UNITED STATES DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE
GULF OF MEXICO REGION

ACCIDENT INVESTIGATION REPORT

1. OCCURRED
DATE: **28-FEB-2007** TIME: **2014** HOURS

2. OPERATOR: **BP Exploration & Production Inc.**
REPRESENTATIVE: **Onstott, Linda**
TELEPHONE: **(281) 366-0219**
CONTRACTOR:
REPRESENTATIVE:
TELEPHONE:

3. OPERATOR/CONTRACTOR REPRESENTATIVE/SUPERVISOR ON SITE AT TIME OF INCIDENT:

4. LEASE: **G15610**
AREA: **GC** LATITUDE:
BLOCK: **782** LONGITUDE:

5. PLATFORM: **A-Mad Dog Spar**
RIG NAME:

6. ACTIVITY:
- [ ] EXPLORATION(POE)
- [X] DEVELOPMENT/PRODUCTION (DOCD/POD)

7. TYPE:
- [ ] HISTORIC INJURY
  - [ ] REQUIRED EVACUATION
  - [ ] LTA (1-3 days)
  - [ ] LTA (>3 days
  - [ ] RW/JT (1-3 days)
  - [ ] RW/JT (>3 days)
  - [ ] Other Injury
- [ ] FATALITY
- [ ] POLLUTION
- [ ] FIRE
- [ ] EXPLOSION
- LWC
  - [ ] HISTORIC BLOWOUT
  - [ ] UNDERGROUND
  - [ ] SURFACE
  - [ ] DEVERTER
  - [ ] SURFACE EQUIPMENT FAILURE OR PROCEDURES
- COLLISION [ ] HISTORIC [ ] >$25K [ ] <=$25K
- [ ] STRUCTURAL DAMAGE
- [ ] CRANE
- [ ] OTHER LIFTING DEVICE
- [ ] DAMAGED/DISABLED SAFETY SYS.
- [ ] INCIDENT >$25K
- [ ] H2S/15MIN./20PPM
- [X] REQUIRED MUSTER
- [X] SHUTDOWN FROM GAS RELEASE
- [ ] OTHER

6. OPERATION:
- [X] PRODUCTION
- [ ] DRILLING
- [ ] WORKOVER
- [ ] COMPLETION
- [ ] HELICOPTER
- [ ] MOTOR VESSEL
- [ ] PIPELINE SEGMENT NO.
- [ ] OTHER

8. CAUSE:
- [X] EQUIPMENT FAILURE
- [ ] HUMAN ERROR
- [ ] EXTERNAL DAMAGE
- [ ] SLIP/TRIP/FALL
- [ ] WEATHER RELATED
- [ ] LEAK
- [ ] UPSET H2O TREATING
- [ ] OVERBOARD DRILLING FLUID
- [ ] OTHER _____

9. WATER DEPTH: **4420** FT.

10. DISTANCE FROM SHORE: **128** MI.

11. WIND DIRECTION:
SPEED: M.P.H.

12. CURRENT DIRECTION:
SPEED: M.P.H.

13. SEA STATE: FT.

17. DESCRIBE IN SEQUENCE HOW ACCIDENT HAPPENED:

During normal operations on February 28, 2007 at approximately 20:11 hours, activation of a Pressure Safety High (PSH-28401) on the water side of Export Compressor #2 Discharge Cooler initiated a shut-down of all compression and Seawater Lift Pumps on the Mad Dog facility.

While the pressure in the Booster Compression System was equalizing, the rupture discs on the High Pressure Compressor #1 Discharge Cooler failed in the reverse direction. Gas from the Flare Header entered the Seawater Cooling System and expanded causing a water-hammer effect, piping damage, and an uncontrolled gas release from multiple damage points in the Seawater Cooling Ssystem. Multiple gas detectors (ASH's) then triggered a facility wide Emergency Shut Down (ESD) and complete facility depressurization when they detected the released gas. Following the incident, the facility was safely secured and inspections revealed equipment damage was limited to the seawater cooling system.

18. LIST THE PROBABLE CAUSE(S) OF ACCIDENT:

As the compressors began to spin down, anti-surge and recycle valves immediately opened, thus beginning the equalization of pressure from discharge to suction. As the compressors shut down, equalization pressure of the High Pressure and Low Pressure Compressors backflowed into the High Pressure and Low Pressure Compressor Feed Headers before the inlet compressor shutdown valves could close. The lack of check valves (FSV's) in the High Pressure and Low Pressure Compressor Feed Headers caused backflow to the High Pressure and Low Pressure Separator's FSV's and began pressurizing the High Pressure and Low Pressure Compressor Feed Headers. In response to this pressurization, the 8 inch flare valves (PV-21905 and PV-21307), located on the Compressor Feed Headers, opened and rapidly blew down the compressors. Process trending indicated during the time of the event that the High Pressure and Low Pressure Compressor Feed Headers built up to approximately 600 psig and 150 psig respectively while the flare valves relieved the compressor equialization pressure. The High Pressure and Low Pressure flare valves set pressure are 425 psig and 122 psig respectively. Normal operating pressures in the High Pressure and Low Pressure Compressor Feed Headers prior to blowdown are 360 psig and 115 psig.

The resulting backpressure on the Flare System built up to at least 100 psig in the Flare Scrubber and thereby caused the rupture disc failure on the Compressor Discharge Coolers.

19. LIST THE CONTRIBUTING CAUSE(S) OF ACCIDENT:

The Booster Compressors (Low Pressure, High Pressure, and Export) are equipped with direct Seawater-to-Process Gas Discharge Coolers. A tandem rupture disc assembly is installed on the seawater discharge of each cooler to protect the cooler from overpressure in the event of produced gas ingress into the system (tube rupture, tube sheet leak, etc).

The tandem rupture disc assembly is made up of a primary rupture disc, designed to rupture at approximately 225 psig, the design working pressure of the seawater piping system. Immediately downstream of the primary rupture disc is a secondary rupture disc designed to rupture at 100 psig in the forward burst direction. A pressure transmitter and local gauge are installed between the two rupture discs to notify

operators of failure or leakage of one or both of the rupture discs.

The secondary rupture disc ruptures in the reverse direction at 50 psig, while the primary disc has a pressure rating of 225 psig in the reverse direction. During this event, visual inspection indicated that the secondary rupture disc failed backwards and impacted the primary rupture disc causing the primary disc to also fail. The failure of both rupture discs caused an open path for gas to enter the seawater cooling piping.

20. LIST THE ADDITIONAL INFORMATION:

A. Seawater Fiberglass Pipe Integrity-There are three possible scenarios where gas could migrate into the Seawater Cooling System causing possible water-hammer:
1. A Compressor Discharge Cooler tube leak.
2. A dual tandem rupture disc failure in forward direction and flare gas migrating back into Seawater Return Header.
3. A dual tandem rupture disc failure in the reverse direction and flare gas migrating back into Seawater Return Header.

In future events of a Pressure Safety High (PSH) trip on the Booster Gas Compressor Coolers, the Seawater Lift Pumps will shutdown on a time delay instead of current instantaneous shutdown.

A study will be performed to model the hydraulic and mechanical response of the fiberglass pipe system in tube leak and tube rupture event. The results of this study will form the basis of a pipe stress and support review which will determine if modifications are required to the fiberglass pipe system.

The proposed check valves (FSV's) between the rupture discs and Flare Header will mitigate gas flow from the Flare Header into the Seawater Cooling System.

B. Summary of Flare Modeling and Verification-The High Pressure Flare system was extensively modeled to determine maximum volume and pressures. The results of this modeling determined that at current operating conditions with the modifications listed below, the highest volume of gas in the High Pressure Flare system is 58 MMSCFD and the highest pressures experienced at the Compressor Discharge Cooler rupture discs is 45 psig. This modeling assumed worst case scenarios with simultaneous blowdown of both Booster Gas Compressors.

The modeling indicates that, at future production rates, additional flare system modifications may need to be implemented.

C. Past Event Failures with Rupture Disc Failure:

July 1, 2005:
During optimization of the High Pressure Compressor seawater cooling, the temperature control valve on High Pressure #2 Compressor Discharge Cooler was inadvertently closed. The Pressure Safety High (PSH) on the cooler was tripped causing all compression and Seawater Lift Pumps to turn off. The rupture discs on the High Pressure #2 Compressor Discharge Cooler failed in the forward direction causing water to enter the High Pressure Flare system. When the Seawater Cooling Supply Header pressure decreased, gas entered the Seawater Cooling System from the High Pressure Flare System. The gas traveled through the Seawater Cooling System and confirmed with gas detection at the Seawater Disposal Caisson vent. No known damage occurred in the seawater cooling piping due to this event.

July 27, 2005:
During a flare event, pressure was indicated on the High Pressure #2 Compressor

Discharge Cooler rupture disc pressure transmitter. Upon inspection, the flare side secondary rupture disc had been inadvertently installed in the reverse burst direction during the July 1, 2005 event. The secondary disc was replaced and installed in the correct forward burst direction.

January 16, 2007:
During normal operation for both Booster Gas Compressors, the discharge pressure began dropping in Booster Gas Compressor #1 causing a Pressure Safety Low (PSL) on the Low Pressure Compressor Discharge #1 Scrubber. The root cause of the Pressure Safety Low (PSL) appeared to be that the surge valve had fully opened thus resulting in a flare. The Booster Gas Compressor #1 was then blown-down during the flare event to troubleshoot and repair the surge valve. At the time of the blowdown, the rupture discs on the Low Pressure #1 and Export #1 & #2 Compressor Discharge Coolers unexpectedly ruptured. It was expected during this event that the High Pressure Flare Scrubber reached 75 psig, however gas did not backflow into the Seawater Cooling System because the Seawater Pumps remained running and the Seawater Header pressure at the Compressor Discharge Coolers was approximately 60 psig.

21. PROPERTY DAMAGED:

Fiberbond pipe connections and supports at various points within the seawater cooling water return lines.

NATURE OF DAMAGE:

Pipe connections parted from the pressure incurred from gas entry into the seawater system. Few sections sustained cracks. Several saddles securing pipe in braces.

ESTIMATED AMOUNT (TOTAL): **$15,000**

22. RECOMMENDATIONS TO PREVENT RECURRANCE NARRATIVE:

Both the Houma District and BP agree that the following corrections are adequate for the prevention of a recurrance of this incident:
1. Install check valves (FSV's) upstream of High Pressure and Low Pressure Compressor #1 & #2 Suction Scrubbers.
2. Install two relief valves (PSV's) set at 600 psig and a PSH set at 532 psig on the High Pressure Compressor Feed Header flare line, which will shutdown both Booster Gas Compressors, to protect overpressure of Fiberglass piping on the Flare Header. Car Seal Open (CSO) the manual valves directly upstream and downstream of the 8 inchflare valves (PV-21307 and PV-21905).
3. Modify the three individual 6" flare tips on the facility Flare Boom.
4. Change secondary rupture disc on Low Pressure, High Pressure, and Export Compressor Discharge Coolers rupture discs to be set at 125 psig.
5. Install check valves (FSV's) downstream of Low Pressure, High Pressure, and Export Compressor Discharge Coolers rupture discs. Change the pipe from AN (carbon steel) grade piping to A3 (316 stainless steel) grade piping downstream of the rupture discs of the High Pressure and Export Compressor.
6. Modify the blowdown orifice sizes on Low Pressure, High Pressure, and Export Compressor blowdown lines to High Pressure Flare.
7. Install a timer to delay shutdown of Seawater Lift Pumps for 15 seconds when tripped by a Pressure Safety High (PSH) on the Booster Gas Compressor Discharge Cooler.

23. POSSIBLE OCS VIOLATIONS RELATED TO ACCIDENT: **NO**

24. SPECIFY VIOLATIONS DIRECTLY OR INDIRECTLY CONTRIBUTING. NARRATIVE:

25. DATE OF ONSITE INVESTIGATION:

07-MAR-2007

26. ONSITE TEAM MEMBERS:

Freddie Mosely / Darrell Griffin / Ben Coco /

29. ACCIDENT INVESTIGATION PANEL FORMED: **NO**

OCS REPORT:

30. DISTRICT SUPERVISOR:

Michael J. Saucier

APPROVED

DATE: **26-APR-2007**