OCS Report
BSEE 2014-01

Investigation of Electrocution on Drilling Rig Ship Shoal Block 170, Well No. 1 OCS-G 33644 26 January 2013

Gulf of Mexico
Off the State of Louisiana

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

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Jack Williams – Chair
Charles Arnold
Jim Hail
Paul Nelson
James Richard

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Executive Summary

On 26 January 2013, on a Spartan Offshore Drilling LLC (Spartan) drilling rig operating for Bois d'Arc Exploration LLC (Bois d'Arc or Operator) offshore in the Gulf of Mexico, a "cementer" (Cementer) for Baker Hughes, a cementing contractor, was trouble shooting an electronic instrument failure. Evidence suggested that he suspected a discharged battery in a battery box that supplied DC power to the instruments to be the problem. It appears that the Cementer attempted to fix the problem by plugging a wheeled battery charger *(like those in all service stations*) into a three-wire extension cord carrying household 115V current. He was subsequently killed by electrocution.

A Bureau of Safety and Environmental Enforcement (BSEE) Panel has investigated the incident and determined that sometime prior to the incident, moisture entered the electrical connection of the battery box and extension cord. The moisture caused a short circuit in the female plug end of the extension cord which burned off the ground wire inside the plug. When the Cementer plugged the battery charger cord into the extension cord, the short allowed the hot wire in the damaged extension cord to connect with the ground wire of the battery charger cord. Because the battery charger cord ground wire was directly connected to the metal case of the battery charger, the case became energized.

The Panel concluded that the Cementer was working alone and without protective equipment. The evidence showed that when he knelt on a wet deck and grasped the energized battery charger handle, current passed through his hand to his knee, stopping his heart.

The BSEE Panel concluded the fatality was caused by a number of different but interrelated factors. These included equipment failure, repair and maintenance including technical support response, training, and supervisory failures by Baker Hughes, the cementing service company. Communication failures between personnel of Baker Hughes also contributed to the fatality.

Equipment:

- The extension cord was damaged, old, and not up to standards or common best practices for use in industrial applications.
- The battery-box was positioned in a wet environment and had been exposed to cement, water, and other liquids. Its electronic connections to the power source were not hard wired or protected from the elements.
- Neither the power inlet socket nor the extension cord's female socket end was NEMA-4 approved water-tight.
- The electronic circuit was not equipped with a ground fault circuit interrupter (GFCI).

Maintenance, training, and supervision: The skid was the property of Baker Hughes who was solely responsible for the maintenance and operation of the equipment. The maintenance of the cementing unit was inadequate. The wiring used an extension cord for long-term primary power transmission which is contrary to industry best practice. The Cementer attempted to troubleshoot the unit but apparently was untrained in the danger of low voltage electricity. No supervision was provided as the Cementer attempted repair of the cementing unit. No discussion of job safety was undertaken prior to the attempted repair.

Prior to the incident, the maintenance department of Baker Hughes recommended an alternative way to provide power to the electronics of the equipment, but the recommendation was not adopted in the field. It was later discovered the equipment's electric circuits were connected incorrectly, indicating the Baker Hughes crew operating the unit may have been unfamiliar with this type of equipment.

When the Baker Hughes repairmen/maintenance personnel arrived to address the issues of the cementing unit immediately after the fatal incident, they created additional safety hazards with a damaged extension cord that was fastened to the cement unit in an unsafe manner. The new location of the battery-box was found to have created a new hazard.

The wheeled battery charger had printed warnings against using an electronic connection that had no ground wire, or whose grounding circuit was damaged. The operating manual of the battery charger warned against using an extension cord except under tightly controlled circumstances, but was either not available or not consulted. No pre-Job Safety Analysis was performed. No Baker Hughes training addressed the use of the battery charger, the use of proper protective gear, or the possibility of electric shock from an ungrounded circuit.

Communication within Baker Hughes was inadequate which contributed to the cause of the fatality. Prior to the Incident, apparent "burn marks" were observed inside the battery box. The Cementer discussed these with the Baker Hughes onshore maintenance personnel before the incident. Though a suggestion was made by the maintenance department to cease operations on the electronics, no definitive orders were given to the Baker Hughes operating crew by their direct supervisors. The maintenance department is apparently considered a support element.

The Panel found the Baker Hughes electronics maintenance support department did not directly attempt to repair the electrical problems of the cementing unit prior to the pending cementing job. The personnel of that department did not proactively follow up to see if the unit was working as designed after the trouble-shooting conversation with the Cementer. They delayed visiting the site until after the cementing job was performed.

After investigating the incident and identifying the causes, the BSEE Panel recommends management consider issuing a Safety Alert to industry that includes the following:

- a brief description of the Incident and a brief summary of the causes;
- specific identification of the danger of the use of substandard and damaged extension cords offshore;
- identification of the consequences of improper electronic maintenance and installation;
- the danger of using an ungrounded connection to an electronic device that requires one and the importance of including a GFCI in the circuit;
- the need for proper training, supervision, equipment, and job planning.

The Panel recommends BSEE consider extending the Safety Alert to OSHA and other onshore safety organizations dealing with electrical issues. The Panel recommends the BSEE District consider issuing a number of violation citations, and consider the possibility of pursuing a civil penalty, with Baker Hughes as the company with primary responsibility. The Panel also recommends that BSEE consider reviewing the regulations for electric wiring for MODUs to see if additional rule-making would be warranted.

The Panel also recommends BSEE management consider whether additional clarification of roles and responsibilities regarding electrical wiring on MODUs should be included when the Memorandum of Agreement (MOA) is next reviewed by BSEE and United States Coast Guard.

Introduction

Authority

An incident that resulted in a fatality (the Incident) occurred on *26 January 2013* at approximately *1450 hours* (hrs) aboard the jack-up drilling rig Spartan Offshore Drilling, LLC, (Spartan) Rig 202 (the Rig) contracted to Bois d'Arc Exploration LLC (Operator or Bois d'Arc) while operations were being conducted for the Operator on Lease OCS-G 33644 (the Lease), Ship Shoal Area Block 170 (SS-170), Well No. 1 (the Well), in the Gulf of Mexico, offshore Louisiana.

The fatally injured person (Cementer) was an employee of the contractor specialty cementing company, Baker Hughes Cementing Services (Baker Hughes). The Cementer was trouble shooting electronic equipment of the Baker Hughes cementing pumping unit skid (Cementing Unit or Skid) installed on the Rig when the Incident occurred.

Pursuant to 43 U.S.C. 1348(d)(1) and (2) and (f) [Outer Continental Shelf (OCS) Lands Act, as amended] and Department of the Interior regulations 30 CFR 250, the Bureau of Safety and Environmental Enforcement (BSEE) is required to investigate and prepare a public report of this Incident. After release of the Coroner's report on 11 March 2013, by memorandum dated 11 March 2013, personnel were named to the investigative panel (the Panel), with all parties informed by 18 March 2013. The Panel included:

Jack Williams, Chairman – Petroleum Engineer/Accident Investigator, Office of Safety Management, GOM OCS Region;

Jim Hail – Supervisory Inspector, Lake Jackson District, Field Operations GOM OCS Region;

Charles Arnold – Special Investigator, Investigations and Review Unit, BSEE, Office of the Director;

James Richard – Inspector, Houma District, Well Operations GOM OCS Region;

Paul Nelson - Petroleum Engineer, Houma District, Well Operations GOM OCS Region.

Background

Lease OCS-G 33644 covers approximately 5,000 acres and encompasses all of Ship Shoal Block 170, Gulf of Mexico, off the Louisiana coast *(see figure 1).* The Lease was purchased in 2010 by Bois d'Arc as 100 percent working interest owner. The Lease has no other working interest owners or operators.

The Lease currently has one well drilled and completed. The Incident occurred while drilling this Well. Bois d'Arc recently installed a production platform *(SS-170 "A" Platform)* and equipment to produce the completed Well, formally named "SS-170 Well No. 1," renamed "SS-170 Well A-1."

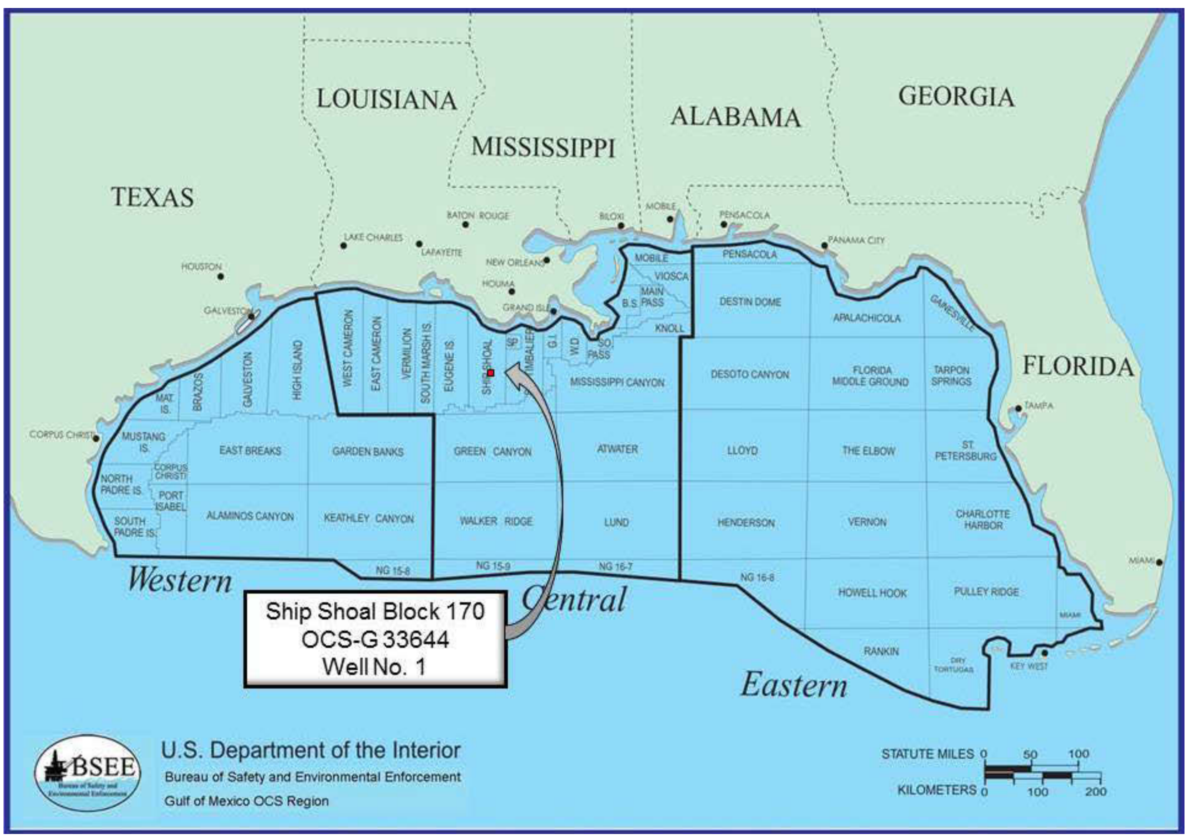


Figure 1: Location of Lease OCS-G 33644, Ship Shoal Area Block 170, Well No. 1

Findings

Objective, Well Permit, and Rig

Objective, Well Permit

On 18 January 2013, the Rig completed plug and abandonment (P&A) of Well No. 1 in Ship Shoal Block 66, State of Louisiana Lease (S/L) 20843. This P&A operation required using the on-board Cementing Unit to set the required cement plugs in the well bore. Subsequently, the Rig was prepared to move to SS-170.

Bois d'Arc's BSEE-approved Well Permit included moving the Rig to SS-170 and drilling the non-deviated exploration Well to a total depth of over 10,000-feet (ft). The approved Well Permit specified that drive pipe was to be driven in place, then the Well was to be spudded and the hole drilled for conductor casing. It was anticipated that approximately two days would be required from spudding the Well before initiating operations to cement the conductor casing.

After the conductor casing was set, the Well Permit proposed to continue drilling hole and setting surface casing, etc., followed by normal operations until the permitted total depth of the Well was reached. If the Well found economic quantities of pay, after setting production casing Bois d'Arc would apply to the BSEE for approvals to enter the test and/or completion phase of the Well operation.

Rig

Spartan 202 Rig is a mat/slot rig originally designed and constructed in 1969 as a 250-ft class jack-up by Bethlehem Steel Corporation in accordance with the rules of the American Bureau of Shipping and is classified as an "A-1 Self-Elevating MODU." The Rig has undergone two major overhauls and upgrades, one in 1991 and the other in 2006. Its operating water depth is reduced to 225-ft due to shortened leg length.

Figure 2: Spartan Rig 202

In the Spartan Offshore Drilling, LLC brochure detailing features of the Rig, the Cementing Unit Skid was noted as being permanently installed (welded to deck) on board the Rig. It is referenced as "rig equipment" in the brochure and is described as follows:

"Cementing Unit: *BJ Services unit currently on board. Unit and all equipment is for Operator's account."*

The brochure continued with details of the cementing equipment, power, rate, and capacities that defined or were included with the Skid.

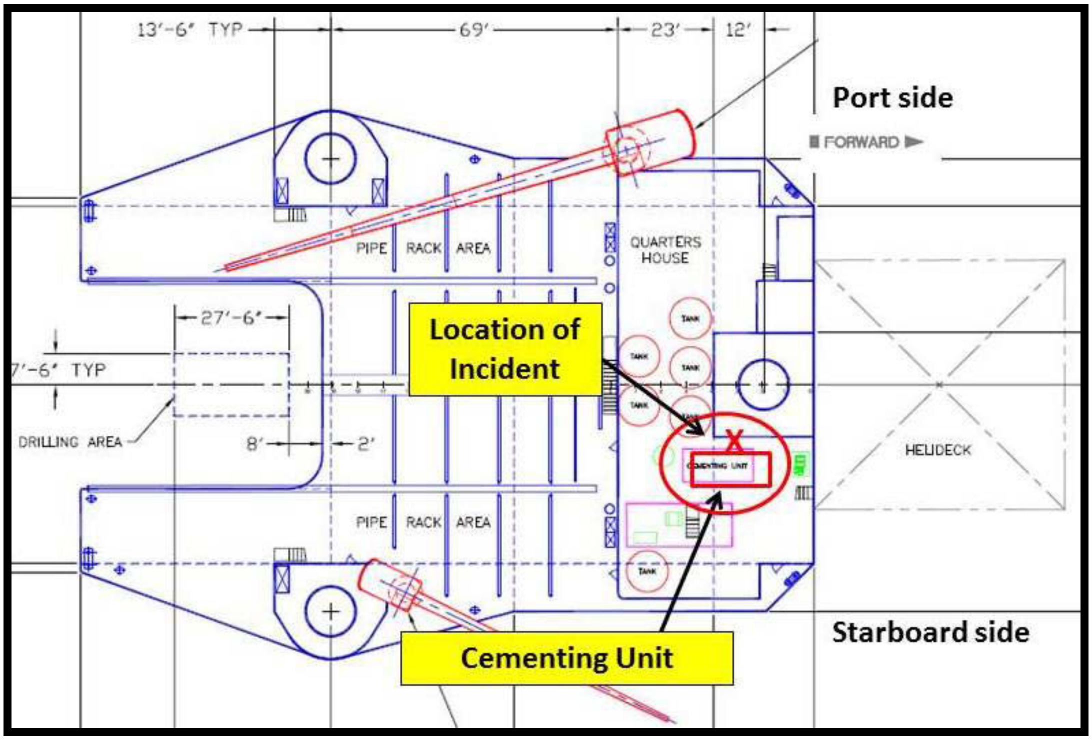


Figure 3: Schematic, Rig main deck - location of Cementing Unit and Incident

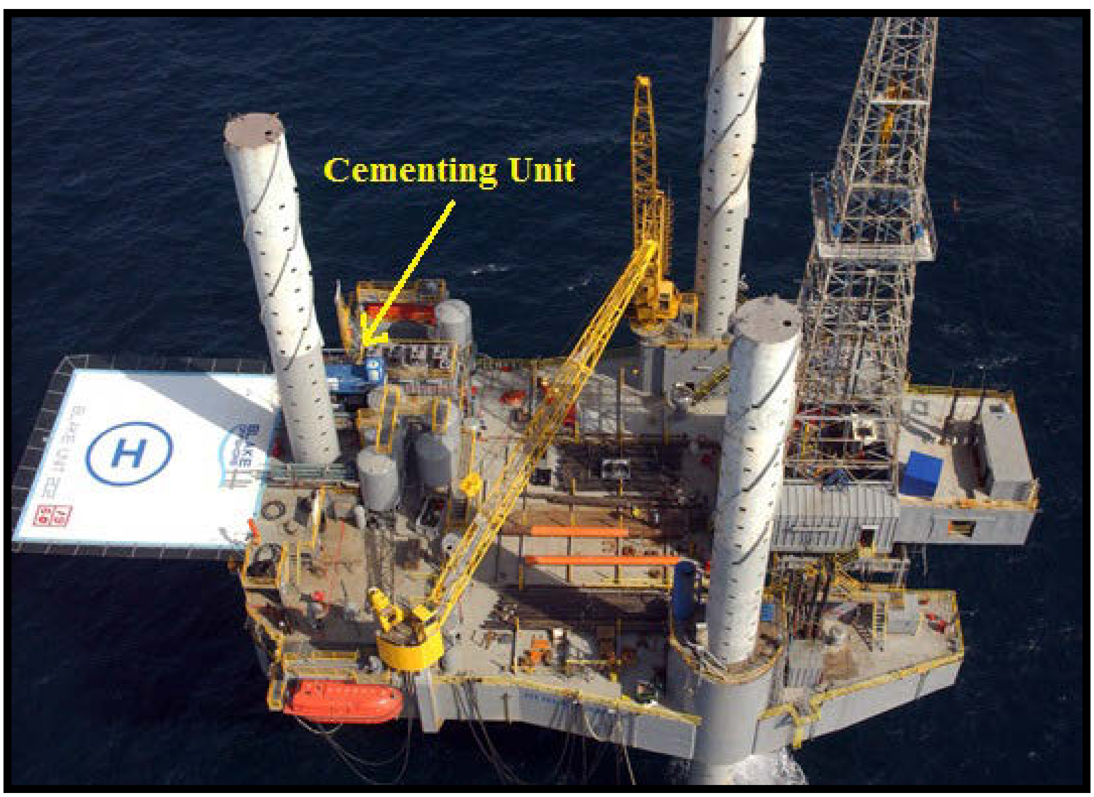


Figure 4: Rig 202 and location of Cementing Unit Skid

Description of Cementing Unit and Process *(see figure 5)*

Cementing is the process of mixing a slurry of cement and water and pumping it down into or around critical points in the annulus, casing, or in the open hole below the casing string. Cementing has two principal functions: (1) to restrict fluid movement between the formations or within the casing; (2) to bond and support the casing. If effective cementing is achieved, other requirements for the well will be met, including economic life, liability and safety concerns, and Government regulations.

Figure 5: End view, Cementing Unit Skid

A cementing operation requires specialty expertise and equipment. When the drilling procedure calls for cementing, an oil-well cementing service company is usually called in to perform this job although the rig crew is available to lend assistance. The cementing unit includes various mixing tanks, measurement devices, connections and special pumps. A modern cementing unit includes a "control room" or area equipped with electronic screens that visually indicate the progress of the cement pumping operation. However, cementing a casing string can be accomplished by the old method of counting pump strokes and monitoring volume input and returns.

Elements of cementing units offshore are commonly combined onto a single "skid" to facilitate movement and lift onto the rig. Because a cementing unit is a large piece of equipment and is an integral part of many rig operations, the equipment skid is often left on board the rig in a specific location to be operated by the service company for the account of the Operator *(see figure 6 for an example of a cementing skid).*

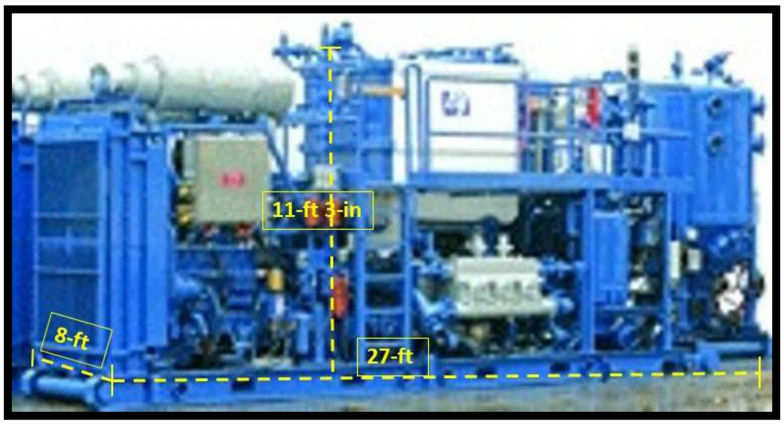


Figure 6: Example, cementing unit skid

The Cementing Unit Skid that was permanently installed (welded to deck) on board the Rig was a Baker Hughes unit that was formerly owned by BJ Services. This [formerly] BJ Services Unit is described in the Rig literature as follows:

"SCP-348A RAM (Skid Cement Pumper with Recirculation Averaging Mixer) is a skid mounted cement mixing and pumping unit. Instrumentation includes a Visiplex and Microplex that monitors and records pertinent job parameters for on-line and post job analysis, and an Automatic Cement Controller (ACC). The unit is equipped with twin drive trains and spare pumps.

"The cementing unit is designed to mix condition and pump cement into the well for a variety of purposes…

"The cement slurry is pumped into the work string and flows to the bottom of the wellbore. From there it is displaced with fluid and fills in the space between the casing and the actual wellbore, and

hardens or sets after the passage of a specified period of time, depending on the cement volume and qualities. This creates a seal so that outside materials cannot enter the well bore, and also permanently sets the casing in place.

"The operator of the cementing unit operates and maintains the unit, makes calculations concerning cement volumes, controls the use of cement and additive materials, and monitors and records the progression of service at the job site. He works closely with the customer's representative and other personnel to minimize the risk of fracturing the formation or loss of well control, by precisely controlling the cement density."

Baker Hughes acquired this Cementing Unit when they bought BJ Services in 2010. According to statements, the BJ Service units thus acquired were being revamped by Baker Hughes, though this particular unit had not yet been reconditioned.

Personnel

Records indicate 37 personnel were aboard the Rig when the Incident occurred. These included three contract persons working directly for Bois d'Arc. Those personnel on board the Rig who were notable during the events of the Incident included the following:

Bois D'Arc

Company Man – The Company Man was the on-site representative of Bois d'Arc during Well operations and was on duty ("tour," pronounced "tower" in many areas*) when the Incident occurred.

I3P Rep, also Safety and Environmental Management System [SEMS] Coordinator – The I3P (Independent Third Party, LLC) representative was onboard the Rig, contracted by Bois d'Arc to coordinate SEMS and to work with Spartan Rigs to insure SEMS compliance, safety, etc. The I3P Rep contracted by Bois d'Arc reported to the Operator, Bois d'Arc,

* "Tour - **1. n. [Drilling]** A work shift of a drilling crew. Drilling operations usually occur around the clock because of the cost to rent a rig. As a result, there are usually two separate crews working twelve-hour tours to keep the operation going… … (Pronounced "tower" in many areas.)" See: http://www.glossary.oilfield.slb.com/en/Terms/t/tour.aspx

separately from the chain of command for the Company Man, but from statements he closely coordinated with the Company Man and worked in his office. After the Incident the I3P Rep acted as the facilitator for the various groups arriving to review the Incident including legal and investigatory representatives from USCG, BSEE, Operator, Spartan Rigs, Baker Hughes.

. **I3P#2** –the I3P#2 was the I3P employee contracted to Operator, who replaced the I3P Rep during crew change after the Incident.

The Panel reviewed the documented training and experience of the above individuals, either from written statements, transcripts, third party accounts and/or verbal reviews, interviews and statements.

Spartan Rigs

Spartan Rigs personnel manned the Rig and conducted drilling operations under direction of the Rig Company's Offshore Installation Manager (OIM) and/or Tool Pusher who consulted with the Operator's representative, the Company Man. Key Rig company personnel were as follows:

Rig Electrician – Electrician for the Rig, Spartan employee.

Offshore Installation Manager (OIM) – The OIM was in charge of all Rig operations. He was on tour when the Incident occurred. He has over 30 year's extensive experience world-wide.

Emergency Medical Technician (EMT) – The Emergency Medical Technician (EMT) on board the Rig was contracted by Spartan from Total Safety, LLC.

The Panel reviewed the documented training and experience of the above individuals, from written statements, transcripts, third party accounts and/or verbal reviews, interviews and statements.

Baker Hughes

Baker Hughes Cementing Services were contracted by the Operator to work with the Rig crew cementing casing as required during drilling operations. Key personnel were as follows:

Field Operator – The Field Operator was also an "Offshore Service Supervisor" as described in BJ Services job description. He was detailed to help this operation because his own cementing unit was not in service and because he had more familiarity with this type of [formerly] BJ Services unit.

Field Supervisor – The Field Supervisor worked for Baker Hughes cementing group. With thirty-two years with Baker Hughes, he was not specifically assigned to the Cementing Unit or to a role in the cementing operation. He was on the Rig in an observer capacity in case help was needed.

Service Supervisor – The Service Supervisor for Baker Hughes was the head of maintenance, Baker Hughes cementing group.

Electronics Maintenance Tech – The Electronics Maintenance Tech was an employee of the Baker Hughes cementing group maintenance department. He stated he was the Baker Hughes acting supervisor of repair and maintenance of electronics.

Contract Electrician – The Contract Electrician was an electrician and serviceman, employee of Southland Energy, a third-party electrical contractor. He was contracted by Baker Hughes to repair working high voltage equipment, which according to Baker Hughes includes the household current wiring of the Skid.

Op Field Operator – The Op Field Operator was the field operator for the Cementing Unit but on the opposite hitch. He completed the cementing operation on the previous well site and crew-changed the day the Rig began a move to the Well site. He referenced extensive repair, cleaning, and maintenance on the Skid while operating on the previous well location before crew-change. He noted that three months previously when he was washing the Cementing Unit, a circuit breaker tripped.

Cementer [fatal Incident casualty] – The Cementer was also a "field operator" and was the casualty from the Incident. The Cementer was hired by Baker Hughes on 11 July 2011, as a "field specialist II," and held that job classification over the eighteen (18) months of his employment. (The equivalent position for BJ Services Company, which was merged into Baker Hughes in 2010, was "offshore service supervisor" – according to statements that position is essentially a "cementer" or "cement hand" in the industry vernacular.)

According to his application and interview, the Cementer had nearly four (4) years of previous experience working on cementing units for Universal Well Services, Inc. in Allen, KY, before hiring on with Baker Hughes. The Cementer's training record was extensive and included courses in the "Electronic Engineering Handbook" and "Equipment and Hand Tools Safety-Awareness."

No information was provided indicating the Cementer received training that covered the hazard of electric shock from household level current, nor in the proper equipment to be worn to prevent such shock.

BJ SERVICES

JOB ANALYSIS

Job Title: Offshore Service Supervisor
Reports To (position): District Operations Supervisor
Name of Person completing this form: [redacted]
Date Completed: 12/16/98

JOB SPECIFICATIONS

ESSENTIAL FUNCTIONS

Those that a person must be able to perform in the job, either unaided or with the assistance of a "reasonable accommodation". List in order of importance.

	Functions	Percent of Time
	recommendations. Maintains an open and business-like relationship with the company representative.	
3.	Monitors and documents all phases of the pumping service process. Confers with maintenance personnel on equipment status to preclude unnecessary equipment down time. Maintain the Dual Skid.	60
4.	Prepares field receipts and obtains customer approval prior to pumping the job and after completion	5

Figure 7: Baker Hughes job description (portion)

A job description of the role of the "offshore service supervisor," "field operator," or "cementer," was developed by BJ Services. Statements were received from Baker Hughes personnel that the BJ Services "job description" was still being used by Baker Hughes and was provided to the Panel. The BJ Services job description had not been updated for the corporate change to Baker Hughes.

A portion of the job description is shown in *figure 7*. Of note, one of the key functions for the "offshore service supervisor," taking 60 percent of his time, was to maintain the skid (equipment) so as to “preclude unnecessary down time.” From statements received and discussions with Rig personnel, Operator, etc., downtime caused by cementing equipment failure is especially onerous during rig operations because of the potential to completely shut down drilling and/or jeopardize the hole already drilled.

Rig Activities – Timeline Prior to the Incident

(Note: all times are approximate)

1/22/2013: Rig barge completed tow from SS-66 to Well location, position, load, jack up, skid out rig package, offload casing equipment, Pick-up (PU) 30-inch (in) drive pipe.

1/23/2013: Run 30-in drive pipe.

1/24/2013: Rig down (RD) drive pipe equipment, install diverter, etc.

1/25/2013: PU bit and bottom hole assembly (BHA), spud well, drilling conductor hole. From statements, during this time Baker Hughes personnel were having trouble with their Cementing Unit. The Rig Electrician was asked by Baker Hughes personnel to check the charge of the battery in the Baker Hughes battery box (Battery Box). He did this using his test equipment and told the Baker Hughes personnel that the battery was reading fully charged.

1/25-26/2013: Rig up (RU), run conductor casing. RU cementing head, circulate hole. Pump cement, displace with mud, bump plug, floats holding. Estimate 55 barrels (bbls) cement returns at surface, Wait on cement (WOC) for 8 hours (hrs). Washout annulus to 30-feet (ft) below mud line, back load casing equipment, begin nipple down (ND) diverter.

1/26/2014: RD cement equipment, cut conductor, install surface equipment, PU drill collars, Make up bit and BHA.

1500 hrs: The Rig Electrician received a call from the Cementer asking if he (Cementer) could use the Rig’s wheeled battery charger (Battery Charger) to charge the Battery Box. The Rig Electrician reminded the Cementer that he had checked the battery and that it was fully charged. However, he told the Cementer that he could use the Rig Battery Charger and also could use his tools, and told him where they were. The Rig Electrician then became involved searching for a ground fault error in another portion of the Rig wiring and did not further communicate or participate with the Baker Hughes personnel.

Approximately 1630-50 hrs: The Incident occurred. At approximately *1650 hrs*, a Baker Hughes and a Spartan employee (hand) found the downed Cementer. They called the OIM who subsequently organized the actions to attempt to revive and care for the Cementer.

Baker Hughes Personnel – Activities Prior to the Incident.

(Note: all times are approximate)

The Cementing Unit was welded onto the deck of the Rig and formed a part of the Rig's equipment, except that the rig literature noted the Cementing Unit was "for Operator's account."

Before the Rig moved onto the Well site, on the previous well location, on *1/03/2013* the Op Field Operator and the Cementer arrived, inspected the unit, and checked the tool boxes.

1/03 – 1/05/2013: The Cementing Unit was used to set several open-hole plugs as part of that plug and abandonment (P&A) operation. From the work log made by the Op Field Supervisor, he made a point to note he was showing the Cementer important steps in cleaning and maintenance of the Skid.

1/07-1/11/2013: Cleaning, changing out equipment and inspecting lines of the Skid were undertaken. The Skid was washed and blocks and chunks of cement were removed. Air switches were repaired, cement was cleaned out of surge can. One note indicated that the cementing Unit was "a mess." Hoses, fill lines were cleaned of cement, vent pipe, drain lines cleaned of cement. Old hydraulic and pump oil filters removed with difficulty.

1/17/2013: After extensive maintenance on the Cementing Unit and several parts ordered and "workarounds" created, work on the Skid was ceased as the Rig moved to the Well location. The Op Field Operator crew changed and the Field Operator arrived on the Rig.

Note: The Panel found that the following is the most accurate time line and the most likely account of what occurred after reviewing statements, interview reports, and documents that at times were contradictory.

1/24/2013 Thursday: The key electronic equipment in the "control room" of the Cementing Unit that displays the information about a cementing operation is the Visiplex unit (Visiplex). Electricity for the Visiplex and related electronics was provided from the Rig generators through a dual outlet plug (Outlet) mounted on the Skid. When tested, the Visiplex screens indicated low voltage. According to statements, the Cementer discussed this problem by phone with the Electronics Maintenance Tech in the onshore Baker Hughes office, and described symptoms which specifically indicated that the digital readout was inoperative, returning a low voltage reading.

The Electronics Maintenance Tech indicated a field operator had three options when faced with a problem offshore: (1) trouble shoot the problem himself*, (the "operator is the repairman");* (2) call for a repairman to be sent out; (3) call in and talk to someone who then advises the operator while he does the actual work. Statements indicate that the Cementer and the Electronics Maintenance Tech discussed the continuing issue with the Visiplex screens focusing on a diagnosis that the problem was associated with the Battery Box. The Electronics Maintenance Tech reported that he decided to prepare a battery box replacement and dispatch it to the Rig. He later said the "failure" of a battery box was a fairly frequent event on these offshore cementing units.

1/25/2013: The continuing conversation about the problem with the Visaplex screens included a discussion of burn residue the Cementer found inside of the Battery Box on the Cementing Unit. Presumably because of the "low voltage" reading, the Cementer reportedly was focused on the battery being discharged. Statements were received that he asked if burn residue inside of the Battery Box could be part of problem. The Electronics Maintenance Tech stated that he agreed the burn residue could definitely be part of the problem and said he instructed the Cementer to leave the electronic problems alone until he (Electronics Maintenance Tech) was able to get to the Rig. He stated that he was scheduled to go out to the Rig on Monday, *1/28*.

The Cementer noted that they were scheduled to do a cement job probably that weekend before the Electronics Maintenance Tech proposed to arrive to repair the system. During the conversation, the Electronics Maintenance Tech suggested the Cementer use the primary power source for the Visiplex. The Cementer told him only one of the two Outlet plugs was operative and the Electronics Maintenance Tech then suggested he (the Cementer) unplug the Extension Cord that powered the alternate supply through the Battery Box *(that had been used as a primary source for an extended time),* and plug in the extension cord that supplied power through the primary source, the AC/DC converter.

The Electronics Maintenance Tech prepared a new battery box and dispatched it to the Rig. No indications were provided during interviews that the Baker Hughes electronic maintenance department followed up the discussion with the Cementer to see if their suggestion to reroute the power had worked and whether the screens were functional. No reasons were given for delaying the trip to repair the electronics on the Skid.

1/25-26/2013: The Rig prepared to cement the conductor casing. RU cement head, circulate hole, pump cement, bump plug.

1/26/2013: WOC for 8 hrs. During cementing of the conductor casing, the electronic Visiplex screens in the quasi-control "room" *(Note: the "control room" is actually just a space with the electronics on top of the Skid)* of the Cementing Unit reportedly did not function properly. The Baker Hughes stated the screens continued to display a "low voltage" reading. The cementing of the conductor casing was then completed possibly using traditional methods of counting pump strokes and monitoring returns, etc.

0200 hrs: The Baker Hughes personnel finished pumping the cementing job on the conductor casing and began rigging down the cement head.

0330 hrs: The Field Operator and the Cementer finished writing the ticket.

0500 hrs: All Baker Hughes hands went to bed.

1200 hrs: The Cementer called the Baker Hughes maintenance department to talk to the Service Supervisor about the problems with the Visiplex. Statements indicate the Service Supervisor was not available, so the Cementer left a message asking him to call back to the Rig.

1330 hrs: Baker Hughes hands ate lunch. While in the TV room, the Field Supervisor and the Cementer discussed the upcoming job. The Field Supervisor was preparing to depart the Rig, awaiting the arrival of the boat.

1400 hrs: The Cementer and the Field Operator discussed the problem caused by the Visiplex not working properly and possible issues with the electronics and Battery Box. The Field Operator told him to call the Service Supervisor. The Cementer then said that he had attempted to contact the Service Supervisor and had left a message. He stated that the Service Supervisor was going to call back and asked the Field Operator to wait for the call. The Field Operator waited in the common room but did not receive the call, so he finally called the Service Supervisor at *1420 hrs*.

1420 hrs: The Service Supervisor and Field Operator had a phone conversation about the Visiplex unit and Battery Box. The Field Operator told the Service Supervisor about the previous conversation with the Electronics Maintenance Tech regarding Visiplex and Battery Box problems and discussed replacement of the Visiplex unit itself. After the phone conversation, the Field Operator and Field Supervisor discussed the issue of the Visiplex, and also what needed to be repaired on the Cementing Unit. They discussed the ordering of parts for the Skid and supplies of cement, etc., for the upcoming surface casing cementing. The Field Supervisor noted he was leaving the Rig around 1700 hrs.

[Note: From statements received and a description of the mechanics of pumping cement, monitoring a cementing operation using the electronic screens becomes more desirable the deeper the casing that has to be set because of the increased volume of fluids and cement. The next cementing operation was scheduled to be the setting of the surface casing which was anticipated to occur about 1/30.]

1500 hrs: The Cementer phoned the Rig Electrician, and told him he wanted to borrow the Rig's Battery Charger to trouble shoot the Battery Box of the Cement Unit. The Rig Electrician told him that he had checked the charge on the battery in the Battery Box the day earlier and that it was good. The Rig Electrician stated that the Cementer continued to believe the problem with the Visiplex screens was a low charge on the battery in the Battery Box. The Rig Electrician then agreed to let him use the Rig Battery Charger and told him where the Battery Charger was. He also told the Cementer he could use the battery test equipment. From statements, the Rig Electrician again reminded the Cementer that the charge on the battery was not an issue because he had previously checked the battery and found it fully charged.

1545 hrs: The Cementer left the common room without telling the other Baker Hughes personnel where he was going.

1545-1650 hrs: From the geography of the area of the Incident and the position of the equipment found at the scene it is deduced that the Cementer pulled the Rig's wheeled Battery Charger into the breezeway passage that allowed access to the Battery Box of the Cementing Unit. At some point he opened the tool case and laid out the tools on a flat surface near the Battery Box. He then unplugged the female end of the Extension Cord bringing power from the Outlet to the Battery Box, and plugged the cord from the Battery Charger into the female end of the Extension Cord.

1650 hrs: The Field Operator accompanied by a Rig employee went to look for the Cementer and found him lying face down by the Skid's Battery Box.

Physical Elements, Actions – Timeline After the Incident

Emergency Procedures, Evacuation, Coroner's Report

1650 hrs: The Field Operator, accompanied by a Rig employee (hand), looked for the Cementer and found him lying face down near the Battery Box in the passage way between the Cement Unit and the pressure storage tanks (P-tanks). The Battery Charger was upright near the Cementer. Tools for checking voltage, etc. were laid out nearby on the Cement Unit. The top for the Battery Box had been removed and placed in the middle of the walkway. The Battery Charger's power cord was plugged into the Extension Cord but the Cementer was not holding onto the Battery Charger.

The Rig hand with the Field Operator moved forward to either grab the Battery Charger or the Cementer. The Field Operator stopped him after noticing the Battery Charger was still plugged into the Extension Cord. The Field Operator then pulled the Battery Charger cord loose from the Extension Cord. He then directed the Rig hand to get the OIM and EMT medic.

The Field Operator and Rig hand were joined by the Rig Total Safety EMT and the OIM. They moved the Cementer to an open space at the end of the Cementing Unit, overturning and moving the Battery Charger in the process. The EMT, the Field Operator, and others began CPR while the OIM informed the Company Man of the Incident. The Operator's Company Man contacted Medivac and the US Coast Guard.

1700 hrs: Medical treatment was continued, directed and administered by the EMT and assisted by others. EMT procedures, including chest compression and artificial respiration, de-fibulator use, injections, and oxygen, were employed in an attempt to revive the Cementer. Though no heart rate or breathing was apparent, attempts to revive the Cementer continued for almost 40 minutes. During this time the EMT was in contact with the medical personnel of the inbound Medivac helicopter and also in contact with a medical doctor (MD) who was consulting with his contractor company, Total Safety.

1738 hrs: The MD on call at Total Safety and in communication with the Total Safety EMT on the Rig conducting and directing efforts to revive the Cementer communicated that in his opinion further efforts would not be productive and CPR ceased.

1925 hrs: The Medevac helicopter arrived, picked up the Cementer, and departed for the Terrebonne Parrish Coroner's Office at *1945 hrs*. The I3P Rep subsequently gave the Coroner a brief summary of the Incident by phone. The BSEE was contacted by the Company Man and preparation of a report was begun. The area of the Incident was taped off by the I3P Rep, including the area where treatment was administered.

1/27/2013: The Terrebonne Parish Coroner's office initially autopsied the Cementer. After discussing the facts with the I3P Rep and receiving the information details of the scene from him, they released a preliminary report stating that electrocution was suspected to be the cause of death pending autopsy and lab reports.

(Note: Post-Incident actions on board the Rig are continued below in "Timeline: Post Incident")

2/24/2013: A lab report was submitted regarding examination of two lesions on the Cementer's right knee. The report concluded that the injuries were compatible with low voltage electric trauma.

3/11/2013: The Coroner completed and released his report which concluded the cause of the fatality was likely electrocution. After release of the Coroner's report and upon learning the fatality was work related, BSEE formed an investigatory Panel, composition completed by 3/18.

Incident Related Geography

The Incident occurred next to the Cementing Unit Skid. The Skid is located on the starboard, bow side of the Rig next to the P-tanks *(see figure 3 and 4, p. 8)* close to the stairs from the heliport. The Cementing Unit Skid is approximately 10-ft x 30-ft and is welded to the deck leaving a 4-ft or 5-ft walkway between the Skid and the tanks. The "control room" of the Skid with the Visiplex screens is located above the pumping equipment on top of the Cementing Unit and is reached via a ladder on the starboard side of the Skid.

The electric Outlet that connected the electric circuits of the Cementing Unit to the Rig power supply was owned and installed by Contractor. It was a dual Appleton type Outlet attached to the Skid above the control room *(see figures 16 and 17, pp. 33, 34)* and was hard-wired to the Rig's 115V AC generator power supply. From the Outlet, the Skid used electric power distributed by extension cords.

The Battery Box that supplied emergency power for the Visiplex screens was positioned inside the lower port side brace of the Cementing Unit in the corridor between the P-tanks and Skid. It was about mid-way along the length of the Skid. When the Cementer was found, the top of the Battery Box had been removed and placed in the passageway between the Cementing Unit and the tanks. The Battery Box top and all sides were heavily splattered with dried cement.

The Extension Cord that supplied power to the Battery Box was routed from the power Outlet near the roof of the control room down to the Battery Box. In routing, the Extension Cord made several loops and turns around portions of the Cementing Unit skid. After the Incident and evacuation of the Cementer, the Extension Cord female plug end was lying on top of the Battery Box. It exhibited obvious signs of extensive burning which blackened the female plug end.

The Rig's Battery Charger, a Dayton Electric Company model 3LE84N wheeled unit, was near the Battery Box and presumably close to the location of the Cementer when he was found. Statements were given by the OIM that the Battery Charger was overturned during evacuation of the Cementer.

The work area where the Cementer was found is shown in *figures 8 and 9*. The photographs were taken the day after the Incident. The Rig deck in the proximity of the Incident location was described in statements as being "damp." Examinations of other photographs taken immediately after the Incident indicates possible residual salt water or other liquid residue on the deck in the proximity of the Battery Box area *(see figure 10, p. 25)*.

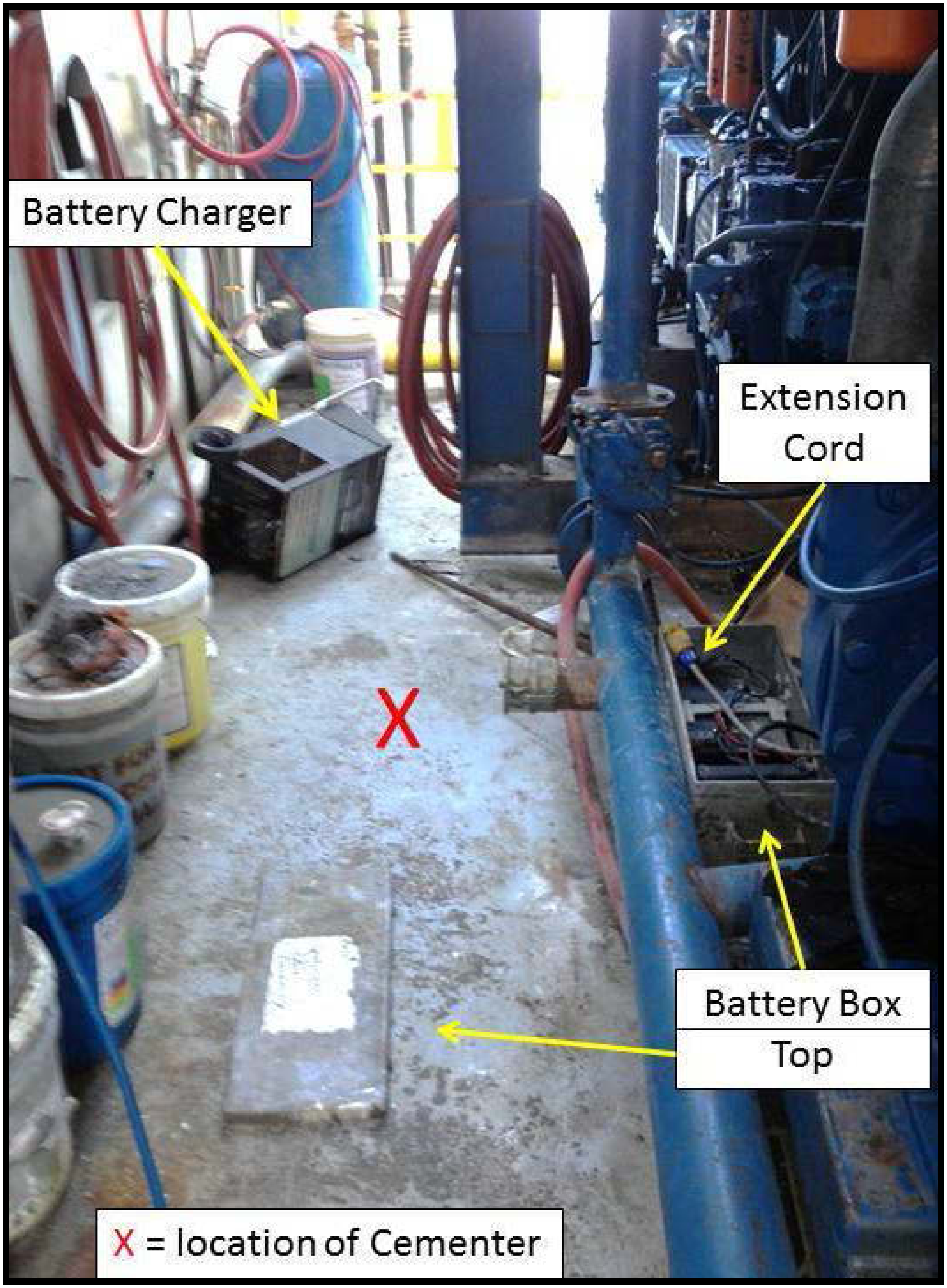


Figure 8: Geography of the scene of the Incident (1)

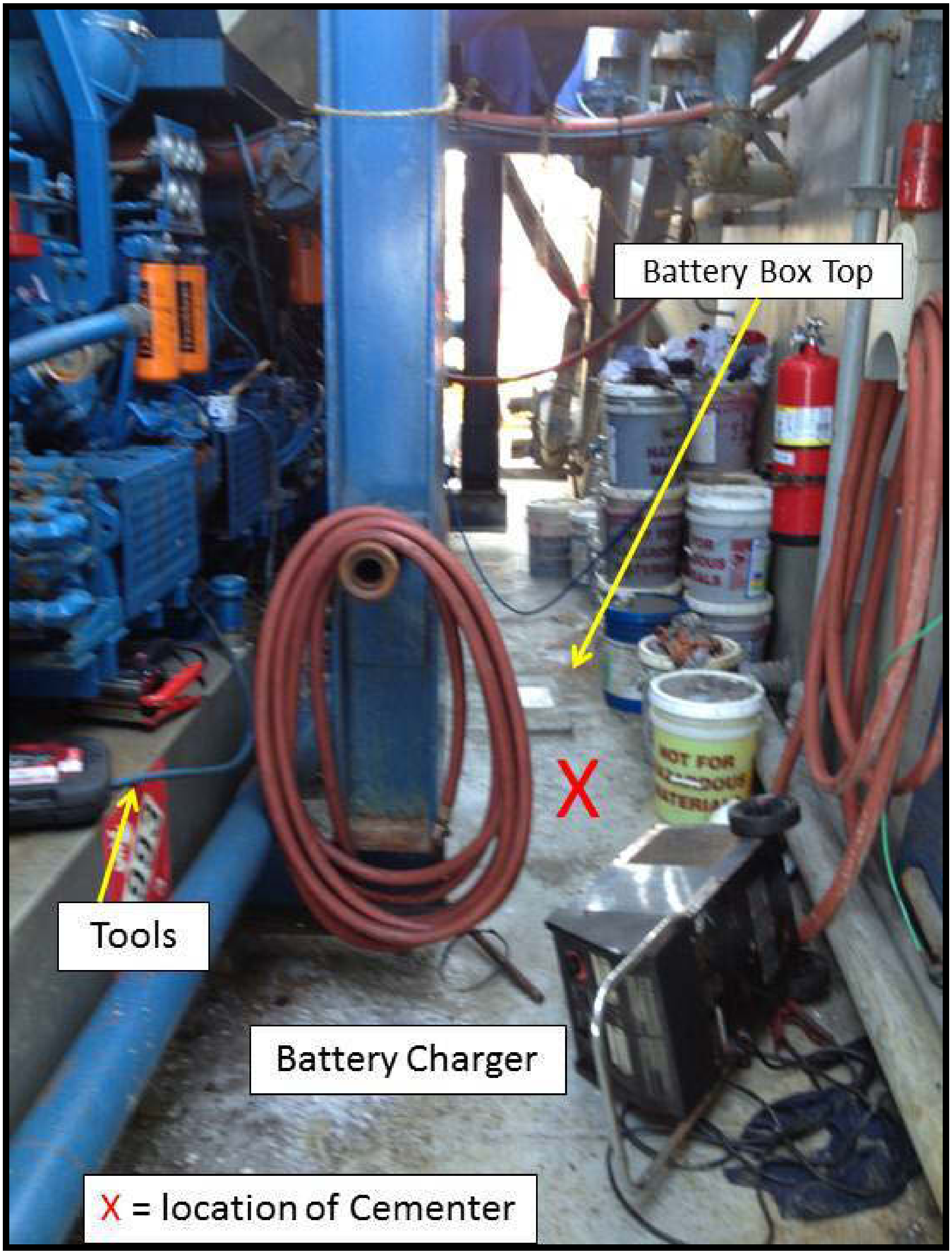


Figure 9: Geography of the scene of the Incident (2)

Figure 10: Deck condition immediately after Incident

Time-line, Post-Incident

1/26/2013 1800-2000 hrs: The I3P Rep taped off the area where the Incident occurred including the area that had been used in the attempt to revive the Cementer. The I3P Rep then took written statements from the crew.

Figure 11: Scene of Incident at time of arrival of BSEE Inspectors.

1/27/2013 morning: The Rig OIM asked Baker Hughes personnel to show him the JSA for the repair of the Cementing Unit electrical system. Baker Hughes personnel reportedly told the OIM that the JSA was locked in the computer. Statements made by Baker Hughes personnel later noted that no JSA had been prepared. The Rig OIM later stated that he requires a JSA for any job performed on his rig and all personnel arriving are informed of this requirement as part of the safety orientation.

1/27/2013 morning: BSEE inspectors arrived, interviewed the EMT, Company man and I3P Rep, and received copies of written statements from the I3P Rep. Shortly afterward, additional representatives of Operator, Spartan, Baker Hughes and the USCG arrived. A number of interviews were conducted and a walk through of the area was performed. Records, data, and photographs were collected.

Note: During the Panel investigation, Baker Hughes provided a copy of their policy bulletin entitled "Incident Investigation: How to Conduct an Investigation User Guide." Bullets in the section entitled "Timely Response to Incident Scene" reads as follows:

- *"Incident scene should be barricaded to preserve the scene.*
- *"If HSE personnel will be unable to respond in a timely way due to distance to the Incident scene, ask on-site personnel to preserve the incident scene, or if not possible request they take multiple high quality digital pictures for a visual record.*
- *"Recovery of damaged items such as burst hoses, broken belts, broken slings, failed bolts, etc., is also critical to ensure accurate determination of mode of failure post Incident."*

1/27/2013 approximately 1400 hrs: According to statements, the Baker Hughes Electronics Maintenance Tech arrived on board the Rig as the initial stages of the investigation were still progressing. The Electronics Maintenance Tech later stated that he was informed that the original Battery Box and Extension Cord were to be taken off the Rig by the departing Baker Hughes personnel.

The Electronics Maintenance Tech proceeded to the Skid ignoring the taped off areas. He later stated he thought he was sent out on a Sunday to investigate the Incident, but was later told he was to return the Cementing Unit to service as soon as possible.

From statements by the Electronics Maintenance Tech, the Field Operator and Field Supervisor for Baker Hughes were leaving the Rig and he stated he thought they were carrying the Battery Box and Extension Cord. He briefly examined the Extension Cord and Battery Box. He later stated in his opinion the custom-manufactured armored Extension Cord that was used to supply power to the Battery Box was not appropriate to be used as an industrial extension cord. According to Electronics Maintenance Tech, armor braids are dangerous for several reasons and he stated he had removed all these type of cords he had run across. He noted that he had not gotten around to inspecting and upgrading this unit and that the Extension Cord on the Skid had been used for a long time, at least several years. No persons from Baker Hughes or the Rig later could recall the origin of the Extension Cord.

He stated he found the new battery box that had been dispatched to the Rig on Friday but it had not been installed or used. Electronics Maintenance Tech stated he scouted the Skid for a new location for the new battery box and discussed the need for a welder during a phone conversation with the maintenance personnel onshore. The new battery box was later installed temporarily beneath the Skid until the welders could construct a new location.

The Electronics Maintenance Tech consulted with the Rig Electrician and carefully went around the Skid checking voltage, etc. to determine if the Cementing Unit was "hot." The Electronics Maintenance Tech then went upstairs to the control room to trouble shoot the electronics. He stated he made up a new extension cord and through testing found that one side of the Appleton Outlet in the control room was not working.

The Electronics Maintenance Tech checked the Visiplex unit and found the power input cord leading from the Battery Box to the Visiplex was plugged into the wrong inlet on the Visiplex. He conducted trouble shooting of the Cementing Unit electronics. He made up the new extension cord and after connecting it to the new battery box, found that the unit powered up from battery power. He then called the Baker Hughes maintenance department onshore and ordered parts and asked for a contract electrician to be sent to re-wire the Outlet.

1/27/2013 afternoon: All inspector and investigatory personnel departed the Rig.

1/28/2013: The Contract Electrician from Southland Electronics under contract to Baker Hughes arrived on the Rig after going by the onshore Baker Hughes office to pick up parts for the Cementing Unit. He brought out certain electronic parts including a new outlet box.

After consulting with the Rig Electrician and after the arrival of the new parts, the Electronics Maintenance Tech and the Contract Electrician changed out the Appleton Outlet plug box and installed a new dual power outlet box that was operative on both sides. They stated the Outlet Box had a mechanical issue in one of the dual plugs that made that plug inoperative. The Contract Electrician stated in his opinion the entire Outlet Box was pretty corroded, especially in the inoperative plug. He stated that in his opinion the plug had probably been in that inoperative condition for some long period.

They were able to get the lights to operate and they checked the Visiplex unit. According to statements, the Visiplex unit was still not operative so the Visiplex screens were replaced, after which the Visiplex worked properly. The two personnel departed the Rig *1/28*. The work ticket and job description of the electronic repair led by the Electronics Maintenance Tech on 1/27/2013 and 1/28/2013 is shown in *figure 12.*

DEPART DATE 1/27/13 RETURN DATE N/A WORK ORDER NO. N/A

RIG NAME Spartan 202 UNIT NO. O421 SERV/SUP [redacted]

TECHNICIAN [redacted]

PROBLEM DESCRIPTION Troubleshoot power problem and display problem with the Visiplex/Microplex System. Check the instrumentation for correct operation

PROBLEM CORRECTION Power was ok from the new battery box, but the power cable was plugged into the wrong input connector on the back of the console. I plugged the power cable into the correct input, and everything powered up and down as should (while on battery power)... The Visiplex would not boot up. I changed it out. Now it works correctly on battery power.
I knew they might have had a problem with the 115VAC power outlets, so I tested them with my meter. One outlet was fine, but the other outlet has a problem with the neutral wire/connection.
To test the 115VAC to 12VDC power converter, I plugged an extension cord I made on sight to the good outlet. All instrumentation powered up and down fine while on the converter. We ran the unit, and all other instrumentation, including the new visiplex worked.
Called the office to inform them of my findings. They plan to send an electrician to the rig to fix the bad 115VAC outlet. I sent an email to [redacted] with part numbers for the electrician to bring out. Also, recommend moving the battery box to a higher-dryer area. This may include a welder. The office is aware of this, but needed time to talk about how, when, and where they want to move it. I am to call the office tomorrow 1/28/13 for further information.

1-28-13
Electrician changed out the 115VAC outlets wit New outlets, The proplem with the Neutral was an open contact inside the old outlet (internal). We test the outlets and ran power to the unit. Unit tested OK again.

Figure 12: Work ticket facsimile

Afterword, considerable confusion was expressed about what happened to the original Appleton Outlet that had been removed. The Contract Electrician thought the Electronics Maintenance Tech had the Outlet, and Electronics Maintenance Tech thought one of the Baker Hughes personnel inspecting the site of the Accident took possession of the Outlet. The removed Outlet was never found.

1/31: The IP3#2 contracted by the Operator conducted a survey of the area and found that the new extension cord from the new battery box was not properly secured, nor was it industrial quality *(see figure 13 for his report)*. He also found that the plug male end looked as if it were burned or melted, but was definitely damaged *(see figure 14)*. During this inspection, the location of the replacement battery box was found to be too close to a fuel tank. The replacement Baker Hughes personnel were told of the identified safety problems and another new extension cord was prepared onshore and sent to the Rig for use on the Unit.

Th-1-31-13 Reviewed Report of marine accident Doc. Regarding 1/26/13 Fatal incident.

Daily Rig walk through. observed. a none industrial power cord is zip tied on to a metal water pipe and routed up to the cement unit. being used a backup for the cement unit.

This is the same area where there was a fatality last week.!

I called the safety rep. [redacted] and cement Lead [redacted] over to the area and explained that zip ties Due to vibration would penetrate the power cord.
Power cord is not an industrial cord.
Rubber clamps should be used with proper equipment.

I3P LLC
Independent Third Party
Weekly Activity Report
209 Marcon Dr. Lafayette, La. 70507
337-593-9987

ep	[redacted]			Start Date:	1/31/13
t:	BOIS D' ARC			End Date:	1/31/13
tion(s):	SS Block170	SPARTAN 202	AFE:2012-03	Computer Service Tag Number:	

Power cord improperly routed.

The Cementer removed the cord & filled out a JAS.

After removing the power cord the cement lead [redacted] Notice the female plug was chard and bright to me and I so I photo & documented the plug.

Battery Box to close fuel tank, not anchored & power cord not properly routed

Figure 13: I3P Safety Inspection Report, 1/31

Figure 14: Male plug, replacement extension cord

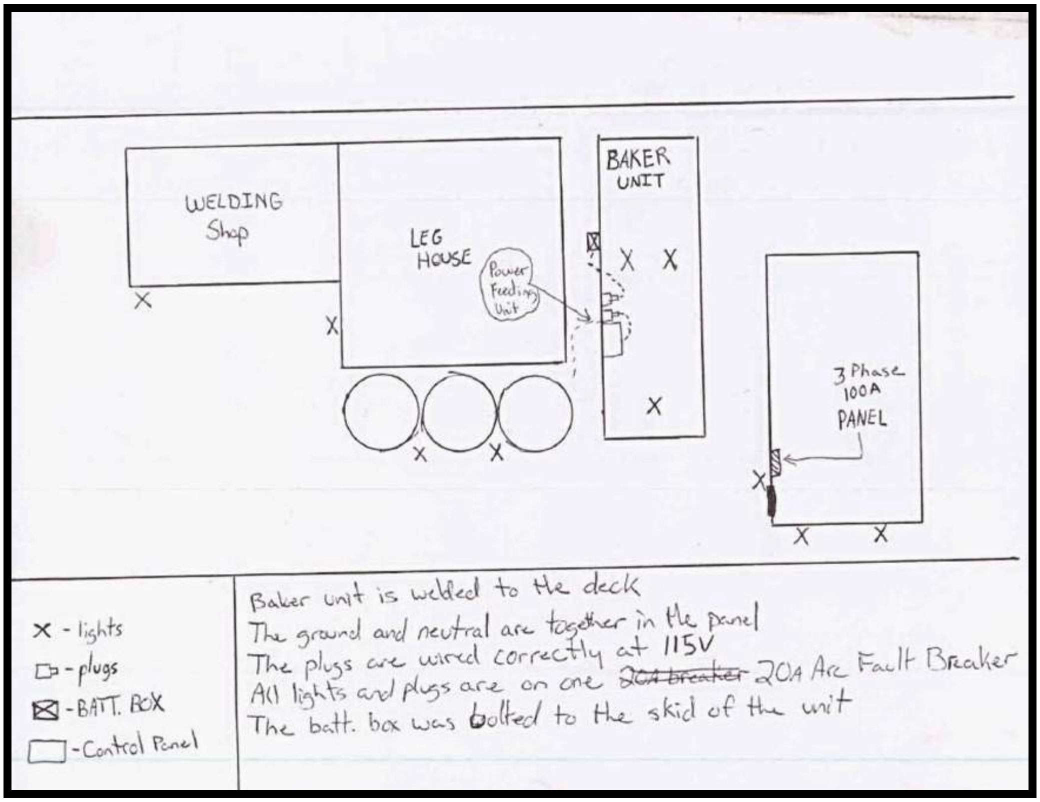
From later statements made by I3P and other personnel, the third attempt to make an acceptable extension cord to supply power to the Cementing Unit screens also resulted in production of a defective extension cord. The fourth cord made up by Baker Hughes apparently worked properly. No information was received about the ultimate relocation site of the battery box or the routing of the extension cord from the Appleton outlet to that new battery box.

Electric Power Provided to Skid

Power from Rig Supply

From statements, diagrams, interviews with Rig and Baker Hughes personnel, electric power was supplied to the Cementing Skid by connecting the Rig's 115 Volt AC system (115VAC) to the dual Appleton Outlet Box mounted near the ceiling of the control room. The Rig Electrician stated he installed the power cable to the inlet of that Outlet Box. The Outlet Box itself and all electric wiring downstream of it on the Skid were the property and responsibility of Baker Hughes and were installed and maintained by Baker Hughes personnel. The Rig Electrician stated that Rig Company rules prevented him from working on other company's equipment. He stated there was no ground fault circuit interrupter (GFCI) on the power line supplied to the Skid; however, the circuit did run through the breaker panel. He indicated a GFCI is not necessarily a part of such a system.

The Rig Electrician supplied two diagrams showing the wiring from the Rig's power supply to the Skid's Appleton Outlet box. He also provided information on the circuits and breakers. His drawings are shown in *figure 15.*



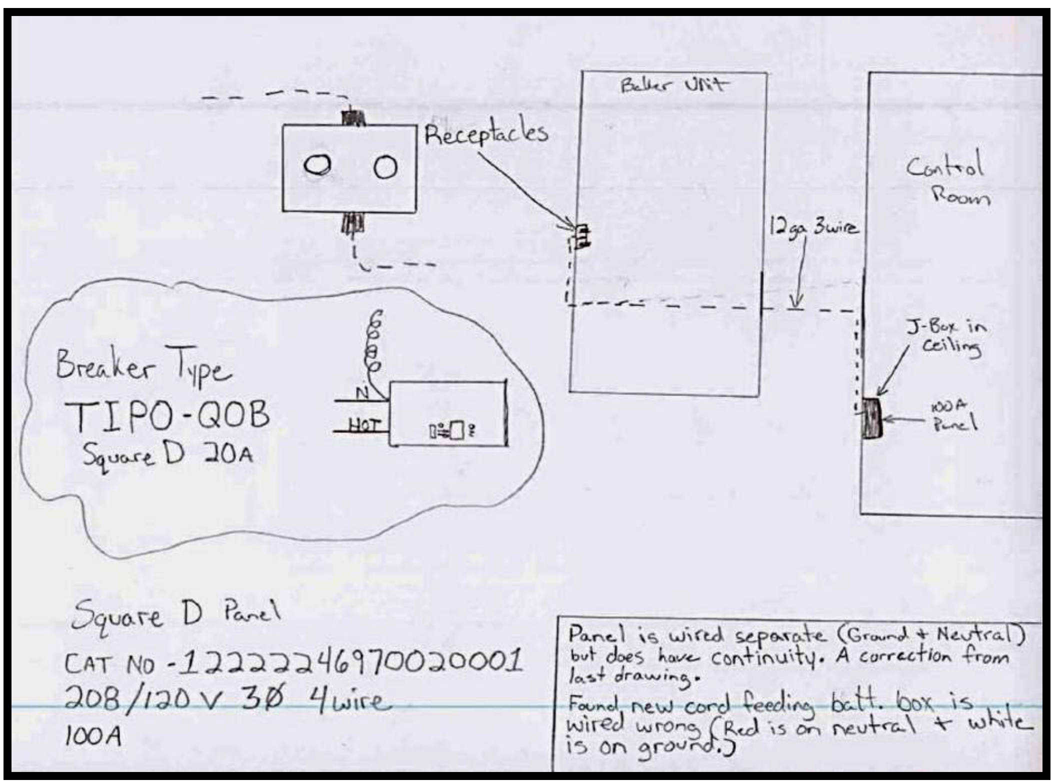


Figure 15: Wiring diagrams from Rig Electrician

Appleton Dual Outlet Receptacle

115VAC power from the Rig generator was fed to an explosion proof, Appleton dual Outlet box located above the "control room" of the Skid *(see figure 16)*. The "control room" was in fact only a tin-roofed area, open to the elements on the sides but partially protected by a tin roof and a tarp *(see figure 17)*. The Outlet was a dual to accommodate the design of the Cementing Unit electrics to provide separate primary and backup power sources feeding the instrumentation. The Outlet and all downstream wiring, electrical fixtures, instrumentation, etc., were installed and maintained by Baker Hughes. Despite being outside, the Outlet had no integral ground fault circuit interrupter (GFCI).

At the time of the Incident, the Outlet Box was defective in that only one of the dual outlets actually worked properly. The casing of the Outlet Box itself exhibited signs of corrosion and appeared to have stress or wear cracks in the connection seals of both plug receptacles.

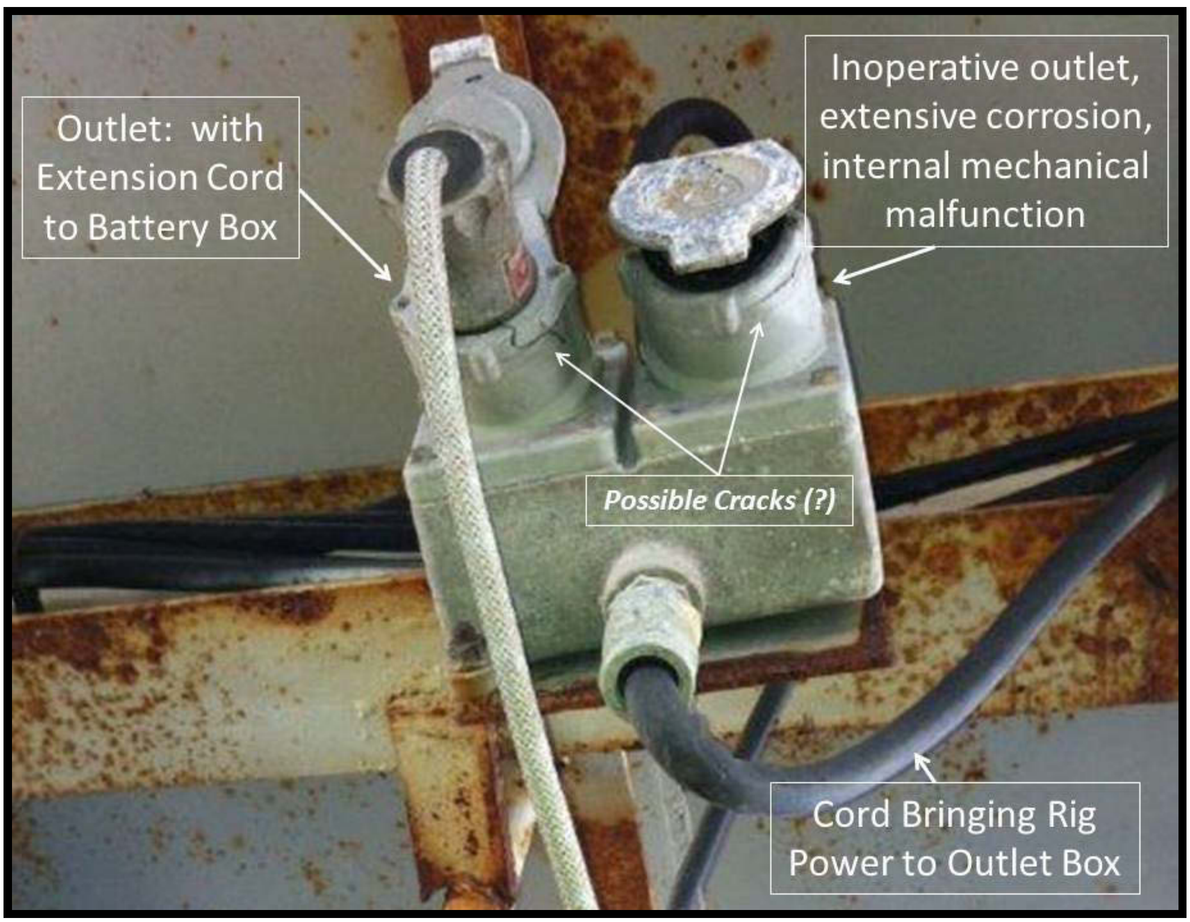


Figure 16: Appleton dual Outlet Box on Cementing Unit Skid

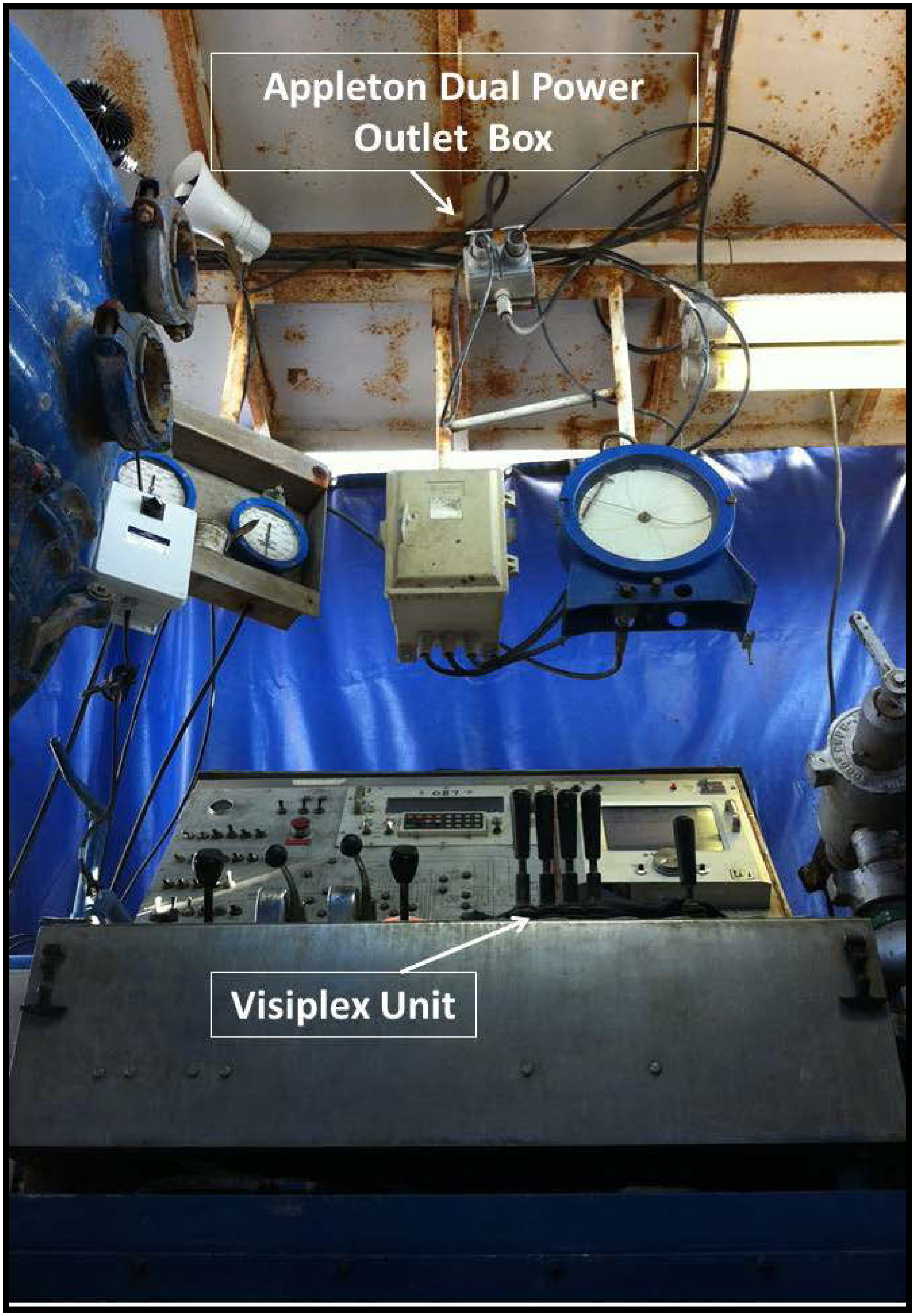


Figure 17: Appleton dual power outlet box in "control room" of Skid (after replacement)

Skid Electric Power Distribution and Instrumentation

The Appleton Outlet plug and all downstream wiring, circuits etc. on the skid are an integral part of the Skid itself and are installed, maintained, repaired by Baker Hughes personnel. The electricity from the Outlet plugs is solely for powering the instrumentation monitoring equipment in the control room. The key piece of that equipment is the "Visiplex display unit" (Visiplex) which allows the operator to visually monitor the progress of the pumping and /or cementing operation. The Visiplex is powered by 12 volt direct current (12VDC).

While the electronic digital readouts of the progress of a pumping operation provided by the Visiplex are a modern and useful tool, statements were received that a pumping or cementing operation can be completed without the electronic monitoring. This can be accomplished by using manual pumping input/returns calculations and visual monitoring, but that is not the preferred way to operate.

To power the Visiplex, two different methods, a primary and a backup, were designed and provided on the Skid. The elements of these two circuits are shown in *figure 18*. As the system was designed, the primary method of getting the 12VDC current to the Visiplex was to use an extension cord running from one of the dual Appleton Outlet plugs to an AC/DC converter. A pronged power connection cord then took power from an outlet jack of the AC/DC converter to the inlet jack of the Visiplex.

To back-up the primary power supply in case of rig power failure, the Skid also had a secondary method of providing power to the Visiplex. From the Appleton Outlet, a three-wire grounded Extension Cord was run to the Battery Box located on the Rig deck positioned next to the bottom rail of the Cement Unit Skid. The three-wire female end of this Extension Cord was plugged into an inlet receptacle on a Battery Box similar to the battery boxes used on larger power boats.

The female end of the Extension Cord stabbed to the aluminum Battery Box's male receptacle within an inlet connection that was NEMA class 5 (dust-tight, not water-tight). The three male prongs of this inlet were insulated from the walls of the Battery Box by a porcelain or Bakelite male socket fixture. Inside the Battery Box, power was taken from the male receptacle and fed to a small trickle charger located at one end of the Battery Box. This trickle charger was in turn connected to a 12VDC commercial boat battery and was installed to insure the battery was always fully charged.

The battery was wired to another outlet plug in the wall of the Battery Box (Cannon socket and plug), which accommodated another connection cord. That cord was (a) plugged into that outlet of the Battery Box, and then (b) plugged into a special connection on the rear of the Visiplex.

In summary, the Visiplex was intended to be powered by the AC/DC converter as primary source, switching to the back-up power provided by the Battery Box circuit if Rig power failed or spiked. The two Cementing Unit circuits, primary and backup, are represented in *figure 18*.

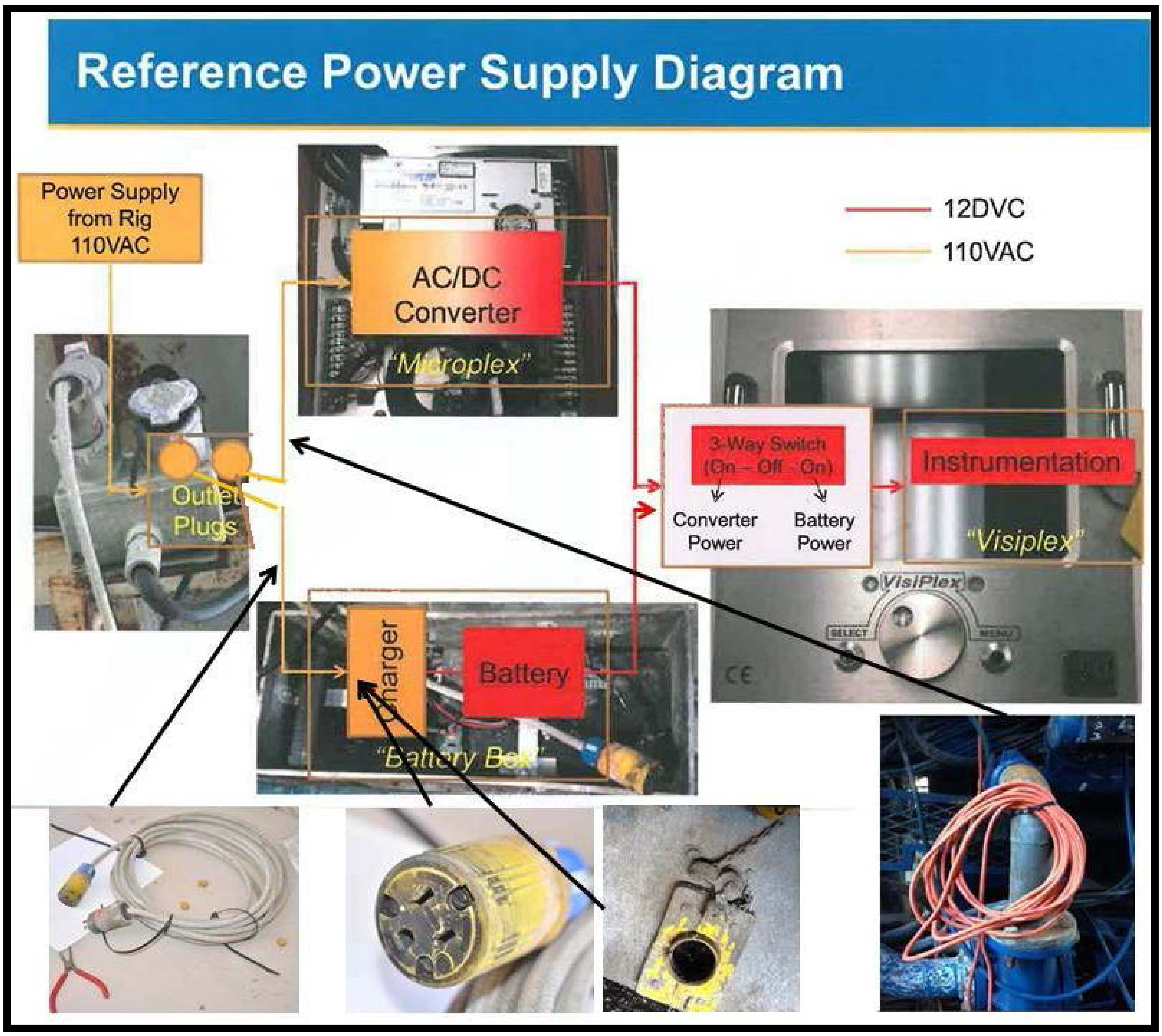


Figure 18: Power supply diagram *(after diagram provided by Baker Hughes)*

Primary Power Source (Inoperative)

As designed, the primary power for the instrumentation in the control room of the Skid including the Visiplex, was supposed to be delivered by an extension cord from the Outlet to an AC/DC converter. This converts the current from 115VAC to 12VDC. A separate cord with appropriate jacks on either end then transferred the 12VDC power to the inlet on the Visiplex unit. From statements, this is the preferred and designed method of powering the Skid's electronics under normal circumstances.

From statements, most operators of cementing units preferred to use current from a battery to operate the Visiplex and instrumentation. They believed taking the current off the battery "smoothed out" fluxions that are inherently a part of power generator electricity. However, current taken downstream of an AC/DC converter is actually "clean" and as free of flux as that from a battery. Despite this fact, statements indicate that many operators of Baker Hughes cementing skids continue to prefer to use the back-up battery as primary power rather than the designed AC/DC conversion unit. It is unknown if Baker Hughes has training or any other efforts in place to alter this wide spread practice and return to using the system(s) as they were designed.

From statements, the Baker Hughes personnel on board the Rig subscribed to the belief that it was preferable to use the back-up power source as primary, taking current from the battery. But in this case, the instrumentation of the Skid in fact could not be operated from the designed primary source running through the AC/DC converter, because: (a) the inoperative plug in the Outlet allowed only one source of power, not two; (b) the extension cord to connect the Outlet to AC/DC converter was apparently missing; (c) the connection cord to link the converter outlet to the Visiplex inlet was not available. Statements indicate that the primary power circuit for this Cementing Unit's screens had not been used for considerable time, "possibly for several years…"

Statements indicated that the preference for using the battery as primary power source may have been a factor in the failure to repair and activate the primary power circuit on the Skid. For whatever combination of reasons, at the time of the Incident, the Skid's instrumentation was operated using the designed backup Battery Box power rather than the primary circuit.

Backup Power Circuit

The original design of the Skid intended the backup power to be provided by a battery enclosed in a battery box. However, because of the deficiencies *(noted above)* in the Skid's electric system and the apparent preference of the Operators, the "backup" power supply circuit was used as the primary power supply to the Visiplex. At the time of the Incident the "backup" circuit was probably the only available working power source for the Visiplex. As such, portions of the backup circuit were factors in the Incident.

Extension Cord

From the Outlet, an Extension Cord was routed haphazardly to supply power to the Battery Box. It was dropped directly out of the Outlet, then twisted several times around several pipe extensions, through a nest of hoses, other wiring and miscellaneous equipment, to the Battery Box *(see figure 19).*

The on-site built Extension Cord was approximately 20-ft long and utilized aluminum armor on the outside and three conductors, white, black, and red. Examination of the Extension Cord after the Incident found it to be of indeterminate age, but estimated to be at least three years old. The armor coating was in poor condition with numerous holes, frayed webbing, and loose armor strands.

Figure 19: Extension Cord, from Outlet to Battery Box

The male plug end attached to the Extension Cord was an 'Appleton' explosion proof type. The female plug end was of an unknown manufacture with a NEMA rating 5-15 *(NEMA type 5 [dust-tight only, not water-tight] – 15 amp)*. The male plug end exhibited obvious signs of corrosion. Additionally, it was damaged and missing one screw attaching the face plate. The female end was not designed or rated for use in a high moisture area. The female end had extensive burn residue extending from the plug end throughout the portion covered by the inlet insertion bracket of the Battery Box, which also had extensive burn residue *(see figures 20, 21)*.

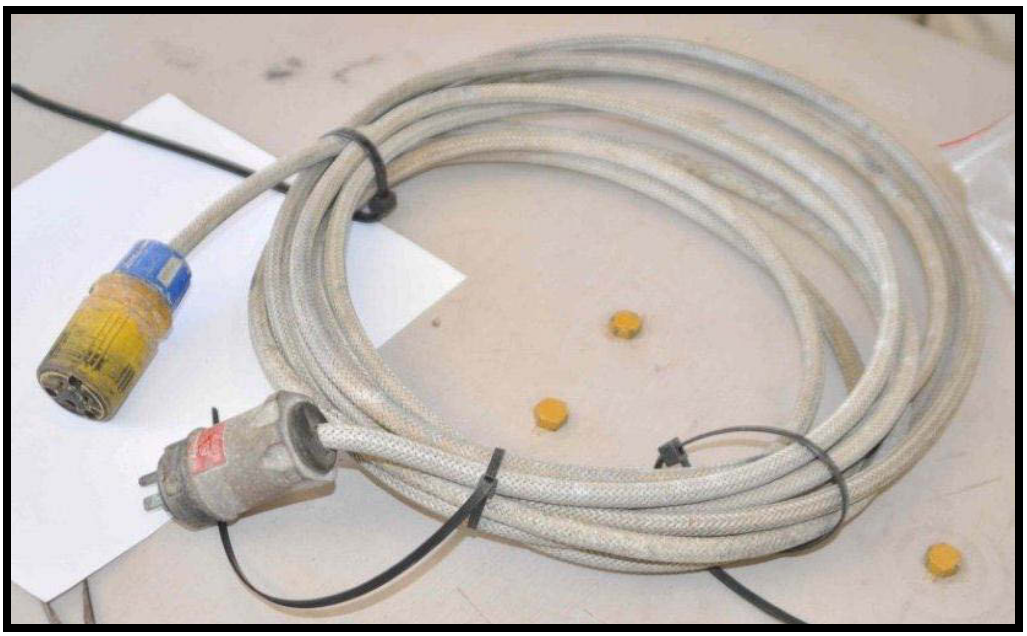


Figure 20: Extension Cord

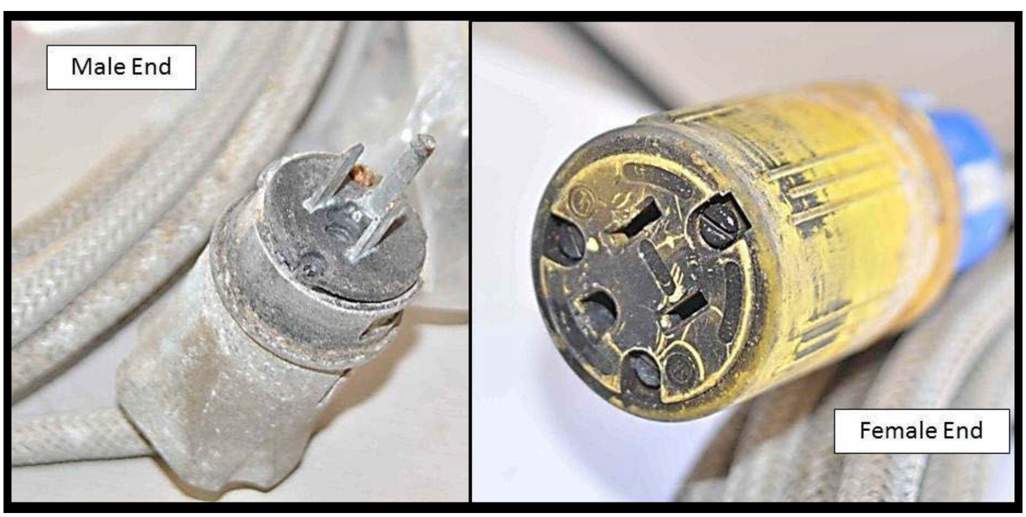


Figure 21: Extension Cord male and female ends

Statements indicate that the materials used to build this Extension Cord were substandard, and though it may have met standard electric code or best practices from a size/length/conduction ratio *(it appeared to be AWG-14 size when AWG-16 is adequate)* the qualities were not tagged on the cord. The Extension Cord was defective from a material standpoint because of the armor.

As previously noted, the “custom-built” Extension Cord was covered by braided aluminum armor. Statements from SMEs and others indicate that this is inappropriate material for an extension cord because frayed stray wires from the armor *(see figure 22)* can cause an increased chance of creating a short by penetrating and connecting two of the three wires of the cord.

Furthermore, the female end of the Extension Cord was not rated for high moisture. However, evidence indicated the location of that end of the Extension Cord in the Battery Box inlet connection was subjected to repeated exposure to various types of liquid including salt water and cement.

Statements from the Baker Hughes electronic maintenance personnel were made that these types of improper extension cords possibly predate the acquisition of BJ Services by Baker Hughes. It was stated that such improper equipment was removed from service whenever encountered by the electronic maintenance personnel. However, no indication was given by Baker Hughes that any directed program was in place to actively inspect all the cementing units in service and remove and/or upgrade the defective and improper extension cords before the Incident.

Figure 22: Armor Condition of Extension Cord

According to statements by the SMEs, at some time prior to this Incident, moisture entered the female plug end and shorted the hot leg to the ground leg of the female socket. This short burned the ground wire inside the female socket. This carbonized black coating, evident inside the female socket, became the new current path inside the female socket to the grounding lug of the socket and to the wheeled Battery Charger's metal case *(see figure 23)*.

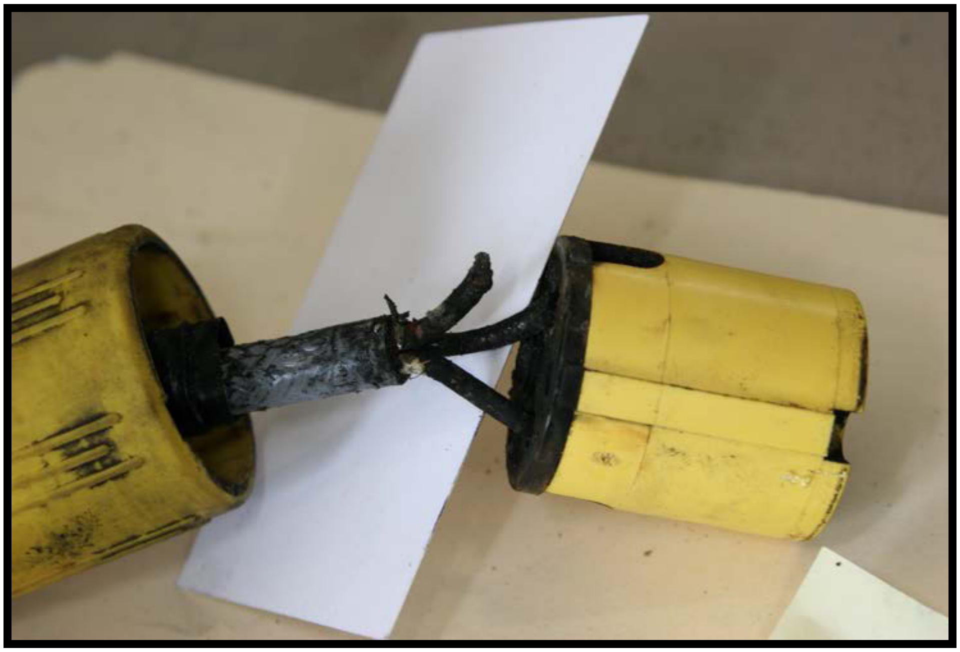


Figure 23: Internal female end of Extension Cord after Incident

Battery Box

The power for the Visiplex screens on the Skid was being supplied through the secondary, backup circuit using the Battery Box. This box, made of aluminum, was positioned inside of the bottom rail of the Skid and had dimensions approximately 36-inch (in) x 14-in,. The Battery Box contained a small trickle battery charger and a large 12VDC boat battery. The box had a removable top to allow access to the internals.

The location of the Battery Box on the deck of the Rig inside the bottom rail of the Skid was in proximity to the pumps, connections to tanks, and open to the weather. This location allowed the Battery Box to be frequently in contact with various liquids including salt water used to wash the deck, and cement. Photos taken immediately after the Incident indicates the deck in proximity to the Battery Box could have been wet. When examined later, the removable top and all of the sides of the Battery Box were found to be covered with dried cement *(see figure 24)*.

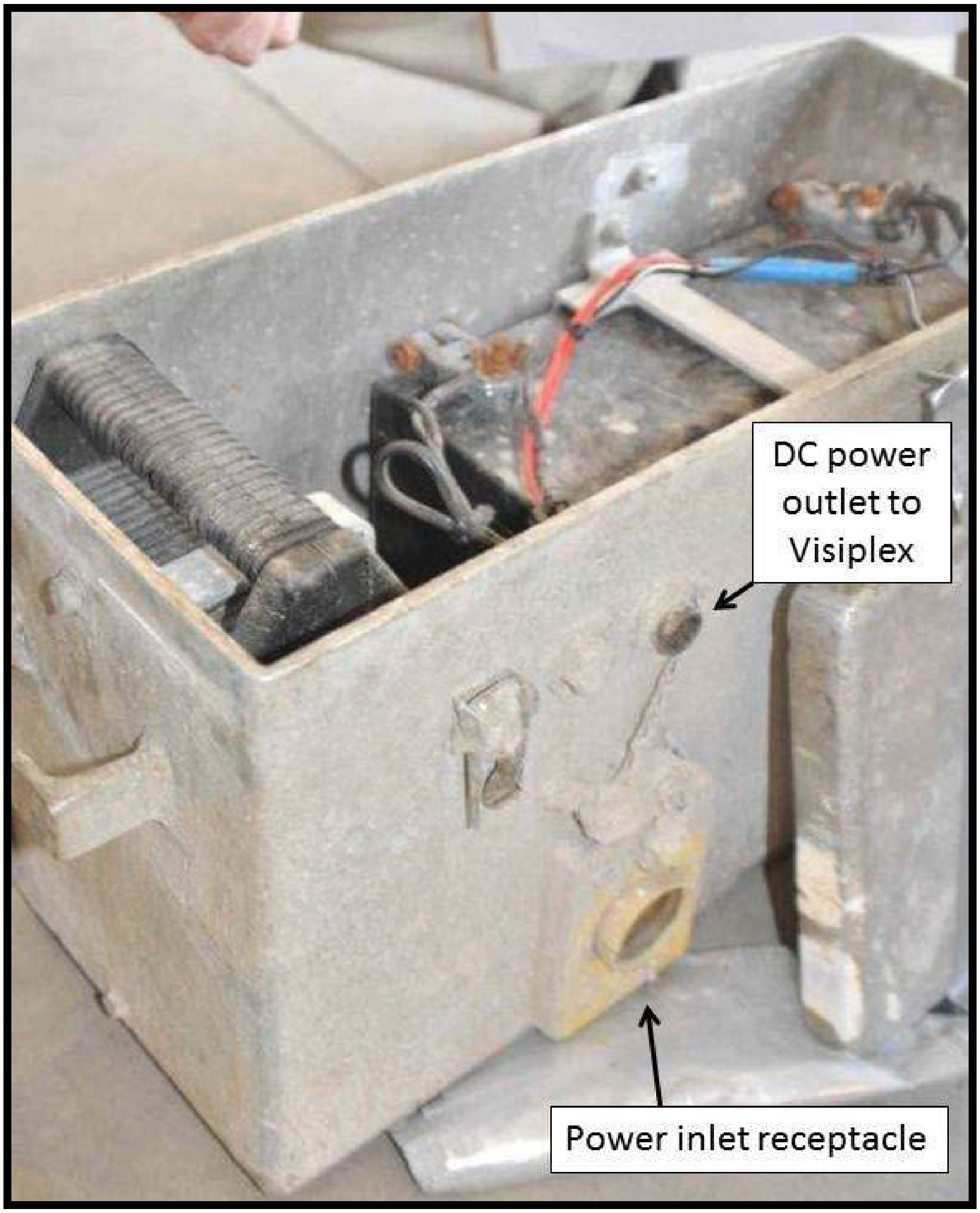


Figure 24: Battery Box opened for SME inspection

Inlet Receptacle

Power to the Battery Box delivered by the Extension Cord was transmitted by plugging the female end of the Extension Cord into a power inlet receptacle containing a male plug, located on the side of the Battery Box. The inlet receptacle had a partial metal guide to insure proper mating. Neither the female plug end nor the inlet receptacle would have met NEMA 4 water-tight standards. The side of the battery box containing the inlet receptacle for the Extension Cord was covered in dried cement as was the receptacle itself *(see figure 24 and 25)*.

Figure 25: Battery Box Extension Cord inlet receptacle

The inlet receptacle on the Battery Box was fitted with a porcelain or Bakelite insulator around the embedded male plug where the line passed through the aluminum wall. Two wires then carried power to the trickle charger within the box which was then connected to the 12VDC battery *(see figures 26, 27)*. A third wire, a ground for the male plug to the case of the Battery Box, was not present. Such a ground wire was installed and present on the replacement battery box (see *figure 28)*. From the 12VDC battery, power was wired to a three prong DC power outlet in the Battery Box wall which was the connection for the cord carrying DC power to the Visiplex.

The SME Group Report indicated the trickle battery charger installed in the metal case of the Battery Box is considered "double insulated" due to the plastic case of the trickle charger, and therefore does not require a ground wire on the trickle charger. However, the replacement battery box was grounded to the case of the box itself by a connection from the male inlet plug. A coating of burned insulation covered the inlet insulator inside the Battery Box *(see figures 29, 30).*

From discussions with SMEs, it is possible that a ground wire originally existed inside the Battery Box but was shorted and burned earlier resulting in the ash residue inside the Battery Box. However, in such a case the trickle charger would continue to operate normally because of the double insulation. A residual metal tab connection for a ground wire from the male inlet plug was not observed during inspection of the Battery Box by the SME Group.

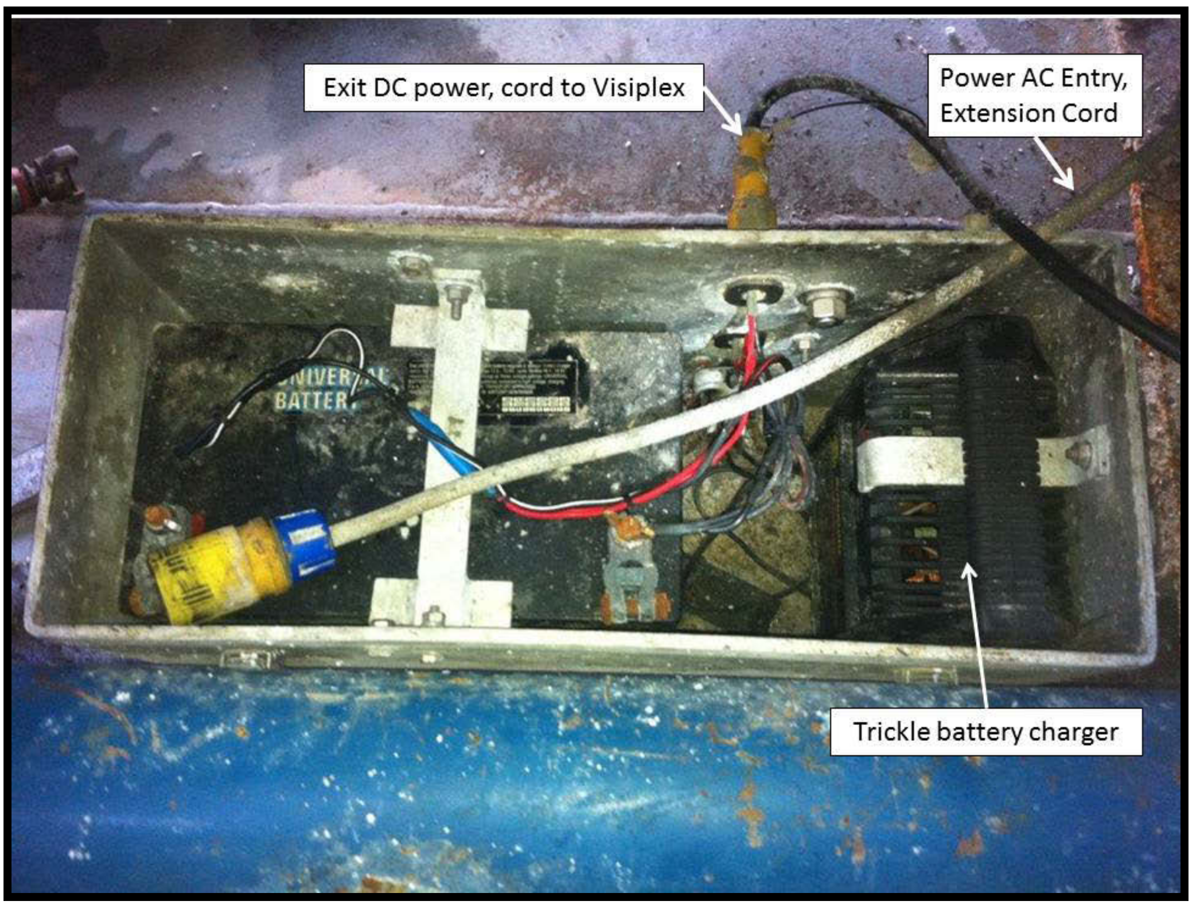


Figure 26: Battery Box on location, one day after Incident

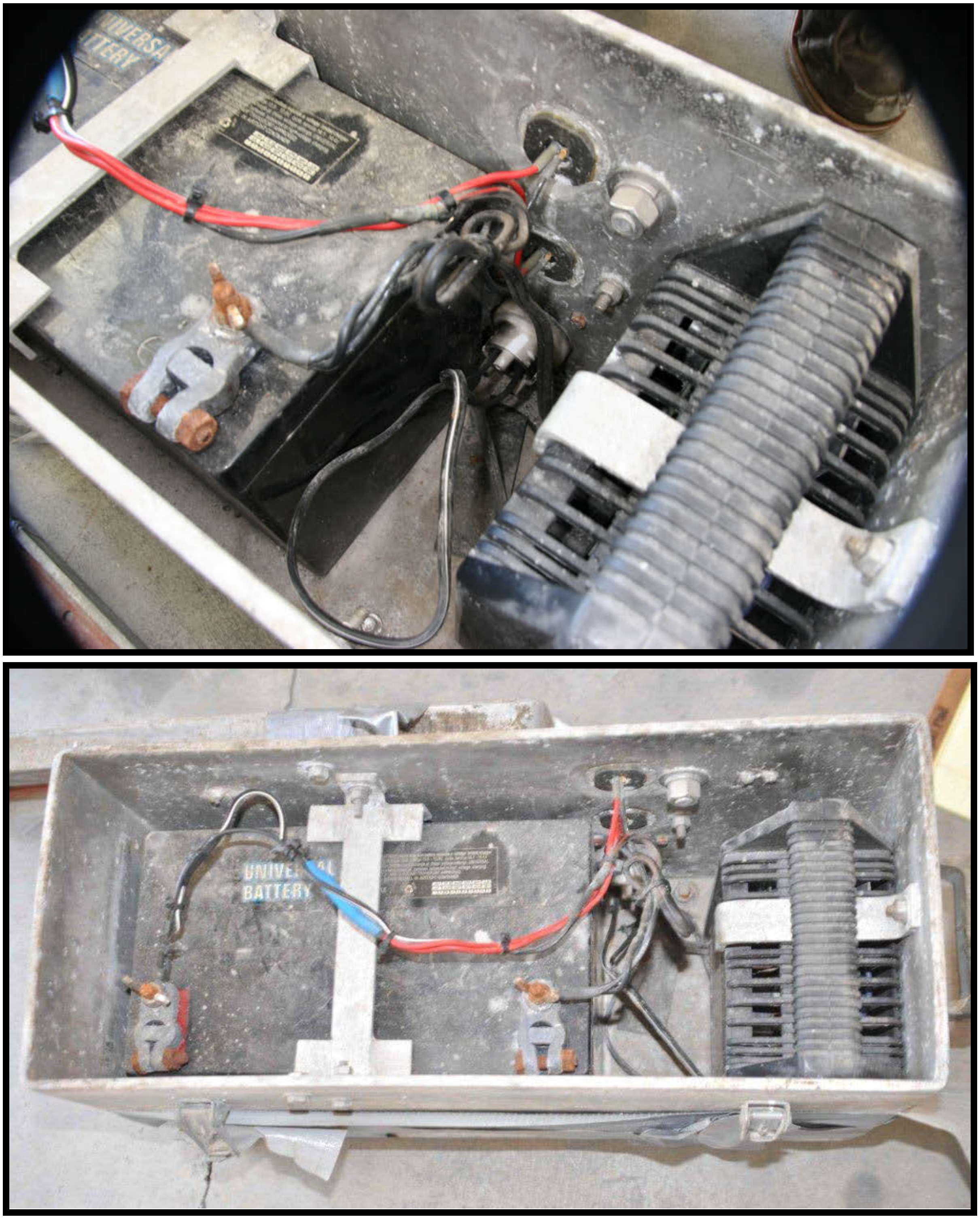


Figure 27: Battery Box opened for SME inspection, 18 March 2013

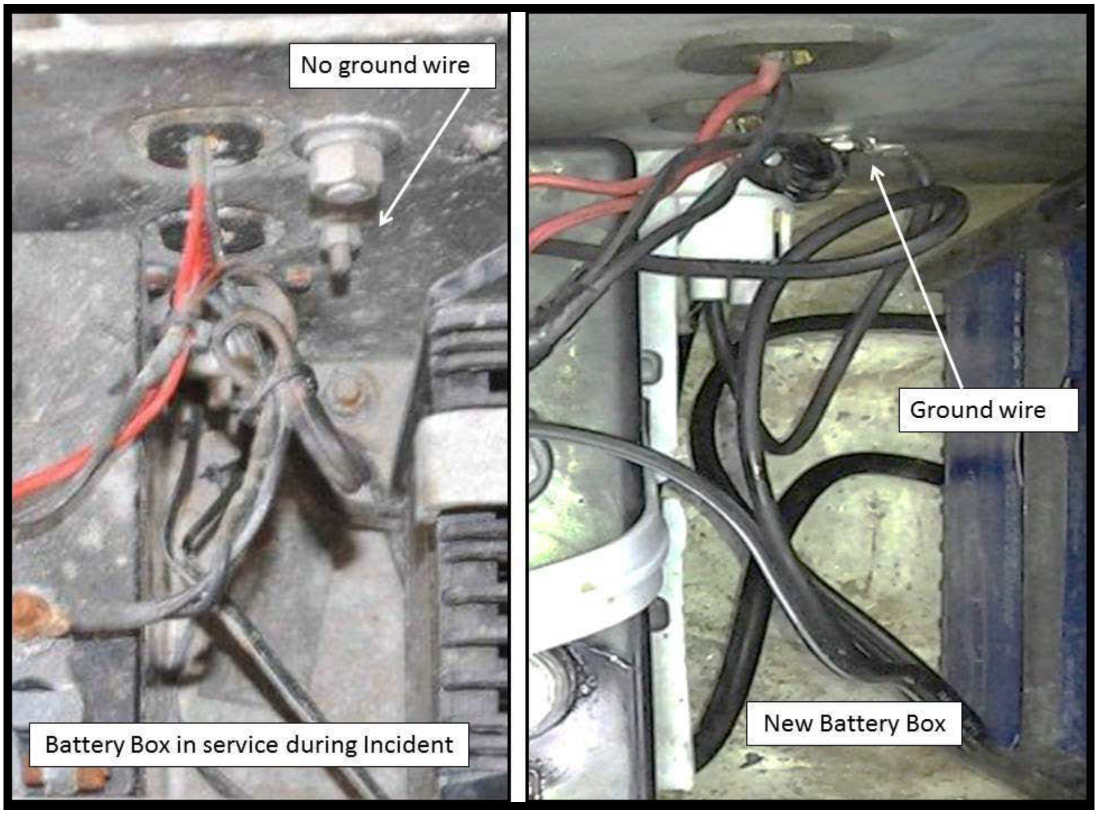


Figure 28: Internals, comparison of battery boxes

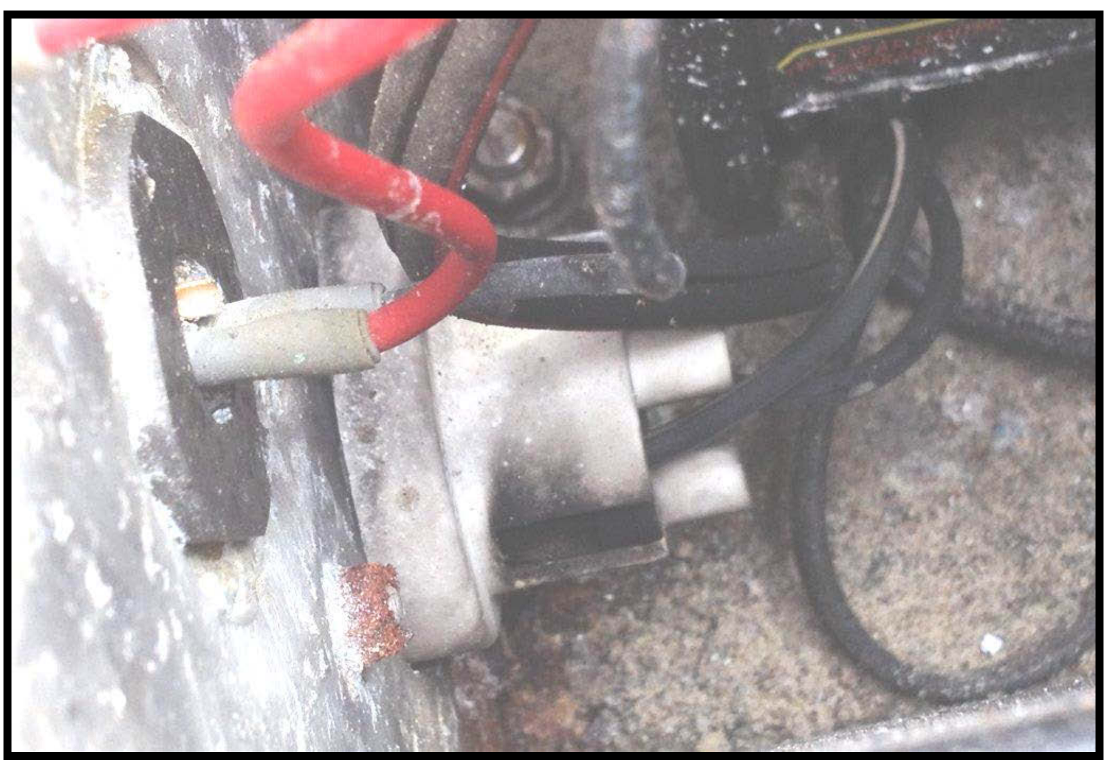


Figure 29: Insulator, power entry, Battery Box at time of the Incident

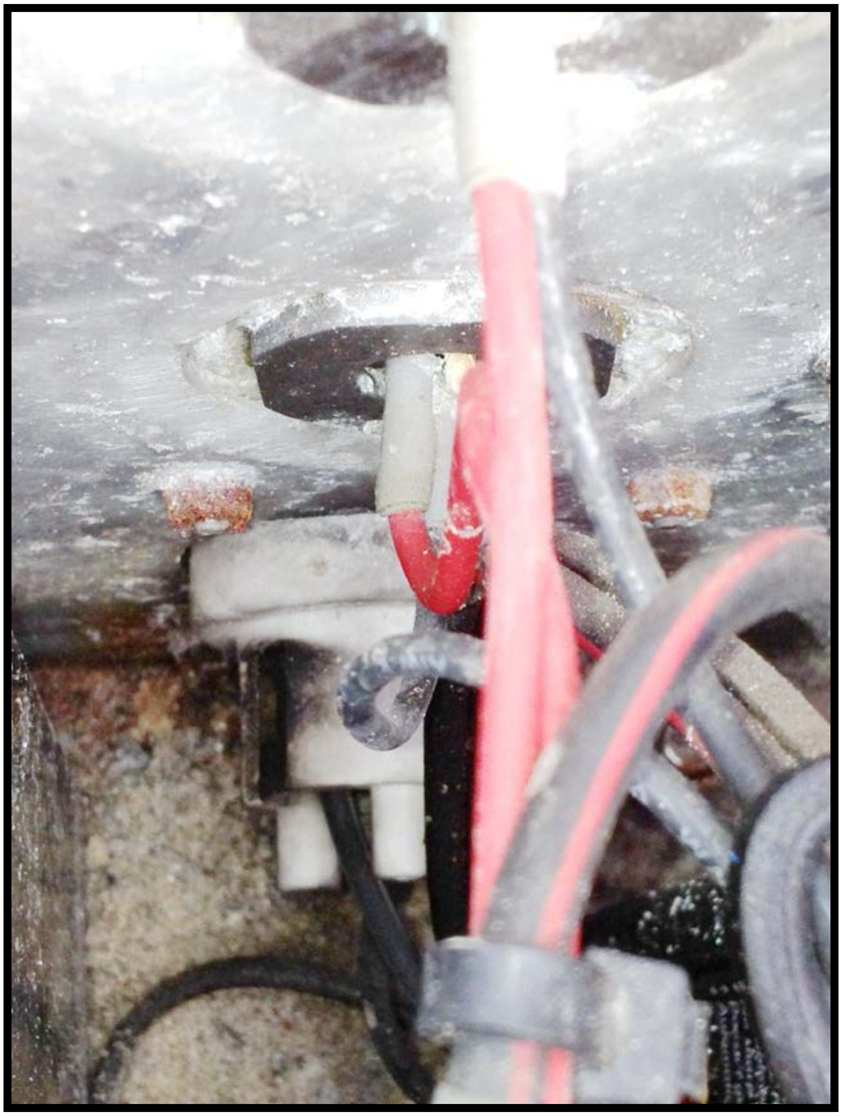


Figure 30: Insulator, power entry, Battery Box (2)

When inspected, the insulator for the male plug receiving power into the Battery Box was found to have a heavy burn residue *(see figures 29, 30).* The power receptacle inlet and guide also had a notable charred appearance and a burned smell that was evident two months after the Incident. The heaviest burn residue on the insulator appeared to be in the approximate location of the ground wire on the replacement battery box male plug.

Information was received that two months previous, on a different cementing job using this Skid but with different Baker Hughes personnel, an operator experienced a tripped circuit breaker when activating the Visiplex. However, the report indicated that thereafter no significant problems were encountered with the electronics during that operation.

Rig Battery Charger

The Rig Battery Charger was a Dayton Electric Manufacturing Co. Model 3LE84N. Dayton is a product name for a line of electrical equipment manufactured by Grainger Industrial Supply. This model battery charger has been replaced in the Grainger/Dayton sales product lines by other products and is no longer being produced. However, there are a great many units of this model battery charger still in service, and the replacement products apparently have similar wiring and capabilities as do many competitor's products. The Battery Charger is described in the literature as being intended for heavy duty use in service stations, maintenance shops, farms and fleets. It meets UL listed standards. Its AC cord is a conductor heavy duty that is 6-ft. long.

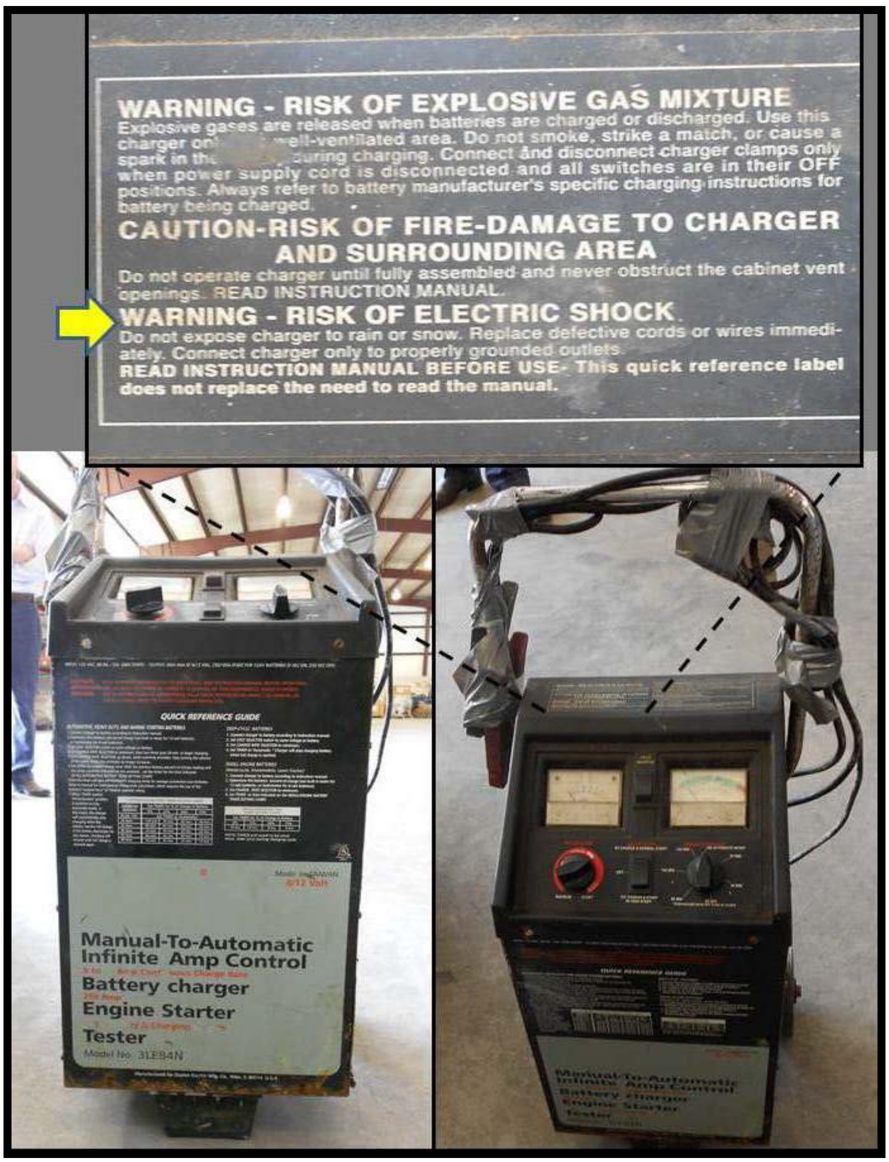


Figure 31: Rig Battery Charger and warning label (1)

Typical of these types of wheeled heavy duty battery chargers, danger warning labels and instructions for proper use adorn the case. Posted in two locations, on the top and the back of the Battery Charger, are specific warnings against the danger of electric shock if using a non-grounded outlet or extension cord *(see figures 31, 32)*. Other warnings include recommendation to avoid contact with rain, or water and instructions to replace defective wiring or cords immediately. Also on the case are warnings to read the instruction manual.

The Batter Charger showed evidence of corrosion and weathering from exposure to the elements despite the warning labels to avoid contact with water *(see figure 33)*. However, examination of the external and internal components of the Battery Charger by the SME Group did not discover any obvious malfunctions that would have contributed to the Incident (s*ee figure 34 for wiring schematic of Battery Charger*).

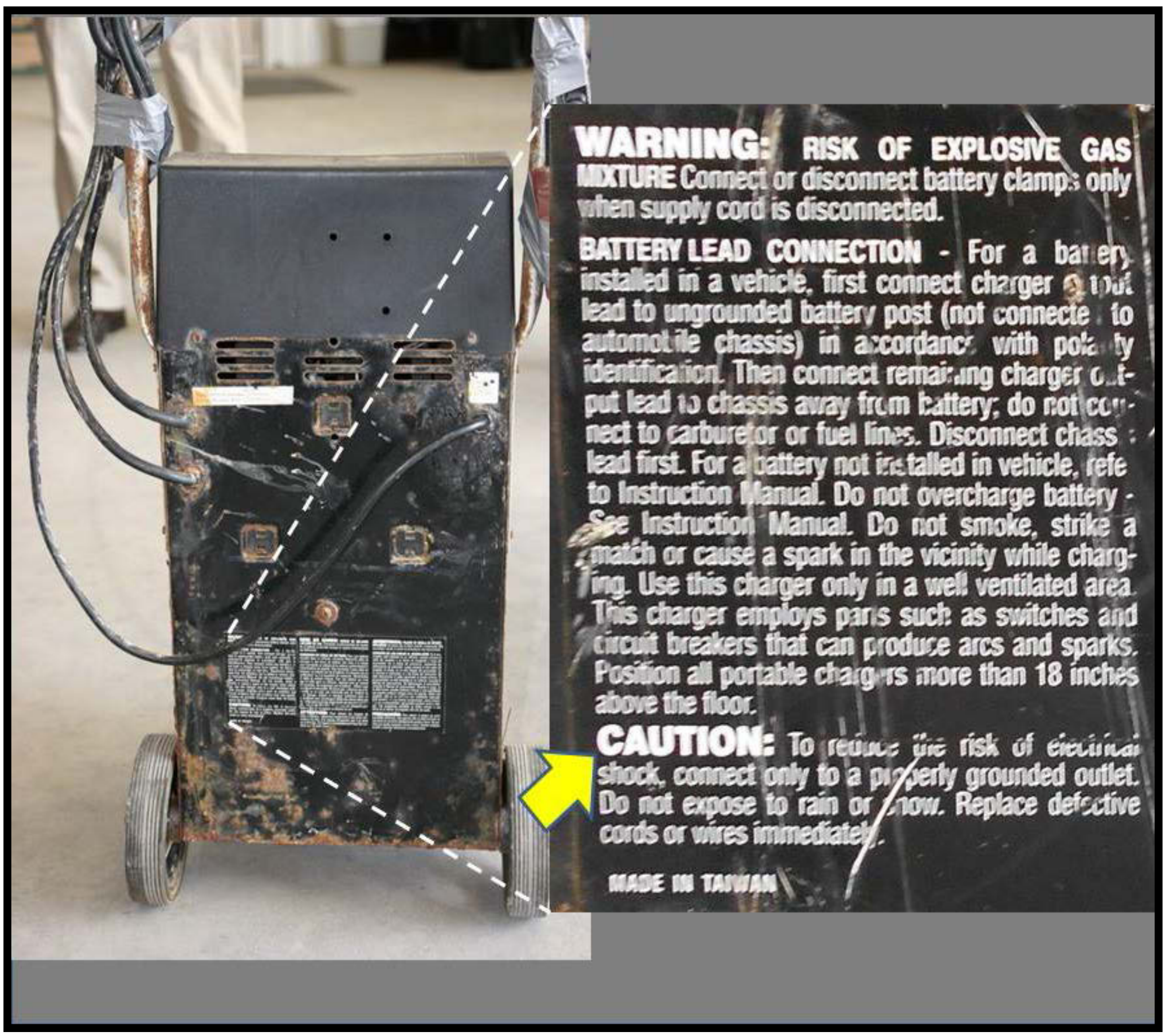


Figure 32: Rig Battery Charger and warning label (2)

Figure 33: Rig Battery Charger weathering, side and back

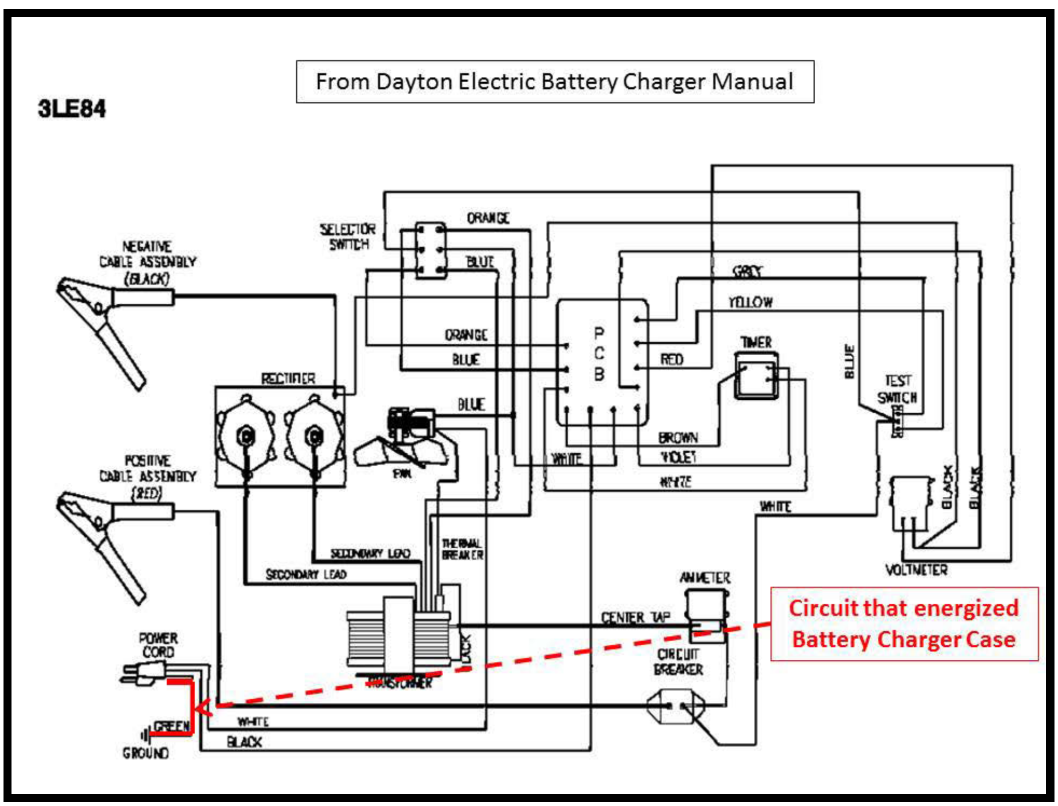


Figure 34: Rig Battery Charger wiring diagram *(after Dayton Electric Operating Manual)*

Operating Manual/User's Guides: Dangers and Warnings, Battery Chargers

Research indicates that electricity shock from a charged item in contact with hot connection especially to the case of an appliance or electric tool, *(other examples: toaster, battery charger, boat hull, aluminum pier ladder, etc.)* is responsible for a considerable number of accidental electrocutions and/or drowning. In such cases, faulty wiring and/or the failure to provide a properly grounded connection were usually the common element.

The Operating Instructions for the Battery Charger were not provided by the Rig Electrician nor used by the Cementer on board the Rig. The operating manual for this model charger includes the following information and wording:

> ***"Important Safety Instructions – Read These First: …***
>
> ***"5**. An extension cord should not be used unless absolutely necessary. Use of improper extension cord could result in a risk of fire and electric shock. If extension cord must be used, make sure that pins on plug of extension cord are the same number, size and shape as those of plug on charger, that the extension cord is properly wired and in good electrical condition; and that the wire size is large enough for the length of cord as specified in the following chart.* [chart, with this entry follows in text]
>
> *Length of cord in feet:* ***25-ft*** *AWG size of cord:* ***16****…*
>
> ***"6.*** *Do not operate the charger with a damaged cord or plug. Replace the cord or plug immediately…*
>
> ***"PERSONAL PRECAUTIONS: 1.*** *Someone should be within range of your voice or close enough to come to your aid when you work near a lead-acid battery. …*
>
> ***"GROUNDING AND AC POWER CORD CONNECTIONS:*** *Charger should be grounded to reduce risk of electric shock. Charger is equipped with an electric cord having an equipment-grounding conductor and grounding plug. The plug must be plugged into an outlet that is properly installed and grounded in accordance with all local codes and ordinances. DANGER Never alter AC cord or plug provided-If it will not fit outlet, have a proper outlet installed by a qualified electrician. Improper connection can result in a risk of an electric shock." …*

The "operator's manuals" for other similar type battery chargers were consulted. The following language was in all the instruction manuals of <u>all</u> major battery charger manufacturers surveyed, including CTEK, Minn Koto, Schauer, Oddesy, Marinco, Forney, et. al.

> *"An extension cord should not be used unless absolutely necessary. Use of the improper extension cord could result in a risk of fire or electric shock.*
> *If extension cord must be used, make sure:*
>
> > *a) That pins of plug of the extension cord are the same number, size and shape of those of the plug on the battery charger;*
> >
> > *b) That extension cord is properly wired and in good electrical condition;*
> >
> > *c) That wire in extension cord is proper size as follows:…"*

Note the almost identical language between the above and the language used by Dayton in its manual. All manufacturers of battery chargers surveyed have this language in their operators guide or manuals. This is apparently the language recommended by UL and is thus incorporated verbatim into the operating manuals of all of these companies. Typically, in many user's manuals additional language, diagrams, etc., were added to pictorially or graphically warn against the danger of electric shock when using an ungrounded power outlet.

Situation at Time of Incident

When the incident occurred, the elements were positioned approximately as shown in *figure 35*.

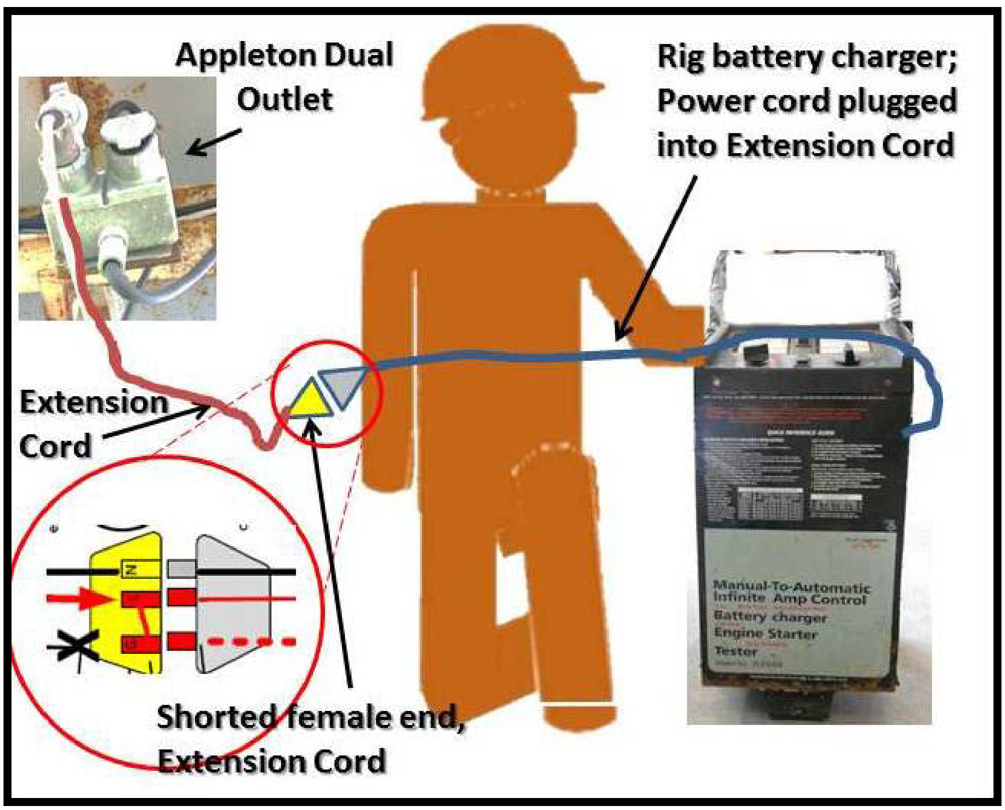


Figure 35 – Position of electronics and Cementer when the Incident occurred.

The Extension Cord was plugged into the Appleton power outlet. The power cord for the Rig Battery Charger was plugged into the Extension Cord. The Cementing Hand was kneeling on the deck having completed plugging the Rig Battery Charger power cord into the female end of the Extension Cord. The burned connection and short in the female end of the Extension Cord was causing the ground wire of the Rig Battery Charger power cord to be energized.

Subject Matter Expert Group's Report

Shortly after the date of the Incident, a document entitled *"Equipment Inspection & Test Protocol"* was developed, drafted, agreed upon, and signed by representatives of all parties representing the Operator, Spartan Rigs, Baker Hughes, and legal representatives of the family of the deceased.

The document established a protocol and procedure to examine and test the equipment. The four parties each assigned an in-house or outside consultant Subject Matter Expert (SME) to a group (SME Group) designated to examine the equipment collectively under terms of the document. BSEE representatives and United States Coast Guard (USCG) representatives reviewed the agreement and did not object to the agreed upon methodology.

On 2 January 2014, the SME Group released their final report on the source of the electricity and the technical and material issues that contributed to the Incident. The report reviewed the component equipment, wiring, electrical circuitry, and the source of the current that caused the fatality. The final report of the SMEs is included in Attachment 1.

The SME report included the following key points and conclusions:

- *"The incident resulted from a defective extension cord that inadvertently energized the portable battery charger's metallic enclosure with 120V.*
- *"At sometime prior to this incident/ accident, enough moisture entered the female socket* [of the Extension Cord] *and shorted the hot leg to the ground leg inside of the battery case and female socket. Burning the ground wire off the terminal inside the battery case and inside the female socket. This carbonized black coating, evident inside of the battery case and inside the female socket became the new current path inside the female socket to the grounding lug of the socket and on to the portable battery chargers metal case.*
- *"The hazardous voltage was created by an electrical extension cord having two related defects:*
    - *"The grounding conductor wire within the extension cord was burned away from the ground terminal within the female socket. This defect was noted by both electrical resistance measurements of the assembled socket, and also by visual inspection of the disassembled female socket.*

- *"The 120V "hot" terminal within the female socket was shorted to the socket's ground terminal. This defect was noted by electrical resistance measurements between the line and ground terminals of the female socket.*
- *"Having no ground-wire connection to the enclosure, the 120V circuit did not create a fault current to trip the rig's 120V circuit breaker even though the charger contacted the grounded rig structure.*
- *"The larger portable charger did use a 3 wire grounded connection. Just prior to the incident, the portable charger's energized enclosure did not trip the circuit breaker because it was isolated from the deck on rubber wheels and a plastic foot.*

- *"The fault current originated in the female socket of the extension cord.*
  - *"The normal 120V "line" voltage shorted to the socket's ground terminal…*
  - *"The line-to-ground short did not trip the circuit breaker due to the broken grounding conductor in the extension cord.*
  - *"The male plug on the charger's cord, when inserted into the extension cord socket, was not wired back to the rig's ground due to the broken grounding wire in the extension cord. The charger plug's ground pin was instead connected to 120V via the short within the female socket.*

- *"The charger cord's normally grounded wire, now connected to 120V by the defective female socket, inadvertently energized the battery charger enclosure."*

Extension Cord Use in Industrial Application – Best Practice

Numerous standards address the use of extension cords in industrial applications. These include extensive OSHA regulations as well as API RP 14 F. Generally, most commonly referenced safety and regulatory sites recommend or require extension cords to be used only under following circumstances:

1. Temporary power transmission with close monitoring of conditions of use including length and rating of cord, condition, etc.
2. Frequent inspection before use;
3. Limit use and length when connecting appliances;
4. Proper personnel protective equipment when using in industrials applications;
5. Replacement minimum every 90 days *(as according to NEC code, see below)*;
6. Proper sizing of extension cord length, quality and wire to correspond with usage.

Below are some of the common best practice standards published by various governmental, industry and/or safety organizations.

API RP 14F

An example of recommendations incorporated by Reference in 30 CFR 250.114(c) is API RP 14F, Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations. API RP 14F is commonly used offshore for Production platforms and those standards are not necessarily applied to a mobile drilling unit (MODU). However, the use of the extension cord in this instance is not part of the mobile drilling unit but rather is part of an industrial skid that happens to be on a MODU.

The American Petroleum Institute RP 14F reads as follows:

> ***12.3 Electrical Tools***
>
> ***12.3.2*** *A power cord permanently attached to an electrical tool that can be an ignition source should not be equipped with an explosion-proof type plug. To allow for use of these portable electrical tools in areas where only explosion-proof receptacles are installed, adapter cords should be provided that incorporate an explosion-proof plug on one end and a three-wire, grounded, nonexplosion-proof receptacle on the other end.*
>
> ***12.3.3*** *The nonexplosion-proof receptacle should be the locking-type, or a means should be provided whereby the connection cannot accidentally be disconnected. These adapter cords should not be more than 2 ft long and should be used only under supervised conditions.*
>
> ***12.3.3.1*** *Alternatively, the adapter cords can be longer than 2 ft provided the end of the cord connected to the general purpose receptacle is used only in unclassified locations or locations where work is being performed in accordance with the procedure described by an authorized hot work permit. Also, the adapter cords can be used in combination with an extension cord utilizing an explosion-proof receptacle on one end and an explosion-proof plug on the other end.*

14F also refers to best practice for use of extension cords as follows:

> ***12.5 Extension Cords***
>
> *Extension cords are designed for, and should be used for, only temporary use. All other electrical connection should be made permanent by proper construction methods. All extension cords should include a grounding conductor within the cable jacket and should be equipped with either explosion-proof or non-explosion-proof, three-wire grounding receptacles and plugs (but not with one of each). The type of receptacle, plug, and cord will depend on the classification of the location in which it will be used. Reference 12.3.2 for adapter cords.*

Other industrial safety organizations address the uses of extension cords and have explicit directions for their use. Some of the governmental and industry groups with such recommendations include National Electric Code (NEC), OSHA, Electrical Safety Foundation International, UL, and Consumer Product Safety Commission among others.

OSHA Regulations and Discussion

(Standards – 29 CFR) address many uses of extension cords.

"The major hazards regarding contact with energized sources are electrical shock and burns. Electrical shock occurs when the body becomes part of the electric circuit, either when an individual comes in contact with both wires of an electrical circuit, one wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor.

"The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current, the length of time of the exposure, and whether the skin is wet or dry. Water is a great conductor of electricity, allowing current to flow more easily in wet conditions and through wet skin.

"When a cord connector is wet, electric current can leak to the equipment grounding conductor and to anyone who picks up that connector, if they provide a path to ground. Such leakage can occur not just on the face of the connector, but at any wetted portion." See informational links: http://www.osha.gov/dte/outreach/construction/focus_four/electrocution/electr_ig.pdf

Additional Information: See Standards, 29 CFR.

- *29 CFR 1926 Subpart K, Electrical. OSHA Standard.*
  - *1926.404, Wiring design and protection*
    - *29 CFR 1926.404(b)(1)(ii), Ground-fault circuit interrupters (see above).*

1926.404(b)

Branch circuits -

1926.404(b)(1)(iii)

Assured equipment grounding conductor program. The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. This program shall comply with the following minimum requirements:

(A) A written description of the program, including the specific procedures adopted by the employer shall be available at the jobsite for inspection and copying by the Assistant Secretary and any affected employee.

(B) The employer shall designate one or more competent persons (as defined in 1926.32(f)) to implement the program.

(C) Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage. Equipment found damaged or defective shall not be used until repaired.

(D) The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and cord- and plug-connected equipment required to be grounded: (1) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous. Etc.

- *Electrical Safety: Safety and Health for Electrical Trades Student Manual. US Department of Health and Human Services (DHHS), National Institute for Occupational Safety and Health (NIOSH) Publication No. 2009-113, (2009, March).*

1910.334(a)

Portable electric equipment. This paragraph applies to the use of cord and plug connected equipment, including flexible cord sets (extension cords).

1910.334(a)(2)

Visual inspection.

1910.334(a)(2)(i)

Portable cord and plug connected equipment and flexible cord sets (extension cords) shall be visually inspected before use on any shift for external defects (such as loose parts, deformed and missing pins, or damage to outer jacket or insulation) and for evidence of possible internal damage (such as pinched or crushed outer jacket). Cord and plug connected equipment and flexible cord sets (extension cords) which remain connected once they are put in place and are not exposed to damage need not be visually inspected until they are relocated.

1910.334(a)(2)(ii)

If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee may use it until repairs and tests necessary to render the equipment safe have been made.

1910.334(a)(2)(iii)

When an attachment plug is to be connected to a receptacle (including an on a cord set), the relationship of the plug and receptacle contacts shall first be checked to ensure that they are of proper mating configurations.

1910.334(a)(3)

Grounding type equipment.

1910.334(a)(3)(i)

A flexible cord used with grounding type equipment shall contain an equipment grounding conductor.

1910.334(a)(3)(ii)

Attachment plugs and receptacles may not be connected or altered in a manner which would prevent proper continuity of the equipment grounding conductor at the point where plugs are attached to receptacles. Additionally, these devices may not be altered to allow the grounding pole of a plug to be inserted into slots intended for connection to the current-carrying conductors.

1910.334(a)(3)(iii)

Adapters which interrupt the continuity of the equipment grounding connection may not be used.

1910.334(a)(4)

Conductive work locations. Portable electric equipment and flexible cords used in highly conductive work locations (such a those inundated with water or other conductive liquids), or in job *locations where employees are likely to contact water or conductive liquids,shall be approved for those locations.*

1910.334(a)(5)

Connecting attachment plugs.

1910.334(a)(5)(i)

Employees' hands may not be wet when plugging and unplugging flexible cords and cord and plug connected equipment, if energized equipment is involved.

1910.334(a)(5)(ii)

Energized plug and receptacle connections may be handled only with insulating protective equipment if the condition of the connection could provide a conducting path to the employee's hand (if, for example, a cord connector is wet from being immersed in water).

Damp and wet locations. A receptacle installed in a wet or damp location shall be designed for the location.

*Use of temporary wiring for a period not to exceed 90 days under paragraph **1910.305(a)(2)(i)(C)** (as provided for in the National Electrical Code, NFPA-70/NEC-305, not to exceed 90 days)*

Electrical Safety Foundation International

The Electrical Safety Foundation International has extensive recommendations and standards published for the use of extension cords in industrial applications. Review the ESFI standards at this link
http://esfi.org/index.cfm/page/Extension-Cord-Safety-Fact-Sheet/cdid/10623/pid/10272

UL

UL is a global independent science company that tests, inspects and certifies electrical safety. UL approval is required for many industrial electrical products and has published what is generally regarded as the industry standards for most applications including extension cords (and battery chargers). Review UL standards at this link.
http://www.ul.com/global/eng/pages/offerings/perspectives/consumer/productsafety/cords/

Consumer Product Safety Commission

The US Consumer Product Safety Commission (CPSC) writes as follows: *"The U.S. Consumer Product Safety Commission (CPSC) estimates that each year, about 4,000 injuries with electric extension cords are treated in the hospital emergency rooms onshore. About half the injuries involve fractures, lacerations, contusions, or sprains from people tripping over extension cords. CPSC also estimates that about 3,300 residential fires originate in extension cords each year,* *killing 50 people and injuring about 270 other. The most frequent causes of such fires are short circuits, overloading, damage and/or misuse of extension cords.*

- ***Extension cords may be used for temporary applications only. "Temporary" generally means it is associated with a one-time job or with a transient condition.*** *Install permanent wiring for long-term or repetitive needs. An extension cord may be used while awaiting permanent wiring.*
- *All extension cords shall be clean and properly maintained with no exposed live parts or conductors, exposed underground metal parts, splices, substantial abrasion, or other damage that might compromise its safe usage.*
- *Around construction sites, in damp areas, or in an area where a person may be in direct contact with a solidly grounded conductive object, such as working in a vacuum tank, extension cords must be protected by a ground-fault circuit interrupter (GFCI)."*

(See link: http://www.americanownews.com/story/21854846/extension-cords-can-cause-fire-injury-and-death)

Other Extension Cord Notes

From statements by SMEs and the written explanations available from certain online electric safety organizations, the most common problem with extension cords is worn or burned insulation that allows the live/hot wire to contact the case of an appliance, and the failure to incorporate a GFCI in the circuit.

"Lacking an earth/ground connection (some people cut the third prong off the plug because they only have outdated two hole receptacles), a severe shock is possible. This is particularly dangerous in the kitchen, where a good connection to earth/ground is available through water on the floor or a water faucet"

One of the SME Group's primary conclusions *(see above)* is that the case of the Battery Charger was made "hot" by a defective cord and then conducted the electricity responsible for the fatal Incident because of the lack of a ground and GFCI. In many similar cases, fatalities have occurred from contact with household current through common household appliances such as toasters, hair dryers, etc. A similar example is linked below.
http://cnx.org/content/m42416/latest#import-auto-id1169737812648

Electric Shock and the Human Body

From several general electrical hazards education sources, the following information on the subject was obtained. When the human body comes in contact with any source of electricity that causes sufficient current, expressed in volts, through the skin, muscles or hair, the result is electric shock. Depending on the magnitude of the current and other factors, the results of the electrical shock will have differing physiological effects on the human body.

For example, a current flow rated at 1 milliampere (mA) has an effect of a feeling or tingling sensation. A current flow rated between 10-20 mA can cause powerful muscle contractions causing the victim to be unable to voluntarily control muscles or release themselves from an electrified object. A current flow rated at 100-300 mA could result in ventricular fibrillation and be fatal if exposure is sustained

In the case of the current path, a lower current can be fatal if the current has a direct pathway to the heart. For example, a low current of 1 mA can cause fibrillation if the flow is through the heart. Fibrillation is typically lethal because it causes the heart muscle cells to move independently instead of in the coordinated pulses need to pump blood and maintain circulation. The relationship of ventricular fibrillation to household current is a particular concern because of the near identical wave length of household AC current and the electrical synapsis that the body produces to activate the heart.

Current will affect whatever muscles are in its path, and shock paths which traverse through the chest area are therefore the most hazardous because of their proximity to the heart muscles. Current from arm to arm, or between an arm and a foot, is likely to traverse the chest cavity, therefore it is much more dangerous than current between a leg and the ground.

Lastly, the longer the duration of the electric shock, the more likely it is lethal. A GFCI is purposefully intended to reduce length of exposure.

Electrocution Hazards and Ground Fault Circuit Interrupters (GFCIs)

The Outlet was not equipped with a GFCI despite being outside and in disregard of best practice recommendations from NEC, OSHA, API, etc. All regulatory and safety advisory bodies address the requirements and use of GFCIs, see previous section for links to NEC, OSHA, API, etc. From several general electrical hazards education sources, the following information on the subject was partially or fully derived.

The major hazards regarding contact with energized sources are electrical shock and burns. Electrical shock occurs when the body becomes part of the electric circuit, either when an individual comes in contact with both wires of an electrical circuit, one wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor. The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current, the length of time of the exposure, and whether the skin is wet or dry. Water is a conductor of electricity, allowing current to flow more easily in wet conditions and through wet skin.

When a cord connector is wet, electric current can leak to the equipment grounding conductor, and to anyone who picks up that connector if they provide a path to ground. Such leakage can occur not just on the face of the connector, but at any wetted portion.

The following information is from the National Safety Council (NSC). The NSC estimates that approximately 300 people in the United States die each year as a result of an electric shock from low voltage systems (120 or 277 volt circuits). People become a fatality when voltage flows through the human body, particularly through the heart. Death can occur in less than 1 second if the touch potential is as little as 50 volts and the current flow through the body is over 50 milliamperes.

To protect against electric shock, dangerous voltage from a line-to-ground fault must be quickly removed by opening the circuit’s current protection device (trip the breaker or blow the fuse). Since death can occur in less than 1 second from ventricular fibrillation, it is critical that the overcurrent protection device open quickly. From OSHA, the following describes the purpose and workings of a GFCI.

“A ground-fault occurs when there is a break in the low-resistance grounding from a tool or electrical system. The electrical current may then take an alternative path to the ground through the user, resulting in serious injuries or death. The ground-fault circuit interrupter, or GFCI, is a fast-acting circuit breaker designed to shut off electric power in the event of a ground-fault within as little as 1/40 of a second. It works by comparing the amount of current going to and returning from equipment along the circuit conductors. When the amount going differs from the amount returning by approximately 5milli amperes the GFCI interrupts the current.

The GFCI is rated to trip quickly enough to prevent an electrical incident. If it is properly installed and maintained, this will happen as soon as the faulty tool is plugged in. If the grounding conductor is not intact or of low-impedance, GFCI may not trip until a person provides a path. In this case, the person will receive a shock, but the GFCI should trip so quickly that the shock will not be harmful.”

The time it takes for an overcurrent protection device to open (clear the phase-to-ground fault and remove dangerous voltage) is inversely proportional to the magnitude of the fault current. This means that the higher the ground-fault current, the less time it will take for the overcurrent device to open and clear the fault.

Best practice for electrical contracting is extensively defined by numerous codes including for naval or offshore facilities. These codes are definitive about the use of a GFCI in circuits to reduce the danger of electrocution. Some of these codes defining best practice are referenced below.

NEC: National Electric Code addresses the installation, testing, and use of GFCIs. See*:*

100.1 Definition

100.1 Definitions. Ground-Fault Circuit Interrupter. A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when current to ground exceeds the values established for a Class A device.

210.8(A) & (B) *Protection of Personnel*
210.8(A)(3) *Ground-Fault Circuit Interrupter Protection for Personnel. Outdoors.*

OSHA Regulations and Discussion: Standards 29 CFR 1926.404(b) addresses the use of GFCIs.

“Because GFCIs are so complex, they require testing on a regular basis. Test permanently wired devices monthly, and portable-type GFCIs before each use. All GFCIs have a built-in test circuit, with test and reset buttons, that triggers an artificial ground-fault to verify protection. Ground-fault protection, such as GFCIs provide, is required by OSHA in addition *to (not as a substitute for) general grounding requirements.”*

Ground-fault protection -

1926.404(b)(1)(i)

General. The employer shall use either ground fault circuit interrupters as specified in paragraph (b)(1)(ii) of this section or an assured equipment grounding conductor program as specified in *paragraph (b)(1)(iii) of this section to protect employees on construction sites. These requirements are in addition to any other requirements for equipment grounding conductors.*

1926.404(b)(1)(ii)

Ground-fault circuit interrupters. All 120-volt, single-phase 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection. Receptacles on a two-wire, single-phase portable or vehicle-mounted generator rated not more than 5kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters.

(iii) Assured equipment grounding conductor program. The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. This program shall comply with the following minimum requirements:

(D) The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and cord- and plug-connected equipment required to be grounded: (1) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.

(1) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous. (1) Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor…

(E) All required tests shall be performed: ... etc.

See informational link:

http://www.osha.gov/dte/outreach/construction/focus_four/electrocution/electr_ig.pdf

Safety Alerts

Baker Hughes Safety Alert

On 16 August 2013, Baker Hughes issued a safety advisory to its employees. The advisory is shown verbatim in figure 40 and 41 below. In addition to the recommendations included in the safety alert, unofficial communication was received that Baker Hughes personnel stating that the company was considering establishing a new location for the battery boxes placed on cementing units.

BAKER HUGHES	Employee Fatality While Performing Electrical Work	SAFETY ADVISORY

DESCRIPTION:

A Baker Hughes employee was fatally injured while attempting to service a battery system that powered an offshore cementing unit control panel. During the troubleshooting the employee reported that the cement unit's battery box receptacle and the extension cord powering it showed signs of electrical burning. The employee was advised by an electrical technician to stop troubleshooting the DC system and use AC power until a new DC battery system could be installed. The employee proceeded to borrow a third-party battery charger to charge the 12-volt battery and the damaged extension cord was used to supply the charger with rig AC power.

The coroner determined the cause of death to be low voltage electrocution. Disassembly and forensic analysis indicated that the extension cord had a faulty female socket with a damaged ground connection that allowed a connection between the ground and live wire inside the socket. When the employee plugged in the third-party battery charger this connection allowed electricity to flow from the AC power in the extension cord through the ground wire of the battery charger power cord and into the metal case of the charger.

It is believed that the employee, without wearing gloves, touched the energized metal case of the portable battery charger while kneeling on the wet metal deck of the rig, creating a path to ground through the employee's body. There was no Ground Fault Circuit Interrupter (GFCI) protection for the electrical circuit to automatically trip the circuit breaker serving the receptacle outlet and potentially stop the current flow.

⚠ CAUTION

Extension Cord with Signs of Electrical Burning

Examples of GFCI Protected Extension Cord and Receptacle Outlet

For doc. verification>david.munzenmaier@bakerhughes.com | **Post for 30 days minimum** | Release date: 16 Aug. 2013 Form Rev1.0 – March 2010

Figure 36: Page 1, Baker Hughes Safety Alert

BAKER HUGHES	Employee Fatality While Performing Electrical Work	SAFETY ADVISORY

IMMEDIATE ACTIONS:

- Always conduct a hazard review prior to starting work. Recognize that any task may pose risks and each employee is responsible to identify and address those risks or STOP WORK.
- Use a qualified electrician and/or electrical technician to conduct electrical work and **follow all instructions**. If an electrician or electrical technician is not available, employees should use a permit to work process to identify and mitigate all associated hazards before beginning work.
- Inspect all equipment prior to use and replace any equipment that shows signs of wear or failure.
- Never conduct work on electrical equipment while in contact with a metal surface without a protective barrier (e.g., isolating footwear, gloves or a rubber mat).
- Recognize that wet areas on a surface (such as a metal platform) increase the risk associated with electrical work.
- Plug electrical tools and equipment into receptacle outlets that are protected by GFCI devices or GFCI extension cords suitable for the environment.
- Ensure third-party owned equipment, where use is authorized, is fit for purpose and in good working condition.

LESSONS LEARNED:

- All activities involve potential risk. Knowing and understanding those risks is critical to safe work.
- Extension cords should be of the appropriate type and be inspected prior to each use.
- Circuits where portable power cords will be used should include GFCI protection.
- Only qualified electrical workers should troubleshoot equipment with electrical problems.
- The metal decks on offshore platforms, which are often wet, pose a potential pathway when working with or around electricity and appropriate precautions should be taken (e.g., establishment of a protective barrier).
- Moisture in clothing adds risk of electrical conductivity.

For doc. verification>david.munzenmaier@bakerhughes.com	**Post for 30 days minimum**	Release date: 16 Aug. 2013 Form Rev1.0 – March 2010

Figure 37: Page 2, Baker Hughes Safety Alert

Spartan Rigs Safety alert

On 22 October 2013, Spartan Rigs issued a Safety, Compliance and Report Alert notification to its employees. A copy is shown in *figures 41, 42*, and *43*.

October 22, 2013

Notification Alerts, Safety, Compliance and Repair

NASCAR

X☐ SAFETY

NASCAR 014-13

☐ REGULATORY

SUBJECT: Fatality of Third Party Employee
DISCUSSION:

In January of 2013 a Baker Hughes employee was electrocuted while servicing the battery system of the Baker Hughes cement unit aboard a Spartan Offshore Rig. While working on the battery system, the employee stated to a co-worker that the female end of a Baker Hughes extension cord and the male battery box receptacle on the cement unit indicated the presence of electrical burning. The co-worker then advised the employee to stop working on the DC system and to use only the AC power. The employee disregarded the suggestion and borrowed the Rig's battery charger to continue his work. When the battery charger was plugged into the cement unit's extension cord to charge the unit's battery, it is believed that the metal case of the battery charger became energized and that the employee, while kneeling on the deck, came into contact with the charger and was electrocuted.

After extensive forensic analysis of all components involved in the incident it was determined that the female end of the Baker Hughes extension cord had a damaged ground connection that allowed the ground wire to come into contact with a live wire inside the socket. This connection allowed AC current to flow through the ground wire into the case of the battery charger. There was no Ground Fault Circuit Interrupter (GFCI) to automatically trip the circuit breaker.

Figure 38: Page 1, Spartan Rigs Safety Alert

NASCAR

014-13

Following considerable research of all applicable regulations and after consulting with both ABS and the Coast Guard, Spartan Offshore has not received any guidance that the use of GFCI receptacles are required in "wet areas" aboard the rigs. Nevertheless, in order to prevent the reoccurrence of an incident of this type, the following actions are to be undertaken going forward:

- A JSA must be completed prior to commencing any task, even if you are working alone. Review all hazards associated with the job.

- Only a qualified electrician should perform any electrical work aboard the rig.

- GFCI receptacles will be installed in all wet areas of the rigs where practicable, to be used with GFCI extension cords.

- Plug electrical equipment and tools into outlets protected by GFCI devices or GFCI extension cords, where available. When working in a classified area, ensure that extension cords, electrical equipment and tools are suitable for the working environment and are intrinsically safe or explosion proof.

- Inspect all equipment thoroughly prior to commencement of the job. Take any questionable equipment out of service.

- Everyone aboard a Spartan rig has the authority and the responsibility to stop work whenever they have a concern with the progression of a job. If Stop Work Authority is utilized, everyone involved in the job should step back, re-evaluate the situation and agree on a course of action before resuming the job.

- All rigs should complete a material requisition order for an AC Circuit GFCI Tester (see below). The cost is less than $10 and will indicate if the GFCI is functioning properly.

Figure 39: Page 2, Spartan Rigs Safety Alert

NASCAR

014-13

Female end of the extension cord. Note the signs of electrical burning.

GE 50957 GFCI Tester

Figure 40: Page 3 Spartan Rigs Safety Alert

Other Issues

When the need for a Panel Investigation of this Incident became evident, discussions were held between BSEE and United States Coast Guard concerning which agency would lead the investigation. The initial evidence and details of the Incident indicated that the Memorandum of Agreement (MOA) between BSEE and USCG may not be completely clear about electrical accidents especially when it is not known for sure if a rig's electrical system was involved *(See MOA, USCG/BSEE Item 4a, and Item 11)*.

The MOA specifies that BSEE is primarily responsible for electrical matters "on the drilling floor" of a MODU. Other electrical issues on a MODU are the responsibility of the USCG. However, other clauses in the MOA indicate BSEE is responsible for "Cementing Units," but it is not specified that this includes the electrical portions of cementing units in addition to the mechanical portions. The MOA seems to separate mechanical and electrical issues. □

Conclusions

The Incident

On 26 January 2013, at approximately 1650-hrs, a Cementer for a cementing contractor, Baker Hughes, was attempting to trouble shoot electrical problems that had been encountered with the Cementing Unit monitoring screens. Working alone, he first unplugged an Extension Cord from its connection to an emergency power supply Battery Box on the Cementing Unit. He then plugged the power cord for a commercial Battery Charger into the Extension Cord. While kneeling on the steel deck, he attempted to pull the Battery Charger into position to connect to the Cementing Unit's battery terminals. When he contacted the handle or skin of the Battery Charger with his hand, he was electrocuted.

Causes of Fatality

(1) The immediate direct cause of the fatality was the use of an old, heavily damaged, short-circuited, electrical **Extension Cord** which caused the case of the Battery Charger to become energized. However, the root cause of the fatal Incident was the failure to adhere to established safe work practices as identified in the NEC NFPA 70, OSHA requirements 29 CFR 1926, and API recommended practice RP 14F, etc.

Other factors primarily associated with Baker Hughes policies and practices concerning repairs and maintenance, equipment issues, employee communications, training, and supervision created contributing causes. These additional specific causes are identified below.

(2) Indications are the **repair and maintenance** of the Cementing Unit, ***especially the electronic elements***, was questionable and trouble shooting was haphazard, which contributed to the other causes of the Incident. Evidence and examples of inadequate repair and maintenance include the following:

- The power outlets were broken and/or inoperative and did not include a GFCI;

- The power outlets were heavily corroded with damage to body and seals that had obviously developed over considerable time.
- The power for the Visiplex screens was not being supplied as per the design. Instead, the emergency power supply was being used. Given that the outlet plug intended for the primary power supply to the screens was broken, it is probable the Skid had been using the emergency Battery Box power supply to power the screens for many jobs. It is probable the failure to repair the Outlet Box and to return the unit to its intended design is an indication that the maintenance of the Skid was not adequate.
- Extension cords were used in lieu of permanent electric wiring to transfer power to the Battery Box and to the AC/DC converter. The routing of the Extension Cord and the general wiring of the unit could be described as being haphazard.
- The Extension Cord was visually damaged, apparently old, with visible fraying of the armored coating, visible burned plug end, and the cord and connections were not up to NEMA or electrical codes either from construction or from age/usage. Yet it was still in use indicating a failure to inspect or to follow recommended best practice(s) and regulations;
- After electronic maintenance and repair personnel from Baker Hughes had repaired and replaced defective equipment following the Incident, additional safety hazards relating to the new battery box and equipment were found by Operator's contract safety representative. These included a burn or other damage on one end of a new extension cord; the new extension cord was not rated for the usage; and it was attached to the Skid in a dangerous manner with zip-ties. Additionally, the new battery box was deemed to be located in a dangerous position near the fuel tank.
- Panel breakers were not labeled correctly.
- Attempts to contact electronics maintenance by the Cementer and discussion of problems did not elicit timely follow-up from maintenance to see if the problem was solved.

(3) Equipment - The Battery Charger was energized because the Extension Cord used to provide power to the battery charger had a pre-existing short circuit that allowed the ground wire to contact a live wire inside the female socket. Notices on the Battery Charger warned against use with an ungrounded plug.

(4) Equipment - The Extension Cord was improperly used as a permanent circuit. It was many years old despite general best practice and regulatory limits on the use of an extension cord to 90 days. It was obviously damaged and compromised with a visibly burned plug end, yet was still in service indicating pre-use inspection had been inadequate.

(5) Equipment - The location of the emergency power supply Battery Box on the Cementing Unit allowed it to be exposed to salt water, cement, etc. The power inlet into the battery box and the end of the Extension Cord were not designed to NEMA standards for water-tight or industrial usage. The damage to the Extension Cord plugs and internal parts of the emergency Battery Box wiring was probably caused by repeated exposure to moisture.

(6) Equipment – No ground fault circuit interrupter breaker was included in the wiring of the cementing unit power supply or the Extension Cord.

(7) Apparently, no Baker Hughes **training** in repair and maintenance of electrical components of the Cementing Unit dealt with the potential for low voltage electric shock including the need for special protective equipment. However, the job description required timely and complete maintenance of all components and other actions to minimize downtime.

The Cementing Unit had been acquired when Baker Hughes bought another company. The Cementing Unit had not been upgraded and manuals and standard drawings were not available. After the Incident, the power lead for the screens was found to be connected to the wrong screen jack. This possibly indicates that the **training** of the Baker Hughes team that used this particular Cementing Unit was not adequate despite the extensive experience of the individuals.

Repair and replacement of elements involved in the Incident were completed during the investigation despite the Baker Hughes guidelines that recommended preserving the site. The removed equipment was subsequently lost. This indicates a probable lack of **training** for the maintenance personnel in the expectations of Baker Hughes during incident investigations.

(8) Supervision was inadequate. The Cementer attempted to trouble shoot the electrical components of the Cementing Unit on his own, with no JSA or discussion, contrary to Rig and Operator policy and against the instructions of the operating manual for the Battery Charger. No policy or supervision practice of Baker Hughes warned against attempting electronic repairs alone which possibly contributed to the circumstances of the Incident.

(9) Supervision – No Baker Hughes policy existed to insure review of manuals before using outside equipment. Even an informal discussion of the trouble shooting methodology may have indicated the potential hazards.

(10) Communications, Baker Hughes guidelines - No guidelines or standard procedures for dealing with electrical problems on a cementing unit were specified by Baker Hughes. No guidelines on protective clothing, insulating gloves, footwear, or procedures were specified by Baker Hughes for their operators when dealing with electrical maintenance or repair. No electrical trouble-shooting guidelines indicated when cementers in the field were to contact the Baker Hughes electrical maintenance personnel, under what circumstances, and what party was the controlling authority for future actions in such situations.

(11) Communications – The Cementer discussed the electrical problems with Baker Hughes electrical systems maintenance personnel. The maintenance personnel suggested that the signs of burning in the battery box could be the cause and suggested the Operator leave the system alone until it could be examined by maintenance personnel. Maintenance suggested another way to power the screens during the upcoming cement job. However, with the cementing job pending, no follow-up by Baker Hughes maintenance personnel checked to see if the condition had been remedied.

While the maintenance department did ship a new battery box to the Rig, the problems proved to be much more systemic than a faulty Battery Box. The verbal communication between the offshore Cementer and the onshore maintenance personnel failed to fully expose the problem with the unit. This could have contributed to postponing repair and maintenance.

Baker Hughes policy did not define the command and control relationship between the onshore maintenance and repair support group and the Cementer offshore. **What <u>was</u> well defined was the requirement of the Cementer to perform good maintenance on his unit to preclude unnecessary equipment down time.**

Potential Enforcement Actions

The appropriate BSEE District Office should review the Panel Report in detail. The District should consider the complex Baker Hughes, Rig, and Operator relationships that existed at the time of the Incident and should consult with BSEE management on whether to contact the USCG about clarifying jurisdiction issues.

The appropriate BSEE District Office should consider issuing an Incident of Non-Compliance (INC) to Bois d'Arc with the Potential Incident of Non-Compliance (PINC) reference of G-110; *"The operator failed to perform operations in a safe and workmanlike manner."* The District should consider pursuing a civil penalty for this INC.

The District should consider issuing an INC with a reference of G-110 to Baker Hughes and/or Spartan for the *"fail*[ure] *to perform operations in a safe and workmanlike manner,"* in accordance with guidelines and policy for "Contractor INCs."

The appropriate BSEE District Office should consider issuing an Incident of Non-Compliance (INC) to Bois d'Arc with the Potential Incident of Non-Compliance (PINC) reference of G-111; *"Employees who maintain your electrical systems must have the expertise in area classification and the performance, operation and hazards of electrical equipment."*

The District should consider issuing an INC with a reference of G-111 to Baker Hughes and/or Spartan for the following deficiency: *"Employees who maintain your electrical systems must have the expertise in area classification and the performance, operation and hazards of electrical equipment;"* in accordance with guidelines and policy for "Contractor INCs."

Recommendations

It is recommended that BSEE consider issuing Safety Alert (s) that contains certain information and alerts operators to the following:

- a brief description of the Incident; and a brief summary of the causes;
- specific identification of the danger of the use of substandard and damaged extension cords offshore;
- identification of the consequences of improper electronic maintenance and installation;
- the danger of using an ungrounded connection to an electronic device that requires one;
- the need for proper training, supervision, equipment, and job planning.

The Panel also recommends that BSEE consider extending the horizon of the Safety Alert to include OSHA, and other onshore safety organizations dealing with electrical safety regardless of industry or location. These could include the manufacturer of the Battery Charger, UL, and any other private, industry group, or governmental electronic safety organizations that may need to be aware of the possibility of reoccurrence of this incident.

The Panel also recommends that BSEE consider reviewing the regulations for electric wiring for MODUs to see if additional definition or rule making would be warranted. One possible consideration could be extending the requirements of API 14F to those operating portions of MODUs when engaged in drilling, completion, re-completion or workover operations.

The Panel also recommends that BSEE management consider whether additional clarification of roles and responsibilities regarding electrical wiring should be included when the Memorandum of Agreement (MOA) is next reviewed by BSEE and United States Coast Guard. □

Attachment 1

Report of SME Group

Executive Summary
Spartan Offshore Rig 202
[Name of fatality] *Electrocution Incident of Jan 26, 2013*

Prepared by: [SME Group lead] *Jan 2, 2014*

Introduction

1. *This summary provides an overview of the electrical circuit involved in the [name of fatality] electrocution incident on Spartan Offshore Rig 202. The incident appears to have occurred while Mr. Anderson was attempting to use a portable 12V battery charger connected to the rig's 120V electrical system. He was troubleshooting a low battery voltage indication on the Baker cement unit.*

2. *This summary is based on the following events and documents:*

    2.1. *Group equipment inspection and testing on Mar 19, 2013 and May 28, 2013.*

    2.2. *Incident reports from on-site personnel.*

    2.3. *Schematic of Dayton battery charger.*

    2.4. *X-Ray examination of assembled extension cord connectors*

    2.5. *Schematics of 480V and 120V systems on Rig 202.*

    2.6. *Inspection (by rig personnel) of 480V and 120V systems on Rig 202.*

Conclusions

3. *Evaluation of the equipment and documents produced these conclusions:*

    3.1. *The incident resulted from a defective extension cord that inadvertently energized the portable battery charger's metallic enclosure with 120V.*

    3.2. *Prior to the incident, [name of fatality] reported signs of burning on the female connector of the extension cord. Although he was advised to stop troubleshooting the low battery condition, he proceeded to use the extension cord with a separate wheel-mounted battery charger.*

    3.3. *The extension cord's internal defects were not obvious.*

    3.4. *The rig's wiring met all applicable codes and was in proper working order.*

Source of hazardous voltage

4. *The hazardous voltage was created by an electrical extension cord having two related defects:*

    4.1. *The grounding conductor wire within the extension cord was burned away from the ground terminal within the female socket. This defect was noted by both electrical resistance measurements of the assembled socket, and also by visual inspection of the disassembled female socket.*

4.2. *The 120V "hot" terminal within the female socket was shorted to the socket's ground terminal. This defect was noted by electrical resistance measurements between the line and ground terminals of the female socket.*

5. *The extension cord normally powered a small battery charger mounted on the cement unit. The extension cord's internal defects were not previously detected because:*

5.1. *The charger was the "2 wire" type that did not use the third wire ground connection of the female connector. The small charger's enclosure was therefore isolated from the 120V electrical supply.*

5.2. *Having no ground-wire connection to the enclosure, the 120V circuit did not create a fault current to trip the rig's 120V circuit breaker even though the charger contacted the grounded rig structure.*

5.3. *The larger portable charger did use a 3 wire grounded connection. Just prior to the incident, the portable charger's energized enclosure did not trip the circuit breaker because it was isolated from the deck on rubber wheels and a plastic foot.*

6. *The attached diagrams illustrate simplified schematics showing both the normal current path and the fault current path. The normal 120V current flowed through the circuit breaker, then through rig wiring and the extension cord, to energize the "line" side of the charger's internal circuitry.*

7. *The fault current originated in the female socket of the extension cord.*

7.1. *The normal 120V "line" voltage shorted to the socket's ground terminal. The short was later measured as intermittent, likely due to loose metallic components within the socket.*

7.2. *The line-to-ground short did not trip the circuit breaker due to the broken grounding conductor in the extension cord.*

7.3. *The male plug on the charger's cord, when inserted into the extension cord socket, was not wired back to the rig's ground due to the broken grounding wire in the extension cord. The charger plug's ground pin was instead connected to 120V via the short within the female socket.*

7.4. *The charger cord's normally grounded wire, now connected to 120V by the defective female socket, inadvertently energized the battery charger enclosure*

"Source of hazardous voltage – The electrical extension cord: *The grounding conductor wire within the extension cord was burned away from the ground terminal within the female socket. This defect was noted by both electrical resistance measurements of the assembled socket, and also by visual inspection of the disassembled female socket.*

"The 120V "hot" terminal within the female socket was shorted to the socket's ground terminal. This defect was noted by electrical resistance measurements between the line and ground terminals of the female socket.

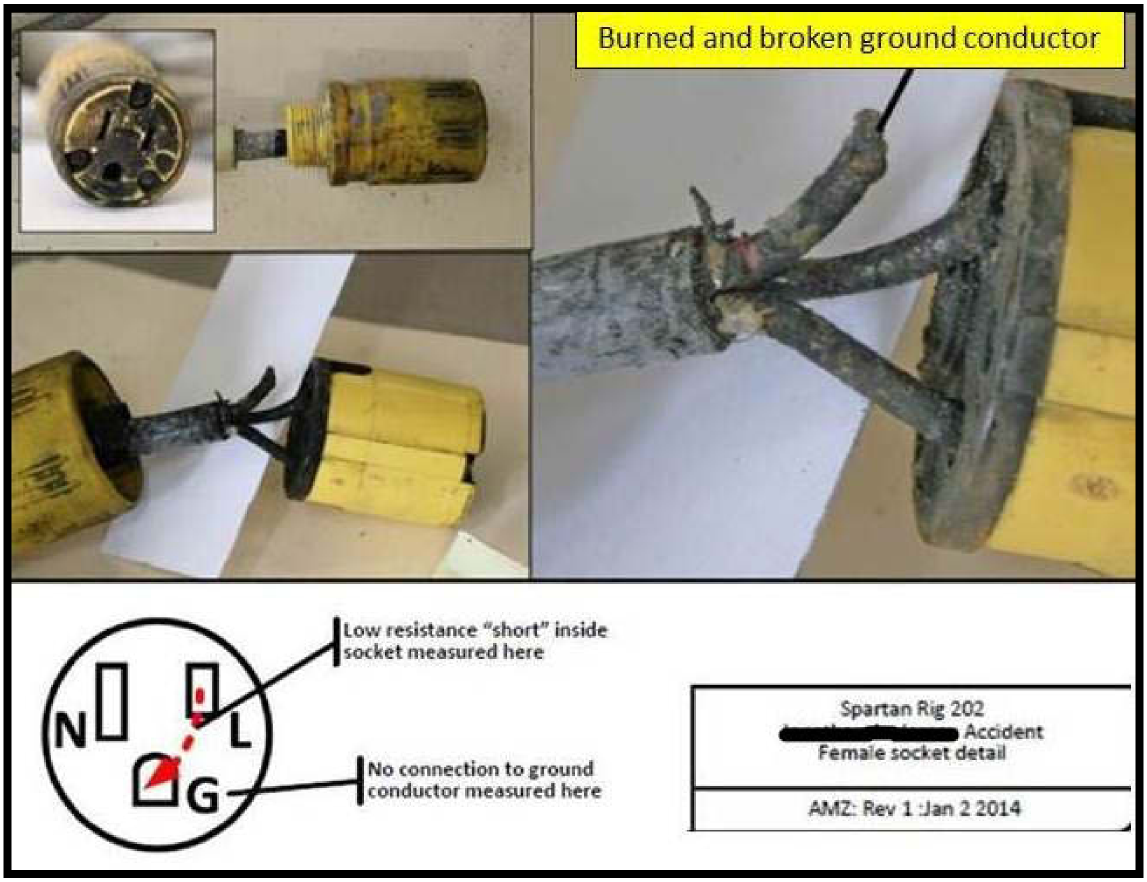


Figure 41: SME Group Report, Attachment 1

Use of the extension cord: *The extension cord normally powered a small battery charger mounted on the cement unit. The extension cord’s internal defects previously noted were not previously detected because:*

- *The charger was the “2 wire” type that did not use the third wire ground connection of the female connector. The small charger’s enclosure was therefore isolated from the 120V electrical supply.*
- *Having no ground wire connection to the enclosure, the 120V circuit breaker even though the charger contacted the grounded rig structure.*
- *The larger portable charger did use a 3 wire grounded connection. Just prior to the incident, the portable charger’s energized enclosure did not trip the circuit breaker because it was isolated from the deck on rubber wheels and a plastic foot.*

“The attached diagrams illustrate simplified schematics showing both the normal current path and the fault current path. The normal 120 V current flowed through the circuit breaker, then through rig wiring and the extension cord, to energize the “line” side of the charger’s internal circuitry.

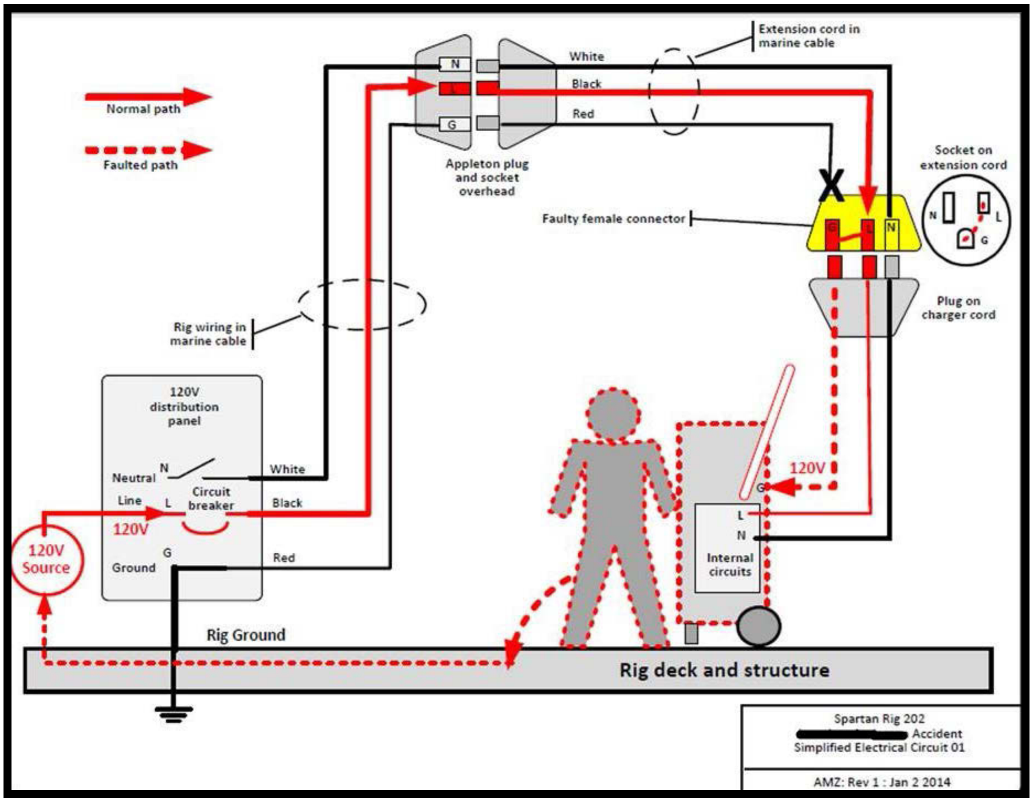


Figure 42: SME Group Report, Attachment 2

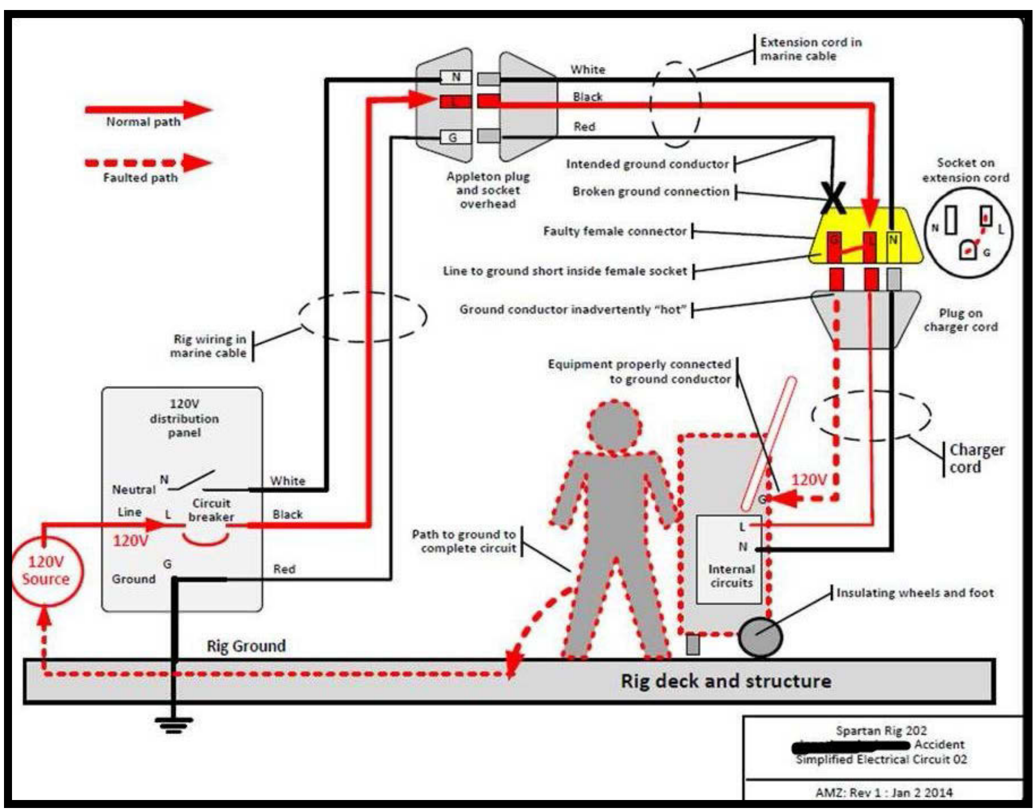


Figure 43:   SME Group Report, Attachment 3

7. The fault current originated in the female socket of the extension cord. (conclusion)
** The normal 120 V "line" voltage shorted to the socket's ground terminal. The short was later measured as intermittent, likely due to loose metallic components within the socket.*

- *The line-to-ground short did not trip the circuit breaker due to the broken grounding conductor in the extension cord.*

- *The male plug on the charger's cord, when inserted into the extension cord socket, was not wired back to the rig's ground due to the broken grounding wire in the extension cord. The charger plug's ground pin was instead connected to 120V via the short within the female socket.*

- *The charger cord's normal ground wire, now connected to 120V by the defective female socket, inadvertently energized the battery charger enclosure. At sometime prior to this incident/ accident, enough moisture entered the female socket and shorted the hot leg to the ground leg inside of the battery case and female socket. Burning the ground wire off the terminal inside the battery case and inside the female socket. This carbonized black coating, evident inside of the battery case and inside the female socket became the new current path inside the female socket to the grounding lug of the socket and on to the portable battery chargers metal case.* □