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**What Lies Beneath**

In August the small Texas community of Moss Bluff made national news when nearly 6 billion cubic feet of natural gas burned for six days as it escaped from an underground salt dome storage facility.

In October, Duke Energy Gas Transmission presented the results of its investigation into the cause of the August 2004 well control incident and natural gas fire at the company's Moss Bluff Hub Partners storage cavern #1 in Liberty County, Texas, to the Railroad Commission of Texas staff in Austin. The commission has regulatory oversight of the facility.

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**Facility Background**

Early on Aug. 19, 2004, a well control incident occurred at the Moss Bluff Hub Partners salt cavern storage facility in Liberty County, Texas, about 40 miles northeast of Houston, that resulted in an uncontrolled gas release and fire at storage Cavern #1. Over a period of six and one-half days, the approximately 6 billion cubic feet of natural gas in the cavern was released and burned. The fire eventually self-extinguished, and at 9:40 p.m. on Aug. 26, installation of a blowout prevention valve was completed, effectively placing the well back under control.

Throughout the duration of the event, the fire was above ground. The top of storage cavern #1 is approximately 2,500 feet below the surface and the cavern itself is about 1,400 feet deep.

The 640-acre Moss Bluff storage facility is primarily comprised of three separated underground caverns leached out of a naturally occurring salt formation beneath the surface; a compressor station to help move natural gas into and out of the caverns; well head assemblies on each of the caverns for operational control purposes; and natural gas, fresh water and salt water (brine) piping and related facilities to facilitate transportation and/or holding of those materials.

Prior to the Aug. 19 incident, storage cavern #1 was operating in normal "de-brining" mode where

brine is withdrawn from the cavern as gas is injected. Brine is brought to the surface through an 8 5/8-inch well string and transported to an above-ground holding pond as gas is compressed and injected into the cavern through a 20-inch casing. Up to the time of the incident, no unusual events occurred in the de-brining process and operator reports indicate that the system was performing normally.

**Investigation Results**

A detailed investigation by company personnel and supported by outside consultants determined that a series of unusual events was the basis for the uncontrolled gas release and fire at Moss Bluff storage cavern #1 beginning Aug. 19.

The series of events included separation of the 8 5/8-inch well string inside the cavern; the breach of the 8-inch brine piping above ground; and the separation of the wellhead assembly above the cavern.

**Well String Event**

A detailed investigation by company personnel supported by outside consultants determined that the initiating event in the Aug. 19 incident was a separation of the 8 5/8-inch well string inside the cavern at or

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above the 3,724 feet level. The reason for this breach event is unknown and the affected materials are not recoverable from the cavern.

The evidence indicates that, as recently as 10 days prior to the incident, the 8 5/8-inch well string showed no signs of a separation that would ultimately have resulted in gas entering the above-ground brine piping during de-brining operations.

Brine Piping Event

When the brine level reached the point where the 8 5/8-inch well string had separated, gas under pressure was able to enter the string, reach the surface and flow into the 8-inch above ground brine piping. The emergency shutdown (ESD) system in place on the 8-inch brine piping off the wellhead assembly operated properly and closed with the detection of a change in pressure, flow and/or composition.

The resulting mechanical forces or "water hammer" produced by the sudden surge of flow caused the 8-inch piping between the wellhead and the ESD valve to breach. The breach occurred at a location in the piping that had general wall loss due to internal corrosion.

The extent of the internal corrosion of the brine piping was not expected due to the relatively short period of time it had been in service (installed and tested in 2000). The breach in the 8-inch, above-ground brine piping just west of the wellhead initially fueled the fire. Due to the location of the breach, the gas release and fire were directed downward at the base of the wellhead.

Wellhead Event

At 1:24 a.m. on Friday, August 20, the entire wellhead assembly then separated from the casings due to the extreme radiant heat and was ejected to the side. The fire self-extinguished for a brief period of time (approximately 28 seconds). Gas then began escaping vertically through the 20-inch production casing.

Other Considerations

Operating procedures were reviewed and found to be adequate and appropriately followed. Valve positions were confirmed and found to be correct. A thorough review of operator logs and employee interviews did not reveal evidence that procedural or human error contributed to the event.

The Moss Bluff facility is manned by trained personnel around the clock, and no unusual circumstances or trespass activities were noticed on the night of the event or during the days leading up to it.

A complete review of the facility was conducted to determine the extent of the damage caused directly by the gas release and fire or indirectly by the heat of the flame. Very little impact of the incident is evident on subsurface facilities. The wellhead and associated piping for Cavern #1 were either lost in the


event or damaged and will be replaced. The remaining above ground piping and facilities incurred damage to external coatings and internal gaskets and other "soft goods," but metallic components were largely unaffected. A similar impact was seen on the compressor units. These units, as well as the valves in the station piping, are being thoroughly inspected, parts replaced as necessary, and retested if applicable. Station wiring that was exposed to the intense heat received extensive damage to the insulation and will be replaced.

According to Reuters, the fire had no impact on natural gas prices, since the amount of the gas affected was not large enough to tip the U.S. supply and demand balance.

Duke Energy Gas Transmission is a North American leader in developing energy infrastructure and connecting major natural gas supply basins to growing markets. The company's natural gas operations include more than 17,500 miles of transmission pipeline and about 250 billion cubic feet of storage capacity in Canada and the United States.

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