OCS Report
MMS 2000-084

Investigation of Drillship Draw Works Failure
Atwater Valley Block 116
OCS-G-13206
October 22, 1999

Gulf of Mexico
Off the Louisiana Coast

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David Trocquet
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U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Regional Office

New Orleans
November 2000

Contents

Investigation and Report

Authority

The draw works failure of the Deepwater Drilling Limited Liability Corporation (DDLLC) drillship *Deepwater Pathfinder* (*Pathfinder*) occurred on Exxon Corporation's Atwater Valley Block 116, Lease OCS-G-13206 in the Gulf of Mexico, offshore the State of Louisiana, on October 22, 1999, at approximately 0840 hours. (The *Pathfinder* was contracted to Chevron USA to drill the Mississippi Canyon Block 1002, Lease OCS-G16670, well #1). Pursuant to Section 208, Subsection 22 (d), (e), and (f), of the Outer Continental Shelf (OCS) Lands Act, as amended in 1978, and the Department of the Interior Regulations 30 CFR 250, the Minerals Mangement Service (MMS) is required to investigate and prepare a public report of this accident. By memorandum dated November 08, 1999, the following personnel were named to the investigative panel:

David Dykes	New Orleans, Louisiana (Chairman)
David Trocquet	New Orleans, Louisiana
Randall Josey	New Orleans, Louisiana

Procedures

On October 23, 1999, inspectors from the MMS New Orleans District Office visited the rig to assess the situation and began gathering information, thereby initiating MMS's investigation of the incident.

On November 01, 1999, panel members visited the *Deepwater Millennium* (*Millennium*). The *Millennium* is an identical sister ship to the *Pathfinder*. The purpose of the visit was to see the arrangement of equipment and to interview the National Oilwell/Dreco and Hitec ASA personnel conducting the diagnostic tests on the draw works. While on location, the panel members interviewed the following personnel:

Tim Watson – National Oilwell/Dreco
Knut Haga – Hitec ASA
Stan Nygrin – Reading & Bates Falcon Drilling

On November 04, 1999, Chevron e-mailed to the panel the statements taken by DDLLC on October 23, 1999, from the following individuals:

Jimmy Emmons, Toolpusher – Reading & Bates Falcon (RBF) Drilling
John Petty, Driller – RBF
Mike Nowell, Assistant Driller – RBF
Pete Daley, Pumpman – RBF
Kevin Wortham, Floorhand – RBF
Jason Fulp, Floorhand – RBF
Duane Struthers, Floorhand – RBF
Ian Donald, Assistant Subsea Engineer – RBF
Bill Wester, Rig Safety & Training Coordinator – RBF
Don Clark, Derrickman – RBF
Clark Fountain, Roustabout – RBF
Kenny Hayslette, Welder – RBF
Miguel Fernandez, Captain – RBF
Avery Brott, Second Officer – RBF
Curt Kuchta, Third Officer – RBF
Stan Rogers, Drilling Foreman – Conoco

DDLLC is a partnership between Conoco Incorporated (Conoco) and Reading & Bates Falcon Drilling (RBF).

On December 01, 1999, a meeting attended by representatives of Chevron, Conoco (representing DDLLC), and MMS was held at the MMS offices in New Orleans. At the meeting, the status of the investigation was discussed as well as a proposed plan to recover the BOP/LMRP assembly.

On February 24, 2000, a meeting attended by representatives of Chevron, Conoco (representing DDLLC), and MMS was held at the MMS offices in New Orleans. At this meeting, findings of the DDLLC investigation were disclosed, as well as corrective measures taken to prevent reoccurrence.

On April 27, 2000, panel members attended a drilling industry workshop hosted by Conoco and RBF. The topic of the workshop was the *Deepwater Pathfinder* incident. At the workshop, the incident was discussed in detail, along with corrective actions taken.

The panel members met at various times to review the investigation findings and to discuss the potential causes of the accident.

Technical information was gathered from RBF records and from numerous telephone interviews with RBF personnel.

The panel met on May 18, 2000, to finalize the findings and conclusions of the investigation and begin the investigation report.

Introduction

Background

Lease OCS-G 16670 covers approximately 5,000 acres and is located in Mississippi Canyon Block 1002, Gulf of Mexico, off the Louisiana coast. *For lease location, see Attachment 1.* The lease was issued effective August 01, 1996, to Chevron and Texaco Exploration and Production. Chevron became the designated operator of the lease at this time.

***Pathfinder* Operational History**

The *Pathfinder* is an ultra-deepwater dynamically positioned drillship designed to operate in a maximum water depth of 10,000 feet. The *Pathfinder* is equipped, however, to operate in a maximum water depth of 7,500 feet and is capable of drilling to a depth of 25,000 feet. The *Pathfinder* has an overall length of 726.5 feet and a beam of 137.7 feet, and drafts 59 feet of water with thrusters. The *Pathfinder* has a variable deck load of 20,000 tons and a total displacement of 103,000 tons. Commissioned on October 01, 1998, the *Pathfinder* had drilled three wells prior to the incident on October 22, 1999: the first in 4,668 feet of water, the next two in 3,978 feet of water. The Mississippi Canyon Block 1002 #1 is in 7,416 feet of water.

The *Pathfinder* was the first of three identical drillships manufactured. National Oilwell/Dreco manufactured the draw works system on the *Pathfinder*. It is a Model AHC (Automated Heave Compensator) 750-

General Electric (GE) draw works. Svenborg manufactured the brakes on this unit. The brakes are disk caliper types that are spring set and hydraulically released.

Brief Description of Accident

The drilling crew was in the process of running the riser assembly. While the vessel was being trimmed, failure occurred in the draw works, which allowed the traveling block to fall and strike the drill floor. The impact of the traveling block striking the drill floor caused the top drive to separate, allowing the riser running tools and riser assembly to fall to the seafloor.

Findings

Preliminary Activities

On the morning of October 22, 1999, at approximately 0840 hours, the drilling crew was in the process of running the marine riser assembly, which consisted of the blowout preventer (BOP) stack, lower marine riser package (LMRP), and 19 joints of slick riser (1,760 feet). The marine riser assembly was hanging below the rig floor with the first joint of flotation riser (additional 90 feet) connected and ready to be lowered. *For a schematic of the riser assembly, see Attachment 2.* The spider was opened after the driller picked up the load on the draw works motors. As the driller lowered the flotation riser, the crew noticed that the string was leaning too far to starboard. The driller contacted the bridge and requested that the vessel be trimmed to allow the flotation riser to pass through the rotary without sustaining damage. Communication among those involved (driller, subsea engineer, drill crew, ship's bridge) was accomplished by headset two-way radios.

Description of the Incident

The driller set the draw works brakes, which transfers the riser assembly weight from the electrical motors to the draw works brakes. The hook load at this time was 1.3 million pounds (the maximum load that the draw works would ever experience during operation). It should be noted that the driller stated after the incident that he thought that the use of the brakes was the best method of supporting the load. The rig floor crew heard the parking brakes set and the driller also received the indication at the driller's console. The driller then moved from the driller's chair to change out a low battery in his radio headset. At this time the rig floor crew noticed the riser "creeping" downward, slowly at first, then with a rapid increase in speed. All personnel on the drill floor evacuated the area. The driller attempted to release the brake and pick up the load with the motors, but with no success. The emergency stop was then activated with no result. The block continued to fall, resulting in the top drive striking the drill floor, parting, and allowing most of the top drive, bails, elevator, riser running tool, all joints of riser, LMRP, and the BOP stack to free fall to the seafloor (water depth approximately 6,900 feet). The time elapsed from the initial movement of the riser to the top drive striking the drill floor was approximately 20 seconds. *For time sequence, See Attachment 3.* Approximately 10 feet prior to the top drive contacting the drill floor, a large fireball was observed coming from the draw works. This explosion sent hot cable and burning debris around the draw works area, causing secondary fires to other materials (trash container, oily rag, and a hydraulic service loop).

Subsequent Activities

The second officer and third officer were on the bridge at the time of the incident. Upon observation of the incident, the second officer gave the order to activate the fire alarm. The third officer immediately sounded the fire alarm and activated the station-hold mode on the dynamic-positioning system. The standby vessel was contacted and advised of the situation. All fires were extinguished within minutes. The drill floor personnel were accounted for within 3 minutes. The moonpool area personnel were accounted for in 4 minutes. All rig personnel were accounted for within 21 minutes.

The remote-operated vehicle (ROV) crew began operations to launch the ROV in order to locate the riser and BOP impact area.

Deepwater *Millennium*

The drillship *Deepwater Millennium* (*Millennium*) is one of two identical sister ships to the *Pathfinder*. The *Millennium* was commissioned on May 01, 1999. Operations were shut down on the *Millennium* immediately following the incident on the *Pathfinder*. Personnel from National Oil Well/Dreco (manufacturer of the draw works) and Hitec ASA (developers of the software interface) were mobilized to the *Millennium* to conduct numerous tests and gather information. The following information was collected:

- Brake pad to disc air gaps
- Brake disc run out
- Brake holding capacity -- before and after the manufacturer's recommended adjustments to the brake pad to disc air gap.
- Type of drill line lubricant
- Control system/GE draw works drive responses.

For pictures of the draw works, including the Svenborg brake *assembly, see Attachments 4-6.*

Key findings from the *Millennium* were the following:

- Air gaps ranged from high 2.44 millimeters to low 1.14 millimeters.
- Air gap average was 1.97 millimeters. The Svenborg recommended air gap is 1 millimeter. Brake holding capacity is reduced approximately 6 percent per millimeter. This air gap of 1.97 millimeters resulted in a 5.8 percent loss of brake holding capacity.
- Holding capacity was 2.7 million pounds before adjustments.
- Holding capacity was 2.9 million pounds after adjustments.
- Drill line lubricant was Brilube #16. Brilube #16 is a mineral oil-based lubricant with a very low viscosity. The original specifications for the drill line for all three drillships called for Brilube #8 lubricant. Brilube #8 is a tar-based lubricant with a very high viscosity.
- Brake pad coefficient of friction was 0.267, which indicates a 33.3 percent loss of brake holding capacity when compared with the Svenborg-recommended coefficient of friction of 0.4.

The RBF offshore installation manager (OIM) on the *Millennium* stated during the panel interview that, given the identical scenario of the

Pathfinder, he would have either put the load on the spider (slips) or left the load suspended on the draw works motors.

The activation and deactivation of the brakes is a two-step process. The driller must engage the brake by pressing the parking brake button and then confirm the brake set by pressing the acknowledgment button. To release the brake, the driller must press the brake release button and then confirm the brake release by pressing the acknowledgment button.

The emergency stop is the parking brake. The emergency stop is simply another electronically controlled hydraulic control valve that dumps all pressure from the brake calipers. The emergency stop does not actuate a separate brake, but rather dumps hydraulic pressure from the existing brake assembly. The activation of the emergency stop is similar to setting the parking brakes; however, there is no acknowledgment of the emergency stop.

When the brakes are engaged, the weight on the hook is then transferred from the draw works motors to the parking brake. When the brakes are engaged, the draw works motors cannot be inadvertently started.

Deepwater Frontier

Immediately following the data collection on the *Millennium*, the personnel from National Oil Well/Dreco and Hitec ASA were mobilized to the drillship *Deepwater Frontier* (*Frontier*) to gather the same information and conduct similar tests to those conducted on the *Millennium*. The *Frontier* is the second identical sister ship to the *Pathfinder*. The *Frontier* was commissioned on March 02, 1999. Key findings from the *Frontier* were the following:

- Air gaps ranged from high 3.86 millimeters to low 1.78 millimeters.
- Air gap average was 2.87 millimeters, which resulted in 11.2 percent loss in brake holding capacity.
- Holding capacity was 3.8 million pounds before adjustments to the brake pad to disc air gap.
- Holding capacity was 4.2 million pounds after adjustments.
- Drill line lubricant – Brilube #8 – tar-based lubricant.
- Brake pad coefficient of friction was 0.41, which is above Svenborg minimum specifications.

Deepwater Pathfinder

Following the data collection and testing on the *Millennium* and the *Frontier*, forensic analyses and calculations were conducted on the equipment on the *Pathfinder*. Key findings and conclusions from the *Pathfinder* forensic analyses were as follows:

- Brake pads showed signs of contamination of light oil.
- Drill line lubricant was Brilube #16 – mineral oil-based lubricant.

The original specifications from DDLLC to Briden Wire Rope called for Brilube #8.

- The hydraulic system is believed to have operated properly, although contamination was present.
- The brake calipers were operating properly during the incident.
- Pre-incident air gaps were estimated at 2.6 millimeters to 3.7 millimeters.
- Approximate air gap loss of capacity equals 9 to 16 percent loss of brake holding capacity.
- Brake pad coefficient of friction was conservatively estimated at 0.15, which indicates greater than 60 percent loss of brake holding capacity.

The original specifications from DDLLC to Briden Wire Rope called for Brilube #8. However, when the drill line was delivered, it was lubricated with Brilube #16 and was accepted by DDLLC.

Further investigation into the RBF maintenance procedures and records for the draw works indicates that maintenance was being performed on the draw works as recommended by National Oilwell/Dreco (the draw works manufacturer). The procedures specific to inspection of the brake calipers did call for measurement of the thickness of the brake pad with a maximum and minimum tolerance. The procedures also called for verifying that the pads did clear (the air gap) the rotor disc in the open position. The procedures did not identify the maximum and minimum tolerance on the air gap (clearance) or the importance of the air gap on brake performance. Svenborg manufactures the brake assembly. The procedures, furnished by Svenborg, identify the maximum and minimum tolerance of the brake pad to disc air gap. The procedures, furnished by Svenborg, also outline the process for measuring this air gap. The Svenborg information and procedures were located with the vendor information as an appendix to the National Oilwell/Dreco operating and maintenance manual for the draw works. National Oilwell/Dreco does state in the draw works operation and maintenance manual on pages 21-22, "Refer to the manufacturer's operating and maintenance documentation for more detailed information. If the maintenance information presented here contradicts in any way with the manufacturer's information, the manufacturer's recommendation shall take precedence." "Before starting maintenance, the maintenance team should read all component operation and maintenance manuals to become familiar with component requirements."

RBF maintenance records indicate that the air gap was inspected by RBF personnel for a maximum air gap tolerance on two occasions. Both of these inspections occurred after the commissioning (October 01, 1998) of the drillship. The maintenance records also indicate that the requirement for checking the air gap tolerance was subsequently removed from the inspection procedures and, as a result, the air gap tolerance was not checked during subsequent inspections. RBF was not able to determine who edited the inspection procedures to remove the requirement or the reason why the requirement was removed.

The nominal friction factor of the Svenborg disc brake assembly is 0.4. The *Pathfinder* friction factor (2.6 - 3.7 millimeters estimated air gap and Brilube #16 contaminate) is 0.15. This calculates out to approximately 62 percent loss of brake holding capacity. Further, Svenborg's ideal air gap is 1 millimeter, not to exceed 3 millimeters maximum, with a rotor run out of 0.6 millimeter maximum. The *Pathfinder* pre-incident air gap was estimated at 2.6 millimeters to 3.7 millimeters. Holding capacity drops approximately 6 percent per millimeter. This calculates out to approximately 10 – 15 percent loss of brake holding capacity.

Noted also during the forensic inspection and analysis of the data from the *Pathfinder* were the set points in the parking brake sequence. The brake system on the draw works is designed as a fail-close parking brake. This design is a spring-loaded design that requires hydraulic pressure to be applied to open (release) the caliper pads from the draw works winch drum rotor. When the braking system is activated, an electronic signal is sent to an electrically activated hydraulic control valve to open and dump approximately 3,000 pounds per square inch (psi) pressure holding the brakes in the open position. As the pressure bleeds off, it is monitored by the electronic system and, when the pressure reaches a certain point, another signal is sent back to the driller's console, indicating that the brakes are set. This signal also deactivates the draw works direct-drive motors and takes them offline. During the investigation it was noted that the pressure setting for the brake-set indication was approximately 1,850 psi. This setpoint indicates that the brakes are fully set when in fact there is residual opening pressuring present at the time of the signal. This 1,850 psi will continue to bleed off to zero, whereby the brakes will be fully engaged.

The driller stated in an investigation interview following the incident that he thought the safest method for suspending/supporting the load at the time of the incident was by use of the parking brake. The OIM on the *Millennium* stated in his interview that he thought the safest method would be to either leave the load on the draw works motors or set the load back in the spider (slips). RBF does not have a written standard procedure for suspending/supporting heavy loads that are at or near maximum weights. Furthermore, no job hazards analysis was conducted for the operation of the draw works, especially for the suspension of heavy loads.

Damages

As a result of this accident, the draw works assembly and top drive assembly were damaged beyond repair. The main bearing of the rotary table was also damaged beyond repair. The riser spider and gimbal sustained damage but not beyond repair. The bails, elevators, 20 joints of riser pipe, and the BOP/LMRP assembly were completely lost. The derrick, along with mux lines support equipment, sustained minor damage. Total estimate of damage and repair or replacement costs is approximately $20 million. *For pictures of damages, see Attachments 7-9.*

Conclusions

The Accident

After a review of all of the information obtained during the course of this investigation, it is the conclusion of this panel that at approximately 0840 hours, the drill crew was in the process of running the riser assembly. The operation was being conducted while the ship was in a drift mode. This drift mode placed the ship approximately 17 miles up current of the location and allowed the ship to “drift” back to the location while the riser assembly was being run. Communications among those involved (the driller, the ship’s bridge, the drill floor, and the moon pool area) in this process were being accomplished through the use of headset radios. The BOP stack, the LMRP, and 19 joints of riser (1,760 feet) were hanging below the rig floor with the first joint of flotation riser (additional 90 feet) connected and ready to be lowered. The driller picked up the load from the spider and released the spider. A member of the floor crew noticed that the riser string was leaning too far to the starboard side to pass safely through the rotary. The driller then contacted the bridge and requested the vessel’s stability be trimmed to allow the riser to pass through. This trimming of the vessel would take several minutes; therefore, the driller decided to set the parking brake on the draw works while the vessel was being trimmed. It should be noted that the driller thought that this was the safest method of suspending the load. It should also be noted that there are varying opinions within DDLLC on the best method of suspending heavy loads. Several members of the drill crew heard the parking brakes set, and the driller also received the indication at the driller's console that the brakes were set. The driller then moved from the driller's chair to change a low battery in his headset, when the drill crew noticed the riser "creeping" slowly at first, then moving with a rapid increase in speed. The driller immediately informed the others via the headset that he did not have control of the draw works. The driller then attempted to pick up the load with the motors but with no luck. It should be noted that to accomplish this, the brake must be released. The driller must disengage the brake by activating the brake release button and then acknowledging its release. This acknowledgment would then allow the motors to engage. It is concluded that the driller activated the brake release but failed to activate the acknowledgment. The emergency stop was then activated with no result. The emergency stop is simply another electronically controlled hydraulic control valve that dumps all pressure from the brake calipers. The emergency stop does not actuate a separate brake, but rather dumps hydraulic pressure from the existing brake assembly. This pressure was released earlier when the driller originally set the parking brake. The riser assembly and block continued to fall and, once the top drive struck the drill floor, it separated, allowing the pipe handler, bails, elevators, riser running tool, all joints of riser, the LMRP, and BOP stack to free fall to the seafloor.

Cause

The immediate mechanical **cause** of the draw works failure was the loss of brake holding capacity.

Contributing Causes

This loss of brake holding capacity was caused by contamination of the brake pads and discs with the wire rope lubricant (Brilube #16) and by excessive air gap clearance between brake pads and discs. Therefore, the contamination and excessive air gap clearance are considered to be **contributing causes** of the accident.

In the original specifications for the wire rope, DDLLC requested Briden Wire Rope to furnish the drill line lubricated with Brilube #8. However, as stated previously, when the wire rope was delivered, it was lubricated with new lubricant, Brilube #16. Because of its lower viscosity, Brilube #16 was more likely to drip onto the pads and discs than Brilube #8. Therefore, the decision by DDLLC to accept the drill line furnished with Brilube #16 is also considered to be a **contributing cause** of the accident. While DDLLC is responsible for accepting a drill line with a lubricant contrary to their specification, it is not unreasonable for a drilling company to accept such a departure from specifications by a highly specialized contractor such as Briden Wire Rope.

It is known that RBF personnel made two inspections in which the air gaps on the brake calipers were checked to see if they were within the allowable tolerance and, if not, the necessary adjustment was to be made. It is not known, though, the actual air gap measurements taken during these two inspections; however, the procedures did call for the air gap to be reset to 1 millimeter. Therefore, since no other measurements of the air gaps were made after the two inspections immediately following commissioning, it is reasonably concluded that the air gap was at or greater than the maximum allowable tolerance at the time of the incident. This conclusion is also supported by the forensic calculations performed after the incident on the sister ships and the *Pathfinder*. None of the air gap measurements taken on the sister ships was equal to or less than 1 millimeter. The air gaps on the two sister ships ranged from 1.1 to 3.9 millimeters. Forensic calculations estimated the air gap on the *Pathfinder* to be in the range of 2.6 to 3.7 millimeters. At these distances, the holding capacity of the draw works brakes is significantly reduced. On the basis of this evidence, it is the conclusion of this panel that this excessive air gap is also a **contributing cause** of the accident.

Possible Contributing Causes

Had the air gap been inspected as per the procedures identified in the Svenborg vendor information, it is reasonable to conclude that the air gap would have been identified as exceeding the allowable tolerance and appropriately reduced, thereby lessening the probability of brake failure. It is also possible that such an inspection would have also revealed the contamination of the brake pads and discs with the wire rope lubricant, and precipitated corrective action.   Therefore, the removal of the procedural requirement by RBF for inspecting the air gap tolerance in subsequent inspections and their inability to explain that removal constitutes a management-of-change oversight. Therefore, the removal of the procedure is considered to be a **possible contributing cause** of the accident.

A job hazards analysis of the operation of the draw works could reasonably be expected to have

- identified brake inspection procedures as a critical element in the safe operation of the draw works, and
- identified the potential failures of the various operations of the drilling unit especially with respect to suspension of heavy loads.

The identification of the brake inspection procedures as critical can very reasonably be expected to have resulted in the continuation of the correct brake inspections beyond the first two inspections after commissioning. Such continued inspections would have resulted in the proper adjustment of the aforementioned excessive brake-pad-to-disc air gap and could also reasonably be expected to have revealed the aforementioned contamination and, therefore, would have lessened the probability of the accident occurring.

A hazard analysis of the methods for suspending heavy loads would have identified the single point failures involved in such an operation. This identification could have resulted in the prevention of the accident through the adoption of a different method of suspending the load or modifying the method by which it was suspended.

Therefore, the failure to perform a job hazard analysis, as described above, is considered to be a **possible contributing cause** of the accident.

Recommendations

Safety Alert

The MMS should issue a Safety Alert recommending that drilling contractors conduct a hazards analysis of the operation and maintenance of their draw works system. The purpose of the analysis should be to identify potential failures within the total system. Once the potential failures are identified, steps should be taken either to eliminate the failure or to reduce the consequences of such failures should they occur. These steps can be accomplished through engineering and/or administrative/procedural practices. The drilling contractors should verify the operation and maintenance program of their individual draw works system to ensure accuracy of and adherence to program directives. Issues to be considered include, but are not limited to, the following:

1. The detection, remediation, and prevention of contamination of the braking surfaces;

2. Inspection and maintenance of braking system to include maximum allowable pad/disc tolerances and proper adjustment when necessary;

3. Manufacturers' recommendations are completely reviewed and addressed;

4. Procedures or guidelines for handling loads at or near the load capacity of the draw works; and

5. Managing changes within the operation and maintenance program to ensure all potential hazards of the changes are identified, reviewed, and addressed.

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MMS 2000-084

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U.S. Department of the Interior
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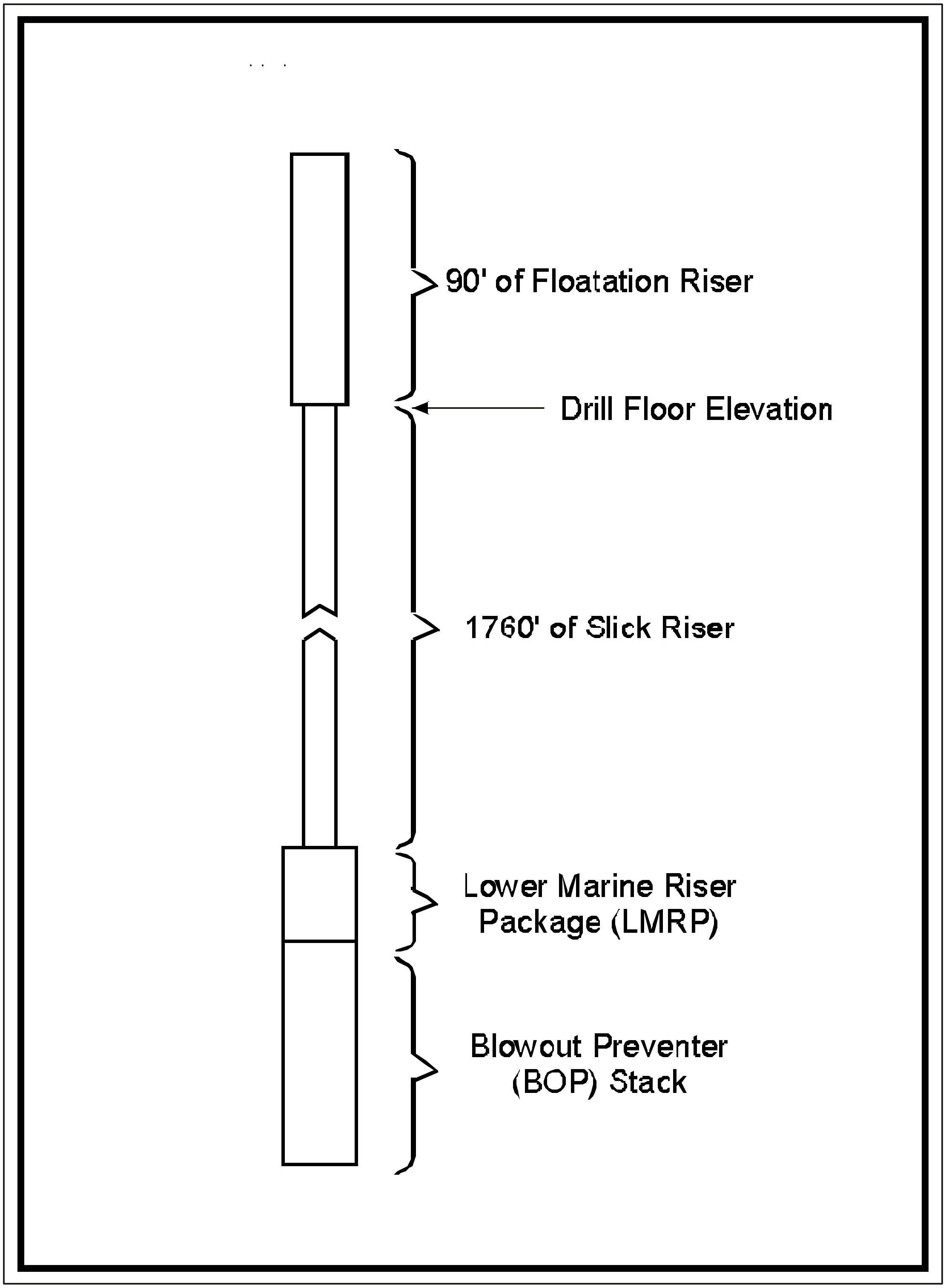
New Orleans
November 2000

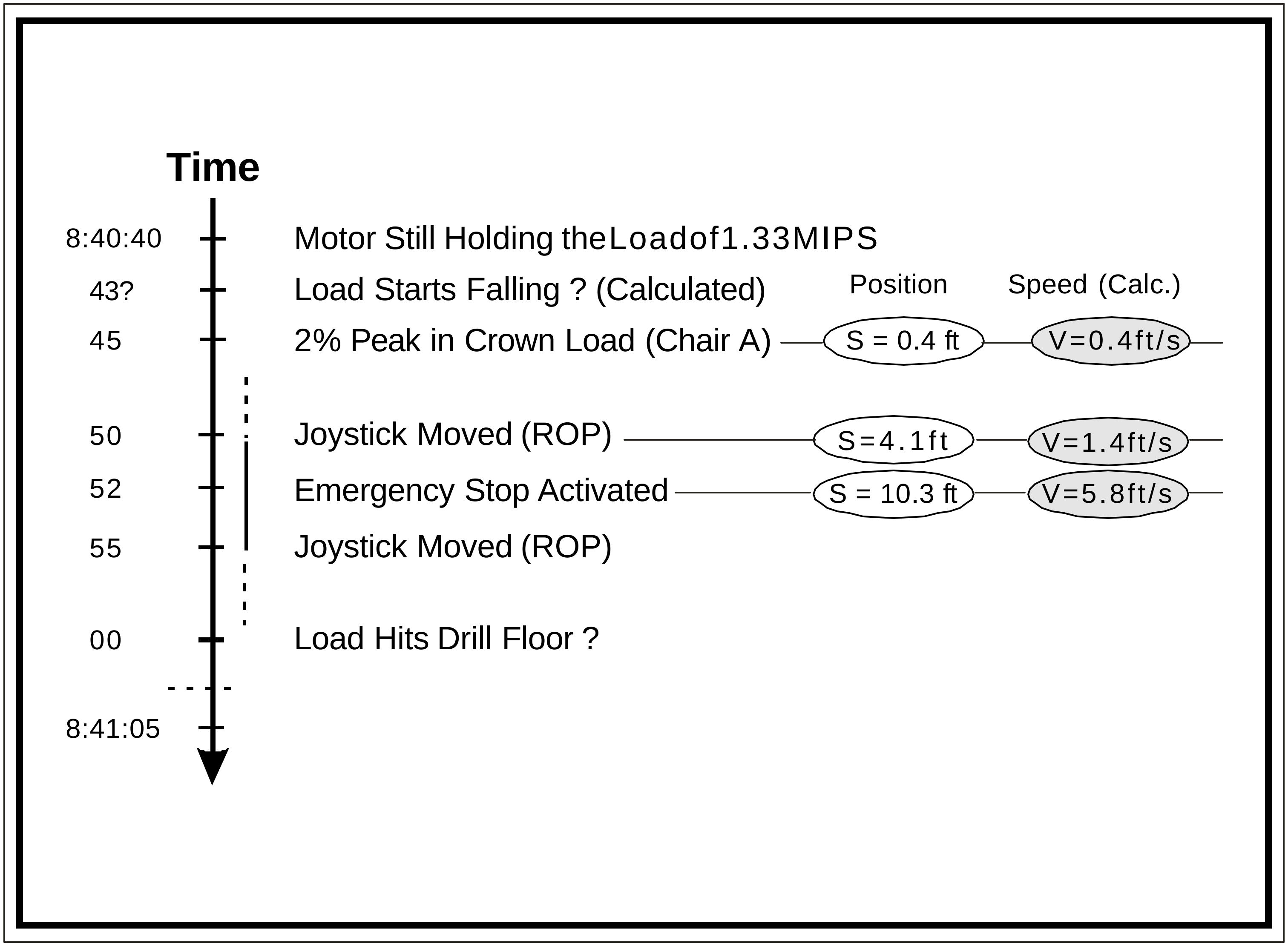
Contents

Lease Locations

Attachment 1

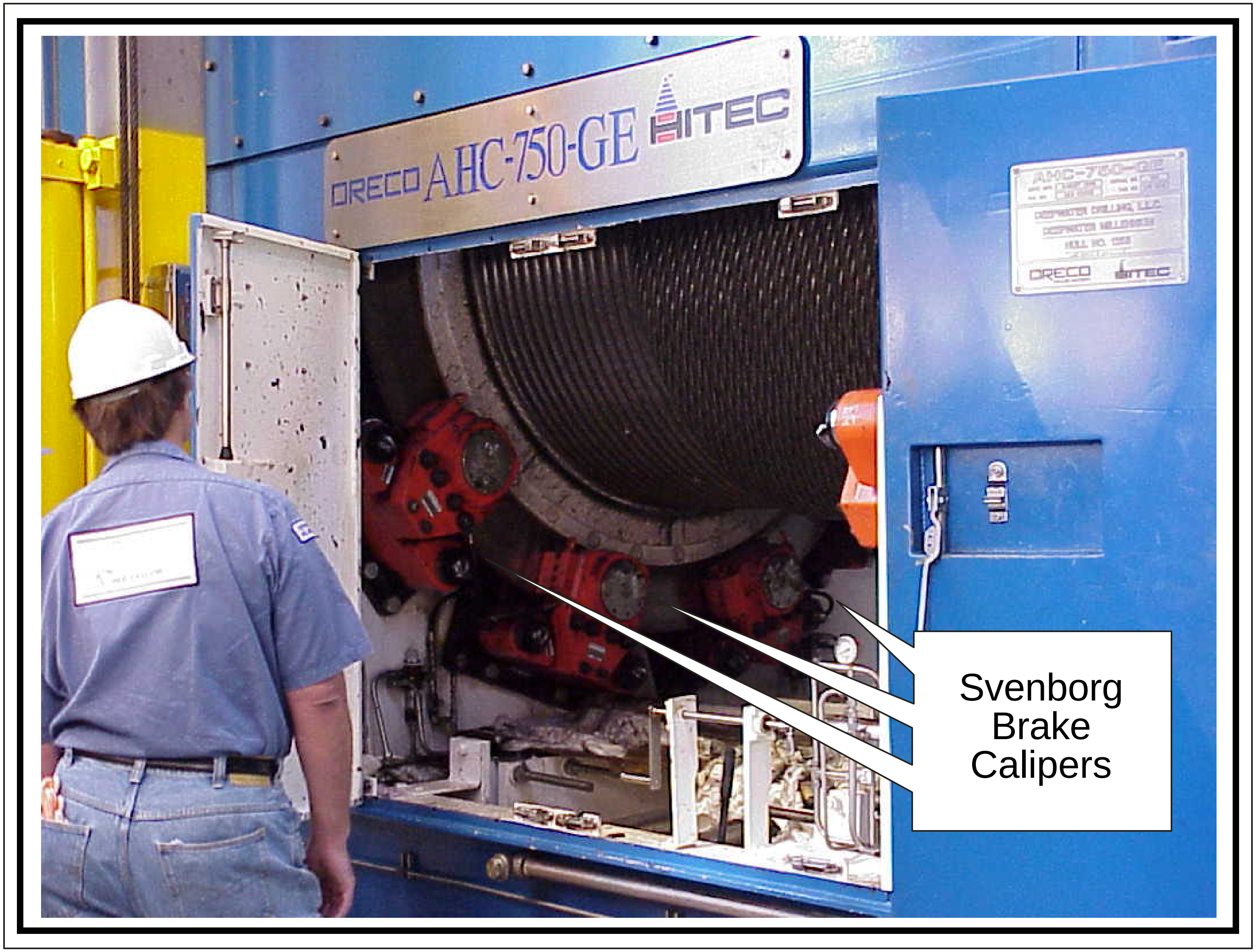


Schematic of Riser Assembly



Time Sequence

Attachment 3

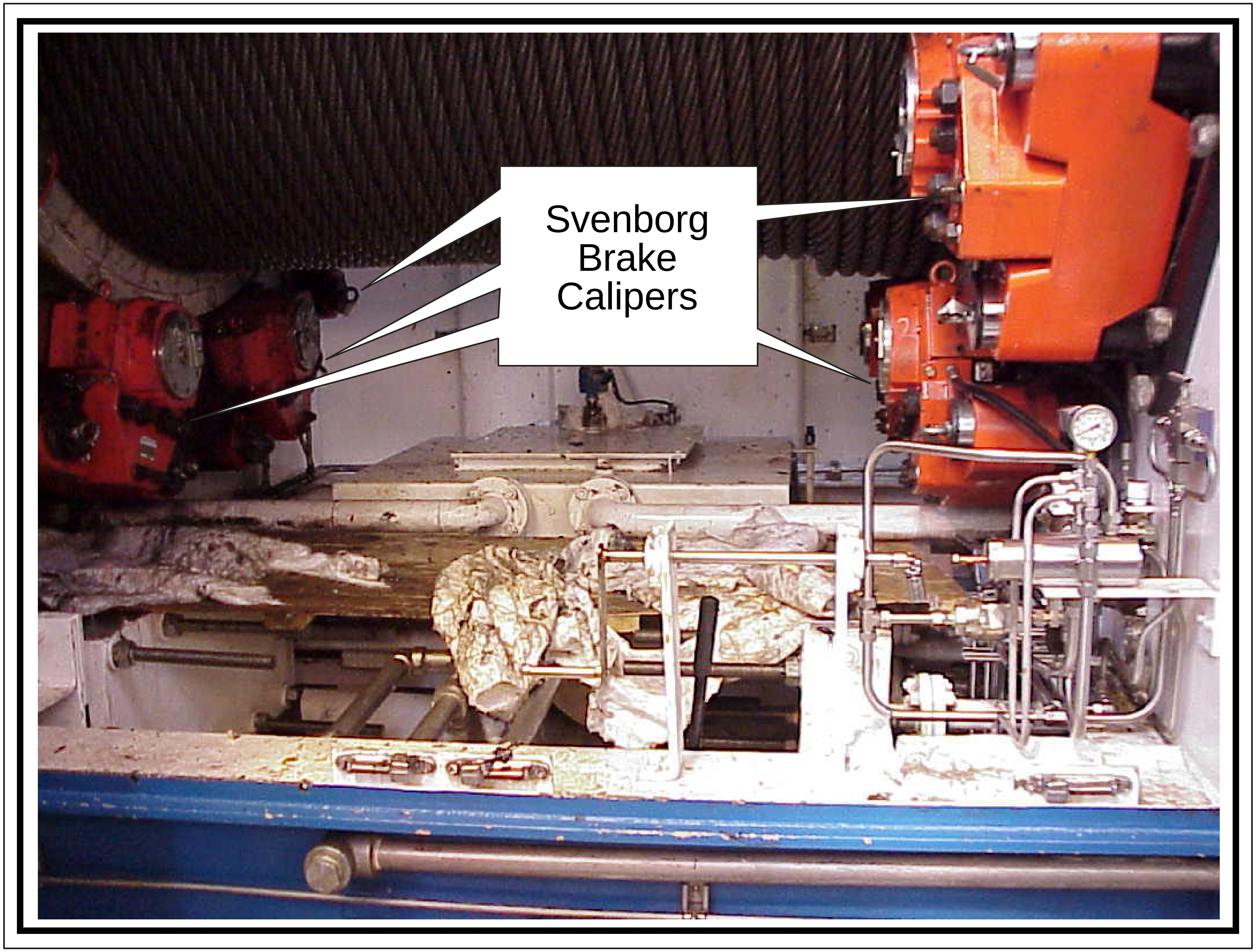


Dreco AHC 750 GE Draw Works with Svenborg BrakeCalipers (*Deepwater Millennium*)

Attachment 4

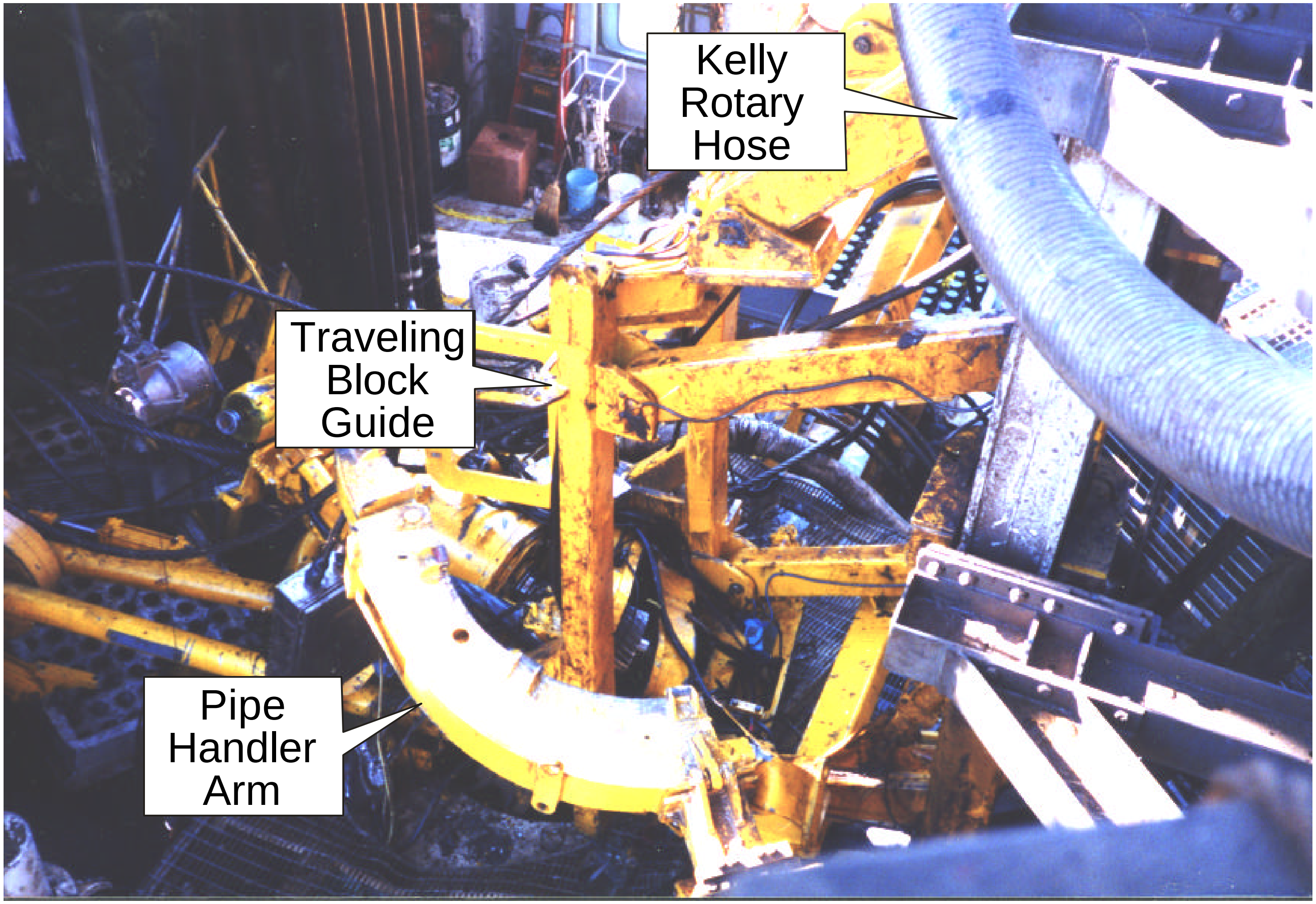
Dreco AHC 750 GE Draw Works with Svenborg BrakeCalipers (*Deepwater Millennium*)

Attachment 5

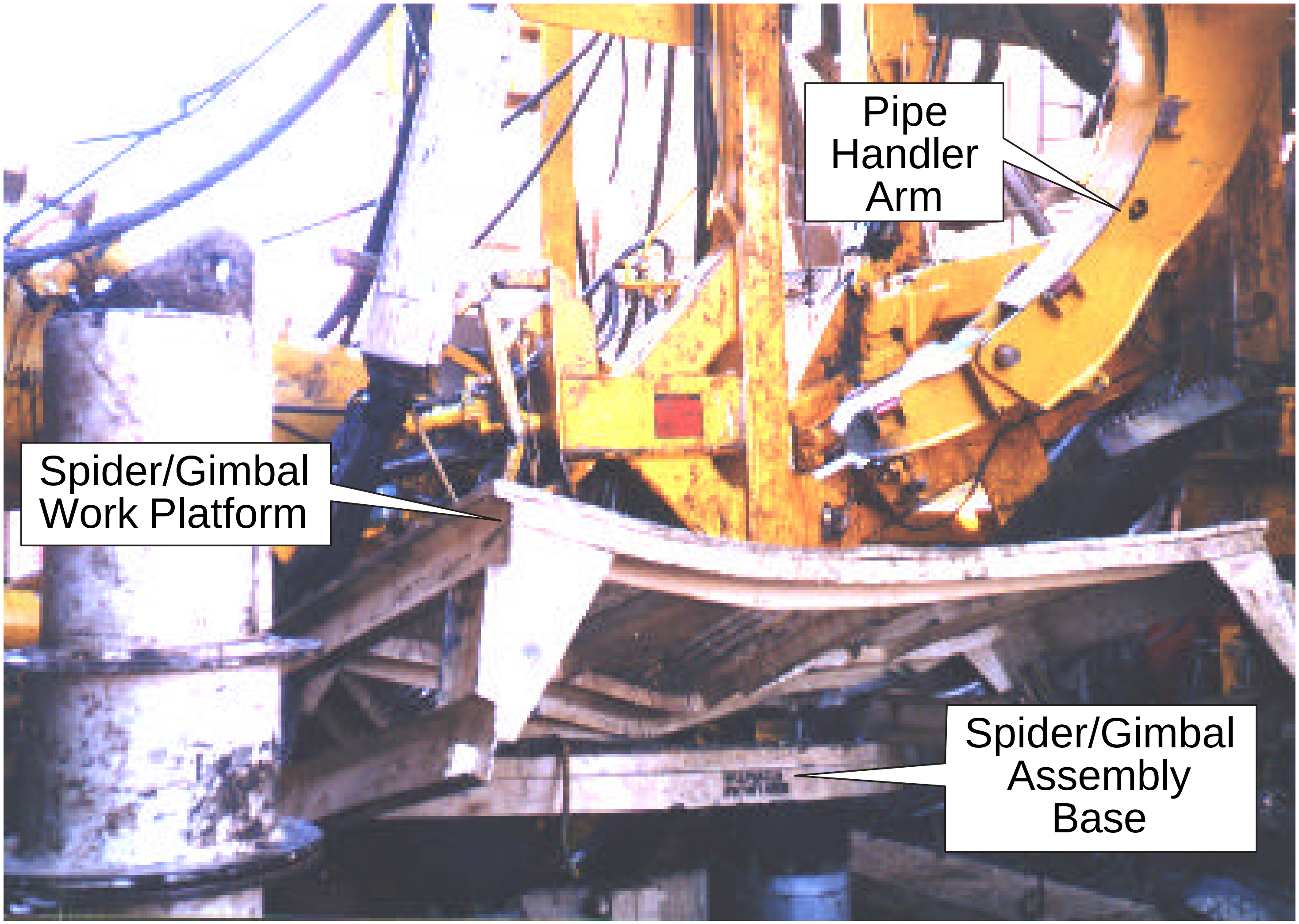


Dreco AHC 750 GE Draw Works with Svenborg BrakeCalipers (*Deepwater Millennium*)

Attachment 6



Damages - *Deepwater Pathfinder* Drill Floor



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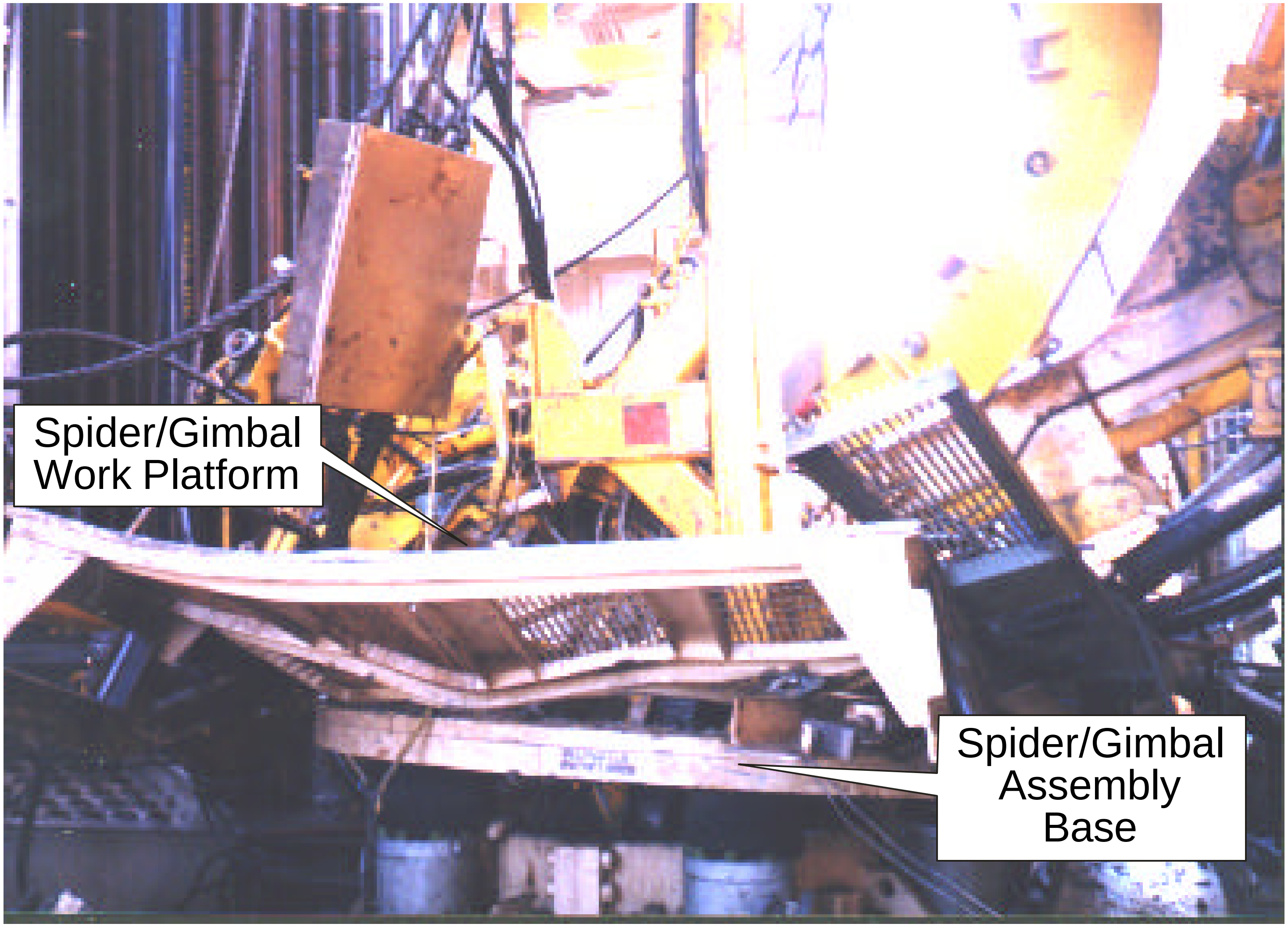

Damages - *Deepwater Pathfinder* Drill Floor

Attachment 9