor, etc.	

Date and Time (hours)	Event	Causal Factors
0128/2013	United Rental delivers two scissor lifts to the area near WHT-14.	Specifications from PBC to United Rental are limited to requested height of extended work platform. Lifts are inspected and accepted by PBC. Scissor lifts are JLG Model 2646ES and Skyjack SJIII 3226.
01/30/2013	PBC begins work on WHT-14.	SWP 356181 issued to remove anodes from inside WHT-14. Begin to pull hoses in preparation for blasting & coating. DM Operations Permit – Required Confined Space Reclassification Form for WHT-14-Brine Tank. Purpose of Entry: to stage manlifts for repair of tank. JHA and Job Safety Plan completed by PBC.
01/31/2013	PBC begins to remove anodes and pull hoses into WHT-14.	DM Petroleum Operations Permit – Required Confined Space Reclassification Form for WHT-14-Brine Tank. Purpose of Entry: remove anodes in preparation for blasting & coating.

Date and Time (hours)	Event	Causal Factors
02/04/2013	PBC prepares to begin blasting and coating of WHT-14.	DM Petroleum Operations Permit – Required Confined Space Reclassification Form for WHT-14-Brine Tank. Purpose of Entry: Blasting & Coating WHT-14. SWP 356174 is initiated by PBC and issued by DM to blast and recoat WHT-14.
02/05/2013	PBC commences blasting operations in WHT-14.	DM Petroleum Operations Permit – Required Confined Space Reclassification Form for WHT-14-Brine Tank. Purpose of Entry: Blasting & Coating WHT-14.
02/06/2013	No work performed because of rain.	
02/07/2013	PBC workers arrive at WHT-14 to continue blasting WHT-14.	
02/07/2013 6:55 a.m.	SWP 356174 is updated by PBC and DM.	
02/07/2013 7:00 a.m.	A morning safety meeting was conducted and qualification form completed by PBC Site Supervisor.	Very foggy and wet conditions.
02/07/2013 9:00 a.m.	Safety meeting completed, equipment set up and checked.	Blasting cannot begin until fog and moisture abate.
02/07/2013 ~9:00-9:30 a.m.	Blasters begin suiting up, checking equipment.	
02/07/2013 9:54 a.m.	PBC Blaster 1 and PBC Blaster 2 enter WHT-14.	
02/07/2013 10:00 a.m.	Blasting begins on two scissor lifts inside tank and on catwalk on top at tank rim.	Blasters in tank are on different scissor lifts than on February 5, 2013

Date and Time (hours)	Event	Causal Factors
02/07/2013 ~10:42 a.m.	PBC Hole Watch felt hose supplying air and abrasive to PBC Blaster 1 pulse then noticed scissor lift with PBC Blaster 1 falling toward center of the tank.	PBC Hole Watch states pulse is a typical reaction in blasting hose when blaster pulls trigger.
02/07/2013 ~10:42 a.m.	PBC Hole Watch immediately sounded an air horn to alert others that a problem had occurred.	
02/07/2013 ~10:42 a.m.	DOE SSR heard the air horn and called DOE Eng by cell to ask her to investigate the situation.	DOE SSR was conducting business at a cavern outside the West Hackberry site main fence line when the air horn sounded. DOE SRR noticed several people moving quickly near the tank. DOE SSR noted the time as 10:42 a.m. and called the DOE Eng by cell phone and asked her to investigate the situation since it would take the DOE SSR time to re-enter the site through the security portal. In response to the accident and air horn, PBC Blaster 3 came down from the tank and the PBC Pot Tender began securing the air compressors and other equipment.

Date and Time (hours)	Event	Causal Factors
02/07/2013 ~10:42 a.m.	Protective Force Officer heard air horn from Main Gate but returned to normal duties.	Protective Force Officer observed activity around the tank. Protective Force Officer did not know what the air horn meant. There is nothing in the West Hackberry site procedures to indicate what an air horn means.
02/07/2013 ~10:43 a.m.	PBC SSR heard the air horn warning and responded to the tank entrance.	PBC SSR was sitting in a truck completing paperwork when he heard the air horn warning. The PBC Hole Watch asked if he should call the Control Room to report the accident, but the PBC SSR indicated to the PBC Hole Watch that he would handle the notifications. Contacting Control room is the required action to initiate a DM ERT response. PBC had no rescue/retrieval equipment set up by the tank nor was it clear who the PBC rescue team was.
02/07/2013 ~10:43 a.m.	PBC SSR immediately donned his fall protection harness and entered the tank.	PBC SSR followed PBC procedures for entering tank.
02/07/2013 ~10:43 a.m.	PBC SSR called PBC Shift Sup and PBC FSS requesting they come to WHT-14.	PBC FSS is a licensed paramedic.

Date and Time (hours)	Event	Causal Factors
02/07/2013 ~10:43 a.m.	In response to air horn, PBC Blaster 3 came down from the tank and the PBC Pot Tender began securing the air compressors and other equipment.	
02/07/2013 ~10:45 a.m.	DOE Eng arrived at WHT-14, noted an injury had occurred and the Control Room had not been contacted.	DOE Eng did not contact Control Room.
02/07/2013 ~10:45 a.m.	DOE Eng contacted DOE SSR to tell her to get to WHT-14 immediately.	
02/07/2013 ~10:45 a.m.	DOE Eng contacted Fire Protection/Emergency Manager Specialist (DM EMS/ERT Lead) and requested he come to WHT-14.	
02/07/2013 ~10:47 a.m.	DOE Eng briefed DOE SSR of situation upon arrival of DOE SSR at WHT-14.	
02/07/2013 ~10:47 a.m.	DOE SSR questioned the PBC Hole Watch and PBC NACE Insp for information about the accident and the status of notifications.	
02/07/2013 ~10:47 a.m.	DOE SSR observed the PBC safety person inside the tank attempting a rescue of some type.	It is unclear if PBC thought they had rescue responsibilities or if there was an understanding that the site would handle that at this point.
02/07/2013 ~10:47 a.m.	DOE SSR attempted to call DM EMS/ERT Lead.	DM EMS/ERT Lead is site confined space expert. DOE SSR asked DOE Eng if the Control Room had been called and was told yes but there still had not been an ERT page issued at this point.
02/07/2013 ~10:47 a.m.	DOE SSR then attempted to contact West Hackberry Site Director.	West Hackberry Site Director did not answer.

Date and Time (hours)	Event	Causal Factors
02/07/2013 ~10:48 a.m.	PBC Site Sup arrived at the scene and entered the tank to evaluate the situation	PBC Site Sup put on retrieval harness prior to entering tank.
02/07/2013 ~10:54 a.m.	PBC FSS arrived at the tank.	PBC FSS found PBC Blaster 1 to be in pain in several locations on the right side of his body, and noted that PBC Blaster 1 was alert and oriented.
02/07/2013 ~10:55 a.m.	DOE SSR contacted Control Room Operator (CRO) and requested the ERT be activated and an ambulance called to the scene.	
02/07/2013 ~10:55 a.m.	DM EMS/ERT Lead arrived at WHT-15 and called the CRO and asked for an ambulance.	The DM EMS/ERT Lead stated he was notified by the DOE Eng to proceed to the tank. Upon arrival, PBC Hole Watch stated the injured had been down approximately 30 minutes. DM EMS/ERT Lead immediately called the control room and asked for an ambulance. DM EMS/ERT Lead took charge of the response and considered the tank a “non-permit required” space.
02/07/2013 ~10:56 a.m.	CRO activated the ERT response.	DM EMS/ERT Lead stated that as he was getting out of his vehicle he heard a call over the radio for the ERT to respond.
02/07/2013 ~10:59 a.m.	ERT fire truck left the bay towards WHT-14.	

Date and Time (hours)	Event	Causal Factors
02/07/2013 ~11:00 a.m.	CRO called for an ambulance.	Call made approximately 20 minutes after accident.
02/07/2013 ~11:00 a.m.	West Hackberry Site Security Captain, having heard radio traffic, directed two security rovers to respond to accident to support ERT.	West Hackberry Site Security Captain directed two security rovers to support the ERT.
02/07/2013 ~11:00 a.m.	Two security rovers responded and upon arrival set a traffic control point on road to escort anticipated ambulance.	The two rovers responded as security personnel rather than medical support and set up a traffic control point on Black Lake road in front of well pad 112 in anticipation of escorting the ambulance.
02/07/2013 ~11:04 a.m.	An announcement was made over the public address system for the ERT to respond.	
02/07/2013 ~11:04 a.m.	DM ERT-1 and DM EMT-1 arrived and entered tank.	EMT-1 was not a member of the site ERT but was allowed to respond into a confined space due to his medical qualifications and experience. ERT-1 and EMT-1 continued to evaluate the injured until relieved of duties by the ambulance crew.
02/07/2013 ~11:08 a.m.	Cameron Ambulance arrived with the Sherriff's Department and was escorted to WHT-14 by two security rovers.	

Date and Time (hours)	Event	Causal Factors
02/07/2013 ~11:08 a.m.	The two ambulance EMTs entered the tank to provide assistance to the injured worker.	In the interest of time the DM EMS/ERT Lead allowed the ambulance personnel into the tank rather than the ERT bringing the injured party out to the ambulance as would be normal procedure.
02/07/2013 ~11:34 a.m.	PBC Blaster 1 was removed from WHT-14 and moved to the ambulance.	An ambulance crew member requested assistance in removing the injured from the tank at the man-way. The DM EMS/ERT Lead directed site ERT, EMT and Security personnel, to assist with the removal of PBC Blaster 1 from the tank. PBC Blaster 1 showed evidence of bleeding from his wounds. DM EMS/ERT Lead had the ERT, EMT and Security supporters to check themselves for blood exposure. A security rover and an ERT member discovered they had been contacted directly with blood from the injured.
02/07/2013 ~11:44 a.m.	The Cameron ambulance departed the site.	

Appendix E: Force Calculations on Scissor Lift

E.1. 3-D Pictorial Representation and Force Calculations for the SPR Scissor Lift Accident

Final Report

Overview

Technical assistance was requested by a Federal Accident Investigation Board (the Board) in order to provide a 3-D perspective of what the Board feels would be the most probable equipment configuration immediately prior to the scissor lift accident at the Strategic Petroleum Reserve, West Hackberry, LA site. An architectural and engineering (A&E) firm was tasked to deliver a 3-D rendering, based on equipment specifications and measurements provided by the Board, which can be manipulated in such a manner that an infinite number of perspectives could be reviewed by the board. In addition, the A&E was tasked with the development of an engineering method for determining the length of blast hose supported by the lift and the amount of lateral force that was applied to the elevated work platform.

Background

The accident under review involved the blast cleaning of the interior portion of a brine storage tank where a worker was utilizing a scissor lift to access the upper interior rim. A blast media hose was used to deliver air-entrained blasting material to a spray nozzle, controlled by the worker, while standing on the work platform of the lift. The media hose entered the tank through a ground level service portal where it was physically fixed (tied) to a bolt hole to ensure it remained stationary at that point. The other end of the hose was physically fixed (tied) to the scissor lift work platform presumably to distribute the load of the elevated portion of the hose and to ensure it remained stationary at the point. The scissor lift toppled, while extended, injuring the worker. The Board was interested in reconstructing the pre-accident work scene in order to study the most probable hose configuration prior to the event and how it may have contributed to the toppling of the lift.

Equipment Configurations and Orientations

The following information, gathered by the Board, was used to reconstruct the project scene. Some photos, post accident, were provided to the A&E firm (Appendix E, Attachment E.1.) in order to assist with the development of the 3-D rendering. Other tank penetrations besides the ground level service portal exists; however, they were not included in the 3-D rendering or force calculations because it was generally felt that they did not contribute to the cause of the accident.

Brine tank dimensions and orientation:

- 110’ 0” outside diameter by 32 feet, 0 inch tall, .65 inch shell thickness;
- Open top;
- 0.44 inch thick base, slope of 3inches in 55 feet 0 inches from the center of the tank;
- Service entrance details are provided in attached diagrams and pictures; and

- The tank is situated such that the center of the service entrance is located 0 degrees from south; location of the center of the toppled scissor lift is approximately 0 degrees from north.

Scissor lift details and orientation:

- Skyjack Model #SJIII 3226.
- The center of the base of the lift was visually approximated to lie directly across from the center line of the service entrance. The Board measured a straight line distance of 105' from the service entrance to the bottom of the right scissor lift wheel that was in contact with floor the tank.
- The as-found vertical distance from the base of the scissor lift wheels to the middle rail rung on the work platform guardrails (where the blast hose was tied off) is 26 feet 0 inches.
- The as-found location of the scissor lift's left and right tires in contact with the tank floor, with respect to a perspective looking through the service entrance, are 53 inches and 64 inches, respectively from the inside north wall of the tank.
- The as-found horizontal distance from the left side of the middle rail rung to where the blast hose is tied off is 16 inches.

Blast hose details and orientation:

- Goodall Rubber Company
- Outside diameter: 2.36 inches
- Inside diameter: 1.50 inches
- Weight: 1.36 pounds per foot (lbs./ft)
- The hose was tied, using rope, to the third bolt hole up from the base of the tank on the right side of the service entrance. The amount of slack in the rope was minimal so it should be assumed the blast hose was taut to the service entrance.
- The total amount of hose from the tie point at the service entrance to the tie point on the scissor lift work platform guardrails was measured by the Board and found to be 111 feet 0 inches.

Abrasive blast material details:

- MineralTech Copper Slag
- Granule density: 0.12 pounds/inch^3

Accident Scene Analysis and Reconstruction

Of critical importance to the analysis was the determination of the length of hose that was suspended above the tank floor. The Board suspected that a significant portion of the hose was in the air and was being supported by the work platform, while in the upright position and just prior to the accident, resulting in significant lateral forces on the work platform guardrails.

The base of the scissor lift (right wheel) was found by the Board to be 105 feet 0 inches from service entrance. The middle work platform guardrail, where the blast hose was attached to the lift, was found to be 26 feet 0 inches from the base of the wheels. Using simple trigonometry the straight line distance from the service entrance to the middle work platform guardrail, when the lift was in the upright position, was calculated to be 108 feet 2 inches (Appendix E, Attachment E.2.). Using a formula for a circle, this distance then represented a chord, and, assuming the 111 feet 0 inches feet of blast hose formed a perfect arc between its ends, the radius was derived. Computer aided design was then utilized to determine that 43 feet 7 inches of that arc lay below the horizontal line (representing the tank floor) leaving 67 feet 5 inches suspended from the lift. The A&E firm was then able to develop a three dimensional mockup of the lift and blast hose configuration prior to the lift toppling (Appendix E, Attachment E.3.). It supports the Board's theory that a significant portion of the blast hose was suspended above the tank floor.

Force Analysis

The lateral force on the work platform guardrail, imposed by the weight of the 67 feet 5inches length of suspended hose, was evaluated by the A&E firm through the use of a cable tension formula and standard mechanical force diagrams and calculations. An example calculation is shown in Appendix E, Attachment E.4. (Note: this example does not take into account the weight of supplied air breathing hose). The Board determined, through worker interviews, that the injured employee had just depressed the "deadman" switch at the blast nozzle when the lift toppled. This implies that blast material and air were flowing through the hose at the time the accident occurred;, adding to the amount of suspended weight. Additionally, a 0.75 inch outer diameter supplied air breathing hose was taped to the blast hose.

It was determined by the Board that the copper slag blast material can add appreciable weight to the hose; however, the amount present in the internal void of the hose is highly dependent on the job. The Board was not able to accurately determine the percent of hose void that was occupied by the blast media; although an internet search found it to be nominally 10% percent for most applications. It was therefore decided that the following table be developed to show the variation in lateral force on the work platform guardrails with respect to the percent of internal void of the blast hose occupied:

Lateral Force at Hose Attachment Point to Scissor Lift Work Platform Guardrail		
Calculation Input:		
Blast Hose Weight	1.36	lbs/ft
Blast Hose Inner Diameter	1.50	inches
Length of Suspended Blast Hose	67.42	ft

Lateral Force at Hose Attachment Point to Scissor Lift Work Platform Guardrail		
Air Hose Weight	0.19	lbs/ft
Blast Material Density	0.12	lbs/cubic inch
Hose Deflection	4.44	ft
Angle of Force (from horizontal)	22.94	degrees

Calculation:

% Void Occupied by Blast Material	Weight Added by Blast Material (lbs/ft)	Total Weight of all Hoses and Contents (lbs/ft)	Force (Tension) of all Hoses and Contents (lbf)	Lateral Force on Work Platform Mid Guardrail (lbf)
0	0.00	1.55	194.04	171.73
10	0.25	1.80	225.88	199.91
20	0.51	2.05	257.73	228.09
30	0.76	2.31	289.57	256.28
40	1.01	2.56	321.41	284.46
50	1.27	2.81	353.26	312.64
60	1.52	3.07	385.10	340.83
70	1.78	3.32	416.95	369.01
80	2.03	3.58	448.79	397.19
90	2.28	3.83	480.64	425.38
100	2.54	4.08	512.48	453.56

The force exerted on the worker, and ultimately the work platform guardrails, by the pressure at the nozzle when the "deadman" switch is depressed must be added to the values presented in the table in order to understand the total lateral force. The blast workers indicated, during interviews, that the typical working pressure for their blast operation is 80 to 100 psi. Follow-on investigation by the Board, using internet searches, substantiated these claims. Standard force calculations then indicate that the resultant lateral load imposed by the pressurized air flowing from the nozzle is 12.82 to 16.75 pounds assuming the use of a standard 0.50 inch nozzle.

Conclusion:

The lateral force on the work platform guardrails resulting from securing the blast and air supply hoses to the work platform guardrails and the blasting operation ranges from 184.55 pounds (no media present) to 470.32 pounds (hose 100% full of media).

Attachment E.1. Accident Scene Pictures and Supporting Documentation

Figure E-1: Board Examining inside of WHT-14 and Scissor Lift

Figure E-2: WHT-14 and Scissor Lift in Relation to Manhole

Figure E-3: Scissor Lift in WHT-14

Figure E-4: Base of Scissor Lift in WHT-14

Figure E-5: Outside Manhole of WHT-14

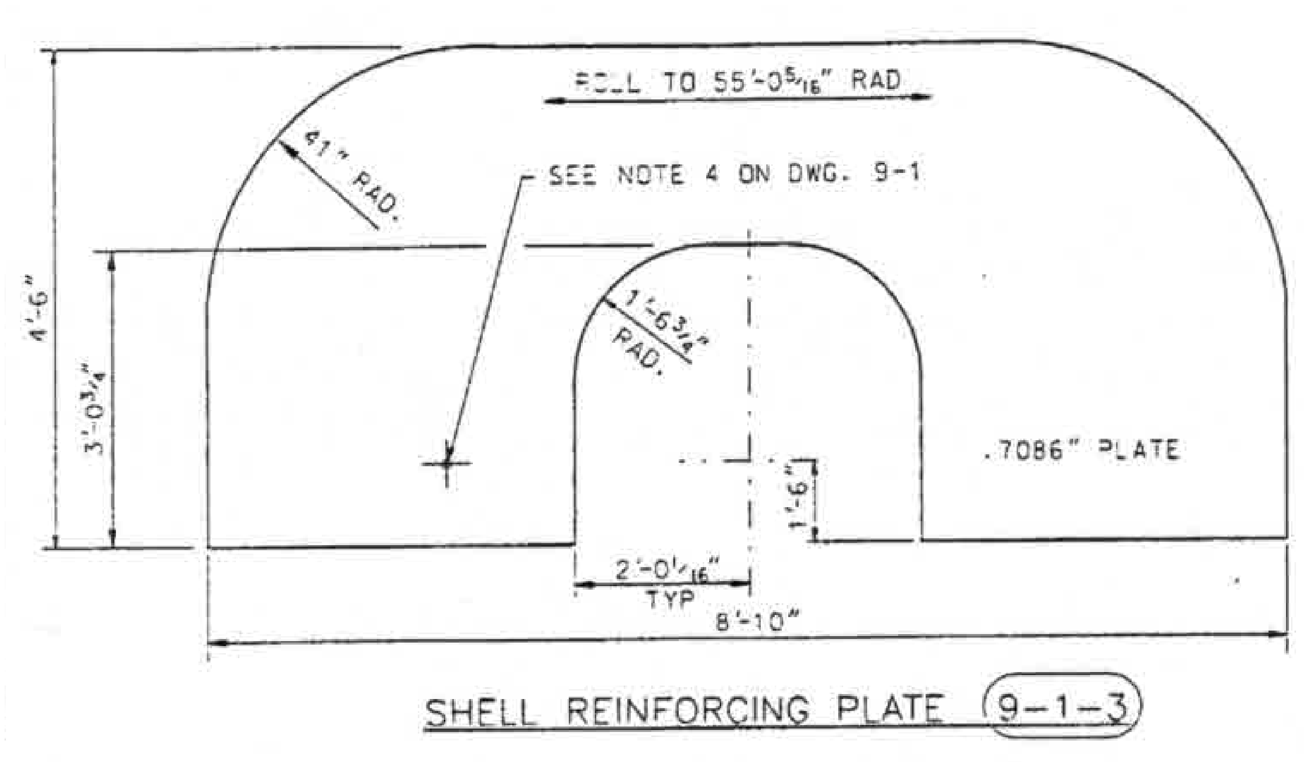


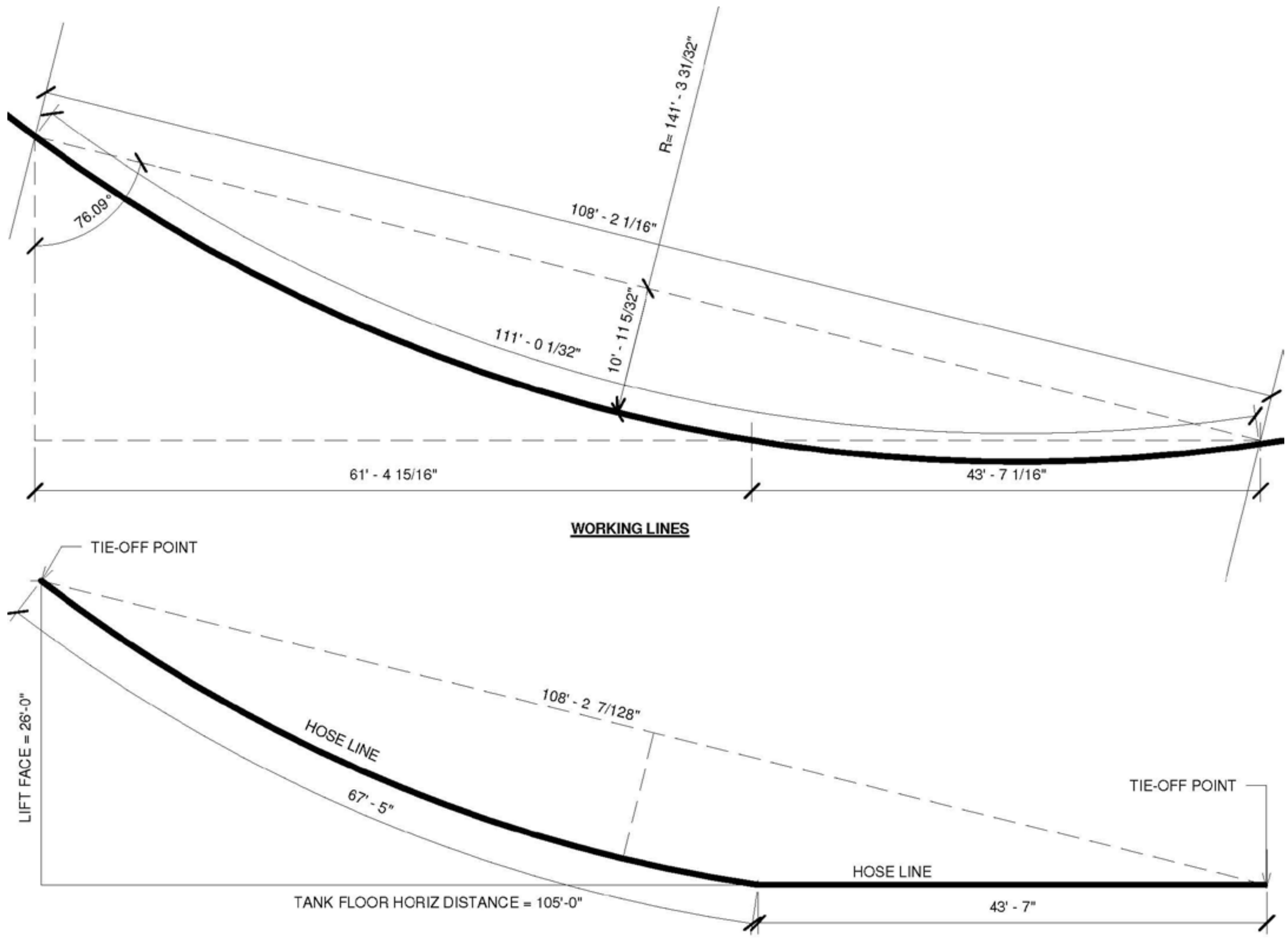
Figure E-6: Sketch of Shell Reinforcing Plate of WHT-14

Figure E-7: View of WHT-14 from Outside Manhole

Figure E-8: Platform of Scissor Lift with Blasting and Electrical Control Cable Attached

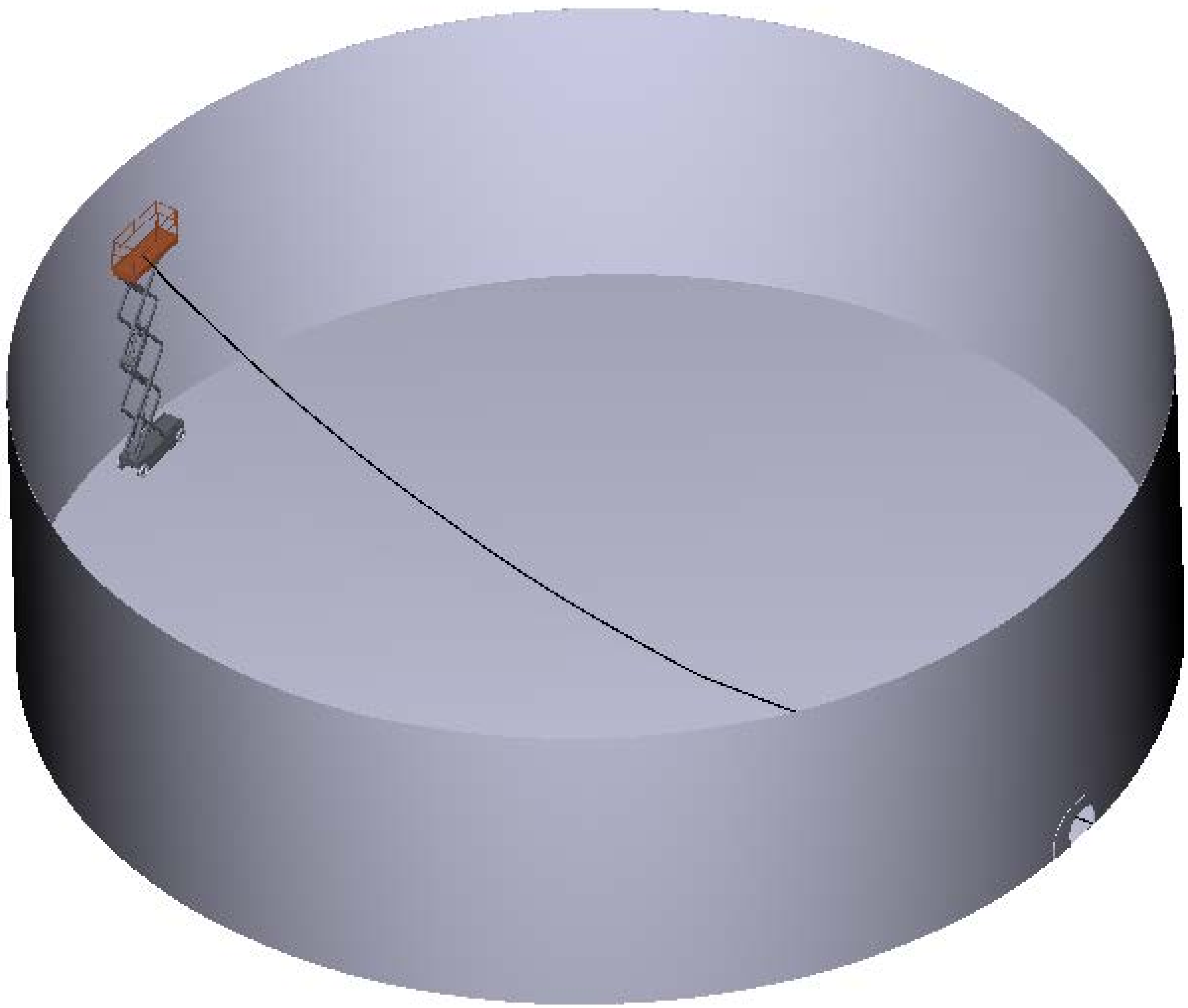
Figure E-9: Close-up of Blasting and Electrical Control Cable Attached to Work Platform Guardrails

Attachment E.2. Line and Force Diagram

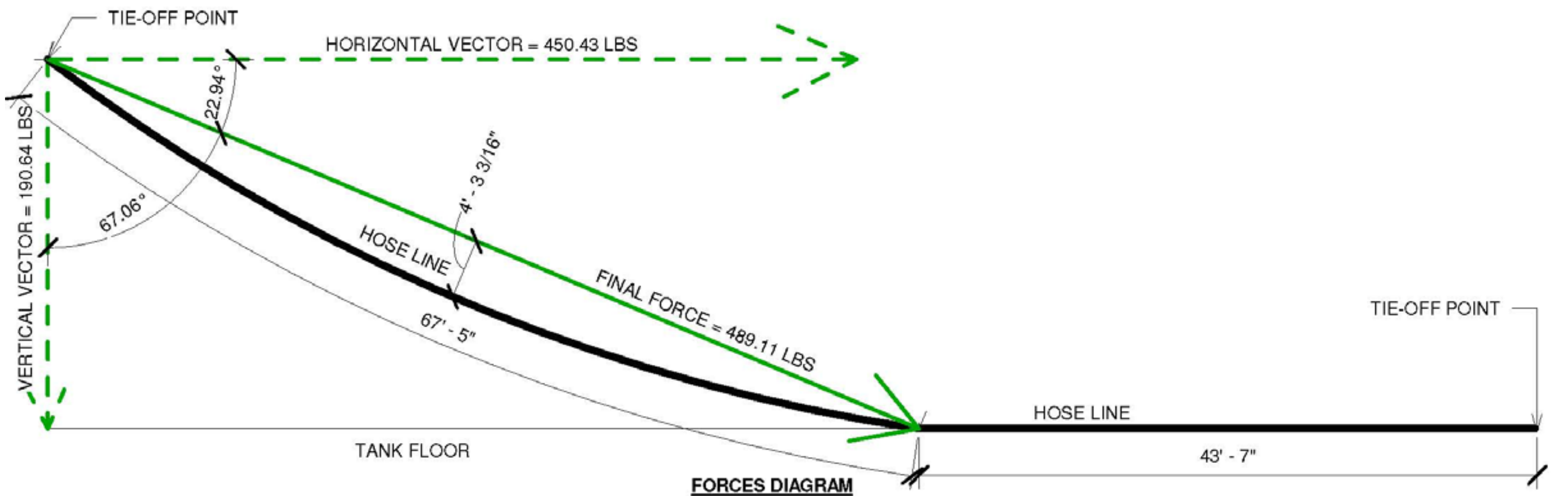


LINE DIAGRAM OF HOSE
SCALE: 1"=10'-0"

Attachment E.3. 3-D Renderings of Scissor Lift and Hose Prior to the Accident



Attachment E.4. Force Analysis Example



FORCES DIAGRAM
SCALE: 1"=10'-0"

Forces Acting on Lift by Weight of Blast Hose
Total weight of suspended hose
= 67.4167' x 3.89 lb/ft = 262.25 lbs.

$T=wl^2/8a$
w = weight of hose = 3.897lb/ft
l = span = 66.75ft
a = displacement = 4.4375ft

$T=wl^2/8a$

$$T=\frac{(3.897)(66.75)^2}{8(4.4375)}$$

T=489.11 LBS @ 22.94° from horizontal

Horizontal vector: sin(67.06)=b/489.11
Vertical vector: cos(67.06)=a/489.11

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