Gas Storage And Single-Point Failure Risk

By John M. Hopper

Accidents at natural gas storage facilities, especially catastrophic ones, are rare. However, loss can be minimized if the facility has been designed to include redundant systems.

On the morning of Aug. 18 I was on a conference call with a prospective customer interested in contracting for firm gas storage service at our Hill-Lake Gas Storage Facility in north Texas. The next morning, following the explosion and fire at Duke Energy Gas Transmission's Moss Bluff storage facility in Liberty County, Texas, I was on the phone fielding questions like: "Could this happen at Falcon's storage facilities?" and "How much insurance coverage does Falcon have?" Fortunately, we've never had anything like this occur at any of our facilities, which are depleted reservoirs, not salt caverns. And we do carry lots of property and casualty insurance, just in case.

The Moss Bluff incident was a real eye-opener. The reported failure of a single emergency shut-off valve severely damaged one of the three salt caverns that had been leached in the Moss Bluff salt dome for the purpose of storing natural gas. The estimated replacement value of the cavern is in the range of $15 to $20 million. Also lost was approximately 6,000,000 MMBtu of gas worth a reported $36 million or more. Fortunately, no serious injuries or loss of life occurred, although many families living in the Moss Bluff area were inconvenienced by an evacuation that lasted several days.

The short-term effects of the Moss Bluff incident – the loss of property and equipment as well evacuation and clean-up costs – presumably will be covered by insurance. More difficult to ascertain are the long-term effects that the incident may have on the gas storage industry as a whole. Customer and investor confidence could be affected adversely. Government oversight may increase at both the state and federal levels. Calls for design changes and additional safety measures may ensue. Casualty insurance premiums may rise. And, of course, the cost of doing business could increase significantly as a result – all at a time when more, not less, gas storage capacity is desperately needed in this country.

NUMEROUS FACILITIES

According to the Energy Information Administration, there were 407 underground natural gas storage facilities in operation in the United States in 2002, of which 340, or 84%, were depleted reservoir facilities; 38, or 9%, were aquifer facilities and 29, or 7%, were salt cavern facilities. Market and investor confidence in the U.S. gas storage infrastructure—as well as the blessings of government regulators—are essential to the stability and success of the natural gas storage business.

Statistically, the odds are remote that single-point failures involving natural gas storage facilities can produce the kind of catastrophic losses such as what occurred at Moss Bluff. Be that as it may, they have happened before. In every case, however, a salt cavern storage facility was the culprit, not a depleted reservoir or aquifer gas storage facility. This is an important distinction and underscores the fact that most underground gas storage facilities in the United States—93% of which are either depleted reservoir or aquifer storage facilities—are not susceptible to the kind of catastrophic failure that occurred at Moss Bluff. Nevertheless, prospective storage customers and investors interested in the gas storage business should consider the nature, risks and consequences of single-point failures when making gas storage service choices or storage investment decisions.

Those of us who live in the Houston area undoubtedly will recall the devastating explosion and fire that occurred at the Brenham salt cavern storage facility in April 1992 when a storage cavern was over-filled and leaked liquid petroleum gas (LPG). Several people were killed in that catastrophe. In 1980, a similar LPG leak caused by corroded casing resulted in an explosion and fire at a salt cavern storage facility located on the Barber's Hill salt dome, which is home to a multitude of salt caverns comprising the Mont Belvieu salt cavern storage complex, not far from Moss Bluff. Another explosion and fire occurred at the Mont Belvieu storage complex in November 1985, killing two people and prompting the evacuation of the entire town's population of more than 2,000 residents. Yet another fire and explosion occurred at the Mont Belvieu storage complex in October 1984 that caused several million dollars in property damage. In 1978, a packer failure at a crude oil storage cavern at the West Hackberry salt cavern storage facility in south Louisiana caused the release of an estimated 72,000 barrels of crude oil, which caught fire and killed one worker. More recently, an explosion and fire occurred in January 2001 at the Yaggy salt cavern facility near Hutchison, Kan., resulting in several deaths and substantial property damage.

Losses from other incidents involving salt cavern storage facilities fortunately have been limited to the destruction of plant, property and equipment. In the early 1970s, the Eminence salt cavern gas storage facility in Mississippi experienced such severe salt creep (i.e., the shrinking or collapse of cavern walls) in one of its caverns that almost half of the cavern's storage capacity was lost. Late last year, a casing leak at Entergy-Koch's Magnolia salt cavern facility near Napoleonville, La., resulted in a large quantity of gas reportedly being vented to the atmosphere, which forced the shutdown of the facility as well as the evacuation of residents in the area until the leak was contained. In the early 1990s, the now-defunct U.S. energy subsidiary of Germany's Metallgesellschaft contracted for a third party to develop a salt cavern for natural gas storage at the Stratton Ridge salt dome in Brazoria County near Freeport, Texas. The cavern failed a mechanical integrity test because it leaked gas when pressured up for storage and had to be abandoned.

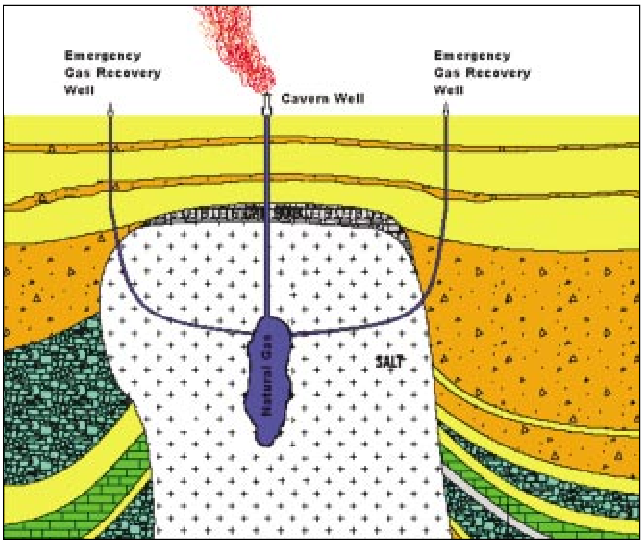
MOSS BLUFF, WHAT HAPPENED?

I do not know exactly what happened at Moss Bluff in August. It has been reported that a single emergency shut-off valve failed during cavern de-watering operations. The cavern had just been expanded using the SMUG (solution mining under gas) process, which permits salt cavern expansion without interrupting gas storage operations. When the valve failed, gas blew out of the cavern, ignited, and ultimately destroyed the single storage wellhead. Regardless of what led to the catastrophe, the inevitable question is: "Can it happen again and, if it does, how will it affect my gas storage inventory?" Or, "How will it affect my investment in a gas storage facility?"

These questions deserve good answers. The first is that not all natural gas storage facilities are the same, just as not all gas pipeline assets are the same. The design characteristics and operational risks that are inherent in one gas storage facility are not necessarily present in another, even though the facilities are similar in purpose. The fact is that salt cavern gas storage poses substantially different developmental and operational risks than depleted reservoir storage.

SINGLE-POINT FAILURE

While single-point failures are not all that unusual in the gas storage business, what is unusual about the events that transpired at the Moss Bluff, Brenham, Barber's Hill, West Hackberry, Yaggy, Napoleonville and Eminence salt cavern storage facilities is the magnitude of loss caused by failure of a single piece of equipment. In each of these cases, the failure of a single valve, wellhead, packer, joint of casing or the structural integrity of the salt cavern itself caused a catastrophic loss. While we've had single-point failures occur at our own depleted reservoir facilities, the worst of them—a damaged compressor shaft – caused a service interruption that lasted only a few days and cost about $150,000 to repair.



Source: Falcon Gas Storage Co.

A single-point valve failure causes a gas leak, leading to fire and an explosion that engulfs the primary storage well. However, backup withdrawal wells can be employed to withdraw the remaining gas inventory that otherwise would be destroyed.

Prudent due diligence requires that prospective storage customers and investors should consider whether the storage facility in question has design characteristics that are susceptible to single-point failure. If so, then risks should be weighed against the cost of installing redundant systems to serve as backup in case of failure.

The storage cavern damaged at Moss Bluff had only one wellbore installed for injection and withdrawal, which is the standard design for most salt caverns. Under normal conditions this works just fine. However, when a wellhead or valve failure occurs and a gas leak ensues it may not be possible to contain the leak if the well catches fire – especially if the cavern is full and hence fully pressured. Since a single salt cavern can hold anywhere from 3 to 8 Bcf or more, the loss of an entire wellbore or storage cavern also can result in the loss of a lot of gas, which in fact happened at Moss Bluff.

BACKUP BENEFITS

Had there been a backup wellbore and wellhead installed at Moss Bluff at a location sufficiently distant from the wellbore that exploded and caught fire, it would have been possible to withdraw the stored gas and prevent most of it from being consumed by fire. The installation of yet a third backup wellbore could serve as either an additional emergency gas withdrawal well or could be connected to an on-site source of water, brine or an inert gas such as nitrogen – any one of which would have made it possible to flood the cavern, preserving its integrity and preventing further damage. However, salt cavern developers rarely incorporate such redundancy due to cost. But with an incremental investment of about $50 million —approximately the cumulative cost of the losses at Moss Bluff—all three caverns at Moss Bluff could have been equipped with this redundant backup.

In contrast to salt cavern storage, depleted reservoir storage typically has many wellbores that are used for injection/withdrawal. Redundancy is in effect built in. The complete loss of a single wellbore or wellhead at a typical depleted reservoir would in the worst case result in the loss of only that gas that could be drained by that single wellbore, and then for only as long as it would take to cap the well in question.

Moss Bluff vented an estimated 1,000,000 MMBtu per day for several days at extremely high pressures, which prevented the well from being capped until virtually all of the stored gas had been lost. Because storage wells in depleted reservoirs are easier to cap if they were to blow out and drain only a limited area of the reservoir, gas loss would be limited. And if a well is lost or damaged at a depleted reservoir, the remaining wells can be deployed quickly to withdraw remaining gas inventory.

More typical single-point failures involve valves and compressor parts whose failure can cause a shutdown or service interruption at any storage facility. Service interruptions at salt caverns, though, can be significantly longer than those at depleted reservoirs, especially if the structural integrity of the surrounding caverns is at risk. Moreover, unlike a valve or a compressor unit, a salt cavern cannot be repaired or replaced quickly. Leaching a new cavern can take up to two years. And repairing a salt cavern to its original structural integrity may not be possible.

Clearly, not all gas storage facilities are alike. Where a customer decides to store gas or an investor interested in the gas storage business chooses to invest capital are decisions driven by any number of factors. Risks and consequences of single-point failures are just two of them—albeit important ones, as the incident at Moss Bluff reminds us. ■

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Catastrophic Events Involving Salt Cavern Storage Facilities Since 1972

Facility	Location	Fuel	Date	Description of Event	Reported Cause
Where Loss of Life or Serious Injuries as well as Property Damage Occurred					
Yaggy	Hutchison, Kan.	Natural Gas	Jan. '01	Fire and Explosion	Casing Failure
Brenham	Brenham, Texas	LPG	April '92	Fire and Explosion	Valve Failure
Mont Belvieu	Mont Belvieu,Texas	LPG	Nov. '85	Fire and Explosion	Casing Failure
Mont Belvieu	Mont Belvieu,Texas	LPG	1980	Fire and Explosion	Casing Failure
West Hackberry	South La.	Oil	Sep. '78	Fire	Packer Failure
Where Only Catastrophic Loss of Property Occurred					
Moss Bluff	Liberty, Texas	Natural Gas	Aug. '04	Fire and Explosion	Valve Failure
Magnolia	Napoleonville, La.	Natural Gas	Dec. '03	Gas Leak and Evacuation	Casing Failure
Stratton Ridge	Freeport, Texas	Natural Gas	1990s	Cavern Failure/Abandonment	Leak-Failed MIT
Mont Belvieu	Mont Belvieu,Texas	LPG	Oct. '84	Fire and Explosion	Casing Failure
Eminence	Eminence, Miss.	Natural Gas	April '72	Loss of Storage Capacity	Salt Creep

Source: Falcon Gas Storage Co.

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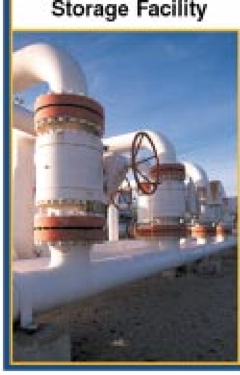

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