BSEE Panel Report 2016-001

Investigation of November 20, 2014, Explosion and Fatality Lease OCS-00842, West Delta Block 105 Platform E

Gulf of Mexico Region, New Orleans District
Off Louisiana Coast

October 26, 2016

U.S. Department of the Interior
Bureau of Safety and Environmental Enforcement

Contents

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Abbreviations and Acronyms

API – American Petroleum Institute
BS&W – Basic Sediment and Water
BSEE – Bureau of Safety and Environmental Enforcement
CFR – Code of Federal Regulations
CPR – Cardiopulmonary Resuscitation
GOM – Gulf of Mexico
IDLH – Immediately Dangerous to Life and Health
INC – Incident of Noncompliance
JSA – Job Safety Analysis
JSEA – Job Safety and Environmental Analysis
LACT – Lease Automatic Custody Transfer
LOTO – Lockout Tagout
LSL – Level Safety Low
MAWP – Maximum Allowable Working Pressure
MCC – Motor Control Center
OCS – Outer Continental Shelf
OCSLA – Outer Continental Shelf Lands Act
PIC – Person in Charge
PLC – Programmable Logic Controller
PPE – Personal Protective Equipment
RP – Recommended Practice
SAFE - Safe Analysis Function Evaluation
SAR – Search and Rescue
SEMS – Safety and Environmental Management System
USCG – United States Coast Guard
UWA – Ultimate Work Authority
WD – West Delta

Executive Summary

An explosion occurred offshore in the Gulf of Mexico shortly after 2:30 p.m. on November 20, 2014, while Turnkey Cleaning Services GOM (Turnkey) personnel were cleaning an electrostatic heater treater[1] at the West Delta (WD) 105 E platform for Fieldwood Energy LLC (Fieldwood). The explosion caused fatal injuries to a Turnkey Supervisor, and injured others in the vicinity of the heater treater.

On or about November 13, 2014, the platform's oil handling systems began to experience excess water and a 'pad' of thick oil and emulsifications. When Fieldwood and contract personnel were unable to resolve the issues, they contacted Turnkey on November 16, 2014, to clean the associated equipment, including the dry oil tank and heater treater on the platform's production deck. The platform stopped producing oil and was shut-in on or about November 17, 2014.

A four-man Turnkey cleaning crew cleaned the dry oil tank on November 19, 2014. That morning, a Senior Lead Operator for Island Operating Company (Island), that was acting as the Person-in-Charge (Island Acting PIC) while the normal PICs were on vacation, took steps to isolate electrical energy from the heater treater's transformer using energy isolation / lockout tagout (LOTO) procedures for the associated breaker located in the platform's Motor Control Center (MCC) building. This action would have prevented electricity from reaching an electrostatic grid located inside the coalescing section of the heater treater, which used an electrical field to assist in oil and water separation.

On November 20, 2014, the Turnkey crew began draining the heater treater and pumping its fluids to containers located on the top deck. Once the fluid level was below a manway hatch on the coalescing section, the crew opened the hatch. Shortly thereafter, three Turnkey employees and a Lead Operator with Island were standing outside the hatch while the Turnkey Supervisor was reportedly rinsing the lip of the manway hatch with water from a hose, when an explosion occurred inside the heater treater.

The initial blast forced the Turnkey Supervisor backwards, landing on the platform deck. The Island Lead Operator and two other Turnkey employees were also forced to the deck, one of which was struck on the head by the hose nozzle formerly held by the Turnkey Supervisor. Platform personnel that responded to the production deck after hearing the explosion described finding the two Turnkey crewmembers and the Island Lead Operator appearing disoriented, and the Turnkey Supervisor not breathing and without a detectable pulse.

Bureau of Safety and Environmental Enforcement (BSEE) Investigators arrived at the WD 105 E platform on November 21, 2014 to investigate the incident. They identified, among other things, that the breaker in the MCC building which controlled the electrical energy to the heater treater transformer had been clasped with a lock and tagged for energy isolation LOTO, but was in the 'On' position. The BSEE Investigators took pictures, conducted interviews and gathered documents and other evidence pertaining to this incident.

[1] An oil processing vessel designed to provide gas separation, freewater removal, and coalescence of entrained water particles to allow oil to meet pipeline specifications.

BSEE convened a panel to investigate the incident, comprised of BSEE investigators and subject matter experts, with additional support provided by United States Coast Guard personnel.

The BSEE Panel found that the explosion was a result of: a partially drained vessel (the heater treater) that contained flammable vapors; an introduction of oxygen upon the opening of the manway; and an ignition source that was not sufficiently removed or mitigated during the preparation for, and activities of, internal cleaning of the WD 105 E electrostatic heater treater. The presence of these elements created a hazardous environment that was conducive to such an explosion.

The BSEE Panel believes the probable cause of the ignition was the unrestricted supply of electrical energy to the electrostatic components inside the coalescing section of the heater treater. However, all other possible ignition sources could not be definitively eliminated.

The BSEE Panel found a number of factors that may have caused, exacerbated or contributed to the incident and/or the source of this ignition. Among the significant findings was that the heater treater breaker was observed on November 21, 2014, to be fastened with a lock and tag through its handle. However, neither this breaker nor the disconnect switch adjacent to the manway that was along the circuit of energy to the electrostatic grid were turned off, de-energized or isolated; nor was there effective verification by authorized and affected personnel. Additionally, the heater treater had not been effectively ventilated to remove flammable or potentially hazardous vapors from within the heater treater.

The Panel also found that the heater treater did not have a low level switch, ground float, relay or shunt trip function to de-energize the transformer and protect the grid in the event that electrical energy was not manually isolated when a low level in the coalescing section of the vessel occurred. Furthermore, personnel who would be cleaning the heater treater appeared not to fully understand the hazards associated with cleaning an electrostatic heater treater. Additionally, those personnel were seemingly given incorrect information that the heater treater was safe to work on.

The BSEE Panel then identified some factors that possibly contributed to the incident. For example, the job safety analysis (JSA) for setting up and cleaning the heater treater was generic, contrary to the cleaning company's procedures (which were also not effectively followed) and lacking specific analysis of the electrostatic heater treater at the WD 105 E. The JSA also included an ineffective sequence of job steps to identify and mitigate all of the potential hazards. Additionally, process equipment and piping isolation for the heater treater was also not completely performed, nor was there adequate verification of this occurring. Further, the configuration and/or use of the water hose nozzle and connections, a possible interaction with salt water and/or static electricity could have also been contributing factors.

As result of this incident, the BSEE Panel makes recommendations to companies operating on the U.S. Outer Continental Shelf to further protect health, safety, property, and the environment. Those recommendations include ensuring that pre-job isolations and verification of isolations are completed for all available isolation locations and by authorized and affected employees with knowledge of how to perform isolation on the equipment, preferably by a qualified electrician or technician; and using group lockout/tagout when appropriate. Additional recommendations include that after product removal through discharge nozzles or other fixed connections (without opening manways or hatches), personnel use approved and appropriate vapor and gas freeing, degassing

and/or ventilating methods to safely displace or dilute potentially hazardous gas and vapors in the tank or vessel; and that a qualified person test and document the applicable atmospheric conditions and ensure levels are safe prior to permitting work inside or around the outside of those tanks or vessels. It is also recommended that operators use procedures or safety devices to ensure protection of electrostatic grids through de-energization when liquid levels drop and expose the grid components.

In addition, the BSEE Panel recommends that authorized and affected personnel ensure JSAs align with approved procedures, address hazards specific to the job at hand and represent an orderly completion of job steps; and that companies ensure contractors are aware of the functions and potential hazards of the equipment on which they are working. Further, the BSEE Panel recommends companies document recommended monitoring for heater treater functionality; regular internal and external inspection of heater treater electrical components; and specific mention of all equipment that must be shut down prior to cleaning and maintenance activities in a platform's operating procedures. The BSEE Panel also makes recommendations for site-specific training and assessments that address all aspects of the actual equipment and hazards at each work site; first aid and project management training; and retraining whenever deviations from or inadequacies in an employee's knowledge or use of energy control procedures are identified.

Introduction

Pursuant to 43 U.S.C. § 1348(d)(1), (2) and (f) [Outer Continental Shelf Lands Act, as amended] (OCSLA) and Department of the Interior regulations 30 CFR Part 250, the Bureau of Safety and Environmental Enforcement (BSEE) is required to investigate and prepare a public report of this incident. BSEE convened a panel investigation that included:[2]

Otho Barnes, Chief, Office of Technical Assessment, Gulf of Mexico Region (GOMR)[3]
Roderick Belson, Safety and Environmental Management Systems Specialist, GOMR
Ross Laidig (Chair), Special Investigator, Safety and Incident Investigations Division
Pierre Lanoix, Accident Investigator / Inspector, New Orleans District[3]
Gerald Taylor, Accident Investigator / Inspector, New Orleans District[3]

The purpose of this investigation was to identify the cause or causes of the explosion and fatality at WD 105 E and issue recommendations in order to reduce the likelihood of a recurrence or similar incident in the future. The BSEE Panel also makes other findings, conclusions, and recommendations relevant to the explosion on November 20, 2014.

Note: In April and July 2016, BSEE obtained transcripts of deposition testimony given by Turnkey and Island personnel more than 15 months after the incident as part of ongoing civil litigation related to the incident. Some of the deposition testimony was not consistent with statements provided by those individuals to BSEE in the days and weeks after the incident. The panel chose to give more weight to the statements it obtained closer in time to the incident than the deposition testimony given over 15 months after the incident.

[2] Additional assistance was provided by United States Coast Guard (USCG) Lieutenant Shawn Karasevicz.
[3] BSEE personnel involved in both the initial onsite investigation and on the BSEE Panel.

Companies Involved

Fieldwood Energy LLC (Fieldwood)

According to its website, Fieldwood is a Houston-based portfolio company of Riverstone Holdings LLC, which describes itself as focusing on the acquisition and development of conventional oil and gas assets in North America, including the Gulf of Mexico. At the end of 2014, Fieldwood was the designated operator of approximately 500.

Fieldwood was the Designated Operator for the WD 105 E platform on November 20, 2014. According to Fieldwood, effective July 1, 2013, it acquired the WD 105 E platform, including the heater treater and related equipment, from Apache Corporation "as is, where is." As the Designated Operator of the WD 105 E facility, Fieldwood had full authority to act on the lessee's/operating rights owner's behalf, to fulfil the lessee's/operating rights owner's obligations under the OCS Lands Act, in compliance with the terms and conditions of the lease, laws and applicable regulations.

No Fieldwood personnel were at the WD 105 E facility during the time of the incident on November 20, 2014. However, under normal operations Fieldwood typically maintained one employee onsite at the WD 105 E that served as the Person-in-Charge (PIC). Contracted employees were then tasked with performing the daily production and maintenance activities on the WD 105 E under the direction of Fieldwood's PIC.

Fieldwood maintained Safety and Environmental Management System (SEMS) Agreements with Island Operating Company and Turnkey Cleaning Services GOM, among others, for their contracted services. The SEMS agreements, sometimes referred to as bridging documents, specified the expectations regarding safety and environmental management between Fieldwood's SEMS and the contractor's safety and environmental policies and practices.

Island Operating Company, Inc. (Island)

In addition to other companies, Fieldwood contracted with Island to provide personnel for production activities at the WD 105 E. According to BSEE records, as of November 20, 2014, Island was a contract operator at 625 structures in the Gulf of Mexico, including the WD 105 E.

On the day of the incident, Island had four personnel working primarily on the WD 105 E as platform operators: an A-Operator who left the facility in the morning on November 20, 2014; and two Lead Operators and a Senior Lead Operator who were on the facility at the time of the incident on November 20, 2014.

Turnkey Cleaning Services GOM (Turnkey)

Turnkey's website identified that it is an industrial cleaning service company specializing in offshore and dockside cleaning of production facilities and more. Turnkey was initially contacted by Fieldwood to perform cleaning activities on the WD 105 E on November 16, 2014. Fieldwood indicated that the cleaning of the dry oil tank and the heater treater unit of WD 105 E was the only time that Turnkey personnel had performed cleaning services on WD 105 E; although Turnkey had previously

performed cleaning operations at other Fieldwood facilities. Fieldwood identified Turnkey as an approved contractor for Tank & Vessel Cleaning/Repair.

A cleaning crew of four individuals working for Turnkey arrived on the WD 105 E on November 18, 2014; and another four individuals arrived on the morning of November 20, 2014.

Background

Operated by Fieldwood at the time of the November 20, 2014 incident, the WD 105 lease block (Figure 1) was originally leased by Shell Oil Company in 1960 as a part of lease number 00842. The platform was installed in 1987, and production commenced during the same year. After a number of transactions regarding the record title and operating rights assignments, Apache became the designated operator for this platform in 1999. According to Fieldwood, it acquired the "E" platform effective on July 1, 2013.

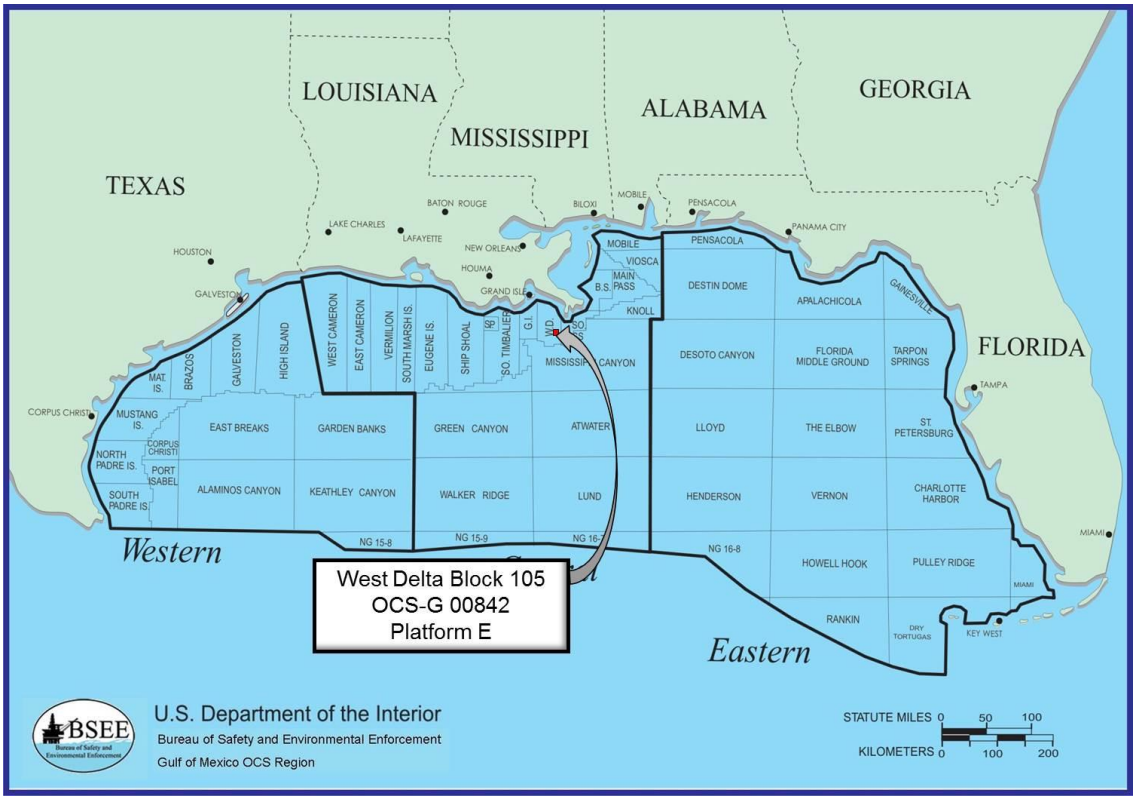

Figure 1 - Location of West Delta Block 105, Platform E

The Platform:

The WD 105 E facility, identified by Complex ID 23415, is an eight-legged fixed structure located approximately 12 miles off the coast of Louisiana in approximately 237 feet of water. The structure has two main decks, consisting of an upper deck on which there are living quarters, offices, a galley and various storage and production equipment; and a lower deck (Figure 2) where various other buildings and equipment are located, including the Motor Control Center (MCC) building, the dry oil tank and the NBK-600 heater treater (all highlighted).

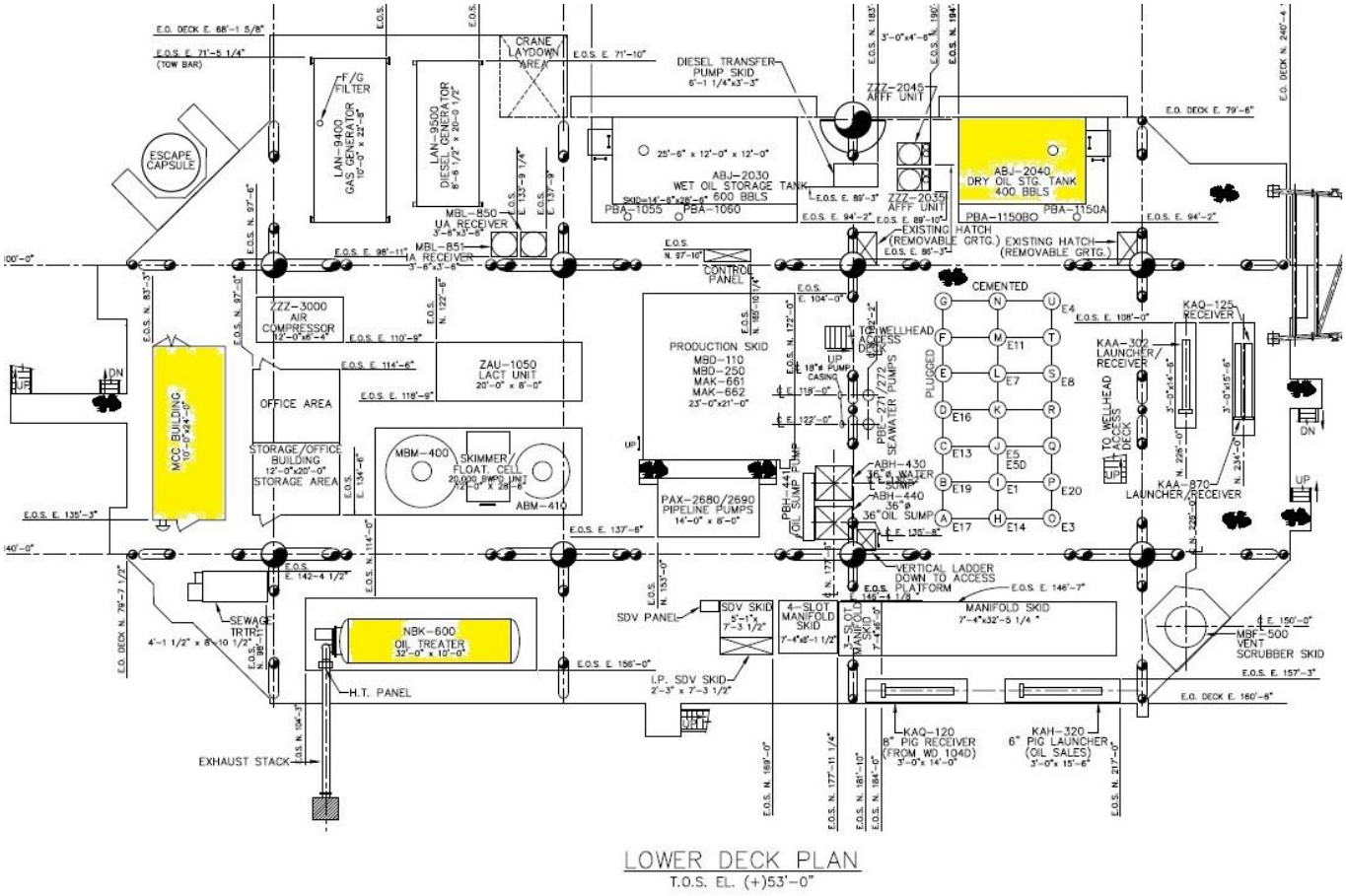

Figure 2 - Partial Lower Deck Plan with Added Highlighting

The WD 105 E platform has 21 well slots, with two incoming pipelines that deliver production to the WD 105 E from two unmanned Fieldwood platforms: the WD 104 D and the WD 122 A. Produced oil is treated and stored at WD 105 E before it is pumped to a departing oil pipeline.

The WD 105 E platform was damaged during Hurricanes Katrina and Rita in 2005, and subsequently underwent extensive repairs. Included in those repairs was the installation of the involved heater treater in November 2006.

Separation and Oil Handling Systems

According to the Fieldwood Operating Procedures for WD 105 E, the separation systems at WD 105 E consist of two production trains: one for WD 104 D / WD 105 E and one for WD 122 A. In each sequence, incoming oil flows through a number of separation processes before eventually flowing to the final separation point in the process, the heater treater, where it is processed at WD 105 E and flows through a Lease Automatic Custody Transfer (LACT) unit to the departing oil pipeline.

The oil handling systems are composed of the primary system, which includes the components involved in oil treating and storage (dry/wet oil exchanger, heater treater, forced draft burner, heater fuel pot, dry oil tank, wet oil tank and the wet oil pumps); and the secondary system, which includes the components involved in pumping the stored oil from the dry oil tank to the departing oil pipeline.

During normal operations, sources entering the heater treater included: wet (untreated) oil

from the separators, which includes associated produced water and breakout gas; gas from the fuel gas scrubber used as blanket gas to provide a gas cap in the vessel; heat from the forced draft fire component's fire tube; and electric field produced from the electric power supplied by a transformer. Exiting the heater treater was: treated oil going to heat exchangers prior to entering the dry oil tank; excess gas from blanket gas and flash gas from the oil going to the vent system; and produced water going to the water treating system.

The dry oil tank receives mostly treated and cleaned oil from the heater treater, and once the level in the tank reaches a predetermined set point the secondary oil handling system activates the LACT booster pumps that send the oil to the LACT unit. If the quality of the oil is acceptable, the LACT unit directs oil to the pipeline pumps for shipping.

The oil entering the pipeline needs to meet a certain quality, such that the amount of basic sediment and water (BS&W) is minimized. Operators might also need to pump the bottom off the dry oil tank until the oil quality meets buyer's specifications. If the oil quality becomes unacceptable, the BS&W monitor opens the LACT unit divert valves to send it back to the wet oil tank to receive further treatment through the described systems. If the separation and/or oil handling systems is not working properly, then the quality of the oil may not meet the buyer's specification for receipt in the pipeline. Thus, the equipment within the systems, such as the dry oil tank and heater treater, may need maintenance or cleaning to address the issue.

Relevant Equipment:

The Heater Treater

The heater treater on the WD 105 E facility was a heater / electrostatic treater labeled as the NBK-600 Heater Treater. This vessel was designed to provide gas separation, freewater removal, and coalescence[4] of entrained water particles to allow the oil to meet pipeline specifications.

Horizontally positioned and cylindrical in shape, it was built and installed in 2006 with dimensions of 72 inches in diameter and 22 feet 6 inches in length. It was originally designed to have a maximum allowable working pressure (MAWP) of 75 pounds per square inch gage (PSIG)[5] and maximum temperature of 200 degrees Fahrenheit. It was designed to process 3,500 barrels per day of oil and 400 barrels per day of water; with a forced draft fired component of 1.0mm BTU/hour.

Oil enters the heater treater at the top of the vessel from the location labeled Oil Inlet in Figure 3.[6] A forced draft fired component (burner) located in the inlet section of the vessel supplies heat to the oil through a u-shaped fire tube which spans most of this section of the vessel, and along with retention time, assists with the initial degassing and separation of oil and water. Fluid is then moved from the inlet section into the coalescing section by holding a constant level through means of pressure and a set weir height. The fluid is transferred over the fixed weir baffle (labeled Weir 1) into a differential oil control chamber, after which it travels downward where an opening to the coalescing section distributor was located beneath the spreader bar.

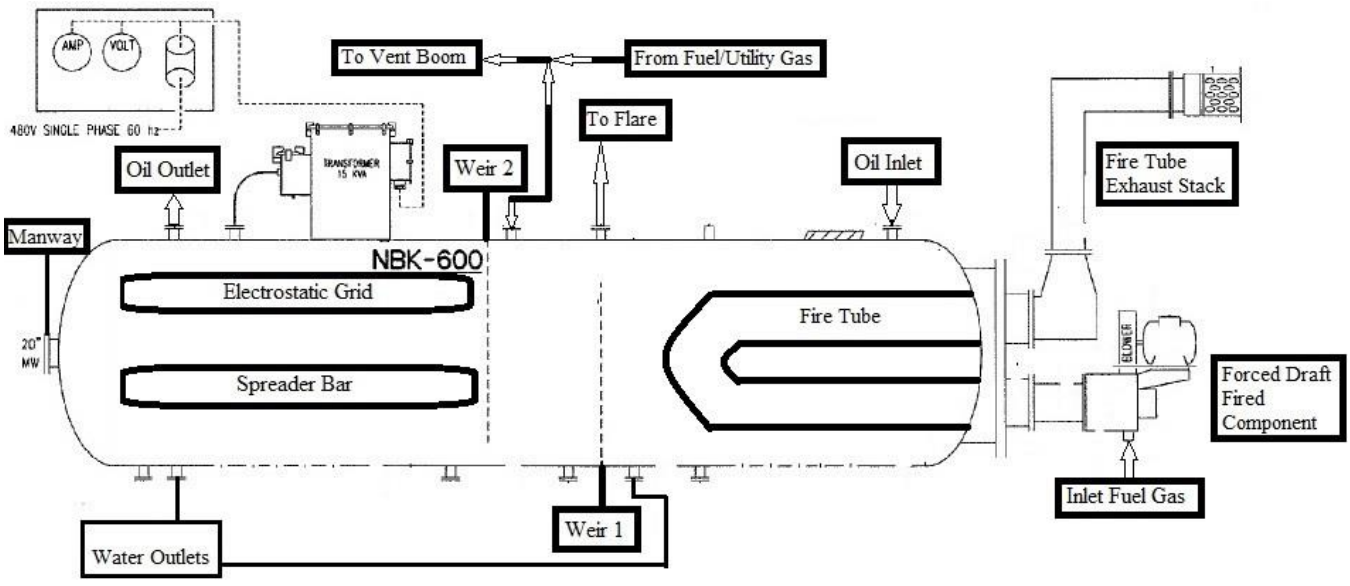

Figure 3 - Mechanical Process and Instrumentation Flow Diagram for Electrostatic Heater/Treater – Edited and Labeled for Relevance and Simplicity (As Built – November 20, 2006)

[4] The process of droplet growth as small drops merge together when they come in contact. If this occurs repeatedly, emulsions break and form two distinct liquid phases that tend to separate (Schlumberger Oilfield Glossary - Coalescence).

[5] The heater treater's MAWP was de-rated to 50 PSIG in 2013 after an external vessel inspection.

[6] Labels and identifications are not to scale, including the diagramed orientation of the weirs / baffles.

The oil and entrained water enters the coalescing (electrostatic grid) section from under the approximate location of Weir 2, and is forced upward, while free water and solids fall to the bottom. When the oil and entrained water flows upward it is uniformly distributed by a spreader bar to utilize the full coalescing area. As the oil and entrained water comes into contact with an electrical field in the upper area of the vessel where an electrostatic grid is located, final coalescing of the water from the oil phase is accomplished. The clean oil continues to rise to the top of the vessel, where it is collected and is discharged through the clean oil outlet valve (labeled Oil Outlet). The coalesced water droplets settle into the water phase at the bottom of the vessel where an interface control then operates a water dump valve that removes the free water.

The Electrostatic Grid

The electrical field within the heater treater coalescing section is created through grid plates that use high voltage alternating (AC) current on every other electrode for coalescing of emulsified water (Figures 4 and 5). The charged grid plates are suspended from the upper portion of the vessel shell with insulated hangers to protect them from the conductive metals of the vessel. Ground grid plates are also attached to the vessel shell via ground hangers.

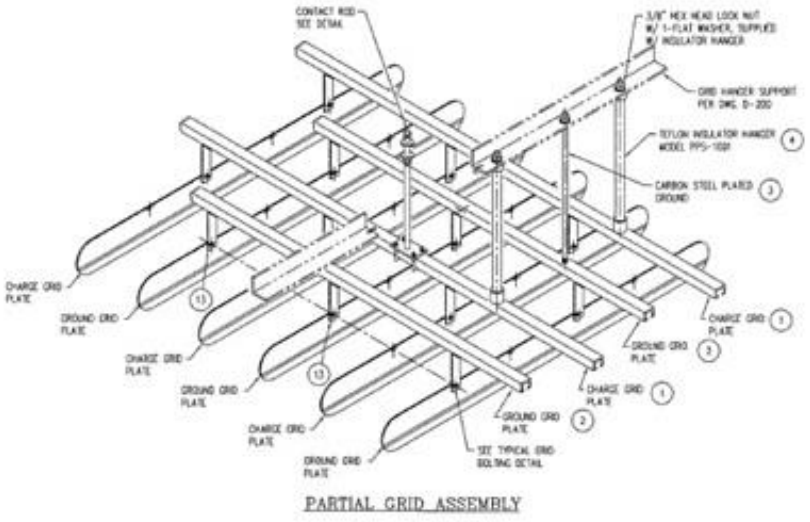

Figure 4 - Partial Diagram of Heater Treater Grid

The electrostatic field created by the grid assists in the oil / water separation process. Due to water molecules polarity, electric fields created by an alternating current vibrate the water molecules with enough energy to break the film of the emulsified droplet allowing it to combine with other droplets (coalescing). After a chemical demulsifier and heat has weakened the stabilizing materials that surrounds the water droplets, the electrostatic field assists gravity separation by reducing the length of time required for oil / water separation.

With the oil and entrained water flowing upwards through the grids and clean oil exiting through the top of the vessel, the water that settles at the bottom of the unit forms a surface which

acts as another electrode for the electrical field.

The Transformer

An externally mounted, oil immersed, high voltage transformer is located atop the heater treater to provide the power to the electrodes (Figure 5). The transformer is equipped with a reactor which is designed to provide 100% circuit utilization for continuous power.

The high voltage secondary of the transformer is connected to the charged electrodes of the grid through a high voltage entrance bushing coated with Teflon to insulate it from the surrounding metals. Conduit assembly, disconnect switch, voltmeter and externally-run indication light are included and are all designed as suitable for hazardous area installations.

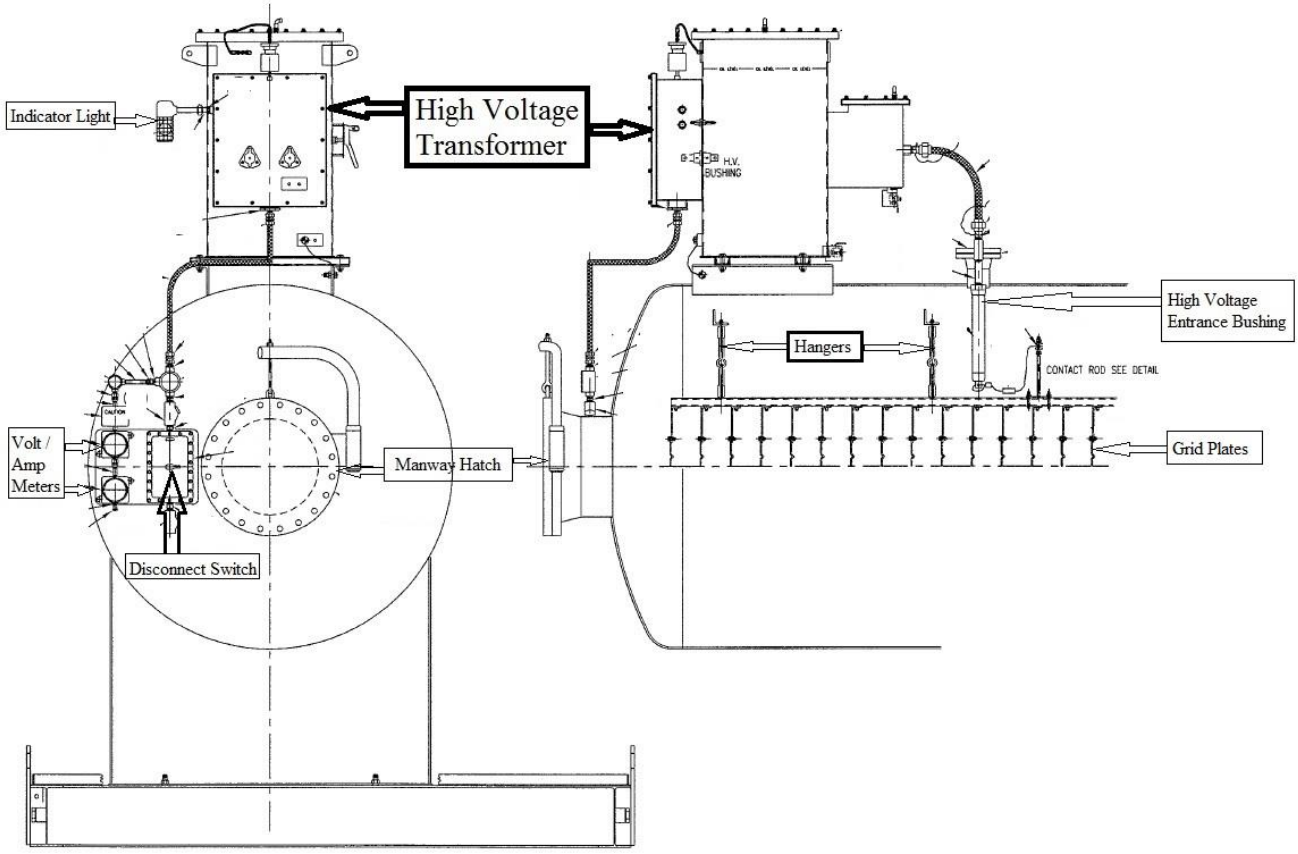

Figure 5 - Coalescing Section of Heater Treater – Front and Side Views – Edited for Relevance and Simplicity

Timeline

November 6, 2014 to November 18, 2014

The WD 105 E A-Hitch personnel departed the platform on November 6, 2014, and the B-Hitch arrived. The Fieldwood A-Hitch Person-in-Charge (PIC) indicated that prior to departing, the production and status of the heater treater were good. Most A-Hitch personnel were due to return to the platform on November 20, 2014; however, the normal Fieldwood A-Hitch PIC was not expected to return until November 27, 2014, because of a scheduled vacation.

The Fieldwood B-Hitch PIC remained on the WD 105 E until November 12, 2014, when he departed for a scheduled vacation of his own. This resulted in leaving contracted A-, B- and Lead Operators to run the facility with no Fieldwood PIC scheduled to oversee the facility from November 12 to November 27, 2014. According to the Fieldwood B-Hitch PIC, operations were normal and the heater treater was working correctly when he departed the WD 105 E on November 12, 2014.

Beginning on or about November 13, 2014, high levels of basic sediment and water (BS&W) were detected in the dry oil tank. Fieldwood temporarily brought company and contractor employees from neighboring facilities to help with production. Over the next few days, operators attempted to bring the platform back online but continued to have problems with high BS&W and a pad of thicker oil and emulsifications that prevented them from selling oil. Also during this time, a Senior Lead Operator from A-Hitch,[7] who was not normally scheduled to return to the platform until November 20, 2014, arrived on November 15, 2014 and assisted with platform operations. Personnel were not able to resolve this issue and it was determined that they needed to drain and clean the oil handling systems.

On November 16, 2014, a Fieldwood B-Hitch Field Foreman contacted Turnkey to arrange cleaning of the dry oil tank and related equipment. The job was originally scheduled to be performed by one four-man cleaning crew during the daytime.

On November 17, 2014, platform personnel continued attempts to flow oil, but they were mostly unsuccessful due to poor oil quality. Production from the WD 105 E was shut-in on or about November 17, 2014. As the most experienced person on the platform the Senior Lead Operator effectively became the Person-in-Charge (Island Acting PIC) when the additional company and contractor personnel from neighboring facilities departed the WD 105 E.

The four-man Turnkey cleaning crew was unable to reach the WD 105 E platform on November 17, 2014 due to bad weather. They arrived on Tuesday, November 18, 2014, but the seas were too rough to offload their cleaning equipment. Platform personnel partially drained fluids and emptied tanks for the cleaning crew.

[7] Employed by Island Operating Company (Island).

November 19, 2014

On Wednesday, November 19, 2014, platform and cleaning crew personnel conducted a safety meeting and discussed operations. This included conducting a job safety analysis (JSA) for 'Setup Equipment and Clean Out Vessel' for the dry oil tank, as well as other JSAs for the daily activities. They also completed additional paperwork for confined space entry to clean the dry oil tank.

Personnel then offloaded Turnkey's equipment from an offshore service vessel onto the platform. This included, primarily, a Turnkey shipping box with equipment, cuttings boxes for fluid storage, a generator and a vacuum unit; all of which were offloaded to the main (upper) deck. The vacuum unit, which would be powered by electricity from the generator, was grounded to the platform.

When the four-man Turnkey crew began cleaning the dry oil tank (Figure 6), which was located on the production (lower) deck, they described draining it into a skid and using the vacuum unit to suction the contents into cuttings boxes located on the upper deck. Three members of the Turnkey crew worked on the dry oil tank directly, while the fourth watched the cuttings boxes to make sure they did not overflow. After the oil was drained from the dry oil tank, the crew relieved pressure inside by opening valves and slowly bleeding pressure as they opened the manway hatch with an air-powered impact wrench.

Figure 6 - Dry Oil Tank Hatch (November 21, 2014)

A Turnkey crewmember described opening more hatches on top of the tank and installing an air horn[8] to aid in ventilation. They reported taking gas readings and started rinsing and cleaning the inside of the tank with water.

The Turnkey crew then performed confined space entry to continue cleaning the dry oil tank. One Turnkey crewmember entered first at 9:45 p.m. and exited at 10:26 p.m. The Turnkey Supervisor then entered at 10:26 p.m. and exited at approximately 11:30 p.m. The job was reported as complete. According to one Turnkey crewmember, they both wore their personal protective equipment (PPE), which included breathing apparatus, a Tyvek suit, rubber gloves and chemical-proof

[8] A cone-shaped device used to circulate air out of an enclosure.

boots.

The incoming and outgoing Fieldwood Field Foremen for the area that included the WD 105 E had a changeover meeting on November 19, 2014, which also included project managers for the Fieldwood contract operators. When his hitch began on November 19, 2014, one Fieldwood A-Hitch Field Foreman was informed of the ongoing cleaning activities at the WD 105 E platform due to high BS&W problems with the oil. During this meeting, he suggested that the cleaning activities be moved to a 24-hour operation to get the job done quicker and get back to production, which Fieldwood decided to do. The Fieldwood A-Hitch Field Foreman therefore contacted Turnkey and arranged for an additional cleaning crew to arrive at the facility the following day, to have two crews working separate 12-hour shifts.

The Fieldwood A-Hitch Field Foreman also described checking-in with the Island Acting PIC at the WD 105 E and discussing what needed to be done for the job, including filling out permits, as well as energy isolation and LOTO on the heater treater; which he said the Acting PIC confirmed.

According to documentation provided to the BSEE Panel, the Island Acting PIC took steps to isolate energy to the heater treater transformer and blower motor on the morning of November 19, 2014 by turning off the breakers in the platform's Motor Control Center (MCC) building. The Island Acting PIC said platform personnel drained a little water out of the bottom of the heater treater before the Turnkey crew started working on it. This was done while the Turnkey crew was working on the dry oil tank.

November 20, 2014

Activities on the morning of November 20, 2014 included JSAs and safety meetings to discuss the analysis of the day's activities, such as daily platform operations and maintenance, crane operations and setting up equipment and cleaning the heater treater. Also included was a crew change for production personnel, a personnel transfer for incoming Turnkey personnel, offloading empty cuttings boxes to the platform and back-loading full cuttings boxes with contents from the dry oil tank.

The Turnkey day crew included four members, three of which had worked together the previous day on the dry oil tank. Rather than using the same Turnkey cleaning crew as the day before, one of the incoming crew members switched with a crewmember from the previous day's work because he was more familiar working with the Turnkey Supervisor.

The Island Acting PIC reported speaking with the Turnkey Supervisor and completing the JSA with him. They spoke about the good job Turnkey had done on the dry oil tank, the upcoming job on the heater treater, and that the heater treater's power source and the gas going to it were isolated. They discussed confined space in the JSA, such that the Turnkey crew had their gas detector and breathing apparatus in case they needed to get inside; which the Island Acting PIC said eventually they would have to do to clean it out. He told them to work safely and to ask him or talk to one of the operators if they had any questions or needed anything.

Turnkey crewmembers described the morning meeting as a regular safety meeting with no specific concerns with the job; nor were there any known hazards or concerns with gas build-up or sparks. They described discussing general topics such as slips, trips and falls; confined space entry; and checking for gas. They were told to be safe and to wear PPE, that the heater treater was ready to be worked on and for them to go straight to work. They recalled being told the platform was not producing and everything was shut off; however, they did not recall being told specifically what was isolated.

Different recollections indicated that the Turnkey crew started cleaning the heater treater between 8:30 and 9:30 a.m. They first staged their equipment, which involved running a hose for the impact wrench that was later used to remove the bolts from the manway hatch, and positioning the vacuum hose from the cuttings boxes on the top deck to the heater treater on the lower deck.

Crew change operators arrived and the Island Acting PIC told them what was going on. They filled out a JSA and the Island Acting PIC said he told them they needed to check on the cleaning crew periodically, make rounds, see if they needed anything and see how they were doing. A Lead Operator with Island arrived on the WD 105 E later than the rest of the crew; believed to be after the JSA was conducted for cleaning operations.

There were no operator representatives specifically assigned to be with the cleaning crew while they cleaned. Throughout the day the Island Acting PIC checked in with the Turnkey crew, took calls on the telephone and did his other duties. He also asked the Island Lead Operator that morning, when the Turnkey crew was bleeding the heater treater, to go down and check the vessel; although the Island Lead Operator did not recall being asked to check in with the cleaning crew themselves.

The Island Lead Operator estimated that at or about 10:00 a.m., he went down to the lower deck where the heater treater was located to double check the vessel. He saw that all the dump valves were closed and the Turnkey crew was bleeding the vessel, so he checked the makeup gas. He said the Turnkey crew was getting ready to drain the vessel but had not yet opened the drain valves.

The Island Lead Operator climbed on top of the heater treater and saw that the blanket gas make up valve was not closed, and although he said the pneumatic shutdown valve was already closed and he did not think it made a difference, he closed it anyway. He said that when he came down he saw the burner [fuel] gas was blocked and the burner was off. Before going back upstairs, he said he saw the oil and water outlets on the burner section were already off and/or blocked as well. He did not check on the electrical equipment associated with the heater treater. He did not recall going inside the MCC building or speaking with anyone from Turnkey.

The Turnkey crew removed the drain plugs and took blind flanges off the bottom of the heater treater to drain its contents into a skid pan (Figure 7) and/or a bucket (Figure 8) under the heater treater, from which they then suctioned the contents with the vacuum hose to the cuttings boxes on the main deck. Of the four-man Turnkey crew that was cleaning the heater treater, the Turnkey Supervisor and two Turnkey crewmembers were located on the lower deck in the general vicinity of the heater treater most of the day, while another Turnkey crewmember monitored the cuttings boxes on the main deck.

Figure 7 - Skid/Drip Pan Below Heater Treater Manway Hatch (November 21, 2014)

Figure 8 - Drainage Bucket Under Heater Treater (November 21, 2014)

At some point during the day, the Island Acting PIC said he went down to talk to the Turnkey crew to see how they were coming along. He said they had a little fluid level left on the sight glass, which indicated they still had more fluid to drain, and they had the ball valves on the bridle opened up so they could vent. He said he thought they were getting ready to start pumping down fluid and open the manway hatch on the coalescing side of the heater treater to make sure everything was ventilated before anyone got in. He said they did not have any problems with the work up to this point.

Turnkey crewmembers estimated it took almost all day to drain the heater treater, finishing around 2:00 or 2:30 p.m. Once they had the contents pumped down and were not pumping anymore, the Turnkey Supervisor reportedly hollered to the Turnkey crewmember on the main deck, who said he cut the vacuum off and went down to the heater treater located on the production deck.

The Turnkey crew then slowly unbolted the hatch using the impact wrench until there were four bolts remaining. The hatch was connected to a davit arm that was intended to support the hatch when removed. However, the eye bolt was broken so they decided to cut it with a hand saw and instead of removing the hatch entirely, they left one bolt and allowed the hatch cover to swing below the manway opening (Figure 9).

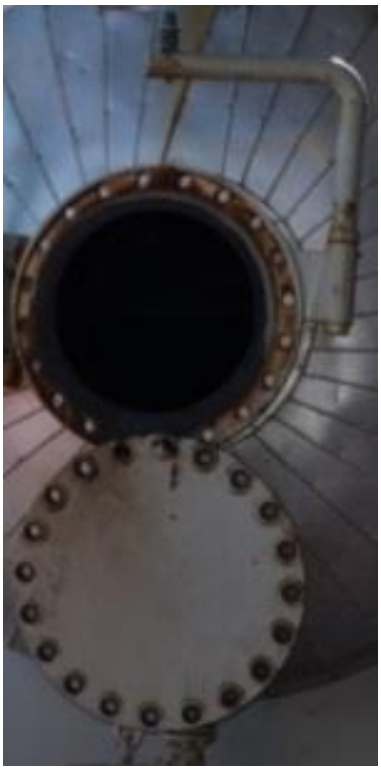

Figure 9 - Open Manway (November 21, 2014)

After they opened the hatch, one Turnkey crewmember said he moved the vacuum hose from a bucket under the heater treater (Figure 8), where they were draining and vacuuming, to inside the hatch opening. He said some fluids then dripped off the lip of the hatch into a skid pan below it (Figure 7), and the Turnkey Supervisor asked him to take the hose out. He indicated that he then took the vacuum hose, walked around the side of the heater treater and placed it back in the bucket before he returned to the coalescing section of the heater treater where he stood facing the hatch.

When the hatch was off, the Island Lead Operator went to the production deck again to make rounds. He said he was curious about what it looked like inside the heater treater and thought he might have asked if he could look in it; which he proceeded to do. He said it was dark inside the vessel, but he could see decently into it. He described seeing a 'pad' of a foam-like, waxy / paraffin layer, and that there was fluid right below the hatch opening and below the spreader bar with a little bit of sand. He did not remember if or where the Turnkey crew was draining at the time, but he recalled seeing vacuum hose inserted in the manway opening around this time and that it smelled like gas and hydrocarbons outside the open hatch.[9]

A Turnkey crewmember who also looked into the hatch said he saw mostly an empty tank, with about three to four inches of product at the bottom, which he described as the material that was too thick to drain. He said there were not too many solids, and it would have been an easy clean. He said

[9] Turnkey crewmembers described that they had a gas detector in the vicinity of the heater treater while they were working, but they could not recall its specific placement or whether readings were specifically taken once the hatch was open. In general, they believed it was located either on the top of the hatch (where crewmembers reported they normally put it to check for gas and at least one believed it to have been at the time of the incident), in the Turnkey Supervisor's pocket (clipped), or on a rail next to the coalescing section. They did not hear any alarms from the gas detector, which they assumed they would have heard if a hazardous gas was present.

he did not see the internal components of the heater treater.

The Turnkey crew described that they had not gotten to the point of ventilating or getting inside the heater treater, as they had not finished getting the entire product out yet and were still in the beginning stages of the cleaning process, but that they would have soon used an air horn to ventilate. They said they were talking about how they might have to get inside the heater treater if they could not get all the material out with a pressure washer.

One Turnkey crewmember explained that there was some buildup of product on the interior walls of the heater treater, and the Turnkey Supervisor was standing outside the hatch using a water hose to wash it. However, this crewmember had gone upstairs to get a flashlight a couple of minutes before the incident and therefore was not present to see what they were doing at the time it occurred.

The two Turnkey crewmembers located at the heater treater at the time of the incident described that the Turnkey Supervisor was using a light flow of water to rinse the lip of the hatch so that material did not drip; but they were not sure and did not know if any water could have entered the vessel. The Island Lead Operator recalled seeing the Turnkey Supervisor with a water hose, but did not see him spray inside the heater treater.

Estimated at shortly after 2:30 p.m., two Turnkey crewmembers and the Turnkey Supervisor all stood outside the coalescing section of the heater treater and faced the open manway. The Turnkey Supervisor stood in the middle, with one crewmember to his right and the other to his left; one of which had his hand on the shoulder of the Turnkey Supervisor during these moments as he looked inside the heater treater, and the other had arrived in this position shortly after returning from moving the vacuum hose to underneath the vessel. The Island Lead Operator had just stepped off the heater treater skid and turned to talk to one of the Turnkey crewmembers. No one reported anyone reaching into the heater treater.

The Explosion:

As the Turnkey Supervisor was believed to have been spraying salt water on the lip of the manway hatch, an explosion occurred inside the heater treater. Force from the explosion exited out of the open manway where the Turnkey and Island personnel were standing (Figure 10). The explosion caused a loud noise that was heard throughout the platform, including the galley and living quarters where most other platform personnel were located at the time.

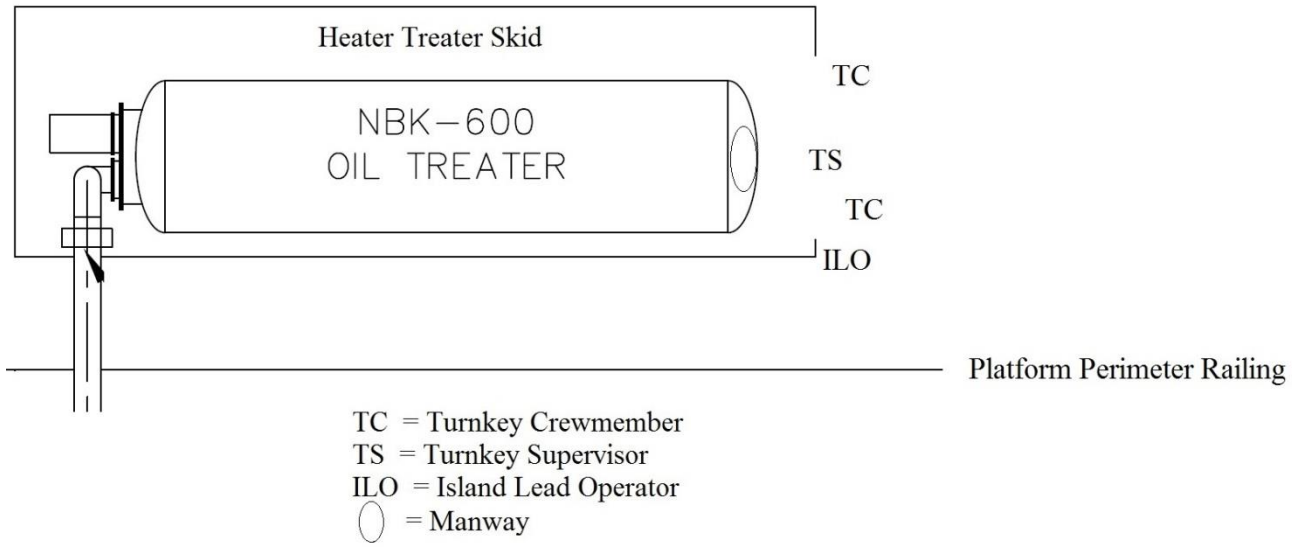

Figure 10 - BSEE Representation of Approximate Locations of Individuals at the Time of the Incident Based on Witness Descriptions – Edited from Lower Deck Plan, Top View

One Turnkey crewmember described the incident as a big, possibly white, flash and feeling like he was hit in the head with the force of a sledgehammer. He also described a noise that sounded like a stick of dynamite had gone off. The water hose that the Turnkey Supervisor was holding hit him on the head causing injury, and he fell to the deck; believed to have been knocked unconscious. When he came to, he saw smoke coming from the hatch, and maybe fire, and the water hose flailing and spraying water. He grabbed the hose, saw that the ball valve to turn it off was broken, and yelled for someone to turn the supply off; which the Island Lead Operator did.

The other Turnkey crewmember that was near the heater treater at the time of the explosion recalled hearing a big boom and seeing a flame come out of the hatch when the explosion occurred. He said his ears were ringing and he saw white smoke coming from the hatch opening; then he blacked out. He thought the explosion threw him 10 feet away from his previous position and possibly unconscious.

The Island Lead Operator had just stepped off the heater treater skid when the explosion knocked him off his feet. He described seeing a yellow fireball or flame come out of the vessel; which only lasted a second. He also heard a really loud noise, which he described as sounding like a deep or sonic boom. He said he felt like he was hit by an 18-wheeler and was sore for days. He did not know where his hard hat, glasses or ear plugs went after the explosion or where he got up, but it was in a different place than where he had originally been standing. When he came to his senses, he saw there was water coming out of the water hose and it was flipping around, so he turned it off. He then went to the intercom system and called for help.

The Turnkey Supervisor had been the closest person to the hatch opening, as he was described by some as being within arm's length and as close as he could get without breaking entry into the hatch. Multiple witness accounts reported that the Turnkey Supervisor was thrown many feet from the manway opening, had sustained noticeably substantial physical injuries, was not breathing and was without a detectable pulse.

The Turnkey crewmember that had been working on the heater treater but left to get a flashlight estimated that he heard the explosion around two minutes after he had gone upstairs.

Post-Incident (November 20, 2014):

The Island Acting PIC was in the galley preparing supper and talking to two operators when he heard a loud noise and they all looked at each other. He went straight to the handrail and looked in the area where the cleaning crew was working on the heater treater, where he saw one of the guys yelling for help. He went back inside the galley and called the Fieldwood A-Hitch Field Foreman, who he told there was a man down and they had people going to attend to him, but he did not know the extent of the injury.

Other personnel that were on the main deck at the time of the explosion reported hearing a loud noise; many of whom ran down to the lower deck to try to help. The Island Lead Operator and the two Turnkey crewmembers that were standing on the sides of the Turnkey Supervisor were described as having been knocked down and dazed, but they could talk and were able to move to the sides of the platform deck. Personnel also indicated seeing white smoke, but no sustained fire.

The Fieldwood A-Hitch Field Foreman was at another Fieldwood platform when he received the telephone call from the Island Acting PIC. He said he instructed the Island Acting PIC to check on the injuries and to do cardiopulmonary resuscitation (CPR) if necessary. He then called his supervisor and informed him of what the Island Acting PIC had told him. The Fieldwood A-Hitch Field Foreman dispatched their field medic, and then called Search and Rescue (SAR) to initiate treatment and transportation of injured personnel shortly before 3:00 p.m. The incident was also reported to BSEE's New Orleans District.

The Island Acting PIC said he stayed upstairs by the radio and telephone for the entire time after the incident and did not go down for any of the incident response. He called the Fieldwood A-Hitch Field Foreman back and reported a possible fatality and other personnel with injuries, including bleeding and hearing problems. The Fieldwood A-Hitch Field Foreman got on a helicopter and went to WD 105 E. In the meantime, Fieldwood's field medic arrived at the WD 105 E and did an assessment; after which it was believed the Turnkey Supervisor was deceased and he did what he could with the injured personnel. This included wrapping bandages on the head of the crewmember who had been hit with the hose nozzle and getting him ready for the SAR helicopter to take him to the hospital. The Fieldwood A-Hitch Field Foreman arranged for transportation of personnel the medic deemed less serious.

After arriving at the platform and getting briefed, the Fieldwood A-Hitch Field Foreman described that he did a quick assessment of the production deck to ensure stability of the systems. He then returned upstairs to look after the personnel that were dealing with the aftermath of this event.

The personnel that remained were asked and agreed to stay on the platform to be debriefed before leaving. The Fieldwood A-Hitch Field Foreman collected witness statements and gathered paperwork associated with the job that he expected people to ask for, talked with the Island Acting PIC and also tried to provide information to the main office about what was going on.

At the direction of BSEE and Fieldwood's onshore offices, personnel cordoned off the incident scene around the heater treater, for which Fieldwood developed a form to record if anyone entered. BSEE also issued Fieldwood a verbal preservation order at approximately 4:50 p.m. BSEE Investigators were informed that no one entered this area except to assist in evacuating the Turnkey Supervisor

when the SAR helicopter returned to get him that night.

The BSEE Investigation

The BSEE Panel collected and reviewed large volumes of electronic and written material, including but not limited to data, emails and other records related to Fieldwood and its contractors' equipment, management systems, supervision of employees and contractors, communications, performance and training of personnel, relevant company policies and practices, and work environment. The BSEE Panel conducted interviews of personnel and was involved in additional fact-finding through inspection, observation and testing of involved equipment on the WD 105 E, including obtaining control of certain items deemed significant to the investigation.

Initial Onsite Investigation:

BSEE Investigators arrived at the WD 105 E platform on the morning of November 21, 2014, to conduct their initial onsite investigation. They documented Fieldwood and Turnkey equipment, the MCC building, dry oil tank area and incident scene, which was considered the area immediately surrounding the WD 105 E heater treater and was cordoned off by Fieldwood personnel the previous evening with yellow tape (Figure 11).

Figure 11 - Production Deck and Heater Treater (November 21, 2014)

During the assessment of the heater treater, BSEE Investigators observed that the transformer disconnect switch, mounted directly adjacent to the still-open manway, was in the 'On' position (Figure 12). This switch was systematically located along the electrical circuit travelling from a main transformer breaker in the MCC building to the electrical grid inside the coalescing section of the heater treater.

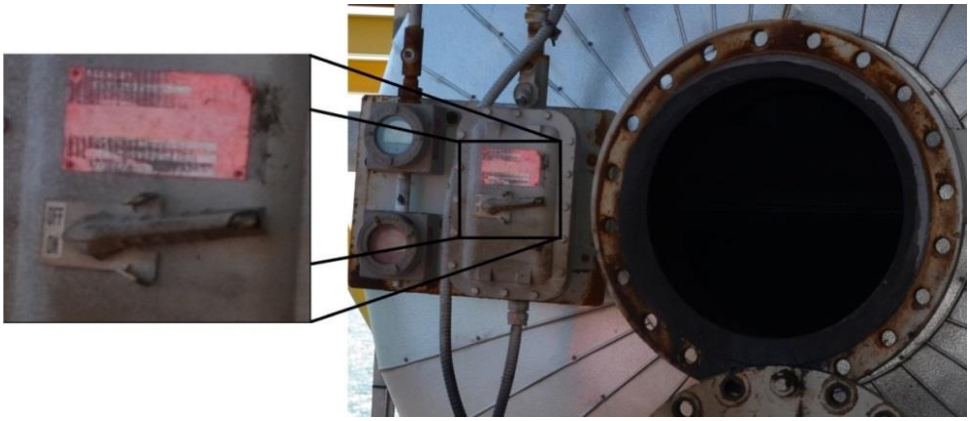

Figure 12 - Open Manway and Transformer Disconnect switch (November 21, 2014)

The BSEE Investigators identified the potential hazard of the disconnect switch in the 'On' position, as it indicated an unrestricted electrical energy pathway at this point within the circuit to the electrical grid. The BSEE Investigators then checked the "TR-5 Feeder 15kVA NBK-600 Heater/Electrostatic Treater" breaker (hereafter identified as the 'heater treater breaker') in the nearby MCC building and also observed it to be in the 'On' position (Figure 13). With the breaker and disconnect switch both 'On,' there was no apparent restriction in the flow of electrical energy from the power source to the heater treater grid. The BSEE Investigators stopped work and directed Fieldwood personnel contact a field electrician to ensure the system was safe and fully isolated.

Figure 13 - Heater treater breaker in MCC Building, as observed by BSEE Investigators on November 21, 2014 (Name Redacted by BSEE)

The BSEE Investigators observed the heater treater breaker affixed with a key-type lock that was fed through the breaker handle and clasped,[10] and a tag displaying the Island Acting PIC's name, date and time of when it was installed. The configuration of this breaker handle was such that it could be locked out or tagged out of service if it were turned 'Off' by positioning the handle entirely to the right and aligning it with corresponding holes on the breaker switch, and a lock were fed through the holes and clasped. It then could not be turned 'On' without unlocking and removing the lock.

The BSEE Investigators then brought the Island Acting PIC into the MCC building and asked him to look at the heater treater breaker. He indicated that he had locked the breaker out and demonstrated to the BSEE Investigators that he had the key to the heater treater breaker lock in his pocket. When BSEE Investigators explained that this was not a safe condition, the Island Acting PIC asked if he should move the breaker to the 'Off' position, which he was informed to do by the Fieldwood A-Hitch Field Foreman. The Island Acting PIC then used the same key to unlock the lock, move the breaker to the 'Off' position, and apply the lock and tag to secure the breaker handle in the 'Off' position correctly.

The BSEE Investigators also took photos during the initial onsite investigation on November 21, 2014. In particular, a close-up view of a photo taken of the volt and amp meters located on the heater treater adjacent to the disconnect switch and manway before the heater treater breaker was turned 'Off' (Figure 14), appeared to show the volt and amp meter readings[11] greater than the readings observed on those meters after the heater treater breaker had been turned 'Off' (Figure 15). This indicated that electricity appeared to have been present up to that point in the electrical circuit prior to turning off the heater treater breaker on November 21, 2014.

[10] It was not possible to lock the breaker handle in the 'On' position, given its design, since holes on the breaker switch were only provided for when the handle was in the 'Off' position.

[11] This volt and amp output also appeared similar to those taken during post-incident investigation testing when third-party experts turned the heater treater breaker 'On,' which is discussed later in this report.

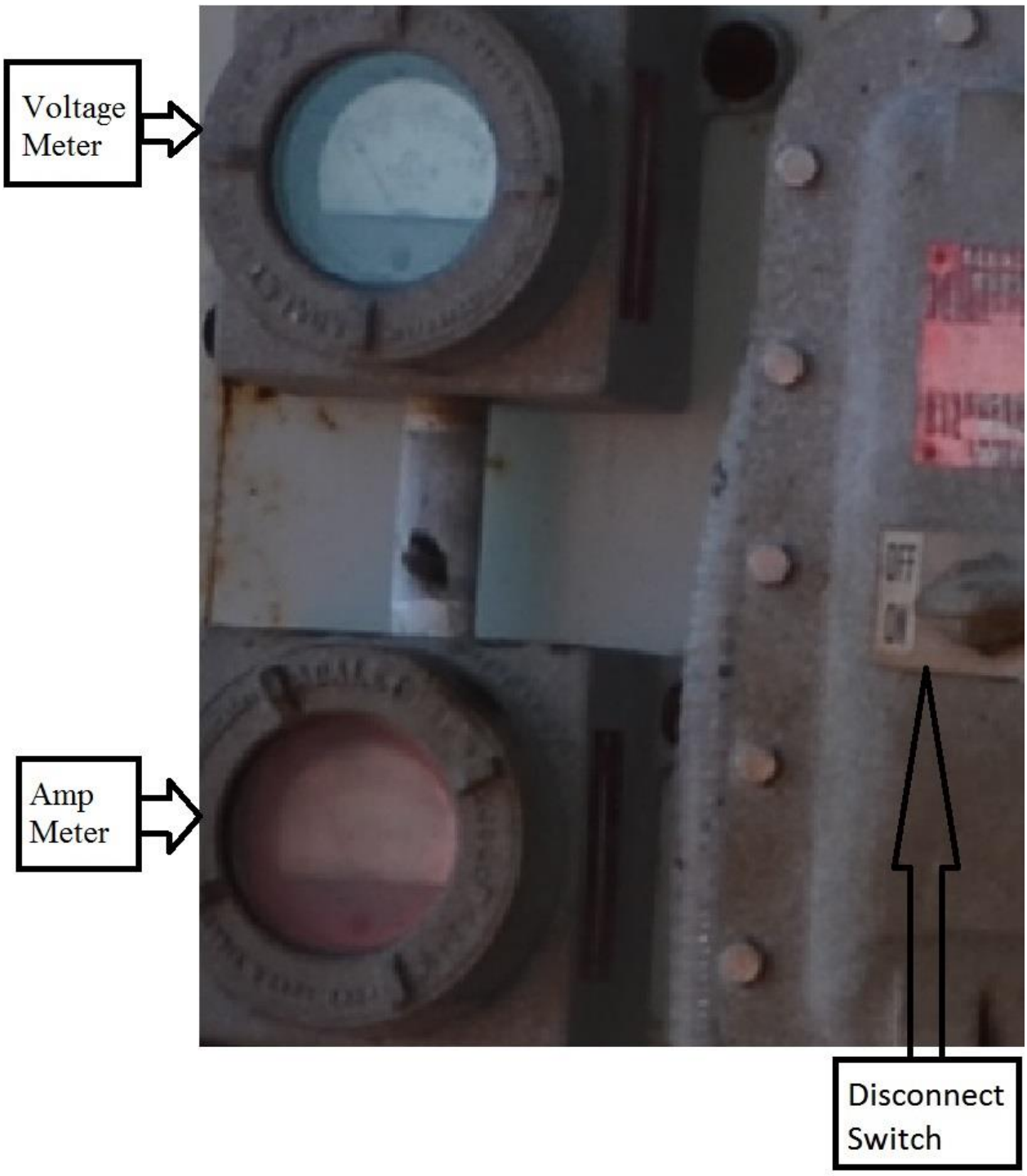

Figure 14 - Disconnect Switch, Volt and Amp Meters Prior to Turning the Heater treater breaker Off (November 21, 2014)

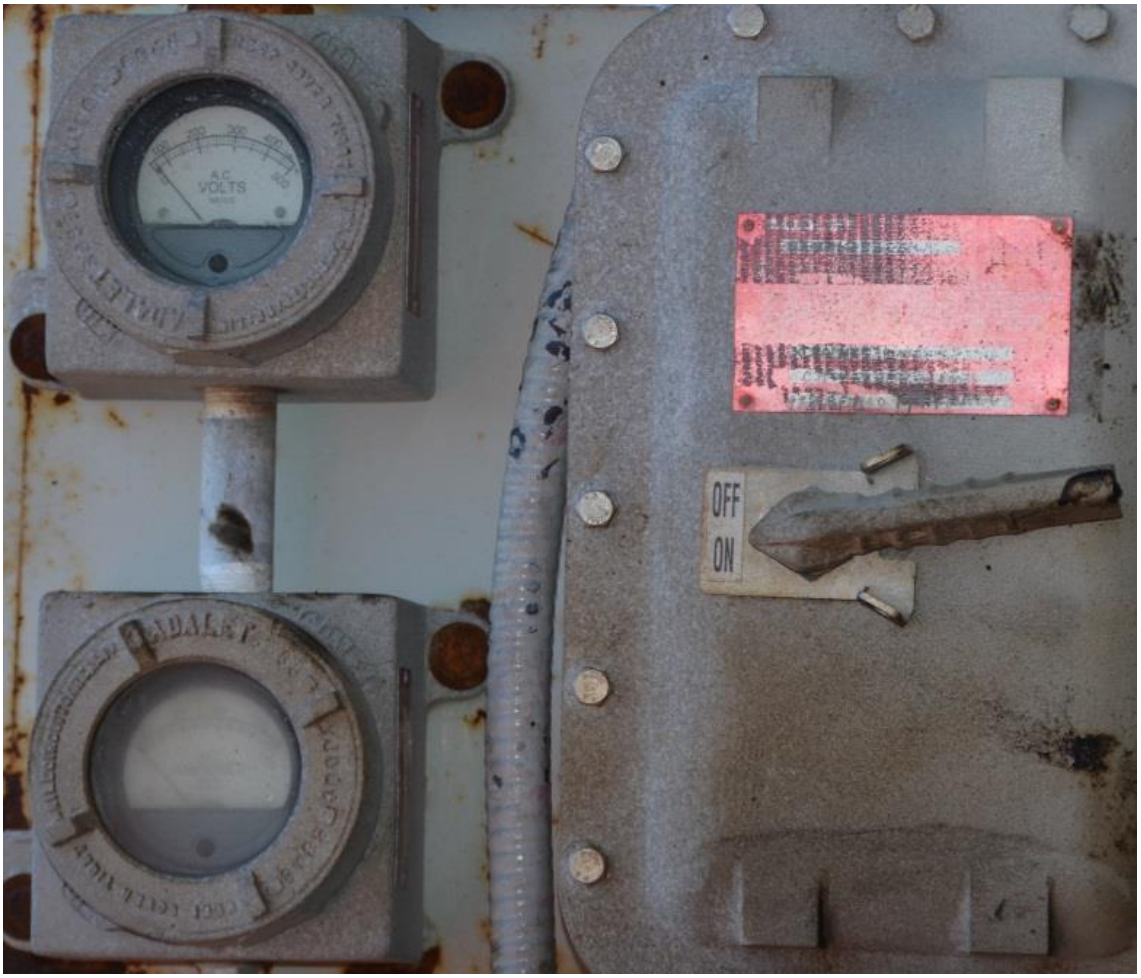

Figure 15 - Disconnect Switch, Volt and Amp Meters After Turning the Heater treater breaker Off (November 21, 2014)

Additionally, hours after the heater treater breaker was turned 'Off' on the afternoon of November 21, 2014, BSEE Investigators observed the temperature gauge on the transformer at slightly over 100 degrees Fahrenheit (Figure 16), which was higher than the outside temperature,[12] and of the same gauge taken the following day (Figure 17).


Figure 16 - Temperature Gauge on Transformer (November 21, 2014)

[12] The National Oceanic and Atmospheric Administration's National Data Buoy Center identified air temperature at on November 21, 2014 never went above approximately 67.2 degrees Fahrenheit at the nearby Louisiana Offshore Oil Port.

Figure 17 - Temperature Gauge on Transformer (November 22, 2014)

Also during BSEE's initial onsite investigation, the BSEE Investigators conducted interviews with personnel that remained on the WD 105 E. BSEE Investigators returned to the platform the following day to ensure that all energy and process piping isolations had been properly performed, including to double-block and bleed all input and output process piping.

Throughout the next several months, BSEE continued to conduct interviews and numerous onsite visits to the facility to gather facts and information relating to the operations of the heater treater, the transformer and the electrical grid; the latter two of which were eventually removed from the facility and maintained by BSEE at its property/evidence facility as of the issuance of this report.

Job Safety Analyses (JSAs):

BSEE's SEMS regulations indicate that companies must ensure JSAs are prepared, conducted and approved to identify, analyze and record the steps involved in a job, including the existing or potential safety, health, and environmental hazards associated with each step and the recommended action(s) and/or procedure(s) that would eliminate or reduce these hazards, the risk of a workplace injury or illness, or environmental impacts.

Fieldwood's SEMS manual indicates that a JSA is required for vessel/tank cleaning or confined space entry jobs; and jobs requiring lockout/tagout (LOTO) procedures. As such, a JSA was conducted using Fieldwood's JSA form by the Turnkey Supervisor for setting up and cleaning the dry oil tank and heater treater on November 19 and 20, 2014, respectively. Personnel explained that it was not abnormal for contractors to use Fieldwood's JSA form since it already contained listings of items Fieldwood identified as requiring analysis. Some Turnkey personnel also indicated that the cleaning procedures were described in these JSAs and other paperwork.

The JSAs for cleaning the dry oil tank and heater treater on November 19 and 20, 2014, both described the job to be analyzed as 'Setup equipment and clean out vessel,' and appeared to be exact copies of the typed information on each form. In fact, the JSA for November 20, 2014 still had the printed date of '11-19-14,' which was manually adjusted to '11-20-14' (Figure 18).

Date: 11-20-14			Location: WD 105 E	
Describe Job Being Analyzed: Setup equipment and clean out vessel			The immediate supervisor of the crew actually performing the work needs to conduct the JSA and make sure all personnel participating with the job/work sign the JSA. Conducted By: [redacted] Designated UWA: [redacted]	
Hazard Checklist:			PPE Checklist:	Permits /Procedures Required:
☐Fire/Hotwork ☐Open Holes ☒Falling Objects ☒Simultaneous Operations ☒Pinch Points ☒Cranes/Rigging ☐Stored Energy	☐Chemicals ☒Spills/Leaks ☒Heights ☒Noise ☒Pressure ☒Fumes ☐Vibration ☐Electricity	☒Weather ☒Lighting ☒Confined Space ☐Moving Machinery ☐Insect/Animal Bites ☒Tools/Equipment ☐Rotating Equipment ☒Other: Fatigue & Dehydration	☒Hard Hats ☒Safety Glasses ☒Face Shield ☐Goggles ☒Steel Toed Boots ☒Gloves ☒Hearing Protection ☐Personal Flotation Device ☒Fall Protection ☒Respirator ☒Other: Tyvek	☐Hot Work Permit ☒Confined Space Entry Permit ☐Energy Isolation/LOTO Permit ☐Open Process Piping Permit ☐Crane Operation and Rigging ☐Fall Protection Procedures ☐Open Hole Barricade ☐Others:

Figure 18 - Date Section of November 20, 2014 JSA for Setup equipment and clean out vessel (Names Redacted by BSEE)

The JSAs were conducted by the Turnkey Supervisor, who was also identified as the Immediate Supervisor of the Job/Task. The Island Acting PIC was identified as the Designated UWA [ultimate work authority][13] and as the Facility PIC or Consultant. Each JSA also contained a checklist of hazards to evaluate when performing a job, many of which were checked, and permits that might be required. Neither JSA identified electricity, fire/hot work or chemicals as a potential hazard, or Energy Isolation / LOTO[14] as a required permit. However, both JSAs identified the need for a Confined Space Entry Permit. The JSAs also had a PPE checklist, for which most of the PPE were checked.

The list of personnel involved with the November 20, 2014 heater treater cleaning included: the Turnkey Supervisor, three Turnkey crewmembers (one of whom was different than the previous day) and the Island Acting PIC. The JSA included initials for all of those individuals as responsible people for each of the 12 job steps.

Both JSAs included a list of the exact same 12 job steps. Each job step identified the potential safety or environmental hazards associated with it, and the safety or environmental hazards control to mitigate the impact of those hazards. The BSEE Panel found it significant to note that the JSA specifically described the job steps as the 'Sequence of Job Steps.'

The investigation identified that for many of the described job steps, the potential safety or environmental hazards and the safety or environmental hazards controls were not specifically, adequately, sequentially and/or completely followed. Examples include: inspecting and becoming expressly familiar with the worksite or potential task hazards; completing an inspection form (that did not exist) on the back of the JSA / JSEA [job safety and environment analysis]; posting the JSA / JSEA at the job site; identifying applicable permits; inspecting equipment and equipment positioning; and possibly positioning an air horn.

Crewmember descriptions appeared to indicate that they were on or around the sixth

[13] Fieldwood defined UWA as "… the authority assigned to an individual or position to make final decisions relating to activities and operations on the facility."

[14] Hazards and permits that would not necessarily be identified for a dry oil tank; but likely should be identified for an electrostatic heater treater.

sequential job step of the JSA, for opening manways and ventilating to atmosphere, when the incident occurred. The potential hazards and mitigations they identified were for securing the manway hatch safely while controlling fluid release; and securing and grounding the air horn. While it appeared that crewmembers generally followed the control methods to open the manway, including possible attempts to control fluid release by rinsing the lip of the manway hatch, at the time of the incident they had not yet installed an air horn to ventilate. According to the crewmembers, ventilation with an air horn would have been their next step had the incident not occurred.

At this point in the JSA's sequential job steps, the Turnkey crew had opened the manway and exposed the interior of the heater treater and its contents to oxygen, while potentially flammable liquids and gasses remained inside the vessel – two of the three components to support combustion (fuel and oxygen) – leaving heat or an ignition source as the only component not knowingly present to the Turnkey crew.

It was then in the seventh job step on the JSA, after multiple activities would have been conducted involving the heater treater to include opening its manways and leaving them vulnerable to the aforementioned hazards, that 'Isolation Procedures' was identified. This step identified hazards of IDLH [immediately dangerous to life and health] conditions / hazardous release, lockout / tagout procedures and stored energy. Hazard controls then included verifying valves were closed and installing skillets where needed; ensuring all lockouts, tagouts, and isolations were made and documented prior to performing any work; and always double checking others work, never making any assumptions and verifying for oneself that there was no energy present prior to performing work.

While the information described in this seventh job step addressed some important isolation hazards associated with this job, the sequential ordering was contrary to Turnkey's Offshore Vessel Cleaning Procedures and what may be considered safe work practices. Those procedures, explained in more detail in the following section of this report, describe that isolation and LOTO should be performed much earlier in the vessel cleaning process.

If the crewmembers were following the November 20, 2014 JSA sequence as the procedures for the job, which some personnel mentioned that they did, then the incident could have occurred before they even reached the step of verifying and ensuring LOTO and isolation had occurred. Further, while the job step mentioned energy, it did not specifically identify electricity, heat or chemical reaction as a potential hazard; the outcome of which could potentially cause an ignition source in certain conditions.

The JSA continued to address job steps of confined space entry, cleaning out the vessel, de-scaling the vessel, flushing hoses and exiting the vessel. Although these steps may have been completed for the intended activity of cleaning the heater treater, the incident occurred prior to completing those steps. Nonetheless, the BSEE Panel found that not until the eighth sequential job step, for performing confined space entry, did the JSA address retrieving an atmosphere reading from the manway; which was also contrary to the Turnkey Offshore Vessel Cleaning Procedures that described taking atmospheric readings shortly after the manway was opened.

The BSEE Panel also reviewed Turnkey work records for previous cleaning and maintenance jobs in the months leading up to November 20, 2014, which showed some of the recent jobs completed by the Turnkey Supervisor and other crewmembers also on the WD 105 E; many of which were also vessel cleaning activities for Fieldwood platforms. Some JSAs for these activities described

the same job to be analyzed as the job on the WD 105 E: 'Setup equipment and clean out vessel.' They also had the same or similar items identified on the Hazard Checklist, PPE Checklist, Permits/Procedures Required, sequence of job steps, potential safety or environmental hazards, and safety or environmental hazards control; despite that some were for tanks or vessels other than a heater treater and some were conducted by other Turnkey supervisors.

In addition, the JSAs completed by platform personnel for daily activities in the days leading up to the incident were the same JSA format as had been used during normal platform operations. The JSAs were not updated for the specific platform operations during the cleaning activities, despite that normal production activity was not occurring due to the platform being shut-in.

While many aspects of cleaning offshore tanks and vessels may be similar, there are important differences between the dry oil tank and the electrostatic heater treater on the WD 105 E that did not appear to be adequately considered in the JSA. The most essential differences are those that would be associated with the fire (burner) and electrical (transformer, grid and blower motor) components of the heater treater that were not present in a dry oil tank or many other offshore tanks or vessels. However, the JSAs for the dry oil tank and the heater treater appeared generic in nature and did not thoroughly address the sequence of job steps, or the particular hazards or mitigation of hazards for the specific job to be performed on the WD 105 E electrostatic heater treater.

Turnkey Offshore Vessel Cleaning Procedures:

Explanations from Turnkey personnel describing the general procedures for cleaning a vessel were more closely aligned with Turnkey's Offshore Vessel Cleaning Procedures rather than with the JSAs that were completed on November 19 and 20, 2014. Those Offshore Vessel Cleaning Procedures consisted of a checklist for tasks of: JSAs / Safety Meetings, Equipment Set-up, Isolation, Opening Manways, Cleaning (external),[15] Cleaning (internal),[16] Return to Service and Secure Equipment for De-mob; each of which had multiple sub-tasks within it. While the procedures did not specifically identify that these tasks were in a sequential order, the described arrangement was more appropriate for safe work practices than the sequence of job steps in the aforementioned JSAs.

Descriptions of the activities Turnkey crewmembers were doing prior to and during the time of the incident indicated that they were engaged in tasks within both the opening manways and external cleaning descriptions of the Offshore Vessel Cleaning Procedures. Those tasks included ensuring containment when the manway was opened, safely and securely opening the manway, and washing and suctioning liquids and solids using wash water and pumps or vacuums.

While the Turnkey Offshore Vessel Cleaning Procedures contained a general order of job tasks that mitigated some significant hazards early in the cleaning activities, it was contradictory to the JSA used in this particular job. In addition, the Turnkey crewmembers had not fully or safely completed job tasks for either of these cleaning procedures or the JSA. Among others, the Turnkey procedures described important sub-tasks that appeared not to have been specifically completed up to and including the task in which crewmembers appeared to working on at the time of the incident. For

[15] The JSA for cleaning the heater treater did not specifically address external cleaning.
[16] This task would have included confined space entry.

example: isolation,[17] verification of isolation, sampling atmosphere, installing ventilation equipment and/or ventilating.

***Energy Isolation / Lockout Tagout**:*

The American Petroleum Institute (API) Recommended Practice (RP) 14 F[18] described the use of LOTO Procedures to guard against electrical shock, injury from movement, or injury from power-driven equipment; and individual facilities should develop proper LOTO procedures so consideration could be given to local needs to assure the procedures are compatible with each facility's operations.

Fieldwood, Island and Turnkey all had policies that addressed energy isolation and/or LOTO, but it is the BSEE Panel's understanding that personnel were to follow Fieldwood's policy. Fieldwood's Energy Isolation (LOTO) Policy did not specifically define isolation, but their Confined Space Entry Policy defined it as the process by which a permit space was removed from service and completely protected against the release of energy and material into the space. Energy isolation could be accomplished through LOTO of all forms of energy. Lockout could then be performed through the placement of a lockout device, such as a lock, on an energy isolating device[19] to ensure that such device and the equipment being controlled could not be operated until the lockout device was removed.

The Operating and Installation for Apache Corporation[20] WD 105 E Electrostatic Heater Treater (Heater Treater Manual) incorporated procedures for manual shutdown of the heater treater, to include, among other things, turning the manual circuit breaker to the 15 KVA transformer (heater treater breaker) to the 'Off' position. The manual also contained instructions for installation, which included an electrical check that underscored the importance of turning off the power supply to the transformer. The procedure described, among other things, that there should be no explosive gases in or around the vessel; and the transformer circuit breaker should be in the OFF position and locked. The manual emphasized that the circuit breaker MUST remain in the… OFF position… until the electrodes were covered with oil. This description highlighted the need to de-energize the power supply to the heater treater when the oil level was lowered below the grid, as it had prior to the incident, since the heater treater grid was designed to operate when immersed in oil. The Transformer Product Manual also emphasized that all maintenance work must be performed with power "Off."

A third-party examination determined that the heater treater breaker and the disconnect switch were manually-operated only, with no means for remote control operation of either to automatically interrupt power to the electrostatic grid. Further, if both the heater treater breaker and transformer disconnect switches were turned on, then it could be expected that the electrostatic grid located inside the heater treater vessel would be energized as designed. If either the heater treater breaker or the disconnect switch were turned off, then the energy to the electrostatic grid would likely have been interrupted.

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[17] Although the procedures described isolation and verification of isolation, they did not state energy or electricity isolation or LOTO, or a task that would mitigate hazards associated with a potential chemical reaction.

[18] Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations.

[19] A mechanical device that physically prevents the transmission or release of energy, including but not limited to a manually operated electrical circuit breaker or a disconnect switch.

[20] Prior operator of the WD 105 E platform.

Personnel described, in general, that it was the operator or operator representative's responsibility to do energy isolation and LOTO to prepare the equipment that would be worked on, such as a heater treater. Turnkey crewmembers indicated that they did not do the isolation themselves, and they largely described that they just cleaned the tanks.

As previously described, BSEE Investigators observed on November 21, 2014, that the heater treater breaker handle in the MCC building was in the 'On' position (Figure 19). A lock had been fed through an opening on the heater treater breaker handle only, was clasped and was affixed with a tag. The design of this breaker handle only allowed it to be locked in the 'Off' position. Thus, the lock was not installed in a manner to that would hold it in a "safe" or "off" position as was required in Turnkey and Fieldwood's Energy Isolation Policies. The tag indicated 'Danger', Equipment Locked Out By: [the Island Acting PIC]; Time: 7am; and Date: 11-19-14; but it did not indicate the purpose for energy isolation, which Fieldwood's Energy Isolation Policy stated should be done.

The heater treater breaker controlled the electrical power supply to the transformer located on top of the WD 105 E heater treater, which powered the electrical grid inside the coalescing section of the heater treater outside of where Turnkey employees were working at the time of the incident. The heater treater breaker handle was labeled such that it could have been in one of three positions through a horizontal range of motion: On (left), Trip (middle) or Off (right). If the breaker were to be in the 'Off' position, then the circuit of electricity would not have reached the transformer; as also would likely have been true if in the 'Trip' position. However, BSEE Investigators observed the handle in the 'On' position when observed on November 21, 2014.

Figure 19 - Heater treater breaker 'On' (November 21, 2014)

To properly lock out the heater treater breaker, prior to affixing a lock to the breaker handle, the handle would first be pushed all the way to the right, or 'Off,' position on the panel wall, in which the color Green would be outward facing.[21] The lock would then be fed through the openings on the breaker handle as well as the breaker panel wall, and then clasped (Figure 20).

[21] When in the 'On' position, the breaker was to the left of the panel wall and with the color Red outward facing (Figure 19).

Figure 20 - Heater treater breaker 'Off' (November 21, 2014) (Name Redacted by BSEE)

In addition to the heater treater breaker inside the MCC building, there was a disconnect switch systematically located along the electrical circuit between the heater treater breaker in the MCC building and the heater treater grid. This 'On/Off' switch was physically located directly to the left of the manway (if facing the manway); and was observed on November 21, 2014 to still be in the 'On' position (see Figure 12), with no locks or tags affixed to it. The BSEE Panel found no indication that anyone involved in the preparation for, or activities of, cleaning the heater treater turned this switch 'Off.' In addition, some platform personnel appeared not to fully understand the function of this switch.

BSEE Investigators also found notes in an 'Electrical Lockout Tag Book' located in the MCC building, which indicated LOTO had occurred for the 'Treater NBK-600 & Blower B-602'[22] at 7:00 a.m. on November 19, 2014; due to 'Cleaning crew on vessel.' The entry also described specific numbers for the keys used; as it was Fieldwood's Energy Isolation Policy that the key to each lock must be specific to that lock exclusively, and must be under the sole control of the authorized employee who applied the lock while the lock was in place.[23]

Additionally, a Fieldwood Energy Isolation Permit, dated November 19, 2014 at 7:00 a.m., and signed by the Island Acting PIC, indicated that Energy Isolation (LO/TO) and Process Equipment / Piping Isolation had been performed for the 'Treater NBK 600 – Grid' and 'Blower B-602.' The reason for isolation was for 'Cleaning out Treater;' and the energy to be controlled was identified as electrical and mechanical. It included a checklist to signify the consideration or completion of each item. While many these items were checked, they were not all effectively accomplished when observed by BSEE Investigators on November 21, 2014, to include: all equipment requiring isolation has been identified; all energy sources have been identified and isolated; all locks and/or tags have been applied as per the requirements of Fieldwood's Energy Isolation Policy; all vessel/piping isolation procedures followed as per requirements of Fieldwood's Process Equipment and Piping Isolation Procedures; all equipment isolation tested, verified to zero energy state; and permit information has been documented in the Lockout/Tagout Log Sheet.

The Island Acting PIC also performed energy isolation for the heater treater blower motor breaker (Figure 21), which was isolated correctly. This breaker was also in the MCC building, but with a

[22] A list maintained by the Acting PIC of valve closures and isolations also showed notes indicating LOTO for the treater grid and blower. On November 21, 2014, BSEE Investigators also observed the breaker in the MCC building for the combustion blower motor was properly locked in the 'Off' position, with a tag indicating it was done by the Acting PIC.

[23] Fieldwood's Energy Isolation Policy also described that for long-term isolation, the PIC would maintain the operational lock keys. As previously mentioned, the Island Acting PIC was observed with the key in his pocket on November 21, 2014.

vertical handle.

Figure 21 - Blower Motor on November 21, 2014 (Name Redacted by BSEE)

The BSEE Panel reviewed all of the Energy Isolation Permits for the WD 105 E from January 1, 2013 to the date of the incident and found that none were completed by the Island Acting PIC, with the exception of the one completed on November 19, 2014, nor was his name identified on any WD 105 E Fieldwood Energy Isolation (Lockout / Tagout) Log Sheets.[24]

In addition, WD 105 E Fieldwood Energy Isolation (Lockout / Tagout) Log Sheets[25] did not show any energy isolation of the heater treater or its components in November 2014. The last LOTO documented on these sheets prior to the incident occurred on October 20, 2014; despite that energy isolation should likely have occurred at least when the blower motor was replaced on or about November 15, 2014.

Additionally, documentation showed that at least one Fieldwood contracted electrician was on the WD 105 E platform from approximately November 12, 2014 until departing on or about November 18, 2014.[26] They assisted with operations and worked on other items to include the heater treater blower motor; but the Island Acting PIC indicated he performed the isolation of the heater treater for the cleaning activities himself.[27]

[24] However, notes in an Electrical Lockout Tag Book may have indicated he was involved in a previous lockout of the blower motor in January 2014.

[25] Through discussions about isolation and LOTO procedures with platform personnel and documentation for those activities, it appeared that B-Hitch personnel at the WD 105 E primarily used the Energy Isolation (Lockout/Tagout) Log Sheets and the A-Hitch primarily used the Electrical Lockout Tag Book. This showed a lack of consistency for the documentation of energy isolation during shift or personnel changes, which could negatively impact personnel's knowledge of existing lockout tagout devices on the facility when shift changes occur.

[26] Fieldwood reported formerly housing an electrician at the WD 105 E, but due to resource limitations they began housing them at various field locations to be called upon to perform electrical activities when needed. Different Fieldwood personnel indicated this change occurred between a few months to a few years prior to the incident.

[27] The activity of performing energy isolation of the heater treater breaker did not require an electrician, and some personnel indicated that Fieldwood's Energy Isolation / LOTO policy should have been sufficient for adequately completing

Descriptions and documentation of the actions and attempted actions to isolate energy from the heater treater transformer appeared to show that the Island Acting PIC had some knowledge of the type and magnitude of the energy, the hazards of the energy to be controlled, and the method or means to control the energy (as required by Fieldwood's policy before turning off a machine or equipment). In addition, the Island Acting PIC had received LOTO training and personnel expressed confidence that he had done LOTO before based on his years of experience; although less certain of whether he could have done it for heater treaters. However, energy isolation / LOTO of the heater treater had not been completed successfully when observed by BSEE on November 21, 2014.

Process Piping Isolation:

Interviews and documentation described that the WD 105 E was shut-in prior to the start of Turnkey's cleaning activities. There was therefore no indication of additional inflow of oil or gas production to the platform after this point.[28]

Nonetheless, Fieldwood had Process Equipment and Piping Isolation Procedures to ensure piping was isolated when performing process equipment repair, service or maintenance activities (as well as for confined space entry); such as that on the heater treater. This isolation was to protect from unintended releases of potentially hazardous substances or energy that could cause injury to employees, damage to property or the environment. The procedures described options of: double block and bleed,[29] slip blind (skillet) or spectacle blind,[30] and/or blind flange.[31, 32] However, during the onsite investigation on November 21, 2014, BSEE Investigators did not observe any of these isolation methods to the process equipment or piping associated with the heater treater.

Turnkey's Offshore Vessel Cleaning Procedures also described installing slip blinds on inlet and outlet piping; as well as signing off on the list that documented this work. The BSEE Panel did not receive any indication that slip blinds were installed or that Turnkey personnel signed any such list.

In addition, the Heater Treater Manual incorporated procedures for manual shutdown of the heater treater, to include process piping, such as: closing inlet and outlet ball valves, and if the shutdown was for an extended period of time, to shutdown the chemical injection pump.

Interviews indicated that the fuel gas source was closed by platform personnel prior to the incident (as seen in Figure 22), and that the closure of the gas source was communicated to the Turnkey crew. Interviews and documentation also identified valves that were closed, which included some water and oil outlets from other equipment in the oil handling system upstream of the heater

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the isolation.

[28] The heater treater was still believed to contain residual chemicals, hydrocarbons and hydrocarbon vapors.

[29] The closure of a line, duct, or pipe by closing and locking and tagging two in-line valves and by opening and locking and tagging a drain or vent valve in the line between the two closed valves.

[30] A solid plate that completely covers the bore and that is capable of withstanding the maximum pressure of the pipe, line, or duct with no leakage beyond the plate.

[31] A machined flange designed to match the size and rating of the corresponding flange which it is isolating.

[32] The procedures indicated that failure to use skillets/blinds may result in a hazardous atmosphere spreading to an undesired and unexpected location or equipment.

treater, make up gas, and incoming and departing shutdown valves; as well as chemical pumps associated with the oil handling system. It was also reported that operators were asked to put red flagging tape on any valve they closed so when the platform came back online everyone was aware they had been closed.

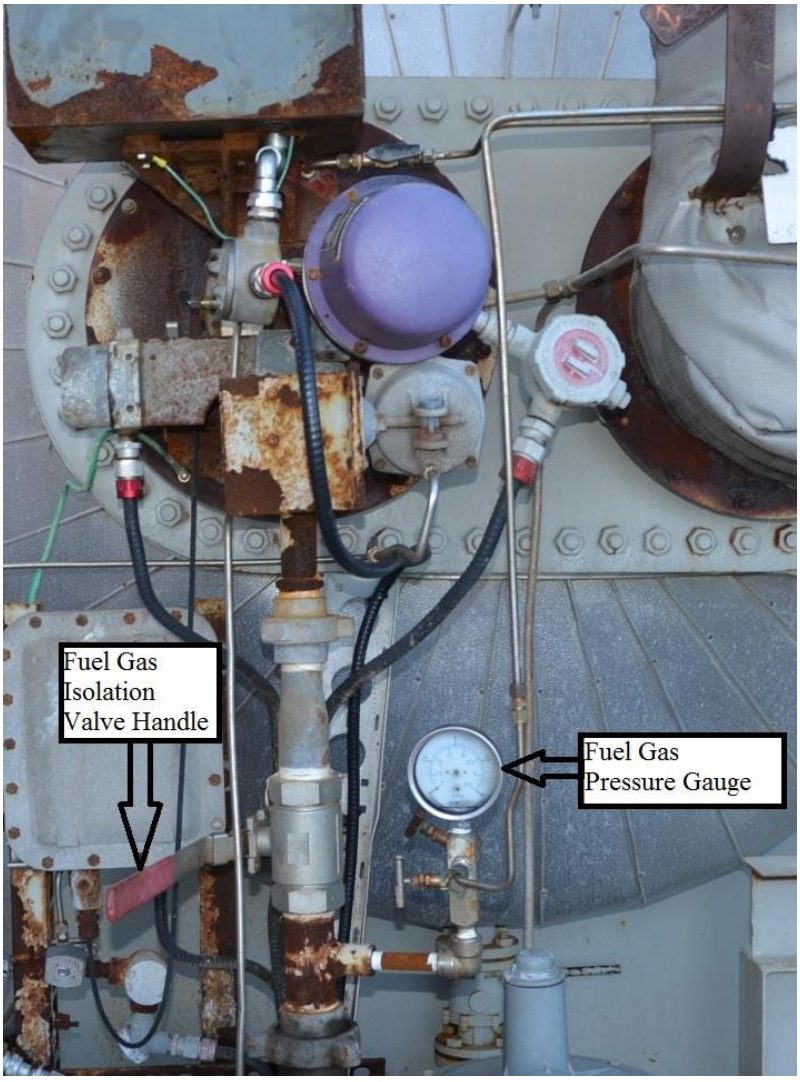

Figure 22 - Burner Section and Fuel Gas Valve (November 21, 2014)

Discussions with Turnkey crewmembers indicated that they were generally not aware of any valves closed, skillets installed or whether other process piping isolation for the heater treater did or did not occur, except for one crewmember that said the Turnkey Supervisor told him everything was skilleted. The same crewmember said it was the operator or construction crew's job to check and/or install skillets before they began their work, which appeared to be the general assumption from other crewmembers as well.

BSEE Investigators observed the fuel gas isolation valve, among others, closed upon their onsite investigation on November 21, 2014. However, they did not see red flagging tape, locks or tags on any of the valves that had been closed.

BSEE Investigators observed that the oil outlet valve from the low pressure separator (which was upstream of the heater treater) had been closed. However, all of the oil and gas inlet isolation valves on the heater treater were not closed, which would have provided additional isolation of the process equipment and piping of the heater treater.

In addition, the pressure gauge associated with the main fuel gas piping was observed as without an attached needle (Figure 23).

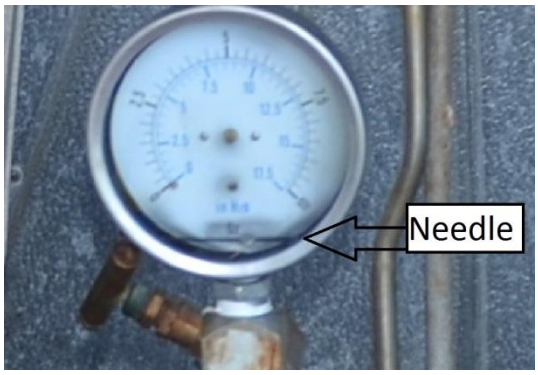

Figure 23 - Main Fuel Gas Gauge (November 21, 2014)

Verification of Isolation:

The BSEE Panel found that multiple opportunities existed to remind personnel of the importance of, and provision for, verification of energy isolation, to include: Fieldwood, Island and Turnkey policies and procedures, the JSA, platform rounds, group LOTO, the Energy Isolation Permit, and other personnel observing the isolation location, among others.

Fieldwood's, Island's and Turnkey's Energy Isolation or LOTO policies indicated that prior to starting work on machines or equipment that have been locked out or tagged out, the authorized employee shall verify that isolation and de-energization of the machine or equipment have been accomplished. Turnkey's Offshore Vessel Cleaning Procedures also indicated that prior to opening manways, they should verify with facility personnel that equipment was isolated and de-pressurized; to include verifying that isolation valves were LOTO with Turnkey locks.

Additionally, although the job step for Isolation Procedures was not identified on the JSA for heater treater cleaning until after opening the manway, controlling fluids and ventilating, the safety and environmental hazard controls for this step mentioned multiple times the need for verifying energy and process piping isolation, using language that included: "verify," "ensure," "double-check," and "never make any assumptions." The JSA indicated that personnel should verify for oneself that there was no energy present prior to performing work. However, this differed from the Turnkey Offshore Vessel Cleaning Procedures, which explained that Turnkey crewmembers should verify with facility personnel that equipment was isolated and de-pressurized.

The Island Acting PIC said he asked operators to make rounds and check in with the cleaning crew periodically. In doing so, the Island Lead Operator checked the heater treater while the Turnkey crew was working on it to make sure nothing was missed, and identified that the blanket / makeup gas valve had not been closed and he closed it; which added additional isolation. However, there was no indication that any operators or Turnkey crewmembers adequately verified isolation of the electrical

equipment associated with the heater treater.

Both Turnkey's and Fieldwood's policies identified a procedure for group lockout or tagout, in which the Turnkey Supervisor and Island Acting PIC could have each affixed a personal lockout or tagout device to the heater treater breaker and/or disconnect switch, which would afford all involved employees a level of protection equivalent to that provided by the implementation of a personal lockout or tagout device. However, there was no indication that group lockout occurred, or that Turnkey locks were used at all for energy or process equipment and piping isolation.

Further, the Energy Isolation Permit for cleaning out the heater treater provided another opportunity for verification, by having designated areas for two approval signatures: for the Immediate Supervisor of Job/Task, and the Facility PIC or Consultant.[33] This form appeared to provide a method for at least two individuals to verify that energy isolation had occurred; however, on this particular permit an opportunity for verification of the energy isolation was missed when the Island Acting PIC printed and signed his name in both of these areas.[34]

As the PIC and Supervisor of the Job/Task of cleaning the heater treater, respectively, the BSEE Panel generally interpreted that the Turnkey Supervisor and the Island Acting PIC would have been considered authorized employees for energy isolation; although anyone on the platform could have checked to see if it had occurred. However, it was reported that the Turnkey Supervisor did not walk down with the Island Acting PIC when he did valve LOTO; and there was no indication that anyone adequately verified that energy isolation, LOTO and/or de-energization was accomplished. Instead, it appeared that personnel involved in the cleaning were either unknowing of the hazards or otherwise assumed that all isolation had occurred based on their prior experiences and communication from platform personnel that isolation of the heater treater had occurred.

Personnel Knowledge of the Hazards of an Electrostatic Heater Treater:

BSEE's SEMS regulations require operators to establish and implement safe work practices designed to minimize the risks associated with operations, maintenance, modification activities, and the handling of materials and substances that could affect safety or impact the environment. These practices include procedures and verification that contractor personnel understand and can perform their assigned duties for activities such as maintenance and specialty work, among others. Under the same regulation, operators are required to inform contractors of any known hazards at the facility they are working on, including but not limited to the potential for fires and explosions. However, documentation and interviews with platform personnel and the crew involved with cleaning the heater treater in November 2014 indicated that personnel working on the WD 105 E heater treater may not have adequately understood the risks associated with an electrostatic heater treater.

One example of this was in the JSAs that were completed for cleaning the dry oil tank and the

[33] The signature areas for these two roles were completed separately by the Turnkey Supervisor and Acting PIC, respectively, on the JSAs for cleaning the dry oil tank and heater treater.

[34] A document review of other energy isolation permits identified that some were only signed by one person on the WD 105 E; which the PICs explained they might do if they were the person who performed the isolation. But in normal circumstances someone else would do the LOTO and they would sign after them.

heater treater on the WD 105 E,[35] which did not specifically mention the vessel for which each job was intended or the appropriate hazards (electricity), permits required (energy isolation / LOTO), job steps and hazards controls for each vessel; despite that an electrostatic heater treater had significant fired and electrical components that were not present in a dry oil tank. Also absent from the JSA was an attempt to address other potential ignition sources, such as a chemical reaction or possibly the fire / burner element of the heater treater.

Additionally, although hazards and hazard controls were identified in the seventh sequential job step of the JSAs for Isolation Procedures, none of the Turnkey crewmembers indicated that these items were specifically mentioned when discussing the JSA, and instead recalled being told to watch out for slips/trips/falls; discussing confined space entry and checking for gas; and hearing that the vessel was safe to work on.

The BSEE Panel and Investigators addressed this topic when it spoke with the surviving Turnkey crewmembers who worked on the WD 105 E electrostatic heater treater, whom Fieldwood reported verifying as properly trained. In general, these interviews identified a lack of awareness or familiarity with the heater treater's internal equipment, including the electrical grid located only inches inside the manway opening; and that the Turnkey crewmembers had minimal experience ever working on heater treaters, let alone electrostatic heater treaters. Instead, the Turnkey crewmembers assumed the Turnkey Supervisor had worked on many heater treaters and knew about those things, and they mostly relied on the operators to get the equipment ready and safe for them to work on while they mainly just focused on the cleaning aspect of the vessel.

The Lead and A-Level Production Operators on the WD 105 E needed to meet Fieldwood's GOM On-Site Contractors Training Matrix requirements, which included piping and vessel isolation procedures and an offshore safety awareness training that included, among others, electrical safety, LOTO, permitting and JSAs. Additionally, Fieldwood personnel expressed confidence that their operators knew how the heater treater operated and how the grid worked through their experience, training, initial orientation, no previous issues and platform operating procedures; although they could not recall specifically speaking with them about how the grid worked.

Island, which had three contract operators on-site at the time of the incident, including the Island Acting PIC, gave its employees site specific operator assessments to ensure operator knowledge of assigned work locations as per BSEE Subpart S requirements. All three of these evaluations were completed, and each operator received the highest rating for each topic in the sections for Treaters and Fired Vessels. However, none of the topics in either of those sections referenced anything about the transformer, grid or any electrical component to the heater treater at the WD 105 E; nor did it specifically reference any topics relevant to the coalescing functions of the heater treater or safety devices in that section of the vessel.

In addition, documentation and conversations with platform personnel provided inconsistent information about certain operating parameters, specific written procedures for shutting off power and/or isolating a vessel like the heater treater. However, most platform personnel appeared aware that the heater treater had electrical components. Largely, personnel indicated that following

[35] A similar lack of attention to energy or electricity was observed on the related Confined Space Entry Forms.

Fieldwood's LOTO / energy isolation procedures should have been sufficient to shut down the heater treater to do any type of maintenance, that the documentation and process was self-explanatory, and/or the PICs were trained on LOTO.

While documentation and interviews indicated that platform personnel's and/or Turnkey crewmembers' knowledge of the electrical equipment associated with the heater treater may have been limited or unassessed, various actions and attempted actions surrounding the preparation for heater treater cleaning activities in November 2014 by the Island Acting PIC (an authorized employee) appeared to show that he was aware of the electrical hazards associated with the heater treater and attempted to perform some isolations.

Operating Procedures and Heater Treater Manual:

BSEE's SEMS requirements describe, among other things, that operators must develop and implement written operating procedures that provide instructions for conducting safe and environmentally sound activities involved in each operation addressed in a SEMS program; must address impacts to the human and marine environment identified through a hazards analysis; and those procedures must be accessible to all employees involved in the operations. Fieldwood's Operating Procedures for the WD 105 E platform (Operating Procedures) provided the general guidelines for the Pre-Startup, Start-up, Normal Operation, Normal Shutdown, and Emergency Shutdown of equipment on the platform.

The WD 105 E Operating Procedures identified the heater treater as a component in the primary oil handling system, for which the shut-down procedures required a process shut-in and referenced a facility shutdown. The procedures described multiple steps for shutting down the burner and fuel gas components/piping on the fired or burner sections of the vessel; as well as describing if a shut-down was performed as preparation for maintenance work, or if the cause of the shutdown required corrective action/repair, then to initiate Fieldwood's LOTO Procedures.

While Fieldwood's Energy Isolation / LOTO policy addressed procedures for energy isolation, nowhere in the WD 105 E Operating Procedures did it mention a coalescing section or a power supply, transformer, grid or other electrical components associated with the heater treater that would need to be shut down, isolated, LOTO or de-energized. In addition, the WD 105 E Operating Procedures did not mention where any electrical shutdown devices associated with the heater treater were located and what steps should be taken to shut down, isolate, LOTO or de-energize them. Therefore, someone unfamiliar with the heater treater's electrostatic components might not know to initiate the energy isolation / LOTO procedures or how to shut down, isolate, LOTO or de-energize equipment for relevant hazards from only the WD 105 E Operating Procedures.

The Heater Treater Manual provided detailed descriptions of both the burner and coalescing sections of the heater treater; including an extensive description of the grid and electrostatic field within the coalescing section, as well as the transformer. This incorporated, among other things, procedures for the manual shutdown at the treater unit that included turning off the breaker.

During the initial visit to the platform on November 21, 2014, BSEE Investigators requested any pertinent Operating Procedures and manuals, but personnel present could not provide the requested documents. Individuals that worked regularly on the facility were unable to provide them and instead

indicated that they were in Fieldwood's document storage system; which some personnel appeared not to know how to access. Additionally, in subsequent interviews with employees that worked regularly on or had oversight of the WD 105 E, those employees provided inconsistent responses about what maintenance might need to be done on the heater treater and where certain procedures regarding operations of the heater treater may have been physically located on the facility.

Level Controllers and Level Safety Devices:

Operators could maintain fluid levels inside the heater treater using level controllers that controlled liquid level inside the process vessel. The heater treater grid was designed to operate fully immersed in oil, so it was important to maintain this fluid level to protect a potentially exposed grid from possible arcing or grounding. Thus, the coalescing section of the heater treater was designed for a level safety low (LSL) device to protect the grid by alarming the operators and shutting down pertinent operations if the fluid level dropped below a designated point. The LSL on the coalescing section of the heater treater was an external, cage-mounted, liquid level switch that could operate shutdown valves and alarm systems when liquid in the vessel reached a predetermined level.

A third party expert reported that according to the supplier drawings and Heater Treater Manual, the LSL-601 should alert the operator that the level of oil in the vessel was below the desired level and the electric grid section was exposed. Additionally, the Heater Treater Manual indicated that the LSL-601 should be a shutdown for the main power supply to the 15 KVA/XFMR [heater treater breaker].

During the post-incident investigation, third-party experts found the as-is condition of LSL-601 to be in a tripped position, which was the correct state since the vessel had been mostly drained. They also confirmed this during a static state inspection of the forced draft treater control panel and review of the electrostatic heater treater transformer controls. The third-party experts then tested LSL-601 and concluded that it operated and functioned as designed.

However, the WD 105 E Safe Analysis Function Evaluation (SAFE) Chart revealed that when activated, LSL-601 was not a safety device that would shut down the main power supply to the 15 KVA/XFMR.[36] Further review of the heater treater's Programmable Logic Controller (PLC),[37] identified that a PLC response upon activation of LSL-601 was an audible alarm and a lamp;[38] and not a shutdown of power to the 15 KVA/XFMR or any other means to interrupt power to the grid as the Heater Treater Manual described that it should do.

A third-party technician confirmed that the heater treater's external low level switch did not turn off the transformer. He indicated that when it tripped it would shut-in the platform, but if no one turned the breaker for the transformer off, the transformer would have stayed on and would have damaged the entrance bushing and/or the Teflon insulators and whatever parts were no longer

[36] According to the SAFE Chart, LSL-601 did shut-in/off, among others: production; compressors; gas lift; blanket gas to the heater treater; burner fuel gas; the forced draft blower; wet and dry oil pumps; and indicate and alarm.
[37] A digital controller programmed to automate the function of devices and processes.
[38] During their onsite investigation on November 21, 2014, BSEE Investigators observed that the annunciator lamp for Low Oil Level Coalescing Section [LSL]-601 on the heater treater control panel was not lit (Figure 33). It remains uncertain exactly why this lamp was unlit. The only lamp observed as lit was for Fuel Gas Low Pressure PAL-603.

immersed in oil due to the low level; as discussed further in later sections of this report.

API RP 14C indicated that LSL sensors on fired components should shut off fuel supply and inflow of combustible fluids; and on exhaust heated components should divert or shut off the fuel or heat source. The SAFE Chart indicated that these actions would have occurred on the WD 105 E. Neither BSEE regulations nor API standards or recommended practices researched by the BSEE Panel identified a requirement for LSL devices to shut down the main power supply to a heater treater transformer or electrical grid.

Internal Grounding Float:

A third-party expert described that it was common for the grid section in an electrostatic heater treater to include an internal float, separate from an LSL, that shunt grounded, or short-circuited, across the grid when the level in the vessel dropped below the top of the grid. This would prevent it from being energized when not covered by oil, which could damage the grid plates and hangers. It was identified that while the installation of the grid was pursuant to the design drawings, an internal grounding float was not installed.

Fieldwood also provided input regarding the topic of internal grounding floats, which they described was not installed in the WD 105 E heater treater by the manufacturer nor was it equipped with one when Fieldwood acquired the WD 105 E facility. They explained that a grounding float / float switch used in some heater treaters was designed to protect the vessel from internal damage, but that it was not a BSEE or API recognized safety device. They explained that the lack of requirement for this component was likely due to the inability to inspect or test the device without isolating, draining, and cleaning the vessel, which prevented ensuring its functionality during routine operations.

While API RP 14 C may not recognize an internal ground float as a required safety device, API RP 14 F indicated that "oil treaters with electric grids… should be equipped with a device (such as a float switch) to de-energize and ground the grid before the liquid level falls below the electrical equipment." Following this recommendation in API RP 14 F, for an internal grounding float to de-energize an electrostatic grid when drained, could act as a safeguard to potentially prevent an ignition source from electrical energy should the equipment not be manually isolated from energy.

Condition of Electrical Components:

The WD 105 E heater treater grid inside the coalescing section of the heater treater (Figure 24) received electrical energy through a high voltage entrance bushing that originated from the high voltage secondary of the transformer and entered the heater treater from the top of the vessel.[39] The high voltage entrance bushing, as well as six hangers that supported the two energized rails that spanned the length of the coalescing section of the heater treater and which transferred electricity to the charged grid plates, were coated with Teflon to insulate them from surrounding metals and

[39] The third-party technician that removed the grid from the heater treater during the post-incident investigation identified that only 22 grid plates were installed in the heater treater, while the drawing identified 23. However, he explained that it was not unusual for the drawing to be different, and that it did not make a difference. Post-incident investigation pictures indicated that the grid plate closest to the manway opening was a ground plate; while the drawings indicated that an energized plate would be closest to the manway opening.

prevent potential arcing.

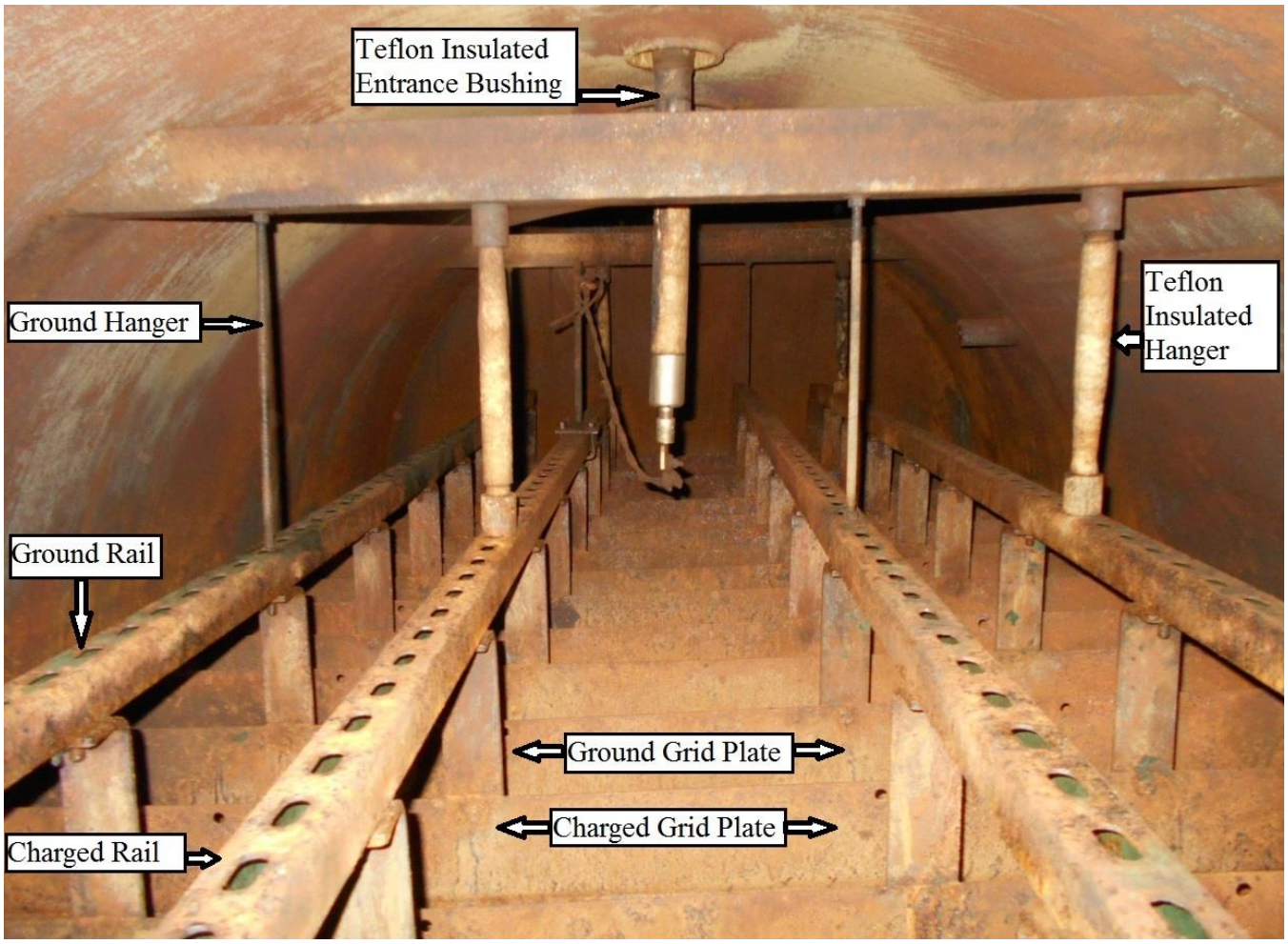

Figure 24 - Internal View of Grid (April 25, 2015)

Upon a post-incident evaluation of the grid in April 2015, a third-party technician identified normal signs of arcing on four of the Teflon insulators, and tracking (a failure mechanism for insulation breakdown) on the entrance bushing and two of the Teflon insulators (Figures 25, 26 and 27). He indicated that the metal grids and hardware were found to be in good condition.

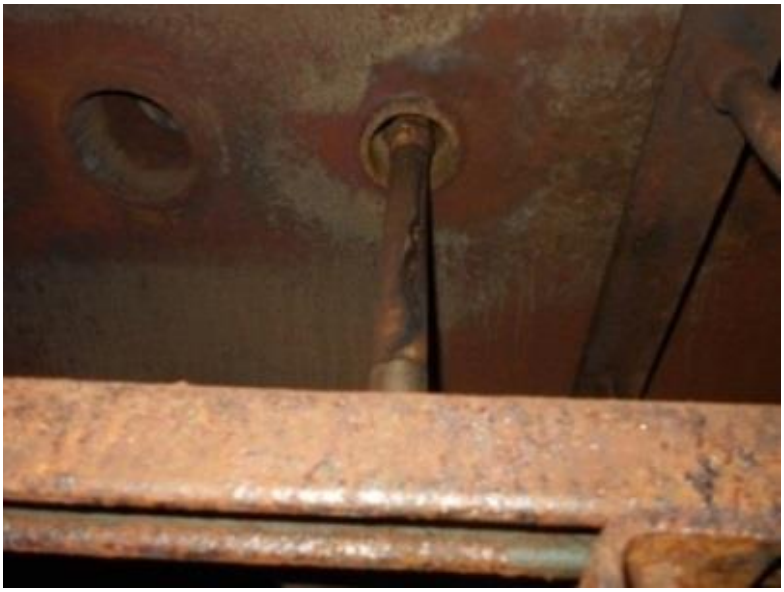

Figure 25 - Internal View of High Voltage Entrance Bushing (April 25, 2015)

Figure 26 - Insulated Hanger #1 with arcing evident (April 27, 2015)

Figure 27 - Insulated Hanger #5 with arcing evident (April 27, 2015)

The third-party technician concluded that the damage to the entrance bushing and Teflon insulators were signs of arcing, which normally happen over a period of time but could happen in a matter of hours if the transformer was left on and the crude oil drained out of the vessel. Under normal conditions, the grid side of the treater was fluid packed to insulate this equipment. However, if the level dropped and exposed the bushing and insulators to a vapor phase, the electricity would run up and jump to ground. Every time it did that, it took a piece of Teflon or metal with it. Without knowing if the grids were working before the shut-in, he reported that it would be hard to determine exactly when the entrance bushing and Teflon insulators started arcing.

The BSEE Panel followed up on information that WD 105 E operators had 'pulled bottoms' on or 'pumped down' fluids in the oil handling system, including the heater treater, at various points in time, including in days leading up to the incident. This topic was addressed with the normal Fieldwood PICs, who described these processes as either draining water or pumping fluids from the tanks or vessels to improve oil quality. However, they indicated that they did not turn off power to the heater treater transformer when they performed these operations.

As the electrostatic grid inside the heater treater was designed to function fully immersed in fluid, any action that could have temporarily lowered the fluid level and exposed the grid to a non-liquid atmosphere while energized could have made the bushing and hanger insulations vulnerable to damage from possible arcing, tracking or otherwise affecting their condition. The condition of this equipment may have occurred over weeks, months or years when the level dropped and the grid remained 'On,' or when the heater treater was drained in the days and hours leading up to, during, or after the incident. However, the third-party technician initially said he did not think the damage to the hangers happened overnight, but rather over a longer period of time. As such, the identified condition of the electrical equipment, if in such a condition at the time of the explosion, may have left it susceptible to have been an ignition source if the heater treater was left energized and drained.

***Ventilation**:*

According to Turnkey's Offshore Vessel Cleaning Procedures, personnel should install ventilation equipment on a vessel and ventilate after opening the manway and sampling the atmosphere, and before cleaning externally. Ventilation was also described in the heater treater JSA on November 20, 2014, as a job step to be performed after opening the manway and before retrieving an atmosphere reading and cleaning.

Descriptions of Turnkey crewmember activities immediately preceding the incident seemed to indicate they were involved in a combination of tasks for controlling fluid release (a step involved in the task of opening the manway) and external cleaning (washing and suctioning liquids and solids using wash water and pumps or vacuums). While personnel indicated that confined space entry had not yet occurred, they described that it was at least contemplated before and/or during the job activities. For those jobs involving permit-required confined spaces, of which the heater treater would have been, personnel should have eliminated any conditions making it unsafe to remove an entrance cover before the cover was removed (Occupational Safety and Health Standards - 29 CFR 1910.146). Among other methods also discussed in this report, such as for isolation, this would likely have included ventilation methods to eliminate any hazardous atmosphere and testing the atmosphere to ensure safe conditions.

Some crewmembers indicated that installing an air horn for ventilation would have been the next step, followed by taking gas readings; while another Turnkey crewmember said they normally let a vessel air out and ventilate, but that they basically opened up the heater treater and went to work – and he assumed gas readings were already taken. Such gas readings were to ensure that vapors were below the allowable percentage of the lower explosive limit (LEL); which Turnkey's procedures indicated was less than 10%. Regardless, they had opened an oil handling vessel and exposed the internal vessel to oxygen, but had not yet ventilated to eliminate any hazardous atmosphere at the time of the incident.

Some offshore vessel cleaning activities may include a nitrogen purge prior to completing cleaning activities to inert the vessel. However, Fieldwood explained that the heater treater should not have been nitrogen purged before cleaning began, as it would not be industry practice, as evidenced by Turnkey's cleaning procedures and other government confined space entry regulations. They indicated that performing a nitrogen purge would have created an immediately dangerous to life and health (IDLH) environment. They further stated that it would have been Turnkey's determination as to whether conducting a nitrogen purge was necessary before beginning to clean the vessel and, if they deemed it necessary, to perform it since they were the expert in vessel cleaning operations; and Turnkey's decision not to perform a nitrogen purge of the vessel before beginning its cleaning operations was correct.

The importance of ventilation was to remove potentially flammable or combustible vapors (a potential fuel source for an explosion) from the enclosed heater treater; a vessel that was known or should have been known to have formerly and even still contained hydrocarbons and/or chemicals.[40] By installing ventilation equipment on the vessel, such as an air horn, it could have served as a tool to circulate clean air into the space and remove the potentially hazardous vapors. However, the Turnkey crew had not yet completed ventilation of the heater treater.

Hose Water:

Accounts from the three surviving individuals that were present at the heater treater at the time of the incident indicated that the Turnkey Supervisor was holding a water hose. While some descriptions about whether the Turnkey Supervisor was spraying water at the time of the incident differed, the two Turnkey crewmembers that were present indicated observing the Turnkey Supervisor spraying the lip of the hatch at the time of the incident. They both indicated that there was not much water pressure from the hose, as one of them described the pressure on the water hose as 'barely cracked' and like a garden hose. They indicated that the Turnkey Supervisor was not spraying directly inside the vessel. However, they were not sure and did not know if water could have ricocheted into the vessel. The Island Lead Operator said he saw the Turnkey Supervisor with the water hose, but never saw him spray anything inside of the heater treater.

Another Turnkey crewmember, who had gone upstairs a couple of minutes prior to the

[40] Fieldwood indicated that no chemicals were added to or used specifically within the heater treater unit during the weeks leading up to the incident. Rather, some chemicals were added to production upstream from the vessel and which some quantity may have been in the heater treater unit after prior processing of the production. While not prohibited or uncommon in production systems, some of the chemicals had identified hazards of flammable liquid and vapor and/or combustible; at least one of which had a hazard identification which described that its vapor may cause flash fire.

incident, described seeing the Turnkey Supervisor standing at the hatch and using a water hose to wash buildup on the walls inside the heater treater. While this description indicates the Turnkey Supervisor may have sprayed the interior walls of the vessel before the incident, the accounts from those present at the time of the incident indicated that he was not directly doing so at the time of the explosion.

The BSEE Panel did not find definitive physical or testimonial evidence that the introduction of salt water into the vessel caused or contributed to the ignition source. However, it remains possible that if it were introduced in the moments preceding the incident then it could have contributed to the ignition source either independently or in combination with actual or proximate contact to energized electrical equipment, a potential electrical field, through interactions with chemicals inside the vessel, or otherwise creating static electricity. As such, this introduction of salt water was also unable to be definitively eliminated as a possible contributing cause.

Other Potential Ignition Sources:

The BSEE Panel evaluated the potential for other ignition sources that may have been present at the time of the incident; including the possibility that the electrostatic grid was not energized at the time of the incident. Such sources included electrical equipment such as cell phones, flashlights or gas detectors; cigarettes; and an extraneous bar found in the bottom of the heater treater during post-incident cleaning operations.[41] However, there was no available evidence that these items played a role in the incident.

The BSEE Panel also evaluated the composition of the water hose, nozzle and connections identified at the incident scene on November 21, 2014. BSEE Investigators noted finding the ball valve in the 'On' position, the handle lying in another location (Figure 28), and the water supply valve closed at its source.

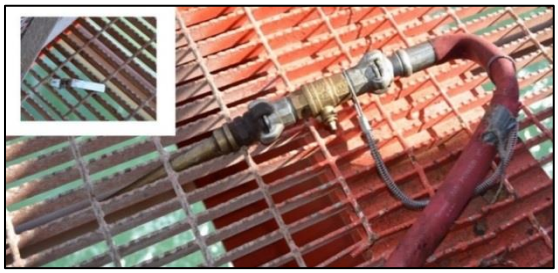

Figure 28 - Hose Nozzle and Handle (November 21, 2014)

Turnkey personnel reported that the nozzles they used were brass to keep them from sparking. However, while the nozzle and ball valve in this assembly did appear to be brass, the connection between the two did not. None of the personnel in the vicinity of the heater treater reported seeing a spark or electrical current that might indicate the assembly to have created the ignition source, and the connection was not reported to have entered the vessel.

The BSEE Panel also reviewed the testimonial and documentary information provided, as well

[41] No experts, technicians or personnel onsite were able to identify the object, its purpose or when it may have entered the vessel.

as input from Fieldwood and the condition in which the BSEE Investigators found the heater treater on November 21, 2014, to evaluate whether the burner or associated components could have contributed to or caused the ignition source of the explosion. Based on the described closure of the fuel gas to the burner, the energy isolation of the blower motor, the state of the vessel, diagnostic information, the design of the fire tube, the shut-in of the platform, the status of safety devices and temperature and pressure readings, there was not sufficient evidence to suggest the burner or burner section was the cause of the ignition source that contributed to the incident. However, the possibility was also not definitively eliminated.

The BSEE Panel also evaluated the potential for an ignition source stemming from the vacuum hose, such as from static electricity. Although the vacuum pump was grounded when BSEE Investigators arrived on November 21, 2014, they identified that the cuttings boxes, rental generator and bucket under the heater treater where the Turnkey crew had been draining and suctioning fluid were not grounded; nor was the vacuum hose itself.

Accounts regarding the status of the vacuum pump and location of the vacuum hose in the minutes leading up to the incident differed among the individuals in the vicinity of the heater treater, ranging from witnessing a hose inside the vessel before the incident, to removing the vacuum hose from the manway to the bucket under the heater treater shortly before the incident, to never having seen the vacuum hose enter the vessel. The vacuum hose was found by BSEE Investigators on November 21, 2014, in the bucket under the middle of the heater treater (Figure 29). In this position, it was not believed to have been a potential source of ignition for inside of the heater treater.

Figure 29 - Vacuum Hose Inside Bucket (November 21, 2014)

Additionally, a third-party expert inspected the electrical installations on the heater treater skid for proper grounding / bonding, and concluded that the main skid and all other electrical equipment on the skid, such as the grid transformer, blower motor, control panel, igniter junction box, and cable tray had proper electrical ground connections. The only issue noted was with the disconnect switch, which did not have an external grounding conductor to positively bond the enclosure to the skid's structural steel.[42]

The BSEE Panel also evaluated the potential for possible ignition from a combination of the hydrocarbons, chemicals and/or water in the heater treater, as certain chemical compositions may

[42] They described that although the disconnect switch enclosure was mechanically fastened with bolts to the steel mounting plate supporting it, this connection was prone to corrode (especially in humid salt-laden offshore atmospheres) which caused a high electrical resistance connection.

lead to an auto-ignition in certain conditions. While the possibility exists that such an ignition could have occurred, the BSEE Panel did not identify direct physical evidence to indicate that one did occur.

While these potential ignition sources were evaluated and not definitively eliminated, other evidence obtained by BSEE Investigators and the Panel in the days and weeks following the incident which are described in this report led the BSEE Panel to conclude that the lack of electrical energy isolation identified by BSEE Investigators on the day after the incident was more likely to have been a probable cause of ignition.

Atmosphere Sampling:

The Turnkey Offshore Vessel Cleaning Procedures described that the atmosphere should be sampled after opening the manway and before ventilation and external or internal cleaning; then continuous monitoring thereafter. Contrarily, the JSA for the November 20, 2014 heater treater cleaning described that this should be done after opening the manway, ventilating and performing isolation procedures, and before cleaning out the vessel. Personnel described that atmosphere samples would be taken by holding a gas detector directly in front of the hatch opening.

The purpose of monitoring the atmosphere in and around the heater treater would be for the crewmembers to identify whether hazardous substances that could cause adverse health effects or a potentially explosive environment were present. Specific monitoring types identified in the Turnkey Offshore Vessel Cleaning Procedures were for oxygen (19.5%-23.5%), lower explosive limit (LEL) (less than 10%) and hydrogen sulfide (zero parts per million). Those procedures indicated that if the atmosphere was outside of Turnkey or customer tolerance, then external washing would be accomplished while under breathing air. The levels for each of those types, and others, could be recorded on Turnkey documentation for confined space entry.

Personnel reported that a gas detector was located in the vicinity of the heater treater during the activities leading up to the incident, either on a rail below and to the side of the heater treater, on the top of the manway hatch or in the Turnkey Supervisor's pocket. However, no reliable information was documented or reported to BSEE to indicate specific atmosphere samples were taken and recorded. Some crewmembers said they had not gotten to the point that they would have specifically taken readings at the time of the incident; while one assumed it had already been done.

Instead, Turnkey crewmembers indicated that the gas detector was 'On' and they believed it therefore would have alarmed in a high-pitched noise if there was a problem with the gas; which they said it did not do. However, the Island Lead Operator, who looked into the heater treater in the moments leading up to the incident (and said he did not recall seeing a gas detector), described smelling hydrocarbons when he looked in; and an internal inspection of the heater treater after the incident showed apparent material still inside the vessel.

On November 21, 2014, BSEE Investigators discovered a gas detector unit at the incident scene. The unit had been separated from its battery, both of which were located on the heater treater skid, but with the gas detector unit to one side of the hatch and the battery to the other (Figure 30). The BSEE investigators collected the two items and retained them for investigative purposes. Also included in the gas detector unit was a media card, on which data usage would be maintained. The gas detector was leased to Turnkey, with the last reliable calibration date of October 31, 2014.

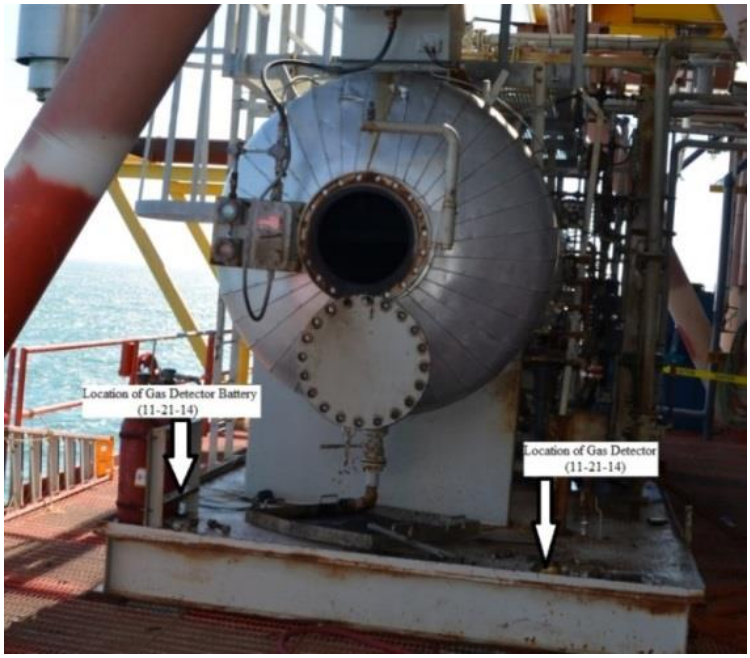

Figure 30 - Gas Detector Unit and Battery Locations (November 21, 2014)

The BSEE Panel attempted to retrieve data from the media card through Department of the Interior resources, as well as through the gas detector manufacturer. However, both attempts to recover data were unsuccessful. The manufacturer believed the reason for the inability to read the data was because of extensive damage to the main unit (Figure 31), as well as physical damage to the card believed to be from an impression in the metal socket of the gas detector unit (Figure 32).


Figure 31 - Gas Detector Front (November 21, 2014)


Figure 32 - Impression in Gas Detector's Media Card Holder (November 21, 2014)

Training:

BSEE's SEMS regulations require that operators establish and implement a training program so that all personnel are trained in accordance with their duties and responsibilities to work safely and are aware of potential environmental impacts.

Fieldwood described themselves as an industry leader in contractor safety management, for which their unique contractor safety management verification process helped to ensure that qualified individuals worked at their facilities and was viewed as the gold standard in the industry. They reported that before contractor personnel were permitted to board any Fieldwood structure, they

must have current and complete compliance with the applicable safety courses and training, and their employer must meet the necessary safety program requirements. They developed a process that utilized contractor management software and an identification scanning system at each shore base, with failure to meet these standards resulting in the person not being permitted to board the helicopter or vessel for travel to and from Fieldwood's platforms.

According to documents provided by Fieldwood, Island received a B-grade in its contractor safety management verification system, and Turnkey received an A-grade; both of which were acceptable for the contractor safety management verification system.

The Island Acting PIC was a Lead Operator with Island, and referred to by some as a Senior Lead Operator. He indicated working on the WD 105 E for about 13 months at the time of the incident, and in the oil and gas industry for approximately 35 years. Personnel described that he had years of experience and knew the platform, had extensive training through Island, had PIC training through Fieldwood and they were confident in his qualifications.

Fieldwood reported that the Island Acting PIC was trained by both Island and Fieldwood as a Lead Operator[43] / PIC, through a training that specifically covered isolation procedures. Fieldwood further indicated that it had complied with regulatory duties under 30 C.F.R. §§ 250.1911, 250.1914 & 250.1915 to ensure that the Island Acting PIC was knowledgeable and experienced through his extensive work experience and his completion of Island and Fieldwood's PIC training programs.

Turnkey personnel indicated that their training was good and adequately prepared them for their work. Additionally, Fieldwood indicated that in compliance with 30 C.F.R. §§ 250.1911 , 250.1914 and 250.1915, they verified through their verification system that the Turnkey personnel assigned to work at the WD 105 E platform were properly trained[44] and properly registered in the system database.

One verification system report from Fieldwood identified all eight Turnkey employees as Tank & Vessel Cleaning / Repair Crew, and none as Supervisor; while another report indicated that two of the eight Turnkey employees on the WD 105 E at the time of the incident had qualifications for activities of Tank & Vessel Cleaning / Repair Supervisor. Although Fieldwood's required qualifications for Tank & Vessel Cleaning / Repair Crew was exactly the same as for Tank & Vessel Cleaning / Repair Supervisor,[45] neither of the employees identified as supervisors on the verification system report were on the four-man crew that worked on the heater treater on November 20, 2014. Both employees described to the BSEE Panel as the Turnkey supervisors for the two anticipated cleaning crews, and who were described

[43] Fieldwood's required training for a Production Operator – Lead, which was the highest level of contract production operator, needed to complete training to include, among others: air monitoring and gas detectors, production safety systems, and piping and vessel isolation procedures; as well as a job specific skills and knowledge verification assessment and a safety awareness training that included, among others, confined space, lockout/tagout, electrical safety, permitting and job safety analysis. Production Operator – A Level had the same training requirements.

[44] Fieldwood's required training for Tank & Vessel Cleaning / Repair Crew and Supervisors included, among others: air monitoring and gas detectors and multiple confined space tasks; as well as a job specific skills and knowledge verification assessment and a safety awareness training that included, among others, confined space, lockout/tagout, electrical safety, permitting and job safety analysis.

[45] According to Turnkey's training matrix had nearly identical training requirements for a Cleaning Technician [crewmember] versus a Superintendent [supervisor].

as Superintendents on Turnkey's project tickets, were indicated as only having the titles of Tank & Vessel Cleaning / Repair Crew in both verification system reports.

Additionally, Turnkey defined their Short Service Employees (SSE) as any employee with less than six months of employment with Turnkey or a current employee who had been in his current position for less than six months. These employees were supposed to be assigned mentors, receive appraisals, host facilities or field supervisors were supposed to be informed of their usage, and they were supposed to be under constant supervision by the supervisor or an employee with more than 12 months experience; and only one SSE was allowed in work crews having fewer than five employees. Fieldwood indicated that they did not have an SSE policy concerning its own employees or the personnel of its contractors assigned to Fieldwood platforms, facilities or other structures.

While the Turnkey Supervisor was described by his coworkers as experienced in cleaning vessels, he appeared to have been an employee of Turnkey for less than six months. The other three Turnkey crewmembers that worked on the crew cleaning the heater treater also reported experience of greater than six months performing offshore cleaning services, but two of them were employed by Turnkey for less than six months at the time of the incident.

Additionally, SSE Mentor Assignment and "SSE" Appraisal forms provided to the BSEE Panel from Fieldwood for all four members of the Turnkey crew working on the heater treater on November 20, 2014, were generally blank or otherwise lacked significant input.

In addition, while Turnkey crewmembers had First Aid / CPR / AED / BBP training, Fieldwood's contractor training matrix did not have this training as a requirement for Tank & Vessel Cleaning / Repair Crew or Tank & Vessel Cleaning / Repair Supervisor.[46] However, due to the hazards associated with the job, cleaning crew personnel were sometimes identified as a part of the rescue in confined space entry and may need to respond to incidents resulting in injuries.

***Heater Treater Control Panel / Programmable Logic Controller (PLC)**:*

The WD 105 E heater treater control system had an annunciator panel located adjacent to the burner section of the vessel that provided visual alarm annunciation via lamps, safety shutdown and control of the heater treater; as well as the PLC. Upon inspection of the panel on November 21, 2014, BSEE Investigators observed one alarm lamp as lit, for: Fuel Gas Low Pressure PAL-603 (Figure 33), before instructing Fieldwood to turn the panel 'Off' for safety reasons.

[46] It was a requirement for A-, B-, C- and Lead Production Operators.

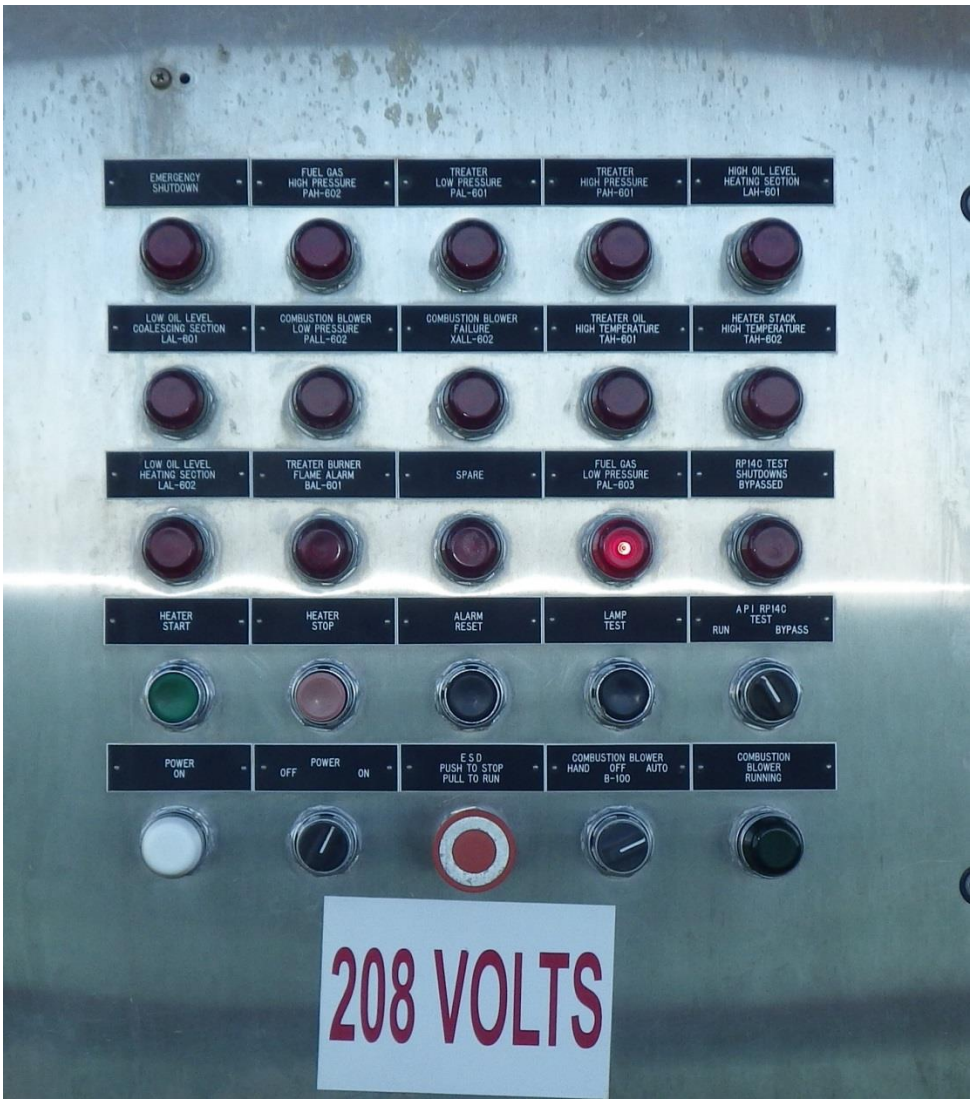

Figure 33 - Annunciator Panel (November 21, 2014)

During the post-incident investigation, third-party experts conducted static state and hardware inspections of the forced draft treater control panel and review of the electrostatic heater treater transformer controls. They identified, among other things, that: the controller was running with no faults or forces, and all other digital input were in the correct static state; and the current drawings did not represent the current state of the forced draft treater control panel. It was also noted that field wiring and components within the control panel were not labeled, and the name plates of some level switches and solenoid valves were either missing or corroded beyond a point that the text could not be read.

Additionally, the third-party experts conducted a PLC code / software verification, and reported that the alarm code was not written with latch type circuits to hold or retain alarms for operator action, but that an alarm could in fact reset on its own if the condition reverted back to a safe condition; which included the Coalescing Section Low Oil Level LSL-601. They continued to explain that the PLC alarms were registered to a single bit and then summarized by the status of another bit, which also did not latch and could in fact reset without operator action if the input signal returned to a safe state. This summary bit was then used in a latch circuit to control the “Burner Run Command.” The

same alarms were then summarized in a non-latching circuit for the master control panel (MCP) common alarm contacts.

The third-party experts identified that the Forced Draft Treater Control Panel functioned solely to control the burner fuel and blower system, and was not connected to the electrostatic bed main circuit breaker or the topsides process control system; and that a connection between the treater control panel could be made using the MCP common alarm contact.

BSEE investigators observed the MCP during their initial onsite investigation on November 21, 2014, which indicated that the Heater Treater Alarm S/D [shutdown], among other safety devices, was in the tripped position, meaning that it had activated.

Transformer (and Indication Light, Voltmeter and Amp meter):

According to the Heater Treater Manual, an externally mounted, oil immersed, high voltage transformer provided the power to the heater treater electrodes associated with the grid. The transformer was equipped with a reactor which provided 100% circuit utilization for continuous power. The transformer also included the conduit assembly, breaker switch, voltmeter and indication light. The manual had no specific description of the purpose or operation of the indication light, except an explanation to evaluate the light's operation in conjunction with troubleshooting issues with the performance of the heater treater.

The BSEE Panel sought information about the status of the transformer indication light from the platform PICs, Field Foreman and contract operators on the WD 105 E. They generally indicated that under normal operations, if the light was 'On' then everything was good with the heater treater's coalescing section. However, it was widely reported that prior to the incident the light was dim or otherwise not consistently lit; and at least two operators, including the Island Acting PIC, described that they could never recall seeing the indication light 'On.'[47]

None of the Turnkey crewmembers working on the heater treater on November 20, 2014, could recall whether the indication light was on or off prior to the incident; nor did they recall looking at the volt and amp meters located next to the heater treater hatch. However, the Fieldwood A-Hitch Field Foreman indicated that when he arrived on the platform not long after the incident on November 20, 2014, the indication light was 'Off,' the disconnect switch next to the manway was 'On', and the volt/amp meters both read zero.

Platform personnel provided possible reasons for the described inconsistent light status, such that it could be if the water level or BS&W was too high, there was water on the grid plates that would shut it down, or there was a pad of paraffin or bunched up chemicals and emulsified oil. The Fieldwood PICs reported that to their knowledge, the water and oil levels were good and the grid was working properly prior to departing the facility for the last time prior to the incident; despite that they both described that the indication light was not lit as it should have been.

[47] The light was 'Off' when BSEE Investigators observed the incident scene on November 21, 2014, before the heater treater breaker was turned off. The bulb was tested during the post-incident investigation, and determined to be operable.

A third-party technician also evaluated operator recollections of the light on the transformer being on, dim or off before the platform was shut-in. He explained that when the light on the transformer was 'On,' the grids were working; and when the light went dim or turned 'Off,' the grids were arcing off or grounded out. He further described that usually when the light went dim the interface level was too close to the grids or there was an emulsion layer that was more conductive than the oil. He related that as the grids started arcing off the light would go dim, and if it went all of the way out then the energized grid was grounded out; which would draw full amps and the output voltage on the tertiary windings would drop down to near zero volts.[48]

Platform personnel described that they would check the volt and amp meters when making rounds throughout the platform. However, they provided inconsistent descriptions of the operation of these and other gauges associated with the transformer, and there were no specific records regarding their operation or the voltage and current output from the transformer. Without documentation of their operation, it might create difficulty for identifying the performance of this equipment over time, especially between different operators throughout different hitches.

After a visual inspection during the post-incident investigation, a third-party expert indicated the transformer's high voltage junction box appeared to be in excellent condition; as the mineral oil level was normal and it was not dark or cloudy (prior to tests performed on the transformer), with no visible signs of contamination. The expert stated that there was no indication of corrosion on internal surfaces and the electrical connections were not loose.

The Transformer Product Manual indicated that the mineral oil should be sampled and tested for Dissolved Gas Analysis (DGA) at least once a year to determine the true operating condition of the power supply. Such testing would also define the recommended time between inspections and tests; in addition to local environmental conditions and the load on the apparatus. The results of any DGA tests performed by Fieldwood or Apache were requested from Fieldwood but as of the time of this report had not been provided to the BSEE Panel.

During the post-incident investigation, third-party experts performed electrical tests on the transformer to check the condition of the electrostatic grid and high voltage lead wire insulation together. First, a continuity check to ground showed an open circuit; which indicated that there was high resistance and it was not shorted to ground. A MegOhm meter was then used to check the insulation resistance of the grid and lead wire, which received 1.7 to 2 Meg ohms and was described by one technician as a low reading and that there was some voltage to ground. Both of these findings provided additional support that energy would likely have traveled to the grid if the heater treater breaker and disconnect switch were both on.

During the post-incident investigation, third-party experts turned 'On' both the heater treater breaker and disconnect switch. They then measured the secondary of the transformer for which a digital voltmeter identified approximately 2.00 to 2.02 kilovolts (KV) of output. According to one third-party technician, the voltmeter on the transformer read around 18% (90 volts per the scale) and the ampere meter read 38-40 amps per the scale. However, another expert reported that the voltmeter read "40" out of a maximum meter scale of 500; which calculated to 8% (40/500 = 0.08) of full voltage

[48] A status which one Fieldwood PIC believed to be proper operations.

(25 kV)[49] or 2 kV (2,000 Volts). Both parties read the same or similar test output, similar to what was seen in Figure 34, so the difference in identified readings was unknown. Regardless, these readings appeared to be similar to what was identified prior to turning off power to the main breaker and disconnect switch on November 21, 2014 (Figure 14, Page 28); and were inconsistent with what might have been expected for the performance of the transformer at the described setting since the output voltage tap was set on 20 KV. If this condition existed prior to the incident, then it could have contributed to the BS&W or 'pad' issues that Fieldwood experienced prior to commencing the cleaning.

The results of these electrical tests on the grid and transformer indicated that it could be expected that the grid inside the heater treater would be energized with approximately 2,000 volts when power to the transformer was turned 'On;' which would occur when both the heater treater breaker and disconnect switch were 'On.'

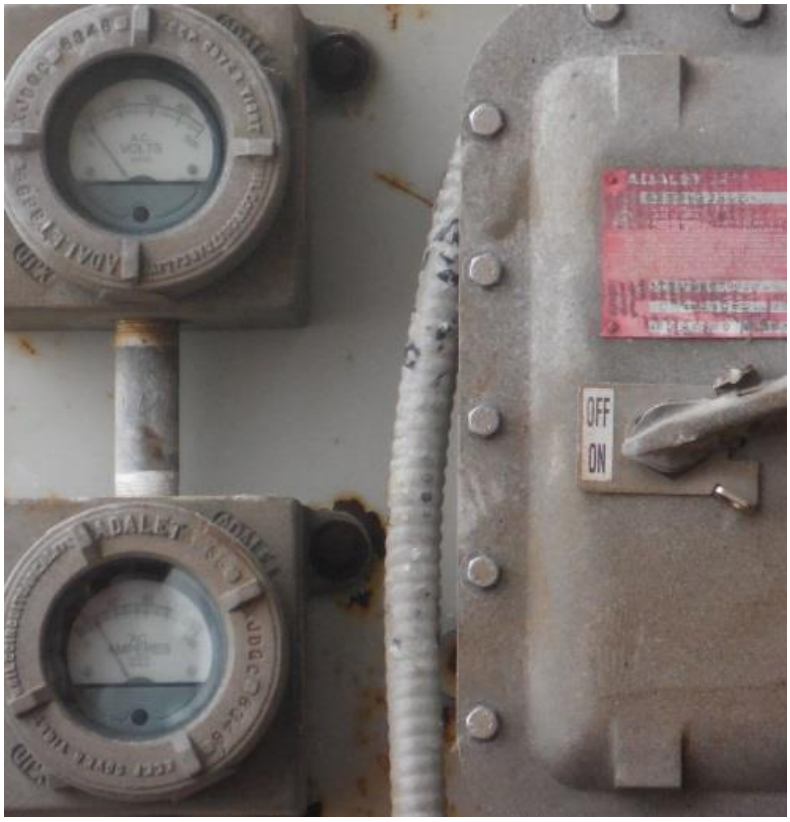

Figure 34 - Volt and Amp Meters When Transformer Energized (April 26, 2015)

If the oil outlet quality was not to specification, as was the described issue with the oil handling system in the days leading up to the heater treater cleaning, then the Heater Treater Manual described multiple means for troubleshooting the heater treater, some of which included evaluation of the transformer indication light, the voltage and amp meters, and/or the dielectric (or mineral) oil in the transformer tank. Irregularities included: low vessel temperature; loss of chemical or reduction in chemical rate; excessive sludge build-up on the interface of the coalescing section; high interface level

[49] The output voltage tap was set at 20 kV.

in coalescing section; recycling of problem emulsions, tank bottoms, etc.; increased flow rate through the system; or recent field rework.

Additional troubleshooting would include searching for potential electrical malfunctions, such as electrical shorts. To perform that troubleshooting, the Heater Treater Manual described ventilating, verifying voltage with a voltmeter after turning the breaker off, disconnecting and removing the entrance bushing and visually checking for burned appearance (tracking), inspecting insulating hangers for burns or other damage, checking for foreign materials, or possibly using a "megger" to check conductivity between each charged electrode and ground, and each other.

While the BSEE Panel could not be certain of the performance of the transformer prior to the incident, the post-incident digital output from the transformer indicated that it was only producing an output of approximately 10 percent (2,000 / 20,000) of the voltage it was expected to produce at its identified setting. The minimal records and varying descriptions from platform personnel about the state of the light and volt/amp meters prior to the incident provided limited information for a definitive diagnosis of the transformer's state at that time. However, there was little evidence to support that extensive troubleshooting of the transformer, voltage and amp meters, indication light, mineral oil, bushings and/or hangers occurred immediately prior to the incident.

Working Late on November 19, 2014:

The two Turnkey crewmembers that worked on the dry oil tank and heater treater on November 19 and 20, 2014, indicated they worked long hours to clean the dry oil tank on November 19, 2014. One crewmember estimated they worked until approximately 12:00 a.m.; and the other until approximately 1:30 or 2:00 a.m., before waking up early the next morning to begin preparations for cleaning the heater treater.

One of the Turnkey crewmembers explained that their crew worked all night to clean the dry oil tank because he was told by the Turnkey Supervisor that the operator wanted them to finish cleaning it, and pushed them to keep working until they finished cleaning it. However, the same crewmember said he did not feel tired when they were working on November 20, 2014. He said no one mentioned a lack of sleep and they were able to take breaks when needed, which he estimated were every hour or so; as well as a lunch break.

Another Turnkey crewmember indicated that the Turnkey Supervisor told him they worked later than usual on November 19, 2014, it was a rush job, and that the operator wanted it done as soon as possible – just mentioning that the operators wanted it done faster than if they had a four-man crew. He said it was for those reasons that Turnkey sent a night crew. However, he described that no one appeared tired, and that the Turnkey crew was perky, and everything was going smooth prior to the incident. He also said they took breaks when needed, which was for about ten to fifteen minutes every few hours. He said there was not much work to do when the tanks were draining, since they were just watching it drain.

The Authorized Entrants Roster for November 19, 2014 indicated that the Turnkey crew finished confined space entry for the dry oil tank at approximately 11:30 p.m., and Turnkey's project

tickets and work records indicated that the four crewmembers that worked on the WD 105 E November 19, 2014 received credit for 18 hours of work.[50]

The Fieldwood A-Hitch Field Foreman indicated that there was no pressure to get the work done in a certain amount of time, they were not behind schedule and to his knowledge no one voiced any concerns about working too many hours. Additionally, none of the Turnkey crewmembers recalled being tired or directly hearing anything about getting pressure to get the job done during the work on November 20, 2014. They all mentioned that they had no concerns for the job, things were going smooth and they had made good progress up until the incident.

Heater Treater Monitoring and Maintenance:

The Operating Procedures described that the platform's safety system provided primary and secondary protection against abnormal conditions and undesirable events associated with the facility production processes, and it was designed to shut down the system or processes necessary to minimize the potential impact. It further explained the importance of monitoring,[51] visually inspecting and maintaining familiarity with observable characteristics of the facility for, for example, early detection of abnormal operating parameters. This might include conducting routine checks and using resources such as prior observations, knowledge of others, the most recent monthly testing report, and SAFE chart to determine whether observable parameters were normal, troubleshooting was necessary or a shutdown was required. Specifically relating to the heater treater, routine checks described examining various operational components. However, there was no specific indication that these routine checks should include monitoring of the volts, amps or any other electrical aspect of the heater treater.

Operators and PICs on the WD 105 E reportedly made frequent rounds on the platform throughout each day, but did not have a form or worksheet for documenting the results of the rounds nor was such documentation described in the operating procedures. The only records of routine daily, weekly or monthly vessel monitoring provided to the BSEE Panel did not document values such as those associated with the electrical input and output relating to the coalescing section of the heater treater.

Some platforms in the same field as the WD 105 E were reported to have used a 'round sheet' to document their observations, but Fieldwood described that they had no written policy concerning the use of round sheets or tally books while conducting rounds; and the use of them was left to the individual. By not documenting the results of daily rounds, it could be difficult to identify abnormalities in certain systems, especially from one hitch to another. Documentation such as this could help to identify abnormalities in components such as liquid level controllers, volt and amp meters, and/or the transformer and its indication light that might otherwise go unnoticed.

The Heater Treater Manual indicated that vessels should be cleaned and inspected at the end of the first six months on heavy oil service and at the end of one year on lighter oil service. Where heavy sand was suspected, cleaning every 60-90 days may be necessary. Future cleaning periods could

[50] The Fieldwood A-Hitch Field Foreman indicated that as a general rule, no one could work over 18 hours a day.
[51] For example, pressures, levels and temperatures.

then be determined.[52] Routine maintenance recommendations, although only intended as a guide, for daily, weekly, semi-annual and annual bases included, among other things, noting any irregularities during daily checks, and inspecting vessel internals for scale and sludge accumulation and corrosion (especially pits) and cleaning as required on an annual basis.

The Heater Treater Manual also provided a troubleshooting section, which described the need to maintain a balanced program combination of chemical, heat, time and electricity in order for the unit to perform as designed. The manual indicated that if all components were constant and the outlet oil quality had changed, it could be assumed the incoming emulsion has changed. Included in the troubleshooting section were descriptions of irregularities, symptoms and procedures for troubleshooting potential problems with the heater treater. As personnel were unable to resolve the issues they encountered with the heater treater in November 2014, any troubleshooting eventually resulted in deciding to clean the vessel.

The Heater Treater Manual explained a procedure for checking if there was an electrical short inside the heater treater, which included visually checking the entrance bushing for burned appearance; and making sure the bushings were clean and testing for conductivity, which could indicate a bad bushing. It further described that sulfides or basic sediment build-up over the length of the bushing could cause an electrical failure; and that insulating hangers should also be visually inspected and replaced if burned or otherwise damaged.

A similar condition to that observed on the entrance bushing and insulated hangers after this incident may have also been observed previously on this platform, as both of the Fieldwood WD 105 E PICs recalled maintenance on the heater treater grid in years prior. They indicated observing similar conditions to some of the electrical components of the heater treater as was observed in April 2015 (see Figures 25 to 27); such as that the entrance bushing was bad. One PIC explained that the insulation was coated with chemicals, paraffin or something else; and electricity jumped over the insulator from the connection point on the top to the insulator and eventually cut a path to travel through. He said they also changed the fitting on the penetration to the vessel, some insulators and hangers. Both PICs explained that something had previously caused the grid to stop working prior to that maintenance, but they did not know what and they did not draw any conclusions regarding the operations of the heater treater in those previous circumstances compared to 2014.

Records indicated that the WD 105 E heater treater was cleaned in October 2013 by a different contracted cleaning service company than Turnkey; and the heater treater was locked out due to the cleaning. No incidents were reported with this cleaning activity; and there was no information provided to the BSEE Panel that abnormal conditions to any components were identified.

Additional heater treater maintenance, as noted by Fieldwood's contracted electricians for the WD 105 E heater treater, as well as from Fieldwood's Energy Isolation (Lockout/Tagout) Log Sheet, indicated that they changed the 120 volt solenoid and light on treater grid in April 2013; changed the temperature safety high switch in August 2013; changed the motor on the treater in November 2013;

[52] The Transformer Product Manual also indicated that periodic maintenance should be performed at least once each six months, or more often when used in contaminating atmosphere and/or unusual loading conditions existed.

addressed an excess of water in the heater treater in December 2013; and troubleshot the combustion blower motor in January 2014 and November 2014.[53]

Confined Space Entry:

According to Turnkey's Offshore Vessel Cleaning Procedures, a confined space entry permit should be complete, authorized, and posted prior to opening the manway. Evidence suggested that at the time of the incident a confined space entry permit had begun to be completed, but appeared not to have been complete, authorized and posted.

The BSEE Panel reviewed the Fieldwood and Turnkey policies regarding confined space entry, as well as documentation to include the JSAs, Confined Space Entry Forms, Authorized Entrant(s) Roster and Confined Space Rescue Action Plans, which needed to be completed before any employee entered a permit-required confined space (PRCS)[54] and must be completed and signed by the UWA[55] before beginning work. Like the JSAs in respect to how they did not significantly contemplate the different hazards of a dry oil tank to an electrostatic heater treater, the majority of the typed information on those documents were very similar for both the dry oil tank and the heater treater.

Based on documentation received and interviews conducted by the BSEE Panel, the Turnkey crew conducted a confined space entry of the dry oil tank on November 19, 2014; and at least contemplated the possibility for confined space entry of the heater treater on November 20, 2014. Based on all available information, at the time of the incident the cleaning activities on the WD 105 E heater treater had not yet become 'entry,' as defined by both Fieldwood's and Turnkey's Confined Space Policies such that a person or part of their body passed through an opening into a PRCS. However, since confined space entry was considered before and/or during the job activities, they perhaps should have considered the aforementioned OSHA regulations discussed in the ventilation section of this report for eliminating any conditions making it unsafe to remove the entrance cover before the cover was removed. For instance, performing ventilation methods and isolation verification prior to opening the manway.

Platform and Cleaning Oversight:

Fieldwood's SEMS documentation described the role of a PIC as the production representative in charge of production operations on an OCS facility, who was responsible for overall safety of the facility and initiating emergency response procedures. The PIC had the UWA, which had the responsibility to follow Fieldwood Energy's safe work practices, assessing hazards, approving JSAs and permits, and communicating with all personnel involved before work began. Their duties included, among other things, coordinating JSAs and any other permitting done in association with it; such as confined space entry, lockout tagout, working nights, etc.; and also oversaw maintenance and a general thorough outlook on the platform.

[53] No JSAs or energy isolation permits were received by the BSEE Panel regarding the replacement of the blower motor in November 2014.

[54] A PRCS was defined as, among other things, contained or had a potential to contain a hazardous atmosphere (i.e. gas, heat, toxic vapor, oxygen deficiency or enrichment, etc.).

[55] Neither Confined Space Entry Form for November 19 or 20, 2014, were signed by the Acting PIC or anyone outside of Turnkey.

Fieldwood reported that they primarily used their own employees as PICs, which was neither required by regulation nor industry standard. They explained that use of a contract lead operator / PIC was a standard industry practice.

For a typical crew change at the WD 105 E, every two weeks the Fieldwood A- and B-Hitch PICs would call each other the night before the change and discuss past and upcoming operations on the platform. They would then have a brief exchange to follow up on the previous night's conversation when crossing paths getting off and on the crew change helicopter the next day. However, the circumstances leading up to November 20, 2014 were different.

In the days leading up to the incident, the B-Hitch PIC departed the WD 105 E on November 12, 2014, due to a scheduled vacation, and the A-Hitch PIC was not due to return until November 27, 2014, also because of a scheduled vacation; so they did not have typical crew changes[56] during that time. When he left the WD 105 E on November 12, 2014, the B-Hitch PIC said he did not hand the PIC duties to anyone specifically, but there were qualified A- and B-Operators[57] there who knew how to do morning reports and the everyday production.

In the middle of dealing with a subsequent process upset shortly after the B-Hitch PIC left, the Island Senior Lead Operator for Island arrived and ultimately assumed the role of Acting PIC. Fieldwood reported that they contracted with Island, which they described as one of the leading contract provider companies on the GOM OCS, to provide a qualified, trained, and experienced Lead Operator / PIC to oversee operations at WD 105 E. They indicated that the Island Acting PIC was trained by both Fieldwood and Island as a Lead Operator / PIC; a training that specifically covered isolation procedures. Fieldwood explained that the Island Acting PIC had decades of experience in offshore operations and a year of experience at WD 105 E. They indicated that they complied with applicable requirements to ensure he was knowledgeable and experienced through his extensive work experience and his completion of the aforementioned training programs. It was also conveyed that the Island Acting PIC had been in charge before.

The anticipated actions for cleaning the oil handling system appeared somewhat unclear, as some individuals interviewed believed it would be a quick and external clean, while others seemed to believe confined space entry would be necessary or at least contemplated. There also appeared to be some lack of clarity in roles on the cleaning crew, including, among other things, that various documentation and witness descriptions identified the Turnkey Supervisor as a Superintendent, Supervisor, Entry Supervisor, Qualified Person, Team Leader, First Responder, and even Authorized Entrant. Some of those roles conflicted with one another as someone who would both clean and/or enter a vessel or tank, and also supervise and be a first responder to those activities.

There was also some difference of opinion regarding the level of oversight that should be provided by operators or operator representatives, as some individuals expressed that an operator or operator representative should be with the cleaning crew while they worked, and others expressed

[56] The two week crew change occurred on November 20, 2014.
[57] The A-Hitch had three contracted Lead Operators; while the B-Hitch had no Lead Operators. However, Fieldwood's contractor training matrix required the same training of a Lead Operator and an A-Operator.

that they only needed to check-in periodically.

Additionally, when one individual was asked if there was anything that could have been done to prevent the incident, he said there should have been a Fieldwood employee on board, who would have made sure the vessel was locked and tagged. However, since there was not, it was the Island Acting PIC's job to isolate the vessel; to which there was no documentation that he had ever isolated the WD 105 E heater treater breaker before.

Documentation and personnel accounts indicated that primary oversight of the platform and cleaning activities on November 20, 2014 were of the Island Acting PIC and Turnkey Supervisor for overseeing that operations were performed safely, equipment was made safe and verifications were performed; but neither could oversee everything and that hazard analysis needed to be a group effort.

Post-Incident Safety:

BSEE's investigation identified that the noise of the explosion alerted most, if not all, of the personnel on the platform, even those reported to have been asleep. Those personnel not directly injured by the explosion appeared to respond in one of three ways: attempt to tend to injured personnel, contact and/or maintain contact with additional aid resources, or remain out of the way so as not to interfere with efforts to aid injured personnel. However, there was no indication of any audible alarms to alert personnel of the incident or any potentially dangerous situation, nor did personnel immediately report to designated muster stations.

The Fieldwood A-Hitch Field Foreman indicated that it was chaos when he arrived on the WD 105 E shortly after the incident, but he evaluated the heater treater area to make sure everything was secure on the platform. He said the disconnect switch was 'On' but the volt and amp meters adjacent to the manway and disconnect switch both read zero; the latter of which indicated to him that there was no voltage going from the heater treater breaker to the disconnect switch. He said he did not check the heater treater breaker in the MCC building.

Fieldwood cordoned off the area surrounding the heater treater with caution tape at approximately 4:45 p.m., to prevent individuals from entering. They also drafted a form to document any personnel that entered the area, which reportedly only occurred to assist with the evacuation of the Turnkey Supervisor at approximately 7:15 p.m. BSEE Investigators were informed that personnel were instructed not to go down to the lower level; and the Field Foreman indicated that no one went inside the incident area or touched anything inside of it.

However, neither the disconnect switch nor the heater treater breaker in the MCC building for the heater treater were 'Off' when BSEE Investigators arrived on the platform the following day. The potential electrical hazards associated with the heater treater in this state represented a potentially unsafe work area.

Conclusions

BSEE Investigators and Panel members conducted interviews, reviewed documents, and observed or engaged in onsite investigations, inspections, third-party testing and analysis to reach the following conclusions regarding the incident that occurred at the WD 105 E platform on November 20, 2014. This information was based on the material that was available and provided to the BSEE Panel.

The BSEE Panel found that when the WD 105 E electrostatic heater treater was partially drained of fluids that were inside the vessel during production operations, there was a significant amount of space remaining where flammable vapors could accumulate. Upon opening of the manway hatch to the coalescing section of the heater treater, these vapors were not promptly or effectively removed from the vessel through ventilation methods, and the interior of the vessel was introduced to oxygen from the outside environment, leaving it vulnerable to a potential fire or explosion should a significant ignition source occur.

Additionally, all potential ignition sources were not effectively removed or mitigated during the preparation for, and activities of, cleaning the heater treater. The presence of each of these elements therefore created a hazardous environment that was conducive to such an explosion.

The BSEE Panel believes the probable cause of the ignition was the unrestricted supply of electrical energy to the electrostatic components inside the coalescing section of the heater treater, which were exposed to flammable vapors and oxygen. This was supported when BSEE Investigators found that the most available means to isolate this energy source, the heater treater breaker to the heater treater transformer in the nearby MCC building and a disconnect switch mounted on the heater treater itself, were both in the 'On' position during the initial onsite investigation on November 21, 2014; in addition to seemingly positive readings observed on the volt and amp meters associated with this equipment.

During BSEE's initial onsite investigation, the heater treater breaker was observed to be fastened with a lock and tag, but was still in the 'On' position. There were no apparent attempts to isolate energy using the disconnect switch. Follow-up testing by third-party experts then confirmed that the electrostatic grid inside the heater treater would be energized with approximately 2,000 volts when the aforementioned breaker and switch were both 'On.'

Further inspection and removal of the electrostatic components of the heater treater identified signs of arc damage to the Teflon-insulated entrance bushing and charged hangers. This damage showed that arcing had occurred inside the heater treater, either over a long period of time or in a matter of hours, and the BSEE Panel believed that these components were susceptible to an arc or other type of ignition at the time of the incident if the transformer was left on and fluid was drained from the vessel.

The BSEE Panel also found that there was ineffective verification of the electrical lockout / tagout of the heater treater breaker, disconnect switch or any other method for isolation of an ignition source to the electrostatic heater treater by individuals on the WD 105 E at the time of the incident. An Energy Isolation Permit for this task was dated November 19, 2014 and had a section for two approval signatures. However, one person signed for both of the approvals.

Additionally, while not a regulatory requirement to function in this manner, the heater treater manual indicated that an LSL device should be a shutdown for the main power supply to the transformer, and which could have interrupted an electrical circuit to the electrostatic grid in the heater treater when the fluid level inside the vessel was lowered. A post-incident inspection found that the LSL on the coalescing section of the heater treater had tripped and also functioned as designed; however, it was not programmed to function as a shutdown for the main power supply.

Another means for preventing the electrostatic grid from being energized when not covered by oil could have come through an internal ground float that could short circuit the grid when the level in the vessel dropped below the top of the grids if manual energy isolation was not accomplished. This safety device, which was not required per API RP 14 C, was not installed. However, it was a recommended safety device as per API RP 14 F.

The BSEE Panel also found that Turnkey crewmembers were informed that the heater treater was safe to work on, and that they appeared to not fully identify or understand the heating and electrical hazards associated with an electrostatic heater treater.

The BSEE Panel found that while it was apparently contemplated, confined space entry had not yet occurred at the time of the incident as it was not reported that a part of any person had entered the vessel. However, it was described by some that the Turnkey Supervisor was using a water hose to rinse the lip of the heater treater manway hatch at the time of the incident, which may have contributed to the ignition.

The BSEE Panel also evaluated other potential ignition sources such as a chemical reaction, the configuration and/or use of the water hose nozzle and connections, static electricity and the heater treater's burner, among others. While there was no significant evidence to support these other means of a potential source of ignition, they were not definitively eliminated as a possible cause.

In addition, the BSEE Panel found a number of other factors could have possibly exacerbated or contributed to the incident and/or the source of ignition, as described below.

- Process equipment and piping isolation for the heater treater was not completely performed or verified; nor was there proper verification of this occurring.
- The JSA for setting up and cleaning the heater treater was generic and lacking insofar as its failure to specifically analyze the electrostatic heater treater at the WD 105 E through identification of electricity as a hazard and an energy isolation / LOTO permit as a required permit; as well as an ineffective sequence of job steps to identify and mitigate all of the potential hazards associated with the job and equipment.
- Turnkey's Offshore Vessel Cleaning Procedures were not effectively followed for addressing the potential hazards of vessel cleaning activities when preparing for and performing cleaning activities on the heater treater on November 20, 2014.
- The WD 105 E Operating Procedures and operator assessments only addressed aspects of the heater treater and its fired components, but did not provide specific reference to its transformer, grid or electrostatic components on the coalescing section of the vessel.

Recommendations

Based on the findings from this investigation, the BSEE Panel recommends companies operating on the U.S. Outer Continental Shelf consider the following to further protect health, safety, property, and the environment.

Pre-Job Safety Analysis: The BSEE Panel recommends that authorized and affected personnel ensure that job safety analyses (JSAs) align with approved procedures, address hazards specific to the job at hand and represent an orderly completion of job steps.

Pre-job Isolation: The BSEE Panel recommends that when a piece of equipment offers multiple opportunities to isolate an electrical or energy hazard, such as a heater treater breaker and a disconnect switch, energy isolation and verification procedures should be completed for all available isolation locations to ensure redundancy; preferably by a qualified electrician or technician and using group lockout/tagout when appropriate.

Verification of Isolation: The BSEE Panel recommends that operators institute policies to ensure that prior to beginning any activities that require energy or process equipment and piping isolation, at least one authorized and affected employee with knowledge of how to perform isolation on the equipment verify and document that energy and process piping isolation is properly performed.

Explanations of Equipment Functions and Potential Hazards: The BSEE Panel recommends that prior to beginning work on a piece of equipment companies ensure they fully explain to all personnel the functionality and potential hazards associated with a piece of equipment on which they are working, regardless of whether the hazards have been mitigated, to include but not limited to specifically making available the associated manuals.

Ventilation and Air Monitoring: The BSEE Panel recommends that for all tanks or vessels that currently or formerly contained chemicals, hydrocarbons or hydrocarbon vapors, after product removal through discharge nozzles or other fixed connections (without opening manways or hatches), personnel use approved and appropriate vapor and gas freeing, degassing and/or ventilating methods to safely displace or dilute potentially hazardous gas and vapors in the tank or vessel ; and that a qualified person test and document the applicable atmospheric conditions and ensure levels are safe prior to permitting work inside or around the outside of those tanks or vessels (API Standard 2015, Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks[58]).

Site-Specific Training and Assessments: The BSEE Panel recommends that operators and contractors perform site specific training and assessments that address and reflect all aspects of the actual equipment and potential hazards at the specific site, including safe shutdown of that equipment.

[58] The scope of this standard was applicable to stationary atmospheric and low-pressure (up to and including 15 psig) aboveground petroleum storage tanks used in all sectors of the petroleum and petrochemical industry. As the WD 105 E heater treater was rated to 50 psig, it is not specifically covered by this standard nor is this standard incorporated in BSEE regulations. However, the BSEE Panel believes certain aspects of this standard can help promote safety when performing cleaning activities on tanks or vessels that contain or formerly contained petroleum or petroleum-related products.

Protection of Electrostatic Grids: The BSEE Panel recommends that operators use procedures or safety devices to ensure protection of electrostatic grid components through de-energization when liquid levels drop and expose the grid components during normal, maintenance and cleaning operations, including but not limited to draining or pumping fluids from the bottom of the vessel. The coalescing side of the treater is a "fluid packed" section. Therefore the safety devices should be installed to ensure all parts of the grid (grid plates, rails, and hangers) are immersed while energized.

Documentation of Heater Treater Functionality: The BSEE Panel recommends that operators create and maintain records of measurements identified when conducting daily inspections of the heater treater and its components during normal operations, such as the electrical output of the transformer, temperatures, pressures, levels, etc., so that variances can be effectively identified and assessed for troubleshooting.

Electrical Inspection of Heater Treater Components: The BSEE Panel recommends operators inspect external and internal electrical components of a heater treater on a regular basis, and with more frequency if there is a history of damage and/or any indication of functional limitations.

First Aid and Project Management Training: The BSEE Panel recommends that due to the job hazards and rescue roles associated with vessel cleaning, operators include training in First Aid / CPR / AED / BBP as a requirement for tank and vessel cleaning crewmembers and supervisors. Additional project management training could also benefit job supervisors.

Specific Shutdown Identification: The BSEE Panel recommends that operators identify in their platform operating procedures the specific items that need to be addressed in their shutdown procedures. For example, for the operating procedures to include mention of the internal electrical components of a heater treater so that personnel know to follow energy isolation procedures when shutting that equipment down prior to cleaning and maintenance activities and how to do so.

Retraining: Retraining be conducted whenever deviations from or inadequacies in an employee's knowledge or use of the energy control procedures are identified.