

**THE BUREAU OF OCEAN ENERGY MANAGEMENT,
REGULATION AND ENFORCEMENT**



**VERMILION BLOCK, PRODUCTION PLATFORM A:
AN INVESTIGATION OF THE SEPTEMBER 2, 2010 INCIDENT
IN THE GULF OF MEXICO**

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EXECUTIVE SUMMARY

Sometime before 9:00 a.m. C.S.T. on September 2, 2010, a fire started on the Vermilion 380 A platform (“VR 380 A Platform” or the “Platform”), a Mariner Energy, Inc. (“MEI”) production platform located in the Gulf of Mexico roughly 102 miles off the coast of Louisiana. The fire caused the thirteen workers on the VR 380 A Platform to evacuate by jumping into the water, where they remained for approximately two hours before being rescued by the first of many vessels dispatched to the scene of the fire. The fire continued burning for several hours until extinguished. The fire damaged several platform components and destroyed several structures on the platform. A small amount of hydrocarbons spilled from the VR 380 A Platform into the surrounding water as a result of the accident.

Shortly after the accident, a Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) accident investigation panel, led by the Investigations and Review Unit, convened to investigate the causes of the fire on the platform. The BOEMRE accident investigation panel (“the Panel”) conducted an extensive investigation that included witness interviews, extensive document review, and expert analysis. The Panel found that the fire occurred following the collapse of the fire tube located inside of a pressure vessel, called the Electrostatic Heater, NBK 8701 (the “Heater-Treater”).

Our investigation concluded that the fire was caused by MEI’s¹ failure to adequately maintain or operate the Platform’s Heater-Treater in a safe condition, as required by 30 C.F.R. §§ 250.107, 802(a). The Heater-Treater is a piece of production equipment that uses heat from a fire tube to separate emulsions. In particular, we determined that: (a) the Heater-Treater was nearly 30 years old and, by the time of the accident, its fire tube had been weakened due to several factors, including heat, corrosion, and pitting; (b) the Heater-Treater was designed for a significantly higher oil production

¹ On or about November 10, 2010, Mariner Energy, Inc. merged with Apache Corp. For the purposes of this report, we refer to MEI, which was the owner/operator of the Platform at the time of the incident.

volume than MEI was processing on the Platform on September 2. This meant that there was most likely too little oil in the Heater-Treater to dissipate the heat generated by the fire tube, which caused the fire tube to overheat. This overheating, along with other factors including pitting and corrosion, caused the weakened fire tube to collapse on September 2.

The Panel found that the immediate cause of the September 2 fire was that the Heater-Treater's fire tube collapsed in a "canoeing" configuration, which created openings in the vessel and fire tube through which hydrocarbons escaped. The hydrocarbons then came into contact with the Heater-Treater's hot burner, which ignited the hydrocarbons and ejected the component assembly section of the Heater-Treater. The ignition produced a noise that the crew described as an "explosion" and released hydrocarbons into the Gulf of Mexico.

Our investigation also revealed that MEI did not have an inspection plan for the VR 380 A Platform's Heater-Treater, as required by 30 C.F.R. §§ 250.198, 803(b). Accordingly, we found that a contributing cause of the fire was likely MEI's failure to follow BOEMRE regulations requiring the development and implementation of an inspection plan. While the regulations do not specifically address the fire tube inside of the Heater-Treater, routine inspection of the Heater-Treater likely would have revealed the deteriorated condition of the fire tube and should have led to appropriate maintenance to ensure that the Heater-Treater would function properly and safely. Had MEI regularly inspected the Heater-Treater, as required, and conducted appropriate maintenance, the accident likely could have been prevented. Furthermore, the Panel found it particularly problematic that the company had been warned by a service contractor on prior occasions regarding the effect of low oil production on this Heater-Treater, and also that MEI knew that this Heater-Treater had experienced temperature related issues, yet MEI still failed to implement an inspection plan.

The company's failure to maintain the Heater-Treater in a safe condition created a serious safety risk to the crew. Nor was this the only undue safety risk present on the Platform on September 2. While they are not causes of the accident, the Panel also found

that the following safety deficiencies posed significant and unnecessary risks to the crew's safety: (a) the manner in which wells were brought back online and certain safety devices were placed in bypass, without monitoring; (b) MEI's failure to maintain the Platform's back pressure valve in a safe condition; and (c) the emergency generator's failure to start after the fire began and supply power to the firewater pump, which left the crew without a firewater system.

Based on all of the evidence developed during the investigation, the Panel recommends that several Incidents of Non-Compliance (INCs) be issued to MEI. These proposed INCs are described with particularity in the "Recommendations" section of this Report, and may provide the basis for the assessment of civil penalties against MEI.²

The Panel makes these recommendations with the goals of helping to prevent a similar accident from occurring on this platform or another production platform, and of enhancing industry awareness of critical operational and safety considerations on production platforms.

² The Panel's findings will be considered by BOEMRE as part of its ongoing evaluation of MEI's performance under the factors set forth in 30 C.F.R. § 250.136. This provision lists accidents, pollution events, and Incidents of Non-Compliance as factors to consider in determining whether an operator's performance has been unacceptable and warrants revocation of an operator designation.

BACKGROUND

The VR 380 A Platform

The VR-380 A Platform is a four-pile platform set in approximately 340 ft of water, located 102 miles offshore of Vermilion Parish, Louisiana in the Gulf of Mexico. The Platform was operated under Lease OCS-G 02580 (the “Lease”), which covers approximately 5,000 acres and is located wholly in Vermilion Block 380 (See Figure 1 for lease location). The Lease was originally issued on May 1, 1974 to Texaco, which purchased 100% of the mineral rights under the Lease and became the original operator of record.

Effective July 1, 1995, Forcenergy Inc. purchased 100% of the rights, title, and interest in the subject Lease and operated under it until December 7, 2000. Thereafter, via a partnership agreement, Union Oil of California and Forest Oil each became 50% owners of the Lease until July 1, 2003, when Forest Oil acquired a 100% interest in the Lease and became operator of record. On December 2, 2005, MEI acquired 100% interest in the Lease and became operator of record.

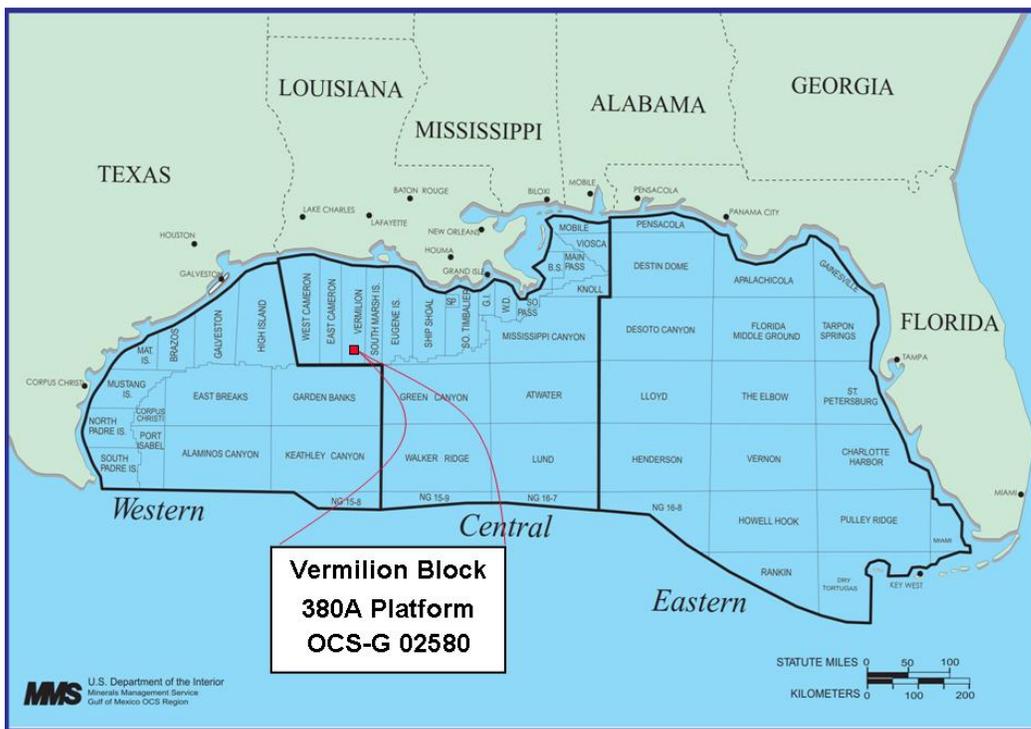


Figure 1: Location of Lease OCS-G 02580, Vermilion Block 380A Platform

Relevant Equipment on the Platform

On September 2, 2010, the VR 380 A Platform had seven producing wells. Three were low-pressure producing oil wells, one of which, the A-20, had been converted to gas lift³ on or about August 31, 2010. The remaining four wells were high-pressure wells, producing gas, condensate or oil.

The VR 380 A Platform contained several pieces of equipment and components that are relevant to understanding the factual events that transpired on September 2, including the Heater-Treater and the back pressure valve (BPV).

The Heater-Treater

The VR 380 A Platform's Heater-Treater was one of the vital pieces of equipment in the Platform's production train and was the source of the fire. Built in 1981, the Heater-Treater received an oily water emulsion that traveled through the production train and then separated the emulsion into oil and water through application of heat, chemicals, and electricity. The Heater-Treater contained a fire tube and a section called a forced-draft fired component assembly section, which housed the Heater-Treater's blower motor, main burner, pilot igniter, and fuel gas inlet lines. The main burner, located in a horizontal position down the center of the tube, produced a flame that heated the fire tube, which, in turn, raised the temperature of the fluids inside of the Heater-Treater. The transfer of heat from the fire tube to the fluid aided in the separation of the oily water emulsion. Once the oil was separated in the Heater-Treater, it traveled to the "good" oil tank, LACT unit⁴, then to the pipeline pump, and then to the shore via a pipeline.

The main burner in the Heater-Treater was not designed to shut off when the system temperature reached its high set point, i.e., its maximum allowable temperature

³ Gas Lift is an artificial method in which gas is injected in oil wells to raise the oil to the surface. *See Nontechnical Guide to Petroleum Geology, Exploration, Drilling, and Production*, Norman J. Hyne, PhD., 2nd Edition, 2001.

⁴ "Good" oil tank and LACT unit are defined in *Appendix I*.

for the Heater-Treater to operate effectively. Rather, it was designed to stay lit and reduce to a lower flame. As explained more fully later in this report, the fact that the Heater-Treater's flame remained lit became critical to the accident: when the fire tube collapsed, the hydrocarbons in the Heater-Treater came into the contact with the main burner's flame and air and started the fire.

The Heater-Treater also had safety devices, including a pressure safety valve (PSV) and associated flow safety valve (FSV) and a pressure safety high (PSH).⁵ It also had two temperature safety high (TSH) instruments – one sensed the temperature of the liquid on the fired side of the Heater-Treater, and the other sensed the exhaust temperature of the burner flame in the exhaust stack. When functioning properly, the TSH was supposed to initiate an alarm and shut down the Heater-Treater. As discussed later in this report, it is possible that the fire tube collapsed prior to the temperature of the liquid reaching the TSH's melting or high temperature set point.

The VR 380 A Platform's Heater-Treater was designed to handle approximately 10,000 to 12,000 barrels of oil per day (BOPD) depending on the temperature of the vessel and the gravity of the oil, among other factors. However, as discussed later in this report, at critical points during the Heater-Treater's operating life, the rate of production through the Heater-Treater never approached the volume that the vessel could handle. This lack of sufficient production volume was a significant factor that contributed to the overheating and collapse of the Heater-Treater's fire tube.

The Back Pressure Valve

The VR 380 A Platform was equipped with a back pressure valve (BPV), a pressure control device used to regulate and maintain a certain amount of pressure on the high pressure production vessels -- *e.g.*, 50 to 100 psig above the pipeline pressure -- in order to automatically feed oil or condensate into the pipeline headed to shore. The BPV

⁵ The PSV, FSV, and PSH functions are explained in the glossary to this report. *See Appendix I.*

on the VR 380 A Platform was installed between the glycol gas scrubber and the gas sales meter skid.⁶

Later in this report, the Panel discusses how the incorrect assembly of the BPV caused it to malfunction and posed a safety hazard to the crew.

⁶ Additional information concerning the Heater-Treater and other relevant VR 380 A components and equipment referred to in this section are found in *Appendix I*. Unless otherwise noted, panel members prepared the definitions and descriptions in the Appendix based on their training and experience, and on their inspection and review of documents related to the VR 380 A Platform.

THE ACCIDENT AND EVACUATION OF THE PLATFORM

The following description of the facts and circumstances related to the VR 380 A Platform accident is based on information from witness interviews, witness statements, circular Barton charts, electronic computer data (e.g. SCADA), photographs, BOEMRE inspectors' evaluations and findings, the Heater-Treater expert's findings, documents from MEI and contractors, and U.S. Coast Guard documents.

At the time of the accident on September 2, thirteen men were working on the Platform: the lead operator, who was the only person employed by MEI; the lead operator's assistants, who were known as an A operator and a C operator; a mechanic; an electrician; a cook; a galley hand; and six members of a blasting and painting (B&P) crew.

On August 31, 2010, platform personnel began injecting one of its oil wells, the A-20, with gas lift in an attempt to bring more oil to the surface. At that time, a member of the production crew adjusted the platform's BPV upward to a higher set point in order to aid the process of gas lifting the well. No one reported any anomalies with the gas lift process.

At approximately 6:00 a.m. on September 2, platform personnel began their workday. The lead operator conducted a Job Safety Analysis (JSA) meeting, which only the B&P crew attended. The B&P team was slated to move equipment that day and prepare the area near the glycol contactor for water blasting. While the JSA meeting was being conducted, the remaining crew members began their usual daily duties. When the meeting concluded, the B&P crew placed Visqueen⁷ and duct tape around the Platform's BPV control box as well as other safety devices in the area to prepare the area for the water blasting. As they readied this area for blasting, the B&P crew was supervised by their foreman, but not by the lead operator.

⁷ Visqueen is a brand name for plastic sheeting.

At about 8:30 a.m., a member of a B&P crew inadvertently bumped the relay for the Level Safety High (LSH) on the glycol contactor while attempting to cover the contactor slave panel with Visqueen and duct tape. The Platform's process alarm sounded, and the seven oil and gas wells began shutting in. The lead operator responded to the master panel and discovered that the contactor's LSH indicator was illuminated, which he concluded meant that someone had accidentally bumped the relay. The lead operator then proceeded to the contactor's slave panel and reset the relay, while the A and C operators went to the well bay on the cellar deck and began closing the chokes and/or wing valves for each well. The mechanic went to the compressor, which was located on the main deck.

The lead operator then rushed to the well panel where he pulled and pinned the relays for all seven wells in order to open each well's surface safety valve (SSV). The mechanic used the gai-tronics communication system to request that the operators begin opening the low pressure wells. The lead operator instructed the A operator to begin opening the wells. The lead operator was still near the contactor's slave panel, where he spoke to the B&P foreman about the incident involving the contactor's LSH relay. Because the B&P crew needed to work in that area, the lead operator pinned, but did not flag, the LSH relay with a tie wrap to enable the B&P workers to cover the contactor's slave panel with Visqueen.

According to the operators, they successfully reopened all of the wells. During this process, some amount of gas traveled through the production train -- *i.e.*, gas was "packing the system." At about this time, the mechanic noticed that the compressor's discharge pressure was rising to a point where he became concerned, so he used the gai-tronics system to attempt to speak with the A operator. When the C operator answered the call, the mechanic told him that the compressor's discharge pressure was climbing too high. The C operator shared the information with the lead operator, who instructed the A operator to begin closing the wells because he knew that something must be wrong. Worried about the pressure, the lead operator hurried to the BPV control box in an

attempt to bleed off some pressure, but he could not open the control box door because it had been wrapped with duct tape and Visqueen by a member of the B&P crew.

The A Operator and lead operator then heard the contactor's PSV suddenly activate. The mechanic heard the compressor's discharge PSV activate and also heard a sound that he described as similar to "someone's hand hitting the desk" emanating from the cellar deck. After hearing this sound, the mechanic observed flames coming from the cellar deck in the area above the storage building on the northwest corner of the platform next to the flare boom. At or about the same time, the mechanic heard the PSV activate on the compressor, and several other crew members described hearing a sound and seeing flames. These witnesses have described the sound as "a firecracker [exploding] under water," a loud "explosion," or "somebody [taking] a sledgehammer and [hitting] it against the wall."⁸

According to the lead operator, he was trying to return to the well panel when he heard all of the wells' SSV and shut down valves closing upon activation of the relays. At this point, all of the wells are shutting in. The mechanic manually shut down the compressor and headed to the south stairway. He began yelling "fire" and activated the general alarm to alert the other crew members while he descended to the cellar deck.

During this time, the Heater-Treater's fire tube collapsed, and the oil and gas residing within the Heater-Treater came into contact with the vessel's hot burner. The forced draft section of the Heater-Treater was ejected from its mounting flange, which caused a noise that several crew members described as an "explosion." Oil burst into flames as it flowed out onto the cellar deck. The fire spread very quickly on the cellar

⁸ As is frequently the case when multiple witnesses experience the same events, the descriptions obtained from crew members are not fully consistent. For instance, some witnesses reported hearing what they called an "explosion" and then seeing fire, while others reported seeing fire first, and then hearing a series of "explosions." Although these inconsistencies most likely can be explained by some confusion as to the sequence of events given the stressful nature of the incident, it also is possible that there were multiple "explosions" or loud noises before and after the fire erupted, and that these sounds reported by the witnesses pertain to different events, including the sounds of the PSVs activating on the HP system and the sounds made by the bursting of fire extinguishers.

deck, and then spread to the main deck where it reached combustibles and ignited the living quarters and other buildings on the Platform. The fire produced a thick, oily black smoke, causing an undetermined amount of hydrocarbons to spill from the Platform into the water.

After the safety system's alarms activated, the lights on the Platform shut off, indicating that the natural gas generator had shut down. No one reported hearing the diesel generator attempting to start – the generator should have supplied power to run the firewater pump so that it could be used to fight the fire. Several portable and semi-portable fire extinguishers ruptured during the fire.

After twelve of the VR 380 A Platform crew gathered at the head of the stairway near the well panel on the northeast side of the cellar deck, they noticed that the galley hand was missing. Two crew members ran upstairs to the main deck to try to locate him. Although the C operator located the galley hand, the two men then somehow became separated from each other. The C operator rejoined the crew on the cellar deck, and these twelve crew members proceeded through the smoke down the only exit stairway that seemed available to the Plus 10 deck. Meanwhile, the galley hand reached the Plus 10 deck by climbing down a fixed metal ladder on the west side of the platform. The crew gave inconsistent accounts as to when during the evacuation they were able to get life jackets, but they all agreed that there were only twelve life jackets accessible to them during the fire.

After assessing the current and the waves, and after the heavy smoke reached the well bay located immediately above the men on the Plus 10 deck, the thirteen crew members evacuated the Platform by jumping into the water. The men stayed together in the water, and the single crewmember without a life jacket was kept afloat by two men who were wearing life jackets. While the crew was in the water, at least one B&P crew member did not understand suggestions in English to swim away from the Platform. At least one crew member reported seeing an oily substance in the water, which he reported made him nauseous.

The thirteen men remained in the water for approximately two to three hours before being rescued by the offshore support vessel *Crystal Clear*. At least one commercial helicopter flew over the men before a U.S. Coast Guard helicopter arrived on the scene. Ultimately, the *Crystal Clear* rescued all thirteen men and transported them first to a nearby oil production platform where they received medical attention. Later, all thirteen men were transported via helicopter to the Terrebone General Hospital in Houma, Louisiana where they were evaluated by medical personnel and released. There were no reported injuries.

THE DAMAGE TO THE VR 380 A PLATFORM

During the morning of September 2, MEI notified BOEMRE that there was a fire on the VR 380 A Platform. In response, BOEMRE inspectors from the Lake Charles District Office traveled via helicopter to the platform while it was still burning. As their helicopter flew over the site, the inspectors observed several small, developing fires burning on the Platform's main and cellar decks. By this time, the crew members had been rescued and moved to a nearby platform. The inspectors also observed a very light, silvery sheen in the water near the Platform, which measured approximately ¼ mile in length by about 200 yards in width. They took aerial photographs of the scene and then departed the area. Later that evening, the inspectors received reports that the fires on the VR 380 A Platform had been extinguished.

The next day, BOEMRE personnel, including inspectors and a structural engineer, visited the platform to examine the areas affected by the fire and assess the structural soundness of the Platform. At the time of their visit, all of the wells on the Platform remained shut in. While the BOEMRE personnel were onsite, they did not observe any evidence of a sheen in the vicinity of the Platform.

BOEMRE personnel concluded that the fire affected both the cellar and main decks of the Platform. For instance, on the main deck, the effects of the fire were visible in the center and the western areas of the platform -- the sleeping quarters, galley, MCC building, gas generator, several storage tanks, and storage buildings all sustained major damage or were totally destroyed. The switchgear building also was damaged. The fire on the cellar deck appeared mainly confined to the north, center, and western bay areas, which contained two out-of-service gas-driven pipeline pumps, the LACT charge pumps, "good" and "bad" oil tanks, and the Heater-Treater and Vent Scrubber, respectively. The components located in the north and center bays⁹ sustained varying levels of damage, which ranged from minimal to severe.

⁹ The good and bad oil storage tanks, the LACT charge pumps, and other piping and wiring.

BOEMRE personnel also observed substantial damage to the Heater-Treater and its immediate surroundings. The Heater-Treater's exterior sustained significant fire damage, and was blackened in various parts. The forced-draft fired component assembly section was found at least eight feet away from its original position on the front of the vessel. The round opening on the front of the Heater-Treater, which was exposed when the fired component assembly was ejected, had three of four bolts still in place with one bolt missing and the corresponding area split, which was consistent with the assembly forcibly being blown off. Viewing through the front of the opening, the BOEMRE inspectors could see that part of the fire tube had buckled or bent in a wavy configuration.

BOEMRE personnel also noticed that the fire walls and deck plating near and above the Heater-Treater were affected by the fire. These barriers appeared to function as intended by helping minimize damage to the Platform. They also observed that ignited liquids appeared to have burned the floor in the area near the Heater-Treater, and that the fire spread on the floor from the Heater-Treater to the area where the "out of service" pipeline pumps and good and bad oil storage tanks were located. Furthermore, the Heater-Treater's electronic control panel, pneumatic slave panel and flame signal panel sustained significant fire damage or were destroyed.¹⁰ The Heater-Treater's slave panel was seriously damaged and bent away from the front end of the Heater-Treater. The damage to these panels impaired the Panel's ability to conduct testing on them, and to reach conclusions regarding possible malfunctions or warning signals in the panels.¹¹

During the investigation, certain Panel members returned to the Platform several times to examine, inspect, photograph and/or test various production components and related safety devices. The Panel's purpose in examining these components was to look for as many possible clues to explain what caused: (a) the accident; (b) the crew to

¹⁰ The burner control panel runs through a sequence to start up and shut down the Heater-Treater's main burner, and also records the Heater-Treater's current temperature and set point. The slave panel contains alarm, shutdown and supply pressure gauges. The flame signal panel records the flame's temperature.

¹¹ The photographs depicting the damage observed on September 2 and September 3 are attached. See Attachments 1-9.

evacuate in the manner that they did; and (c) the causes of various safety risks present on the Platform.¹²

¹² The Panel's significant findings related to the Heater-Treater and the safety risks are described later in this report. *Appendix 3* contains the findings for the devices and components that neither played a role in causing the fire nor are related to the safety deficiencies.

BOEMRE REGULATIONS AND POLICIES

BOEMRE regulates, among other things, companies engaged in offshore production of oil and gas on the Outer Continental Shelf (OCS).¹³ Applicable regulations designed to protect health, safety, property, and the environment require lessees to: (a) perform all operations in a safe and workmanlike manner; and (b) maintain all equipment and work areas in a safe condition. *See* 30 C.F.R. § 250.107(a). In addition, lessees are to conduct operations in accordance with approved applications. *See, e.g.*, 30 C.F.R. §§ 250.410, 802 (related to SAFE charts).¹⁴

BOEMRE has specific regulations and policies that apply to the components and equipment on an oil and gas production facility. Below is a summary of the regulations and policies relevant to the VR 380 A Platform accident.

Heater-Treater

Pursuant to 30 C.F.R. §250.802(a), “all production facilities including separators, treaters, compressors, headers, and flowlines shall be designed, installed, and maintained in a manner which provides for efficiency, safety of operation, and protection of the environment.”

BOEMRE regulations also require that a lessee comply with certain American Petroleum Institute recommended practices (API RPs) incorporated by reference. *See* 30 C.F.R. § 250.198. Particularly relevant to Heater-Treaters is API 510, Pressure Vessel Inspection Code: In-Service Inspection Rating, Repair, and Alteration. 30 C.F.R. § 803(b). API 510 recommends that an operator have an inspection plan for Heater-Treaters. This inspection plan “shall contain the inspection tasks and schedule required to monitor damage mechanisms and assure the mechanical integrity of the equipment (pressure vessel).” *See* API 510, Section 5.1.2. The inspection plan, at minimum, shall:

¹³ *See* Title 30, Code of Federal Regulations, Part 250.

¹⁴ The SAFE Chart depicts the safety systems on a platform and shows which valves are supposed to shut in when an undesirable event occurs.

define the type(s) of internal or external inspections needed; identify dates for each inspection type; describe the requirements of any needed pressure test; and describe the inspection, the extent and locations of inspection, and any required repairs. *Id.*

Furthermore, API 510, Section 5.4.1 warns that pressure vessels are “susceptible to various types of damage,” and that “typical damage types” include corrosion, surface-connected cracking, and metallurgical changes.

Fire Water System

BOEMRE regulations also require that a lessee’s firefighting system comply with API RP 14G, Recommend Practice for Fire Prevention and Control on Fixed Open Type Offshore Production Platforms. *See* 30 C.F.R. §§ 250.198, 803(b)(8)(ii). API RP 14G Section 5.2 a.(4) states in relevant part that “fire water must be available to allow time for fire fighting or abandonment,” and that “fuel or power should be available for at least 30 minutes of run time during platform shut-in.” In addition, Section 5.2 a.(5)(a) provides that controllers “should be equipped for automatic and manual starting,” and that “automatic starting should be accomplished using pressure switches for on/off operations or automatic start upon activation of the [emergency shut down], fusible loop, or other fire detection system.” Section 5.2 a.(5)(b) states in part, “If electric fire pumps are to switch to emergency generators upon loss of primary power, then an automatic transfer switch should be provided.”¹⁵

Bypass

BOEMRE regulations and policies also govern the circumstances under which safety devices and systems on production platforms may be bypassed. For production safety systems, safety devices can be bypassed or blocked out of service only if: (a) the bypassing is temporary and for the purpose of startup, maintenance or testing procedures;

¹⁵ API RP 14F, Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities, Section 11.7.2.1 states that all electrical fire pumps should be installed with a wiring system “that will withstand direct flame impingement for a minimum of 30 minutes.”

(b) only a minimum number of safety devices are taken out of service at any one time; (c) the safety devices that are bypassed are monitored by personnel until placed back in service; and (d) safety devices that are bypassed or blocked out of service are flagged. *See* 30 C.F.R. § 250.803(c); Notice to Lessees (NTL) 2005-G01.¹⁶

Record Keeping

BOEMRE regulations require lessees to maintain specific records related to equipment and safety systems in certain locations. For instance, 30 C.F.R. § 250.804(b) requires a lessee to keep surface and subsurface safety device testing records at its field office “nearest the OCS facility.” Other BOEMRE regulations require a lessee to keep additional records related to operations, testing, and inspection at OCS facilities, including pollution inspection records (30 C.F.R. § 250.301) or records relating to the flaring/venting of gas and burning liquids (30 C.F.R. § 250.1105(d)). In addition, BOEMRE policies allow lessees to electronically store test records and other documentation in an Internet-accessible database or filing system. *See, e.g.*, BOEMRE NTL 2008-G13.

However, neither BOEMRE regulations nor policies require an operator to keep duplicate copies onshore of the kinds of records that became relevant to the Panel’s investigation, the only copies of which MEI claims were maintained on the Platform and destroyed in the fire.¹⁷ Nor do BOEMRE regulations require operators to generate and maintain records on the normal daily operating temperatures or pressures related to a Heater-Treater, and MEI did not keep such records. Thus, the Panel lacked access to data reflecting the exact temperatures and pressures of the Heater-Treater at the time of the fire on September 2. Such information would have greatly assisted our investigation.

¹⁶ MEI produced to the Panel internal documents that reflect its policy on the proper procedure for bypassing safety devices, which is consistent with BOEMRE regulations.

¹⁷ *See* the “Findings” section below for the records requested from MEI, which MEI represented were destroyed in the fire.

OVERVIEW AND SCOPE OF THE PANEL’S INVESTIGATION

A team of five people comprised the BOEMRE panel charged with investigating the accident: Gina Simms (IRU); Marcus “Scott” Mouton (Lake Charles District) and Julie King (Houma District), Field Operations, GOM OCS Region; David Izon, Accident Investigations Board, Office of Regulatory Programs; and George “Mike” Conner, Technical Assessment & Operations Support, GOM OCS Region. The Panel also obtained the expertise and assistance of Wayne Meaux (Lake Charles District), Field Operations, GOM OCS Region.¹⁸

Our investigation focused initially on identifying the causes of the fire. However, after uncovering issues that occurred on September 2 that posed appreciable risks to safety, we expanded our investigation to examine these issues. The Panel also received valuable assistance from the U.S. Coast Guard investigators who obtained the first statements from the VR 380 A Platform crew,¹⁹ and provided the Panel with relevant fire and safety-related documents. While the Panel has made certain findings related to lifesaving, evacuation, and firefighting issues, we have referred these issues to the U.S. Coast Guard for evaluation and, if appropriate, further investigation.

During our five-month investigation, we interviewed seven people who had been working on the Platform at the time of the accident, including the lead operator, the A and C operators and certain members of the B&P crew. The Panel also reviewed all of the oral and written statements provided by crew members to the U.S. Coast Guard immediately after their rescue.

BOEMRE Panel inspectors witnessed the removal of the fire tube from the Heater-Treater. The inspectors examined the fire tube and found significant amounts of corrosion and pitting. These and other salient pieces of evidence that aided the Panel in

¹⁸ The Outer Continental Shelf Lands Act (43 U.S.C. §§ 1348(d)(1), (2)) and Department of Interior regulations (30 C.F.R. § 250.191) require BOEMRE to investigate and prepare a public report of this accident.

¹⁹ Within a few hours after the VR 380 A Platform crew was rescued, the U.S. Coast Guard dispatched several Spanish- and English-speaking personnel to the Terrebonne General Hospital to take oral and written statements from members of the crew.

reaching its findings and conclusions are discussed below in the Findings section of this report.

The Panel also requested that MEI produce a substantial quantity of documents, including all documents related to any operating procedures, modifications, inspections, maintenance, and repairs of the Heater-Treater. We also asked the company to provide records on the rate of oil production at various points during the four years prior to the fire, as well as documents relating to the bypass of safety systems and firefighting and evacuation procedures. We also obtained documents from several companies related to the maintenance and repairs of the Heater-Treater and the Platform's BPV. As discussed below in the Findings section, certain types of documentary evidence were either unavailable or not provided by MEI.

In addition to lacking important documentary evidence, some potentially relevant physical evidence also was unavailable because it was damaged or destroyed by the fire. For instance, the Heater Treater's electronic burner control panel, pneumatic slave panel, and flame signal panel were damaged or destroyed. The absence of this physical evidence impaired the Panel's ability to determine with complete certainty the extent to which heat, pressure, and other factors contributed to the fire tube's collapse and caused the fire.

Finally, the Panel interviewed representatives from the manufacturer of the Heater-Treater and a certified fire and explosion investigator retained by MEI. We also reviewed all available documentary and photographic evidence. The Panel also consulted extensively with an oil production and Heater-Treater expert to assist the Panel in formulating its assessment and conclusions regarding the likely causes of the VR 380 A Platform accident.

FINDINGS

On the basis of all the evidence, BOEMRE determined the probable causes of the fire and found the most likely explanation for the safety deficiencies that occurred on September 2. Our findings related to the causes of the September 2 accident on the Platform, and the attendant safety risks identified by the Panel, are as follows:

Findings Related to the Accident

Findings on the Fire Tube and Heater-Treater

Members of the investigative team witnessed the removal of the fire tube from the Heater-Treater. As the fire tube was being removed, they observed that the fire tube was collapsed in a “canoeing” configuration—in other words, it was caved upward and inward from the top and the bottom. When members of the investigative team examined the Heater-Treater where the fire tube was originally located, they concluded that two openings were created, both of which were located on the fired side of the fire tube near the mounting flange. The underside or bottom of the fire tube caved upward and inward, separated from the mounting flange, thus creating one large opening. The top of the fire tube collapsed downward and inward, creating a smaller opening. The “canoeing” extended from the point at which the fire tube separated from the mounting flange through the middle section of the tube turn.

Upon careful examination of the fire tube, members of the investigative team found that it was blackened in color and there was evidence of a darker spot or “hot spot” on the top of the tube at a point near where the main burner’s flame was located when the tube was inside of the vessel. There was a crack in the first weld of the tube turn on the fired side, which was also located at a point close to where the main burner’s flame was located. Evidence of heavy corrosion and pitting (dimpling) were found along various parts of the fire tube, mainly on the fired side.

All of these factors suggested that the fire tube was affected by heat that, in turn, contributed to the deterioration of the steel comprising the tube. *See Attachments 10-15, Photographs of the Heater-Treater.*

In addition, members of the team examined the Heater-Treater's level safety low (LSL)²⁰ in an attempt to determine its set point in relation to the top of the fire tube. We were interested in determining whether the LSL was positioned far enough above the top of the fire tube. Based on their observations and measurements from outside of the vessel, the LSL appeared to be positioned just below the top of the fire tube. This likely meant that, if the liquid level had, in fact, dropped below the fire tube, the LSL might not have activated upon sensing a decrease in liquid below the top of the fire tube. If the fire tube were exposed, then there likely was not enough liquid to use the minimum amount of heat available at a low flame, and the proper temperature was not maintained in the tube because the heat was not adequately dissipating. While we were able to make this preliminary examination of the LSL, the Panel was not fully able to develop sufficient information to determine whether the fire tube was definitely exposed on September 2. Ultimately, as set forth below, the Panel relied upon the expert's conclusions related to the effect of heat on the fire tube.

Members of the investigative team also examined the Heater-Treater's TSH, PSV and its associated FSV, and stack arrestor to determine what role, if any, pressure or heat played in the fire tube's collapse. As a preliminary matter, none of the VR 380 A Platform's crew interviewed reported hearing the Heater-Treater's PSV activate on September 2. Upon examining the PSV, we found that a significant amount of hydrocarbon build up -- most likely due to age and the fire. We could not test the PSV's pilot due to fire damage. However, a member of the team applied pressure to the inlet side of the PSV valve body, pressure immediately leaked through the valve, and then the piston "popped" at 30 psig.²¹ The FSV on the Heater-Treater's PSV discharge outlet piping was stuck open, but we did not have adequate evidence on which to base a

²⁰ Level safety low is defined in *Appendix 1*.

²¹ MEI's records for the Heater-Treater indicated that its maximum allowable working pressure was 50 psig, and that its PSV was last tested in January 2010 and it registered at its set point.

conclusion as to why it was stuck open or for how long. If, however, the FSV was stuck open on September 2 and the Heater-Treater's PSV was also stuck open-- or a significant amount of gas impacted the PSV and moved it-- then, the FSV device would not have stopped the possible back flow of gas from the high pressure vent piping system into the Heater-Treater. Such pressure thus could have aided the collapse of the fire tube. In view of the PSV's condition and the absence of information related to it, we lacked sufficient evidence to conclude that the PSV activated on September 2 in response to any increase in pressure in the production train.

With respect to the Heater-Treater's TSH ex-lines, members of the investigative team pulled and viewed the elements from the liquid media and exhaust stack sides; neither one was damaged. The set points were 178°F and 1170°F, respectively. However, MEI's records reflect that the liquid media TSH was last tested in May 2010 and its set point was 136°F, and that between May 2006-May 2010, the TSH's set point was 136° F. Thus, the Panel concludes that MEI installed a higher temperature TSH (178° F), possibly in response to the vessel's having experienced high temperatures. However, MEI failed to update its testing paperwork to reflect this fact. In addition, as described below in the section containing the Heater-Treater's expert's findings, it is quite possible that the TSH failed or that the fire tube melted before the temperature was transmitted through the still liquid to the TSH.

When members of the investigative team inspected the Master Panel after the accident, they found that the Heater-Treater's indicator was the only indicator tripped in the shut down group. We concluded that this could mean that, on September 2, the Heater-Treater's PSH activated, or that the tripped indicator signified that other indicators (level safety high or level safety low) activated. Alternatively, it could mean that when the Heater-Treater's pneumatic slave panel was knocked over on September 2, the shut down signal line between its slave panel and master panel was severed and the indicator was tripped to signify this fact. Because of the damage to and destruction of physical evidence related to the Heater-Treater, there is no way of knowing whether a safety device indicator activated or the shut down signal line was severed on September 2.

Thus, regrettably, our analysis of the Platform's Master Panel does not help in determining the causes of the accident.

Finally, members of the investigative team examined the stack arrestor and found it to have a large accumulation of hydrocarbons and rust build up. In addition, a 2" to 4" section of the element was broken and separated from the stack arrestor's housing. We found that this could be consistent with the stack arrestor receiving some amount of pressure before the fire or from the impact of the gas and liquid stream blowing the forced draft assembly off the vessel. Thus, we cannot rule out completely that pressure played some role in the fire tube's collapse.

In sum, based on the examination of the Heater Treater's PSV and TSH devices and its fire tube, we found that heat and pressure most likely played a role in causing the fire tube's collapse and subsequent fire. We provided this information and findings to the expert, who, as set forth later in this report, analyzed and expanded upon these findings, which enabled us to reach conclusions about the causes of the accident.

The Fire Tube and Heater-Treater: Historical Information

In order to obtain as much information as possible about how the Heater-Treater actually functioned, and was supposed to function, prior to September 2, we: (a) interviewed and obtained information from a contractor who repaired and evaluated the Heater Treater in 2006 and 2009; (b) re-interviewed the lead operator and also reviewed statements made by the A operator; and (c) obtained and reviewed documents from MEI related to oil production levels on the VR 380 A Platform.

Contractors' Information Related to the Heater-Treater

After we reviewed information produced by MEI and other companies related to the maintenance and repairs performed on the Heater-Treater, we determined that this specific Heater-Treater had a history of performance issues that provide evidence as to why the fire tube eventually failed.

For instance, in 2006, several issues arose related to the functioning of the Heater-Treater. In June 2006, MEI hired Contractor #1²² to rewire the Heater-Treater's PLC panel after it was discovered that the wrong voltage had been previously fed into the system and its wires burned. In September 2006, issues arose related to the proper functioning of the Heater-Treater's forced draft burner. Specifically, the burner would light but not stay in service, and it emitted white smoke out of its stack. In response to these problems, MEI hired Contractor #2, who pulled the burner assembly and discovered a crack in the top of the fire tube. According to the lead operator and MEI, a now-defunct company cleaned the Heater-Treater and pulled out and steam-cleaned its fire tube. MEI claimed that this company also welded the crack in the fire tube, and then reinstalled the fire tube in the Heater-Treater. We requested records to substantiate MEI's claim that the fire tube was repaired. In response, MEI did not produce any of these requested records, claiming that it did not possess the records. Similarly, MEI did not produce records establishing that the repair was in fact done – and if so, whether it was performed by the now-defunct company, its own personnel, or other contractors hired to work on the VR 380 A Platform.

In October 2006, Contractor #2 was again hired by MEI to investigate the source of temperature and heat spikes that the vessel had been experiencing. Contractor #2 warned MEI that the oil volume might be too low for the Heater-Treater to operate properly, and the burner was overheating the fire tube thus causing the liquid temperature to be too high. Contractor #2 stopped the temperature spikes by isolating the water dump valve on the fire tube side of Heater-Treater.

²² In this report, the contractors hired shall be referred to by different numbers.

Thereafter, in January 2009, MEI again reported to Contractor #2 that it was having problems regulating the Heater-Treater's temperature. Documents obtained from Contractor #2 reflect that he examined the Heater-Treater and its burner. Following this examination, Contractor #2 again warned MEI that the oil production may be too low for the Heater-Treater's burner flame. Later, in October 2009, MEI asked Contractor #2 to evaluate the Heater-Treater to determine its functionality. Contractor #2 told us that an MEI representative asked for this assessment because MEI was planning to increase production on the Platform and wanted to ensure that the Heater-Treater could handle the increased oil production rates. Contractor #2 also told the Panel that he examined the Heater-Treater in October 2009 and determined it was functional, but that he recommended that MEI make several repairs to it.²³ Ultimately, MEI did not hire Contractor #2 to do the Heater-Treater repair work that he recommended.

Documentary Evidence Related to the Heater-Treater

According to MEI, the sole copies of the Heater-Treater's operating procedures and certain key drawings and schematics related to the Heater-Treater were only kept on the Platform in a binder above the lead operator's desk. The lead operator also stated that tally books/log books that purportedly reflect all of the normal activities and anomalies that occur on a platform were also on board the VR 380 A on September 2. MEI represented that all of these documents were destroyed in the fire.

In response to the Panel's request for all information related to the maintenance, inspection, and repairs performed on the Heater-Treater, MEI admitted that they did not have an inspection plan for the Heater-Treater as required by BOEMRE regulations. In addition, we found that MEI failed to produce any records indicating that at any time after 2006, the fire tube was removed and inspected by any contractor. Nor did MEI produce any records that demonstrated consistent, periodic inspection and maintenance of

²³ For instance, the contractor noted that the Heater-Treater's fire tube gasket was leaking and required replacement parts, and that a visual inspection of the fire tube could also be performed at the time the work was done. According to the contractor, replacing the gasket reduced the chances of it leaking, which translated into less "down time" or less time that the fire tube was not functioning properly.

the Heater-Treater's fire tube. With respect to records related to the inspection, repairs, and maintenance performed on the Heater-Treater in general between 2006-2010, the Panel determined that MEI's record keeping was, at best, incomplete. For instance, while the Panel obtained several significant documents related to the Heater-Treater's condition from MEI's contractors, MEI—the entity with the ultimate responsibility for safe operation of its platform—did not have much of this information. MEI did not specifically represent that these records were lost or destroyed; rather, MEI told us that it produced all of the records it had. Thus, the Panel concludes that MEI cannot furnish any evidence demonstrating that it performed routine inspection and maintenance of the Heater-Treater.

Although BOEMRE regulations do not specifically require inspection of the fire tube, given this prior history of significant Heater-Treater malfunctions, the Panel was troubled that MEI did not heed any of these warnings and failed to implement an inspection plan for the Heater-Treater, as required by BOEMRE regulations. Routine inspection of the Heater-Treater most likely would have revealed the deteriorated condition of the fire tube and should have led to appropriate maintenance to ensure that the Heater-Treater would function properly and safely. Had MEI conducted appropriate maintenance on the Heater-Treater the accident likely could have been prevented. Moreover, as discussed below, the rate of oil production through the Platform remained lower than the volume that the Heater-Treater was designed to process efficiently—another factor that MEI was warned about, yet ignored.

Information from the VR 380 A Platform Crew Related to the Heater-Treater

None of the witnesses interviewed reported being near the Heater-Treater on September 2. Accordingly, there is no person who can report exactly how the Heater-Treater appeared before the accident. In addition, the A operator stated that the Heater-Treater's main burner was not set up to shut off when the Platform shut in after the LSH on the contactor was tripped. The lead operator also told us that the Heater-Treater's operating temperature was normally set at 140°, and its operating pressure range was 38 to 40 psig. He said he did not regularly record Heater-Treater temperatures, although he

claimed that he performed daily visual inspections on the Heater-Treater to check for “irregularities.” The lead operator acknowledged, however, that there was no documentation to corroborate his claim of having performed daily inspections.

Both the lead operator and A operator told us that the only time they recalled the fire tube being pulled and inspected during the past four years was in 2006. The lead operator also stated that he did not recall the Heater-Treater being pressure tested during the roughly 4 to 5 years that he worked on the VR 380 A Platform.

Significantly, the lead operator corroborated Contractor #2’s account that there was a crack in the fire tube in 2006, and that Heater-Treater experienced temperature spikes in 2006 and 2009. In particular, he stated that when the temperature inside of the Heater-Treater got too high, the crew would have to “cut it off.”²⁴ In addition, the lead operator acknowledged that as recently as January 2009 Contractor #2 warned the company that there was too little oil production for the Heater-Treater, and that this caused the Heater-Treater to experience frequent temperature spikes. The lead operator claimed, however, that when the A-20 well was brought online in January 2009, the temperature-related malfunctions ceased. The lead operator claimed that there were no other temperature-related issues with the Heater-Treater after 2009.

Finally, the lead operator told us that Contractor #2 had warned him of the dangers of having a Heater-Treater with a forced draft burner: “ ‘*You’re best off out of the area in case of a malfunction.*’ [Contractor #2] said, ‘*a forced draft Treater is a time bomb. And it is notorious . . . I’m surprised to even see one in the Gulf still.*’ ”

²⁴The lead operator added that there was what he called a “malfunction” with the Heater-Treater’s electronic flame signal temperature panel where it would “steady flash alarm.” He claimed that when one looked at the burner control panel, there would be no indication that anything was amiss. According to him, efforts to fix the “false alarm” were unsuccessful, and the company never rewired the alarm system.

Production Levels

As part of the investigation, we reviewed MEI records related to the volume of oil processed through the VR 380 A Platform at certain specified times. The records reflect that the highest rate of production through the platform was in the early 1980s when the rate averaged approximately 3,000 barrels of condensate/oil per day. The rate of production declined steadily thereafter. Immediately prior to Hurricane Rita in September, 2005, the rate of production on the Platform was less than 200 BOPD. Hurricane Rita damaged the production platform, which caused all production to cease for several months. In approximately mid-2006, the Platform returned to production.

When Contractor #2 discovered the crack in the Heater-Treater's fire tube in September 2006, the total rate of oil production for that entire month was approximately 5400 barrels (bbls). In October 2006, when Contractor #2 first warned MEI that the rate of production was too low relative to the Heater-Treater's burner flame, the total rate of condensate/oil production for that month was approximately 5100 bbls. In September 2008, Hurricane Ike severely damaged the Platform and its production facilities. Repair of the Platform was completed in 2009. About one week after Contractor #2 again warned MEI that the rate of production was too low for the Heater-Treater, the rate of production through the Platform was approximately 816 BOPD. Finally, during the week preceding the accident, the rate of production through the Platform ranged between a high of 1604 BOPD to a low of 1472 BOPD, which was the production rate on September 1, 2010, the day before the accident.²⁵

Based on this evidence, we concluded that during the past few years, the rate of production never approached the estimated volume that the Heater-Treater should have been handling. We also concluded that, at the time of the accident, the platform was almost surely producing less oil than the Heater-Treater was designed to process.

²⁵ There is no production data available for September 2, 2010. The A operator told the Panel that the rate of production around this time was approximately 1800 BOPD.

According to our expert, this low level of production, a problem that MEI was aware of, was a significant factor contributing to the fire tube's collapse.

Given this prior history of warnings to MEI concerning the effect that low production volume had on the Heater-Treater, we find it deeply troubling that MEI failed to implement an inspection plan for the Heater-Treater. Equally troubling to the Panel was the fact that MEI undertook significant repairs to its platform after it was damaged by two Hurricanes, yet it failed to pay attention to its Heater-Treater and implement an inspection plan. Had MEI regularly inspected the Heater-Treater, as required, and then conducted appropriate maintenance, the accident likely could have been prevented.

Information Provided by Experts

In order to better understand why the fire tube collapsed and how the fire occurred, we interviewed the manufacturer of the Heater-Treater and the Certified Fire and Explosion Investigator hired by MEI.²⁶ The Panel also hired and extensively consulted with a Heater-Treater expert.

Heater-Treater Manufacturer

We interviewed representatives from the company that manufactured the Heater-Treater (the "Manufacturer") with the hope of gaining further insight into why the Heater-Treater's fire tube collapsed. The Manufacturer has made forced draft and natural draft Heater-Treaters for many years. Based on that experience, the manufacturer described numerous scenarios that could cause a fire tube to weaken. For instance, "stress cracks" can arise on a fire tube's surface if incompatible metals or bad welding procedures are used to repair the fire tube. The manufacturer also opined that exposure of the fire tube outside of the liquid bath would increase stack temperature radically. If

²⁶ At the time that he was interviewed, the fire expert had not reached any conclusions as to the origin or causes of the fire. However, he did opine that the fire most likely originated in the Heater-Treater's "vicinity," and that he preliminarily believed that an explosion may have occurred inside of the Heater-Treater. He also preliminarily opined that the hydrocarbons located inside of the Heater-Treater most likely fueled the fire. None of his preliminary findings are inconsistent with our findings.

the fire tube is not covered in the bath as designed, temperatures would increase because fluids would not be present to dissipate the tube's heat. The heat would continue to increase on the exposed fire tube and radiate to all of the exposed tube including the stack. Furthermore, the normal flame pattern within the fire tube is directed in the center of the tube, but anything that changes the centering of this flame could create hot spots and heat stress. According to the manufacturer, hot spots weaken a fire tube to the point where only a small amount of differential pressure on the tube could help cause the fire tube's collapse.

Heater-Treater Expert

To obtain an expert's analysis, we consulted with Al Porter at Casbanan Engineering Associates, LLC, who has more than 50 years' experience with, among other things, the design, construction, manufacture, maintenance, repair, and disassembly of Heater-Treaters, as well as in systems of oil production platforms. Mr. Porter examined the fire tube, and noted the crack, "canoeing," and appearance of pitting and corrosion. He also observed what he called a "hot spot" or "bubble" on the top side of the collapsed fire tube, which he opined was evidence that excessive heat that weakened the fire tube. He also reviewed relevant scientific literature on the main burner and the fire tube, and evaluated a report prepared by another company on the structural integrity of the Heater-Treater after the fire. This report indicated that the shell of the Heater-Treater that contained the fire tube was not damaged. Mr. Porter concluded that this fact would tend to negate the possibility that overpressure played a role in the fire tube's collapse. However, he did not rule out the possibility that the Heater-Treater's operating pressure aided the collapse of the already-weakened fire tube.

Mr. Porter produced a written report, upon which the Panel relied in reaching its conclusions as to the causes of the accident. *See Appendix 2*. In sum, the expert concluded as follows:

During its nearly 30-year life, the fire tube was in regular use and experienced high-temperature spikes, which likely caused the strength of the fire tube's steel to diminish and the fire tube to weaken. After the wells shut in, the Heater-Treater's main burner did not shut off, but, rather, went to low flame. Heat continued to be introduced into the Heater-Treater's fire tube, and its temperature most likely continued to rise because circulation of oil to the Heater Treater ceased for approximately 3 to 5 minutes while the wells were shut-in. When the wells were shut in, the production flow through the Heater-Treater most likely was greatly reduced or lost, and the heat flux rate on the fire tube became too high. Because the Heater-Treater was designed to handle a large volume of oil per day, it was oversized for the volume of oil that it was most likely processing on September 2. This meant that there was not enough liquid to use the minimum amount of heat available at a low flame, and the proper temperature was not maintained in the tube. Without sufficient heat transfer away from the tube, a higher temperature most likely resulted, which, further weakened the integrity of the already-diminished fire tube.

With respect to the TSH, Mr. Porter could not explain why it did not activate and automatically shut down the Heater-Treater. He suggested that one possibility was that the fire tube could have collapsed prior to the temperature being transmitted through the static liquid and reaching the TSH shut down device.²⁷

Mr. Porter further opined that the already weakened fire tube collapsed inward on both the top and the bottom in a "canoeing" configuration. The hydrostatic pressure of the liquid in the vessel plus the normal operating pressure on the Heater-Treater (35

²⁷ The results of metallurgical testing were not available for inclusion in this report. These results most likely would have provided the temperature of the fire tube when it collapsed and also the exact yield strength of its steel. If the fire tube's yield strength was diminished, then it is possible that as little as 35 psig operating pressure would have been necessary to help cause the collapse of the fire tube. Mr. Porter believes that the metallurgical testing would serve to confirm not negate his conclusions that the 30-year old fire tube collapsed because it had decreased yield strength and was subjected to too much heat over time, including by virtue of the fact that the burner's flame was too high for the volume of oil actually being processed through the Heater-Treater (the oil was being "cooked").

psig), would have been enough to help cause the tube's collapse. A fire most likely erupted when hydrocarbons ignited when a surge of liquid and gas came into contact with the still-lit burner and air and then forcibly ejected the flange from the unit—Mr. Porter suggested that this is the most likely explanation for the “explosion” that the crew reported hearing that caused the bolts that held the burner mounting flange to be bent and/or blown off.²⁸

Summary of Findings

In sum, our conclusions on the causes of the accident are based on: inspectors' findings regarding the Heater-Treater's fire tube and its devices; the expert's findings; statements by crew members; MEI and service contractors' records; oil production records, and information from the Heater-Treater manufacturer. We concluded that on September 2, 2010 the fire tube was weakened by heat and other factors, and that the Heater-Treater's operating pressure most likely aided the fire tube's collapse in a “canoeing” configuration. We also found that this Heater-Treater had a prior history of temperature-related malfunctions and that MEI had been warned about the effect that low oil production volume had on the Heater-Treater. We further found that MEI did not heed the warnings regarding production volume, nor did it implement an inspection plan for the Heater-Treater as required by BOEMRE regulations.

Based on all of the evidence, we ultimately concluded that MEI failed to adequately maintain or operate the Heater-Treater in a safe condition. The specific causes of the accident are articulated below in the “Conclusions” section.

²⁸ The expert, however, did not rule out the possibility that the “explosion” that the crew described occurred inside of the Heater-Treater.

Findings Related to Safety Conditions on the Platform

With respect to the safety conditions on the Platform at the time of the fire, we considered the statements of crew members related to fire and evacuation drills and bypass of safety devices. We also evaluated the evidence related to firefighting and lifesaving equipment and emergency drills conducted on the Platform. We interviewed an MEI electronic data (SCADA) technician and a technician knowledgeable about BPVs and also evaluated the physical and documentary evidence related to the BPV, the firewater pump, and the bypass of safety devices.

This section contains our findings on the BPV and bypass, which support our recommendations that INCs be issued. It contains our findings on lifesaving equipment, emergency drills and evacuation, which were made to aid the U.S. Coast Guard in their investigation. We note that the absence of important documentary evidence and inconsistent statements from some of the crew members prevented us from reaching firm conclusions regarding whether the safety deficiencies related to emergency drills and the evacuation of the Platform occurred.

The September 2 Pressure Event

Back Pressure Valve and SAFE Chart

By way of background, according to the A operator, the BPV controller was adjusted from a set point of 1050 psig to 1100 psig for the purpose of gas lifting Well A-20 on August 31, 2010. After the adjustment, the Platform did not experience a shut-in of all the wells until the B&P crew member bumped the relay on the contactor and caused the Platform to shut in on September 2.

Our investigation included examining the Back Pressure Valve in an attempt to better understand the increased pressure in the production train on September 2, 2010 and to determine whether overpressure played a role in the fire tube's collapse. The BPV

was removed and visually inspected and found to have a little scale build up. The inside of the BPV controller showed evidence of wet fuel gas (i.e. flapper and nozzle were corroded, nozzle was partially plugged with debris, and there was a rust stain on the vent port of the proportional band adjustment control). During the process of disassembling the BPV controller, we discovered that the bourdon tube linkage bearing was not located in the correct position. Also, after reviewing the Fisher parts manual, we discovered that there was one flat washer missing on the bourdon tube linkage. In addition, after speaking with a technician familiar with Fisher parts, Panel members learned that it was critical for the linkage bearing to be correctly positioned and for the controller to be properly calibrated in order for it to function properly.²⁹

Based on statements of the crew and our review of evidence, we found that after the wells shut in, the reciprocating gas compressor remained online, and well A-20's production casing continued to slowly pressure up with gas-lift pressure. This most likely resulted in a decrease of system pressure, which likely caused the Platform's BPV controller to increase output pressure to the valve's actuator, thus moving the BPV to the closed position. As a part of the process to bring the Platform's wells back online quickly to prevent the compressor from shutting completely down, all of the wells were rapidly opened rather than being brought on slowly. This caused an amount of gas pressure to build up rapidly within the production system, especially within the high pressure system. Because the controller's bourdon tube linkage was inappropriately assembled, and the controller appeared corroded, the controller most likely did not function effectively in response to the rapid rise in the Platform's system pressure. Because the BPV could not open fully or fast enough to relieve the system pressure, the pressure rose on the blocked system, and the PSVs on the glycol contact tower and the compressor activated. This presented a safety hazard to the crew. This sequence of events led us to recommend that the INC outlined later in this report related to the BPV be issued.

²⁹ Furthermore, the technician also stated that the control box must be properly vented to enable pressure to escape.

We also reviewed the most recent SAFE chart related to the compressor and other components that MEI submitted to BOEMRE, which was dated January 2010. The SAFE chart showed the addition of multiple shut down functions, including the shut down of the compressor when the LSH on the contactor was tripped. Yet, when interviewed, none of the crew members said that the compressor shut down when the B&P worker accidentally bumped the LSH relay on the contactor. As set forth in the “Conclusions” section, had the compressor shut down, the crew would not have been in such a hurry to keep production online and the pressure-related events might have been averted. Accordingly, we recommend that an INC be issued to MEI for failure to conduct operations in accordance with approved applications, in violation of BOEMRE regulations.

Bringing the Wells Back Online After the Shut In

According to the lead and A operators, after the shut in occurred their goal was to bring the Platform back online before the compressor shut completely down, because this would require a more involved process to bring the wells back online.

In addition, the mechanic told us that after the wells were reopened, he noticed that the compressor’s discharge pressure was rising to a point where he became concerned, so he alerted the operators. Worried about the pressure, the lead operator rushed to the BPV control box in an attempt to bleed off some pressure, but he could not open its door because it was wrapped with duct tape and Visqueen. The PSVs on the contactor and compressor activated, which corresponded to an increase in pressure within the high pressure system.³⁰

In order to further understand the September 2 pressure event reported by the crew, we examined the Platform’s well panel and test separator slave panel, and considered the statements of the lead operator, A operator, and mechanic about what safety devices were pinned out of service after the wells were shut in.

³⁰ A sudden spike in pressure was recorded on the Barton circular gas lift pressure chart.

On September 3, 2010, when we examined the Platform, the seven wells relays were not pinned; however, there were tie wraps hanging on each relay, and one relay had a tie wrap located behind it. Because the crew reported that the pressure continued to rise on the HP and LP system, including the compressor, we concluded that it is most likely that all seven wells were pinned out of service with tie wraps and not monitored by the operators. With all seven wells most likely pinned out of service with tie wraps, the flowline PSHL as well as all other safety devices on process components were rendered ineffective and unable to perform their designed function -- *i.e.*, to shut in the wells. Statements made by the crew suggested that the operators did not monitor the pressure on the flowlines as they brought on the wells. If they had monitored the flowlines, they most likely would have noticed an increase in pressure within the production train and could have closed the chokes and wing valves for the wells before the PSVs activated on the compressor and contactor.

Finally, during the initial onsite visit on September 3, 2010, we observed that the relays for the LSHLs on the test separator slave panel were pinned with tie wraps and not flagged.

All of these violations led us to recommend that the INCs outlined later in this report related to bypass be issued.

Credibility of Statements Concerning Bypass

One crew member stated that the wells were not “pinned” out of service with tie wraps. We did not find this claim credible in light of the evidence that supported the opposite conclusion. As outlined above, we found that the VR 380 A Platform’s wells were, in fact, pinned out of service with tie wraps on September 2. When confronted with evidence supporting this theory, the lead operator admitted putting the wells into bypass to start up the Platform following the shut in, yet denied pinning the wells in service with

tie wraps, even though there were some tie wraps found on the panel.³¹ We believe that the lead operator denied pinning the wells in service because he is aware that BOEMRE regulations only allow a minimum number of devices to be put in bypass upon start up, or because he knows that BOEMRE regulations require personnel to monitor bypassed safety devices. We inferred that the lead operator did not want to admit to violating BOEMRE safety regulations.³²

The lead operator said that he pinned the relay for the contactor LSH with a tie wrap and did not flag it after the initial shut-in in order to facilitate the covering of the contactor's slave panel. He claimed that he did this only to allow the B&P crew to work in that area without triggering another shut in. However, when confronted with evidence that the relays for the LSHs on the test separator slave panel were pinned with tie wraps and not flagged, he denied pinning the devices and claimed that the A operator also denied knowing why the tie wraps were there.

While we cannot prove with certainty that the lead operator's statements about bypass were deliberately false, they are inconsistent with the other evidence gathered during the investigation. We note that when BOEMRE investigates an incident, it is critical that all operator personnel with knowledge of relevant facts be completely candid with investigators, particularly where, as here, the incident resulted in the destruction of critical evidence. The failure of operator personnel to be candid with BOEMRE investigators calls into question the operator's overall cooperation with the investigation. BOEMRE considers operator cooperation in its incident investigations as part of its evaluation, pursuant to 30 C.F.R. § 250.136, of whether an operator's performance is acceptable.

³¹ MEI provided the panel with documents that clearly-articulated the company's policies concerning appropriate methods of bypassing safety systems, which are consistent with BOEMRE regulations. We find that the lead operator did not adhere to those policies.

³² According to MEI, copies of the "Device Bypass Logs" for August 2010 which purportedly would show all devices bypassed and the frequency of bypass, were destroyed in the fire.

Firefighting and Lifesaving Equipment

According to MEI documents provided to us, fire extinguishers, personal flotation devices (PFDs), and life rafts were onboard the VR 380 A Platform on September 2.³³ The documents provided by MEI contain several discrepancies as to the total number of PFDs that were on the Platform at the time of the incident. Based on statements obtained from the VR 380 A Platform crew and on a review of photographic evidence, we determined that 12 life jackets were inside of the life jacket box located at the head of the stairway near the well panel on the northeast side of the cellar deck where the crew gathered as they decided to evacuate the Platform. In addition, we found that two life rafts and an additional life jacket box were located near the master panel and Heater-Treater on the southwest side of the cellar deck, away from where the crew congregated when they decided to evacuate. Finally, we found a life float hanging near the northeast stairway on the cellar deck.

We found that the Platform was equipped with an electric firewater pump and manually-activated deluge system in the Heater-Treater and Reboiler bay. When examined after the accident, we found the manual valves in the closed position. Inspectors also found that the electric pump had a transfer switch and an associated wiring system, but they were damaged in the fire. Crew members stated that after the fire erupted the lights went out on the platform, and they never heard the diesel generator start. Based on these statements and examination of the physical evidence, we found that after the fire began, the firewater pump failed to switch to the emergency generator either upon loss of the primary power or because its circuitry was burned, which caused the crew to be without a firewater system that worked for the thirty-minute period required per BOEMRE regulations. *See* 30 C.F.R. §§ 250.198, 803(b)(8). The failure of the emergency generator to energize upon Platform shut-in most likely resulted when the switchgear building and wiring was damaged by the fire. The switchgear building was located on the top deck, directly above the out-of-service gas-drive oil pipeline pumps. The damage to the switchgear building prevented the motor controllers from performing their designated functions of activating and energizing the diesel generator to give the

³³ *See Appendix 3* for a list of this equipment.

electric firewater pump continued power to operate. The placement of the switchgear building and lack of risk assessment when the equipment was installed, in all likelihood created a hazardous and potentially pernicious situation for the crew on board.

Documents Related to Emergency Drills and Evacuation of the Platform

On January 12, 2010, a BOEMRE inspector, acting on behalf of the U.S. Coast Guard, performed a complete U.S. Coast Guard inspection of the VR 380 A Platform. At that time, the inspector reviewed MEI's 2009 Coast Guard Form 5432 as well as documents related to the emergency drills conducted by Mariner in 2009.

We asked MEI to produce documents related to emergency drills conducted by the company from January 2010 through September 2010. MEI failed to produce complete records that established the emergency drills conducted between September 2009 and September 2010. MEI maintained that it was unable to produce these records because the records were kept on the Platform and destroyed in the fire.³⁴ As set forth below, the MEI witness and MEI's contractors were unable to provide concrete or consistent evidence regarding emergency drills conducted by MEI. The Panel, therefore, cannot conclude that the documents the BOEMRE inspector reviewed in January 2010 explain adequately and completely the kind of emergency drills that MEI says that they conducted some eight months after the inspection.

Statements Related to the Fire and Evacuation Drills

Some VR 380 A Platform crew members indicated that they conducted emergency and evacuation drills, while other crew members indicated that there had been no drills during the roughly two-week period prior to September 2. The Panel was not able to precisely determine whether these contradictory statements were innocently made or were deliberately misleading. However, the Panel determined that on September 2, the crew did not appear to act consistently with any duties assigned to them.

³⁴ MEI claimed that the "Weekly Emergency Drill Reports" documentation related to evacuation, simulated fire and man overboard drills, and weekly fire pump inspection reports for August 2010 were destroyed in the fire.

We received varying accounts of the evacuation from the Platform. According to one account, the crew passed the life floats and life jackets on their way down to the boat landing and had to come back up to get the life jackets. According to another version of events, some crew members grabbed life jackets on their way down to the boat landing, and then two people returned to the cellar deck to retrieve additional jackets. In addition, two men went up to get the Galley Hand and didn't get any of the life jackets on the way down to the Plus 10, nor did they get them from the crew's quarters. At no time did anyone launch any of the life floats, life rafts, or ring buoys. Moreover, witnesses gave differing accounts as to how the personnel arrived at the Plus 10 deck. Furthermore, the crew was unable to notify anyone before evacuating the Platform. While the explosion and fire likely were extremely frightening and led to confusion on the Platform, we found that the crew failed to act in accordance with a regularly-practiced and drilled procedure. In sum, the Panel found that the crew probably did not perform adequate and effective emergency response and evacuation drills while the B&P crew was onboard.

The witnesses interviewed by the Panel were consistent in their statements that there were not enough life jackets accessible where they needed them -- only twelve men donned life jackets, while the C operator remained without a life jacket.

We were unable to determine with certainty whether the fire, evacuation, and other emergency drills did, in fact, occur during the three weeks prior to the fire. Accordingly, we respectfully recommend that the U.S. Coast Guard consider pursuing an investigation into whether emergency drills were conducted on the VR 380 A Platform with this crew, and if so, how often, as well as investigate the placement of life saving equipment, and the crew's failure to avail itself of that life saving equipment on September 2.

Communications with the B&P Crew

Several members of the VR 380 A Platform crew told us that, on September 2, the lead operator conducted a Job Safety Analysis meeting that was not attended by the entire crew, but only by the B&P crew. In addition, the lead operator stated to the Panel that he did not supervise the B&P crew as it was wrapping the BPV control box with duct tape and Visqueen in order to perform their operations for that day.

In this case, we did not find any violations of BOEMRE rules and regulations on JSA meetings or supervising third party contractors performing temporary work on a platform. However, we determined that the acts did pose a risk to safety.

In addition, the Lead Operator told us that there were several non-English-speaking members of the B&P crew. When the crew was in the water, at least one of those persons did not understand suggestions in English to swim away from the Platform. We found that the language barrier posed a risk to his safety because the worker could have been seriously injured by falling debris.

CONCLUSIONS

Causes of the Accident

We found that the fire was caused by MEI's failure to adequately maintain and operate the Platform's Heater-Treater in a safe condition. The immediate cause of the fire was that the Heater-Treater's weakened fire tube became malleable and collapsed in a "canoeing" configuration, ripping its steel apart and creating openings through which hydrocarbons escaped, came into contact with the Heater-Treater's hot burner, and then produced flames.

In addition, we determined that a probable contributing cause of the fire was that the fire tube sustained high temperature spikes, operating heat from regular use, substantial pitting and corrosion during its nearly 30-year life, which diminished the strength of the fire tube's steel and contributed to its weakening. Moreover, the Heater-Treater's normal operating pressure aided the collapse of the already-weakened fire tube.

We also found that a possible contributing cause of the fire was the fact that the Heater-Treater was designed for a significantly higher production (process fluid) flow rate than was most likely being processed on the Platform at the time of the incident. This meant that there was not enough liquid to use the minimum amount of heat available at a low flame, and the proper temperature was not maintained in the tube because the heat was not adequately dissipating.

Furthermore, we found that a possible contributing cause of the fire was the company's failure to follow the BOEMRE regulations related to API 510 that require an inspection plan for Heater-Treaters and its failure to regularly inspect and maintain the Heater-Treater. BOEMRE regulations require the operator to routinely maintain and inspect the pressure vessel. While the regulations do not specifically address the fire tube inside of the Heater-Treater, weaknesses in the fire tube and temperature-related issues would likely have been identified if the operator routinely inspected the Heater-Treater.

Finally, we found it inexcusable that, even though MEI knew that the Heater-Treater had previously experienced temperature-related issues and been warned on prior occasions regarding the effect of low oil production on this Heater-Treater, MEI still failed to implement an inspection plan.

Safety Risks

We found that several factors created unnecessary safety risks and contributed to the severity of the event that forced the VR 380 A crew to evacuate the Platform. First, after the wells shut in on September 2, the incorrect assembly of the BPV's controller most likely prevented it from functioning effectively in response to the rapid rise in the Platform's system pressure. Because the BPV could not open fully or fast enough to relieve the system pressure, the Platform's high pressure system was packed with the gas that was flowing from the wells. The pressure rose on the blocked system, and the PSVs on the glycol contact tower and the compressor activated. Second, the lead operator could not open the door to the BPV control box because it was wrapped with Visqueen and duct tape.

Third, during the process of returning the Platform to production following the shut in, relays for all 7 wells were most likely pinned out of service with tie wraps and the flowline pressures were not monitored. Had the crew monitored the pressure on the flowlines, they would have noticed an increase in pressure sooner and could have closed the chokes/wing valves before the PSVs activated. Fourth, if the compressor had shut down as indicated per the SAFE Chart, the crew would not have been in such a hurry to keep production online and the pressure-related events might have been averted.

Finally, as a result of the fire, a total platform shut-in occurred when the power was lost. The wells' SSVs shut-in, and the platform lighting went out as a result of the gas generator shutting down. The diesel generator failed to start and supply electrical power to the electric-driven firewater pump, which is required by regulation to run for 30 minutes. This prevented the crew from being able to fight the fire and cool the area with water.

Recommendations

We recommend that:

1. The following Incidents of Non-Compliance (INC) be issued to the Operator³⁵:

(a) **G-111**- The lessee failed to maintain all equipment in a safe condition to provide for protection of the lease and associated facilities:

Heater-Treater- G-111 C

(i) We concluded that the fire resulted because the operator failed to maintain its Heater-Treater in a safe condition, as required by 30 C.F.R. §§ 250.107(a)(2), 250.802(a). In particular:

- (1) the fire tube was 30 years old, sustained heavy pitting, corrosion, temperature spikes, all of which most likely weakened the steel's strength;
- (2) the oil production through the Heater-Treater was too low relative to the lowest BTU setting for the main burner, which caused excessive heat;
- (3) the weakened fire tube became malleable and collapsed, and openings resulted through which hydrocarbons inside of the vessel escaped and came into contact with the hot burner and then ignited. Flames resulted that spread throughout the Platform.

³⁵ Effective October 2010, changes were made to the National Office Potential Incident of Noncompliance (PINC) List identifiers for enforcement actions. Because the accident occurred in September 2010, the Panel used the identifiers in effect at that time in its recommendations section.

Back Pressure Valve- G-111 C

- (i) We concluded that the BPV controller's bourdon tube was incorrectly assembled, and the controller was corroded, which rendered the BPV inoperable and presented a safety issue that violated 30 CFR § 250.107 (a)(2).
- (b) **E-100-** The lessee did not prevent pollution of offshore waters:
- (i) We concluded that hydrocarbons were released into the Gulf of Mexico when the Heater-Treater's fired component was ejected and its contents spilled from the Heater-Treater and onto the deck.
- (c) **G-110-** The lessee failed to perform all operations in a safe manner to prevent harm to personnel, damage to the equipment, and discharge of liquid hydrocarbons into the Gulf waters:
- (i) We concluded that the crew probably acted too quickly in bringing the Platform's wells back online to prevent the compressor from shutting down completely, and opened all of the wells rapidly rather than slowly. This caused pressure to rapidly build up in the high pressure system. Thus, the wells were not brought back online in a safe condition, as required by 30 C.F.R. § 250.107(a)(2);
 - (ii) We concluded that MEI personnel did not supervise the B&P crew during the process of covering critical production process components and safety devices like the BPV control box. We further conclude that the BPV control box was wrapped with duct tape and Visqueen. Because the BPV control box was wrapped in duct tape and

Visqueen, the Lead Operator could not gain access to its adjustment controls after the increase in system pressure, which contributed to an unsafe condition, in violation of 30 C.F.R. § 250.107(a)(2).

(d) **P-103**—Each surface or subsurface safety device which was bypassed or blocked out of service, or out of service due to start up or testing, was not flagged or monitored by personnel, in violation of 30 C.F.R. § 250.803(c):

Bypass of Safety Devices

Specifically, we concluded that:

- (i) The relays for the LSHs on the Test Separator panel were pinned out of service with tie wraps and not flagged;
- (ii) The relay for the contactor LSH relay was pinned with a tie wrap and not flagged after the initial shut in;
- (iii) During the process of returning the Platform to production following the shut in, the relays for all 7 wells were pinned out of service with tie wraps and the flowline pressures were not monitored. Had the crew monitored the pressure on the flowlines, they would have noticed an increase in pressure sooner and could have closed the chokes/wing valves before the PSVs activated.

(e) **G- 115** – Operations were not conducted in accordance with approved applications per 30 C.F.R. §§ 250.410, 802:

(i) We concluded that when the level safety high on the glycol contactor was tripped, the compressor failed to shut down as required per the last-approved SAFE Chart dated January 2010.

(f) **P-132** –Fuel or power for the firewater pump drivers was not available for at least 30 minutes of run time during a platform shut in per 30 C.F.R. §250.803(b)(8)(ii):

(i) We concluded that at the time of the incident, the diesel generator failed to start and supply electrical power to the electric-driven firewater pump. This prevented the crew from being able to fight the fire and cool the area with water.

2. We further recommend that BOEMRE take the following actions:

(a) BOEMRE issue a Safety Alert that briefly describes the evidence related to the fire incident on September 2 and its causes, and addresses the issues set forth in the draft Safety Alert.

(b) Refer to the USCG for its consideration of appropriate action our findings and conclusions in this report with respect to life saving equipment and emergency/evacuation drills.

(c) Because there are no specific BOEMRE regulations that require an operator of a forced draft Heater Treater to maintain normal daily operating temperature-related and pressure-related records, or to keep duplicate copies of any kind of Heater-Treater records, we believe that the agency should reanalyze its regulations on documents to be maintained by operators related to Heater-Treaters. This will aid future accident investigations by ensuring the availability of documents critical to assembling a better picture of what caused an event.

(d) Because there are no specific BOEMRE regulations that require operators to keep a duplicate copy of operating procedures, diagrams, and schematics for production components onshore, or to keep records relating to safety devices put in bypass onshore, we believe that the agency should reanalyze its regulations and consider taking appropriate steps to change the regulations governing the documents that the operators are required to keep onshore. This will aid future accident investigations by ensuring the availability of documents critical to assembling a better picture of what caused an event.

(e) Reissue Safety Alert #203 to include: (1) a recommendation that JSA meetings be attended by the entire platform production crew so that everyone is familiar with daily platform activities; and (2) a requirement that operators directly supervise/oversee a crew that performs work that may have an effect on the safe operation of the equipment that they are working on.

Appendix 1

Glossary

Compressor (Gas) - a device that raises the pressure of a compressible fluid (gas). Compressors create a pressure differential to move or compress a vapor or gas through the production system.

Compressor Scrubber - a vessel in the production train through which fluids are passed to remove dirt, other foreign matter, or an undesired component of the fluid. Used to separate entrained liquids or solids from gas. Often also used to recover valuable liquids from a gas or vapor originating upstream.

Flow Safety Valve - a valve that minimizes the back flow of liquid or gas.

Glycol Contact Tower (“contactor”) - a vessel or piece of equipment in the production train inside of which two or more substances are brought together. In a glycol dehydration system, there is a vertical vessel in which wet gas is brought into contact with triethylene glycol to remove water vapor.

Glycol Gas Scrubber- a mechanical device in the production train designed to remove liquids from the natural gas stream.

Good Oil Tank- Reservoir that holds oil that has been separated in the Heater-Treater and is ready to be sold. It holds this pipeline grade oil before it travels to the pipeline pump and then to shore via the pipeline. A **Bad Oil Tank**, in contrast, is a reservoir that holds the oil with too much water or other impurities in it and then sends it back through the production train to be reprocessed so that it can be converted into “good” oil ready for sales.

Heater-Treater- Previously defined in the Panel’s Report. The VR 380 A Heater-Treater also had a stack arrestor designed to provide a means for exhaust gases and heat inside of the fire tube to vent, and to prevent flame migration outside of the fire tube. In addition, this particular Heater-Treater had an electrostatic grid section that was not in operation, which meant that the treating temperature of the fluid may have been about 15°F higher. This Heater-Treater also had one level safety high (LSH) and two level safety low (LSL) devices, which are defined below.

Heater-Treater Pressure Safety High - a sensor designed to alert the operator to a pressure upset and to shut down all input sources to the Heater-Treater (*i.e.*, the wells) when the pressure becomes excessive.

Lease Automatic Custody Transfer (“LACT”) unit- a system that uses automatic equipment to measure, sample, test, and transfer oil to the pipeline and to record that transaction. *See* Nontechnical Guide to Petroleum Geology, Exploration, Drilling, and Production, Norman J. Hyne, PhD., 2nd Edition, 2001.

Low Pressure Separator -an item of production equipment used to separate liquid components of the well fluid from gaseous elements. Separation is accomplished primarily by gravity, the heavier liquids falling to the bottom and the gas rising to the top. The oil empties into the Heater-Treater, the water empties into the Water Skimmer, and the gas goes to compressor suction scrubber.

Level Safety High- a sensor installed in a process component or a vessel that alarms or shuts off the source when a liquid level gets higher than the allowable maximum operating level, which could possibly impair the component's or vessel's functioning.

Level Safety Low- a sensor installed in a process component or a vessel that alarms or shuts off the source when a liquid level gets lower than the allowable minimum operating level, which could possibly impair the component's or vessel's functioning.

Pressure Safety Valve- a valve that opens at a preset point to relieve excess pressure within a vessel or line. The valve is designed to ensure that the pressure does not exceed safe working pressures. This valve may also be called a "pop valve," a "relief valve," a "safety valve" or a "safety relief valve."

Test Separator: a vessel used to separate and meter relatively small quantities of oil and gas. Test separators can be two-phase or three-phase, or horizontal, vertical or spherical. They can also be permanent or portable. Test separators sometimes are equipped with different meters to determine oil, water and gas rates, which are important to diagnose well problems, evaluate production performance of individual wells and manage reserves properly. The Test Separator on the VR 380 A fed oil and water into the Heater-Treater by way of a dump valve without a choke.

Appendix 2

MARINER

VERMILION 380 “A”

HEATER TREATER FIRE

REPORT



Casbarian Engineering Associates, LLC

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INTRODUCTION

On September 2, 2010, a fire occurred in the vicinity of the emulsion treater (NBK-8701) on the offshore platform, Mariner Vermilion 380A, resulting in the abandonment of the platform. This study was performed to determine the cause or causes of the treater erupting into flame. This is strictly an engineering study focused on and limited to the treater and does not intend to lay blame on any party, or on any of their actions.

The sequence of events follows:

1. The high level safety shutdown (LSH) on the platform glycol dehydrator tower was accidentally triggered by a painter performing maintenance work.
2. The wells were shut in by the shut down devices.
3. After resetting the LSH and verifying that conditions at the glycol dehydrator tower were normal, the operators placed the facility on bypass and proceeded to open the wells. There is no criticism of this procedure.
4. The relief valves on the high pressure vessels opened when the wells were placed in the production mode. Gas flow did not commence to the sales line. This was the result of the platform back pressure valve failing to open due to a clogged pilot orifice. The platform high pressure system was packed with gas flowing from the wells, the pressure rose on the blocked system and the relief valves opened due to high pressure (this pressuring gas was basically "gas cap" gas and it is not thought that any liquid flowed from the wells).
5. Fire was observed in the vicinity of the treater.

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6. The platform was abandoned.

EXECUTIVE SUMMARY

It is the opinion of this report that the fire at the treater was probably caused by the rupture of the 24" x 10' fire tube. Even with the wells shut in, heat continued to be introduced into the tube due to the continued operation of the treater burner, albeit at "low heat". The production flow through the treater was lost when the wells were shut in and the heat flux rate on the tube (BTU per square foot of tube service) became too high. Without heat transfer from the steel tube, high temperature resulted which in turn deteriorated the integrity of the fire tube. This resulted in the tube rupture. Residual hydrocarbon (oil and blanket gas) in the treater provided fuel for the fire. The high temperature shutdown (TSH) that should have shut in the burner did not activate for undetermined reasons. A possible cause for the failure of the safety device is that the panel was bypassed. However, there was a possibility that the heat rose so quickly that the heat was not transferred to the area of the shut down. (See notes) Because of the destruction caused by the fire, there is no physical evidence to support the position that the unit was on bypass, and it is mentioned only as a possibility.

TREATER DESIGN

The treater should be understood before a full evaluation is made. This unit is a premium treating system. It has free water knock out capability, heating ability and an electrostatic grid section which uses an electric charge system to remove water from the oil. The grid design was actually introduced to the refinery sector of the industry in the very early 20th

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century. In that refinery service it was used to remove very minute amounts of water to allow the salt in the crude to be removed with that water. The units were often called desalters and are still utilized for that today. In the early 1960s the design was brought into the production sector with many modifications by the manufacturer of the subject unit. The free water concept was added because well head production contains free water where the refineries do not accept any free water. Heating was added to aid the electrostatic process and to treat at a far lower temperature than the conventional treating process then in use and also deal, in some cases, with paraffin. The three systems, water knock out, heating and particularly the grid design greatly increased the treating capacity of a treating pressure vessel. The unit can be scientifically sized using oil samples but there are some rules of thumb. Based on gravity an electrostatic sizing can be done by figuring barrels of oil per day per square foot of grid. This grid loading can go from 75 barrels per day per square ft of grid to as much as 200 barrels per day per square foot. (At 200 barrels the temperature will be in the mid 130°F with normal GOM crude). As a matter of information Shell is presently flowing 200 barrels per square ft of grid on the MARS facility at 138 degrees F. The subject unit had an 8' X 10' grid section. That is 80 square feet. With 40 API crude a 125 barrel rate would be a conservative choice. That means the treater can process 80 sq. ft X 125 bbls per day per sq ft = 10,000 barrels per day. A 12000 barrel rate is perhaps more realistic. The idea of using a treater like this is to treat a large volume of oil with produced free water at the lowest possible temperature in the smallest vessel. This treater is far oversized for its present service.

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The following comments are based only on data produced for the preparation of this report.

- 1) The front free water knock out section was blocked off because there was not enough oil flow to prevent the oil from overheating. That means fuel was being used to heat water. That is inefficient.
- 2) If the report that the gravity was 41 degree API is correct and the treater was being operated at 140°F, the temperature was far too high to treat this gravity crude even in a conventional non electrostatic mode. The light ends which should have been sold as oil were being "cooked off". With an oil analysis, "flash" calculations can be run to determine the loss of production. If 140°F was necessary, an evaluation of the chemical program should have been made. With the electrostatic feature turned off a treating temperature increases approximately 15°F. Further in this report there are calculations showing fuel loss caused by this abnormally high temperature. Admittedly, with only experience as a guide, the treater should have been operating between 115° F and 120°F if every thing was functional. If paraffin is not a problem and with the grid area available even this might be a high operating temperature. The way it was being utilized, minus the service of the grids, a 130 degree temperature would have been more applicable. It is acknowledged that these statements are made without field knowledge and assuming the data presented is correct.

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3) As an opinion only, the oversized force draft burner should have been removed and replaced with a conventional flame arrestor and a natural draft burner. The fire would go completely off, when the desired operating temperature is reached with this natural draft burning arrangement. Calculations and economic numbers should be considered in returning the grids to service. It is also noted the stack arrangement would require changing with the exhaust going up vertically.

FIRE TUBE

The fire tube was made of A-53 - B carbon steel with a thickness of .375".¹ The subject fire tube is a standard unit fabricated to welding standards. The industry routinely uses this treater design. The manufacturer of this treater is the accepted premium supplier of the unit. There are hundreds of these tubes and treaters across the industry world wide. Although welding techniques have improved over the years this type tube design goes back to the 1940's. Nothing in the fire tube design contributed to the accident.

The ruptured tube was inspected on December 13, 2010, in the yard of Acadian Contractors near Abbeville, Louisiana. The tube was collapsed on both top and bottom in a "canoeing" configuration. The top collapsed downward and the bottom failed in an upward direction. The top collapsed in a more pronounced dip. This larger dip is due to gravity. Also the top is hotter. It was also obvious that the tube had started to "bubble" before the accident due to heat right at the fire ball area. This bubbling often occurs before full collapse. The top side of the tube went down. It was welded to the return

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bend at one end and to the fire tube flange on the other end. The return bend retained its circular cross sectional integrity and the fire tube flange secured the other end. When the tube collapsed and fell, the steel was ripped lose at the return bend and at the flange because the falling weight of the tube pulled the steel apart. Holes were on both ends of the tube from these rips. This opened two entrances for water and hydrocarbons to escape into the red hot fire tube where the burner was probably still burning. The hydrocarbons were ignited. There was some discussion that there may have been an explosion because the burner was blown off. That may be correct. A very qualified opinion of this report is that the rush of liquid and gas, which was probably at approximately 35 psig, simply blew the burner off its mounting plate. It is doubtful there was any explosion. The burner mounting flange is fabricated from 1/4" plate and its only purpose is to hold the burner with light bolts. It has no structural responsibility. The fact that the stack arrestor was not blown off gives some indication there was no explosion. Even when "back fires" sometime occur during igniting fires in tubes these stack arrestor devices are usually blown from the stack.

There are a few remarks about this particular tube.

- 1) This unit has been in service 30 years. Time reduces the yield strength of the steel. The tube had also been subjected to several high heat spikes which would have further reduced the yield strength.
- 2) Records ² show that this tube was repaired in 2006. The repair was made in a crack immediately downstream of the mounting flange. Overtime, this type of

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crack is not that unusual. The tube "floats" in the vessel and there is minute upward-downward movement that can cause a fatigue crack. This repair was poorly performed. The proper repair with a tube this old is to replace the lower barrel of the fire tube with new pipe. This was not done and may have contributed to the accident. Also, the fire tubes are made so they can be reversed. The side that accepts the fire is subjected to far more heat than the return segment to the stack. The fire tube always shows more corrosion on the hot side. This tube should have been reversed after repair if the lower barrel was not replaced. The decision not to replace the pipe was probably a cost saver. Perhaps new pipe in the fired side of the tube would have resisted collapse, but that is not taken as a firm position.

- 3) The steel hand book ³ shows carbon steel loses yield strength with time. Heat has a huge effect on the yield strength. At 800°F the yield is 77% of design. At 1,000°F, the steel has 63% of yield strength. At a temperature of 1,200°F, the steel has only 37% of yield strength. The data goes no further than 1,200°F because the steel is beginning to melt at that temperature. These temperatures need to be remembered because the fire ball of the burner can approach 2,000°F in these tubes. Liquid must be present and flowing to move the heat away from the steel tube. Also, remember, 30 years of hard service has reduced the yield strength further. As mentioned, if new pipe had been used in the repair or if the tube had been turned the original exhaust side would have been in burner duty and might have been able to sustain more heat.

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THE MAXON BURNER ⁴

This is a much recognized burner in many industries. Its usage offshore most often occurs when a large platform has a hot oil system. Special oil is heated as high as 700°F in a common heater and pumped to the areas of the process that requires heat. This burner is seldom seen in the type of service it was performing on the subject platform. Texaco made the units a standard on some of their facilities to more easily locate equipment below deck and not have stack and draft problems. As can be seen on this facility, the stack points in a downward direction because natural draft is not required. This can eliminate such things as helicopter downdrafts blowing out fires. The disadvantage to this device is that it is more complicated than the more common natural draft burners. This burner does not completely turn off fuel on low heat demand. It goes to a low heat mode, but there is always burner fire present. This is critical in the accident. The fire ball is supposedly reduced from close to 2,000°F to 1,000°F. THIS IS IMPORTANT. When new and perfectly adjusted, the fire ball is 1000°F at low heat. After 30 years it could be higher. Remember, the steel in a new condition loses 63% of its yield strength at 1000°F, and the yield strength decreases with age. This tube was 30 years old. The condition existed with a minimum of 1000°F fire on steel with its yield reduced below 63% due to age, and there was no flow removing the heat from the tube. Flow was not taking heat away from the steel. The particular burner on this unit is rated at 3,800,000 BTU per hour. The usual fire tube design on a natural draft burner is to transfer 10,500 BTU per square ft. of fire tube area to the process liquid. This fire tube

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has a nominal rating of 1,350,000 BTU per hr. if in natural draft service. It can be seen the burner is larger on a forced draft unit. This is because the gas and air are both being blown into the tube, fire is better distributed than with a natural draft burner and more of the fire tube area is utilized. Also, at start up, more heat is needed and the burner is designed to have some "slack" to allow for not burning full blast all the time. A problem arises here. This treater is designed to handle approximately 10,000 to 12,000 barrels a day depending on treating temperature, gravity, etc. This is an estimate based on data furnished indicating the oil was 41° API gravity. This facility is handling less than 2,000 barrels per day. Earlier the treater was treating such a small amount that when the heater went on low flame it was heating the minute stream to such a degree that the high temperature shutdown was shutting the unit down on a regular basis. There was not enough liquid to use the minimum amount of heat available at low flame. The service technician blocked the water knockout section and let the water that normally is removed prior to heating to be allowed into the heating section.² This was a wise move, but waste fuel. It used the excessive low burner heat. Maxon states the burner has a 10% downturn. That is 387,000 BTU per hr. The high heat to low heat is regulated by a linkage. There is a possibility that the 10% requires some adjustment and it might have a more practical turndown somewhat higher under field adjustments. That means at low flame we could have perhaps 400,000 BTU per hr. being introduced into the tube.

Sample Calculations:

Assume 50° decrease rise in temp required

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Assume 1500 bbls oil per day

Assume 300 bbls water per day

150 BTU raise 1bbl. of oil 1 ° F X 1500 bbl./ 24 hrs X 50 = 468,750 BTU/hr.

350 BTU raise 1bbl of water 1° F X X 300 bbl/24 hrs X 50 = 218,750 BTU/hr.

Total BTU Demand 687,500 BTU/hr.

(Any desired flow rates can be inserted in these formulas)

At low flame it is possible to generate 400,000 BTU output against a demand of 687,500 BTU. That is satisfactory as long as production remains at these conditions. At low production flow there is too much treater fire power. Gas lift production can be a "heading" situation with flow going up and down. At no flow the tube is accepting 400,000 BTU/hr. with no removal of the heat from the fire tube. This is also based on the theory that the heater went to low fire. If there was a malfunction and the heater went to high fire it would even be more critical.

These figures are clearly hypothetical and are intended only to indicate too much heating capacity. That is why the treater at one time had a history of high temperature shut downs due to high heat spikes². A MAJOR contributory factor toward this fire was a burner too large for the heat load. As a side note, it is very obvious to see the difference in natural draft and forced draft by viewing the fire. The forced draft fire appears to be a furnace.

Another interesting side factor is this is an electrostatic treater. This treater is meant to use electrostatic grids to treat oil. This feature was out of service for some time. What

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does this mean? It means the treater could treat more oil with the grids in service, but it also means the treater will treat at a 15 degrees lower temperature than the 140°F. If gas is valued at \$3.00/mcf, it would save \$10,000 a year in fuel if the electro static element was in service.⁵ In that electrostatic mode the burner would even be more oversized.

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THE HISTORY OF THE FIRE

The wells were shut in by the inadvertent tripping of the contactor's LSH. Witness reports indicate no attention was paid to the treater or the glycol reconcentrator during the crisis. Apparently the burner of the treater was allowed to run and not be shut down by the emergency. This does not violate regulations. There was absolutely no flow through the treater, and the treater temperature may have been high already. The treater is insulated. The heat went up and the high temperature shut down failed to shut off the fire. After the wells had been shut in for a short while, a noise was heard sounding like a hand hitting a table. This could have been caused by the burner being blown off its mounting flange. At that point, fire was detected at the treater end of the lower deck. The very firm opinion is that the fire tube literally burned up. There is no doubt that the visual inspection of the ruptured tube confirms this. This report can come to no other conclusion. The tube literally melted and the steel hand book data³ shows that this was due to a great reduction in yield strength.

GENERAL COMMENTS

1. Since the fire at the treater occurred while the high gas pressure incident was occurring, it comes naturally to infer that the fire was triggered by the pressure malfunction. However, the chances of high pressure incursion into the treater are insignificant:
 - a. The only way gas could normally enter the treater was from the high pressure test separator level control valve and the low pressure separator level control

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valve. These valves were probably closed because no liquid was flowing into those vessels. If the valves, were leaking the trim in the valves would have restricted flow. The test separator was really the only vessel dumping into the treater with high pressure production, and it has a restricting choke downstream of the dump to prevent high rates into the treater.

- b. High pressure at the vent system due to the relieving of the high pressure safety devices can only back flow into the treater through the PSV line, if the check valve is frozen open (it was) and the treater's PSV is open. There was no indication that the PSV on the treater opened. If the valve was open any excessive high pressure on the vent side would have probably forced the treater PSV to close because of pressure on the top of the valve plug.

It is the belief of this report that no over pressure was introduced into the treater. The treater's normal operating pressure of 30 to 35 psig would have been sufficient to collapse a heat weakened firetube, a tube hot enough to develop a bubble at the fire ball. As a side comment, from many years experience on other collapses particularly with glycol dehydrators, over heated tubes can collapse just from the hydrostatic pressure of the liquid in the vessel with no pressure on the unit. As a comment, although this report disregards over pressure as a factor in the failure, if the treater had been over pressured the high pressure shutdown would have shut the unit down. That would mean there was another failure of a shut down device on the treater. The Owensby & Kritikos Report ⁶ gives no

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indication there was any damage to the vessel. The report indicates there was no over pressuring of the vessel. It is a very preliminary opinion of this report, but the treater can be returned to service with a smaller burner. A close inspection needs to be performed.

2. BOEMRE has a report from an engineering firm, TEC⁷, on the relief system on this platform. It states the relief valves are snap acting and the flare piping is not adequate to relieve the facility. Here are comments on that:
 - a. Based on experience the tendency in the industry is to use snap acting relief valves so they open and close quickly. This prevents leaks developing that can be caused by throttling through the valve seats, "cutting" them. Throttling cuts valve seats.
 - b. The size of the relief header is questioned in the TEC report. That whole study is based on the design capacity of the facility that was sized for much greater flow. This facility can produce only 14 million cubic feet per day. It was mentioned that the flare system has some modifications and some 4" pipe was introduced into the system which could cause further restrictions. A program⁸ was run based on a full 14 million ft rate and a flare system of 400 ft of totally 6" pipe. This is chosen as an average of 8", 6" and some short sections of 4" pipe. It is understood that the 4" pipe that was added was minimal in length. This is a conservative guess. Detailed engineering was not considered necessary, but if desired the whole flare system can be measured for a more accurate pressure. With 14 million entering 400 ft of 6" pipe at

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1,250 psig the pressures along the equivalent of 400 ft of pipe are shown. The maximum pressure is 36 pounds in the 6" pipe. At the treater area it is probably about 15 to 17 pounds. There is no indication of any over pressuring.

CONCLUSION

It is concluded that the sequence of the accident is as follows:

The painter hit a level shut down control on the glycol tower starting the process. The wells shut in. The relief valves opened when the wells were brought on production in a bypass mode because the back pressure valve failed closed. Production could not leave the platform. The system was pressured up. The treater was firing with no flow from the wells and it erupted in flames at the failure of the fire tube.

The 30 year old structurally weakened fire tube failed because it was overheated:

- a) The turn down on the forced draft burner was too high. In effect, the burner was too large for the service as evidenced by prior service records.
- b) The high temperature safety shutdown (TSH) failed to shut in the burner. The fire damaged control panel can not provide sufficient confirmation, but it is conjectured that the treater panel may possibly have been on bypass during the incident. There is no firm evidence that this was the case. Past history with a significant time lapse shows a high temperature problem from a low flow condition. Another very logical conclusion was the tube heated so quickly that

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in its weakened condition it burned up prior to the temperature being transmitted through the still liquid to the temperature shut down at the outer edge of the vessel shell. That control was designed for action with some flow moving the heat.

The cause of the fire was material failure of the fire tube due to excess heat. There is a possibility that the age of this tube caused a rapid failure of the steel and the tube failed prior to having the high temperature device trip. The poor repair may have contributed. There was no flow to quickly move the heat to the shutdown instrument (See notes).

EPILOGUE

It is not the responsibility of this report to go into operating philosophy. However, it is important to look at the overall industry to prevent further accidents such as this.

This platform is a typical example of what producers on the Shelf of the Gulf of Mexico are facing. The facilities they are buying are old facilities that have in some cases been allowed to deteriorate prior to their sale. The pilot that kept the back pressure valve closed was old and corroded. A thirty year old treater with a critical fire tube is a possible hazard because of loss of yield strength in the steel from which the time the tube was manufactured. The electrostatic section of the treater, which is a premium design, was out of service. Much of the equipment, like this treater, is oversized. Inexperience alone may have stopped the tube from being turned over. That act alone would have

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been a significant improvement although, again, it is not intended to make this a definite cause of the fire. It is thought that inspection of some items should be expanded without establishing overbearing control. Experienced people with strong backgrounds need to be involved in developing these rules. Testing of pilots alone is not sufficient.

ADDENDUM

- 1) Manufacturer Data Sheet on Fire Tube
- 2) Process Solutions and Products (formerly Process Techs) Reports
- 3) Steel Construction Hand Book Data sheet
- 4) Maxon Burner data
- 5) Electrostatic Treater Data and Sketch of Treated and also a discussion of design
- 6) Owensby & Kritikos Report
- 7) TEC Report
- 8) Pressure Drop in Vent Piping With Relief Valves Opened

NOTES

1) The difficult problem in preparing this report was in the effort to explain the failure of the high temperature shut down to turn off the fuel. Much time and discussion was spent on attempting to answer this question. The first conclusion was the panel was on by pass. This may well be true but can not be proved. One of the problems is that almost every person in the GOM industry is most familiar with natural draft burners. As mentioned earlier in this report there are very few production vessels in the Gulf with forced draft units. Without experience in seeing how much stronger the fire is in a forced

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draft burner fires it is difficult to imagine the difference in heat. Perhaps a natural draft unit would not have caused failure. (Remember also, the natural draft unit turns the fire totally off). Maxon was contacted and indicated the stoppage of flow was critical. To further clarify the problem, Mr. Robert Coggins, the 88 year old retired president of Natco, was contacted. Through the 1960's 1970s and well into the 1980's Mr. Coggins was recognized as arguably the best production equipment engineer in the industry. He was deeply involved with the huge team flood systems that were used in the Bakersfield, California area. These units used force draft burners. Mr. Coggins feels without a doubt that the heat could have risen so quickly in the tube that it could have failed prior to the high temperature being tripped when there was no flow. He was also highly critical of the age of the fire tube. There are many tubes in the industry as old as this unit but all use natural draft burners.

- 2) The interviews of operators are not included in this report. That information was used in the preparation of this report. The interviews are on file with the BOEMRE.
- 3) There are interviews with Natco personnel that have little relevance to this report. They are on file with the BOEMRE. They furnish general information. The report does mention anodes. Anodes are certainly aids to prevent corrosion. Over the production history of the Gulf of Mexico few treaters have had anodes installed and the failure by corrosion is minimal. This treater is an example. It was in service 30 years and corrosion was not a cause of failure. Anodes require maintenance and unless a disciplined program of inspection is established they

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will not be replaced on schedule. It is doubtful that such expense is warranted on the Shelf considering historical data.

Appendix 3

On various dates between September -December 2010, the Panel inspectors also examined and/or, when possible, tested the following devices : bulk oil separator, bulk gas separator PSV and PSH, contactor PSV, compressor, low pressure (LP) separator, and Flare (vent) scrubber. Of this universe, the panel concluded that there were findings related to some devices and components that did not explain the causes of the fire. Here are the findings related to those devices and components:

Bulk Gas and Oil Separators

- When tested, the PSH on the Bulk gas separator failed to trip 3 times. Then, after lubrication of the Fisher 4660 relay, the PSH tripped at 1185 psig. Also, the PSH was tested to the end device, and the relay that was supposed to trip at the main panel did so and shut the required wells in.
- When tested, the PSV on the Bulk gas separator tripped at 1250 psig. Its set point was 1250 psig.
- The Bulk Oil Separator was out of service at the time of the fire, so the inspectors did not perform any tests.

Glycol Contact Tower (“Contactor”)

- The inspectors were unable to test the PSH on the contactor because it did not have one.
- When tested, the PSV on the contactor tripped at 1240 psig. Its set point was 1250 psig.
- Based on the Lead and A Operators’ statements that the PSV on the contactor activated before any of the wells shut in, and the unfavorable test results of the PSH on the bulk gas separator, the Panel concluded that the bulk gas separator

PSH may have failed to activate on the day of the incident or the bulk gas separator PSH may have been in bypass at the time of the incident. The most likely scenario is that the relays for the HP wells were pinned in service with tie wraps and unable to shut in upon receiving a signal from the bulk gas slave panel and/or the master panel.

Compressor

- The PSH was tested to the end device, i.e. the compressor fuel gas shut down valve.
- There was no pressure control valve on the compressor suction piping.
- When tested, the PSV pilot on the Compressor's 3rd stage discharge activated at 250 psig. No other testing of this device was performed because it sustained significant fire damage. Its set point was 1250 psig.
- When tested, the PSH on the Compressor's 3rd stage discharge activated at 1210 psig. Its set point was 1187 psig. The difference in the trip point and the set point could be the result of heat from the fire in this area, but there was no evidence of fire damage on the compressor panel. Based on the mechanic's statement that he manually shut down the compressor after the PSV on the 3rd stage discharge cylinder activated, and the fact that, when tested by Panel inspectors the PSH on the 3rd stage discharge cylinder functioned, the Panel concluded that the compressor panel most likely was in bypass at the time of the incident on September 2. Had the compressor's PSH not been in bypass, the PSH could have performed its designated function.
- Witnesses reported that the compressor malfunctioned at 4:11 a.m. on September 2. The compressor alarm sounded and the compressor shut down. Shortly thereafter, the A operator responded to the alarm and discovered the control line for the compressor's blow down valve (BDV) had split. The A operator theorized that the compressor shut in because a vibration within the compressor sheared the BDV's control tube and caused the valve to open. The malfunction did not result in the wells shutting in.

Heater –Treater

- Upon viewing the inside of the Heater-Treater, inspectors noticed a black discoloration on the weir plate near the location of the crack in the first weld near the tube turn. There was also an indentation in this area.
- The Heater-Treater's oil inlet was equipped with a shut down valve that had been removed.
- The Heater-Treater's blanket gas relief system and PSV discharged into a common high pressure/low pressure vent pipe header, which vented to the platform's flare (vent) scrubber.¹
- The SAFE Chart dated May 2003 reflected that the Heater-Treater's make up gas relief discharged to the vent scrubber and the Heater-Treater PSV relieved to the LP flare scrubber. The later SAFE Chart, dated April 2008, reflected that the Heater-Treater make up gas relief and the PSV relief are tied into the HP vent scrubber.

Low Pressure (LP) Separator

- The LP separator dumped oil to the Heater –Treater, and there was no choke installed on the outlet piping of the LP separator oil dump valve.
- The inspectors did not test the PSH on the LP separator because they were more focused on the high pressure components and how they impacted the Heater-Treater via the vent system.

¹ The VR 380 A platform's flare/vent system was originally designed with three separate flare/vent scrubbers -- high pressure (HP) flare scrubber, MBF 8701; low pressure (LP) flare scrubber, MBF 8702; and 40# vent scrubber, MBF 8704. The platform's SAFE Chart and Flow Diagram, dated April 28, 2008, depicted the removal of the LP flare scrubber and the vent scrubber.

Flare(Vent) Scrubber Pump

- The flare (vent) scrubber pump discharge housing had a hole in it.

In addition, the Panel's review of MEI documents related to firefighting and lifesaving equipment indicate that the following were located on the VR 380 A on September 2:

Main Deck:

13 handheld fire extinguishers
Wheel unit located west side of deck.
2 Life rings
1- 12 Man Life Float located southwest side.
Hose reel with 60 gallons of Aqueous Film Forming Foam (AFFF).

Cellar Deck:

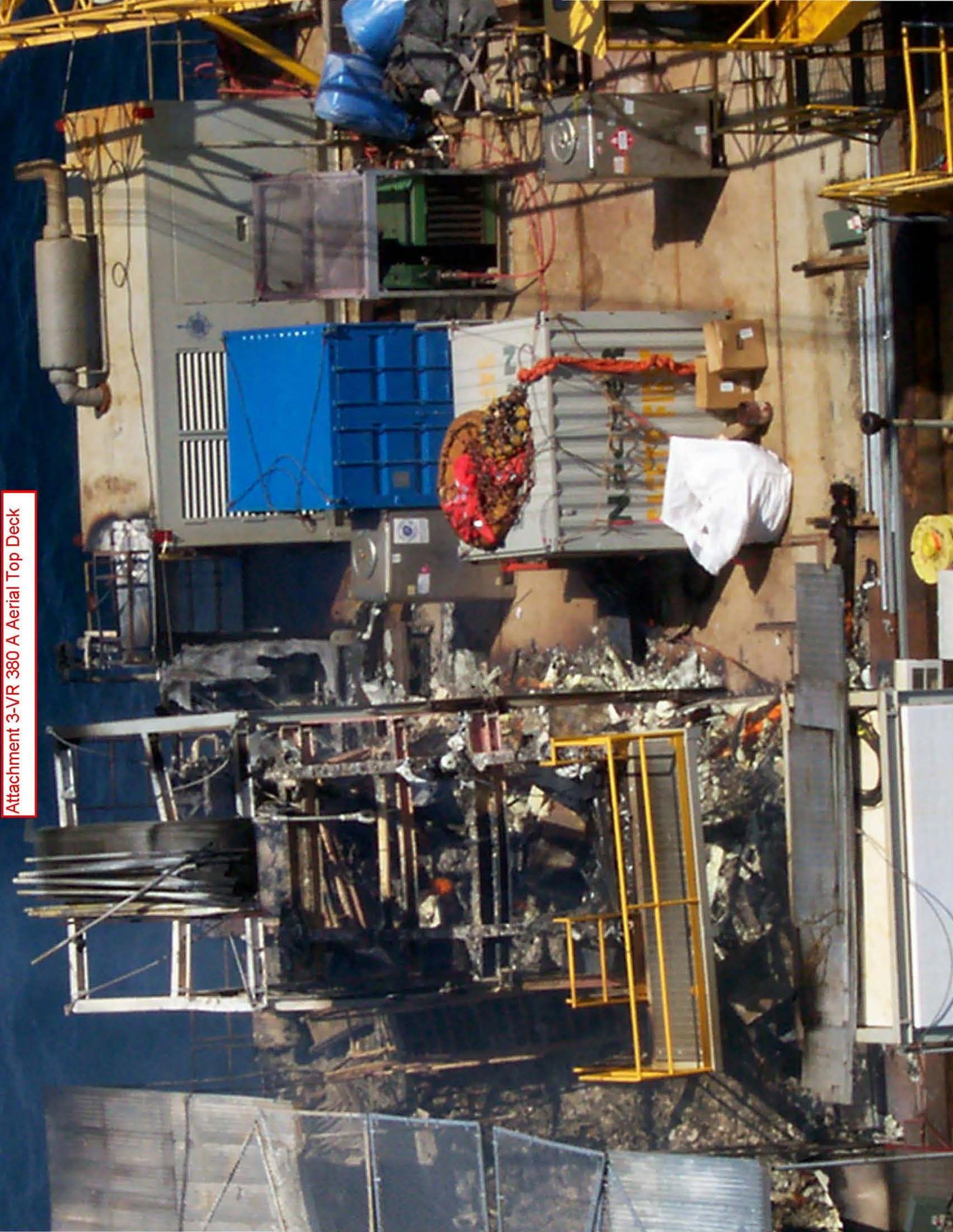
18 hand-held fire extinguishers
3 wheel units
4 Life rings
1- 12 Man Life Float
2- 12 Man inflatable life rafts
4 Hose reels

Attachment 1- VR 380 A Aerial NE





Attachment 3-VR 380 A Aerial Top Deck



Attachment 4- Heater-Treater





Attachment 5- Heater Treater (side and rear)



Attachment 6- Deck Plating Above Heater-Treater



Attachment 7- Out of Service Pump Bay Area

Attachment 8-Fire Damage:
Upper Deck



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Attachment 9- Fire
Damage: Cellar Deck

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Attachment 10- Fire Tube: Opening (Top)

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A close-up photograph of a heavily rusted metal joint. The metal surfaces are dark brown and covered in a thick, porous layer of rust. A significant crack is visible, running along the edge of the joint. The crack is deep and appears to be a fatigue crack. The lighting is somewhat dim, highlighting the texture of the rust and the sharp edges of the crack.

Attachment 11 - Tube Turn Crack



Attachment 12- Fire Tube: Opening (Bottom)

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Attachment 13- Opening: Front of Heater-Treater

Attachment 14- Top of Fire Tube





**Attachment 15 - Front of Heater-Treater
(air intake side and fire tube outlet side)**