TESORO

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April 13, 2018

Mr. Randy Sawyer
Director, Hazardous Materials Division
Contra Costa Hazardous Materials Program
4585 Pacheco Blvd.
Martinez, CA 94553

Via email
Original will follow in the mail.

Subject: **Root Cause Analysis Report for the November 14, 2017 #4 Gas Wet Gas Compressor Release**

Dear Mr. Sawyer

The Tesoro Refinery is submitting a Root Cause Analysis report for the November 14, 2017 #4 Gas Wet Gas Compressor Release. This incident met the "Major Incident" definition under the Program 4 requirements of the recently updated CalARP regulation. This update is provided in this format per our discussion last week.

If you have any questions regarding this report, please call me at (925) 370-3279 or Ms. Sabiha Gokcen at (925) 370-3620.

Sincerely

James Jeter
Environmental, Health and Safety Manager

Cc: Ms. Cho Nai Cheung
Ms. Nicole Heath

Root Cause Analysis Report
Tesoro Martinez Refinery
November 14, 2017 #4 Gas Wet Gas Compressor Release

Summary of Event:

On November 14, 2017, a bolt failed on the valve cap of the #6 Wet Gas Compressor located at #4 Gas Plant resulting in a release of 894 lbs of flammable gas. Operations immediately responded to isolate the compressor. There were no injuries from this incident.

A brief timeline follows:

20:36 hrs:	Operations receives an H2S monitor alarm from #5 Wet Gas Compressor area
20:37 hrs:	Operations receives an LEL monitor alarm from #6 Wet Gas Compressor area
20:42 hrs:	Operations confirms the release is in the compressor house
20:48 hrs:	Operations shuts down #5 Wet Gas Compressor
21:00 hrs:	Operations shuts down #6 Wet Gas Compressor

Agency Notification and Response:

This incident did not meet CWS agency reporting criteria.

Emergency Response Actions:

Operations immediately responded to isolate the compressor. Additional process actions were taken to accommodate the shutdown unit and loss of steam.

Material Released:

The material released was flammable gas from the #6 Wet Gas Compressor. The release amount was estimated at 894 lbs. This event met the API Tier 2 criteria.

Meteorological Conditions:

The weather conditions were clear and dry on 11/14/17. The average wind speed and direction, during the event was 6 mph and 217 degrees respectively (wind direction primarily from the Southwest). The temperature was about 53 degrees F.

Injuries:

No injuries were reported on or off site.

Community Impact:

There was no community impact from this event.

Incident Investigation of the event:

This investigation focused on the loss of primary containment that occurred on the #6 Wet Gas Compressor at the #4 Gas plant.

Background:

#4 Gas Plant is the gas plant associated with the Fluid Catalytic Cracking Unit (FCCU). #4 Gas Plant utilizes six integral engine reciprocating compressors to pressurize wet gas from the FCCU main accumulator to the 4Gas Deethanizer tower. The six compressors are two stage compressors, which means the gas is compressed twice before leaving the machine. This allows for a greater pressurization of the gas than a single stage compressor. Reciprocating compressors have valves that control the entry (suction) and exit (discharge) of gas. The valve is a dynamic part of the compressor controlling the flow of gas. However, while the internal part of the valve is dynamic, it is important for the valve body to remain static to maintain sealing of the gas inside the compressor.

All six compressors use the same suction knock-out pot, suction header, interstage system, and discharge header. The #6 Wet Gas Compressor is at the end of the suction header. There is a vacuum quill system installed at the end of the suction header near the #6 Wet Gas compressor to remove accumulated liquid and prevent liquid ingress to the compressor. Liquid is not compressible and its presence in a compressor results in a greater gas compression than desired. The vacuum quill system is a safeguard against liquid ingress to the compressor.

The compressor machines are housed in a brick building with large open doors to atmosphere. Installed in the building are LEL and H2S detectors that provide the board operator alarms and sound a local emergency horn.

#4 Gas Plant Wet Gas Compressor Release:

On November 14, 2017, a bolt failed on the valve cap of the #6 Wet Gas Compressor resulting in a release of 894 lbs of flammable gas. Operators were alerted to the release by alarms associated with the H2S and LEL detectors located in the compressor building. Operators responded immediately to the compressor building with detection equipment and verified the release. Operators then immediately responded to isolate the compressor. 894 lbs of flammable hydrocarbon gas was released to atmosphere over a 27 minute period. This incident met the API Tier 2 criteria. In addition, this incident met the Major Incident definition in CalARP. There were no injuries from this incident.

Once the compressor was isolated, the Operators identified a hole on a low stage suction valve cap of #6 Wet Gas Compressor. The hole was approximately 1 ¼" in diameter. Directly below the hole, operators found a retention bolt that had liberated from the threaded hole. The acorn nut was still threaded to the retention bolt stud. Maintenance personnel were notified and conducted further inspections on the compressor the next morning. The cast iron valve cap on #6 Wet Gas Compressor showed severe thread degradation and the bottom section of the retention bolt was

severely eroded. The valve cap, valve chair, and valve were removed for inspection. The valve chair exhibited plastic deformation at the retention bolt location and a significant amount of liquid was found inside the compressor cylinder.

Further evaluation of the valve determined that the valve cap design was antiquated and was susceptible to retention bolt failures. The retention bolt serves to keep the valve intact. In addition, this design required threads, a flat surface, and lead (Pb) wire to maintain containment of process material. These structures are subject to failure that will allow the release of process gas.

The investigation analysis further revealed that there was no clear direction to craftsmen regarding the torqueing requirements for the retention bolt. There was no written document or guidance that provided the required information to ensure that bolt was properly tightened.

Steam injection is important for maintaining clean valve internals on the compressor. The steam is injected immediately upstream from the compressor suction valve. However, it was determined that there was no pressure or flow monitoring capability on the steam injection system that would allow operators to add the correct amount of steam. Too little steam can result in poor cleaning of the valve internals and could promote equipment damage or corrosion. However, too much steam can result in liquid accumulation in the compressor. As previously stated, liquid is not compressible and its presence in a compressor results in a greater gas compression than desired. Prevention of liquid ingress is important to compressor reliability.

The vapor composition of the wet gas that flows into the wet gas compressors contains vapors at saturation temperature. When these vapors enter the compressor, liquid condenses from the gas. As previously stated, liquid accumulation in the compressor is undesirable as it is not compressible and results in greater gas compression than desired.

The investigation also found that the suction piping on the #6 Wet Gas Compressor was not insulated like the other 5 compressors. This would result in the wet gas cooling as it approached the compressor, which would promote liquid condensation prior to entering the compressor. This would also contribute to liquid accumulation in the compressor.

The reciprocating Wet Gas Compressors have a rod that goes back and forth during the compression cycle. Lubricant oil is injected to perform the key function of reducing heat on the rod. The excess lubricant oil drains to "packer pots" which in turn drain to the seal drains. The seal drains promote removal of any accumulated lubricant oil liquid and prevent the liquid from entering the compressors. To facilitate the lubricant oil removal, the seal drains connect to a system with an auto-pump, SE-3872. SE-3872 was not functioning properly causing liquid accumulation to be managed by periodic use of vacuum trucks. The investigation found that no work request had been put in to repair the auto pump. The investigation also determined that the use of vacuum trucks was not frequent enough to ensure that the lubricant oil was properly removed.

The six Wet Gas Compressors draw wet gas from the same suction header. The #6 Wet Gas Compressor is at the end of the suction header. As previously mentioned, there is a vacuum quill system installed at the end of the suction header near the #6 Wet

Gas compressor to remove accumulated liquid and prevent liquid ingress to the compressor. The investigation found that the vacuum quill system was not sufficiently removing liquid from the suction header. The vacuum quill system outlet was lined up to direct flow overhead to the #5 Gas Plant Accumulator and did not provide sufficient pressure differential to siphon liquid through the quill. The vacuum quill system is a safeguard in the unit PHA to prevent liquid ingress into #6 Wet Gas Compressor.

The investigation also examined the isolation of the leak on the compressor. It was determined that the operators did not have a means to isolate the compressor leak without entering an LEL atmosphere in bunker gear. The isolation valves require manual manipulation and are located close to the compressor.

This investigation reviewed the #4 Gas Unit PHA, SPA, ISS/HCA Study and Corrosion Study (DMR) per CalARP requirements.

Root Causes:

The causal analysis for this incident yielded the following root causes and corrective actions (see table):

Root Cause #1: The valve cap design was antiquated. This particular design is susceptible to failures that can cause the release of process material.

Root Cause #2: The retention bolt installation torque requirement was not properly communicated to maintenance craftsmen.

Root Cause #3: There was no accurate means of setting or monitoring steam flow in the steam injection system.

Root Cause #4: The composition of the wet gas process stream contains vapors at saturation temperature.

Root Cause #5: The 1st stage suction piping to the #6 WGC was not insulated causing potential liquid accumulation with the cooling of the process stream.

Root Cause #6: The automatic pump SE-3872 was not functioning properly to remove excess lubricant oil.

Root Cause #7: The vacuum quill system outlet was lined up to direct flow overhead to the #5 Gas Plant Accumulator and did not provide sufficient pressure differential to siphon liquid through the quill.

Root Cause #8: Operators did not have means to isolate the compressor leak without entering the LEL atmosphere in bunker gear.

Corrective Actions:

	Corrective Actions	Anticipated	Root	ISS/HCA

		Date of Completion	Cause	Level Strategy
1	Procure and install High Security Restraint (HSR) valve caps similar to the other wet gas compressor valve caps. Additionally, add the HSR caps to the equipment's Bill of Materials. (Note: HSR valve caps are an upgrade of the equipment)	7/15/18	1	**Level:** 2nd Order Inherent / Passive **Strategy:** Moderate
2	Conduct a site-wide evaluation of all reciprocating compressors still using the antiquated valve cap design and submit work notifications to upgrade as required.	5/15/18	1	**Level:** Passive **Strategy:** Moderate
3	Perform an engineering analysis of the current retention bolt design. Then, given the evaluation develop a torque target specification to include in the wet gas compressor fastener torqueing document.	Complete	2	**Level:** Procedural **Strategy:** Moderate
4	Develop an action plan to improve the valve cleaner injection system in order to control injection flow and phase.	7/15/18	3	**Level:** 2nd Order Inherent **Strategy:** Moderate
5	Perform an evaluation of the wet gas process stream and its relation to saturation temperature. Develop a solution and submit an engineering request to minimize and monitor condensable carryover to the wet gas compressors.	12/15/18	4	**Level:** Procedural **Strategy:** Moderate
6	Install suction piping insulation to the #6 wet gas compressor as specified in Work Order 10158681	Complete	5	**Level:** Passive **Strategy:** Moderate
7	Submit a work request to repair/replace the autopump SE-3872	Complete	6	**Level:** Procedural **Strategy:** Moderate
8	Develop and implement an alternate option for operators to drain SE-3872 during scenarios when the auto pump is out of service.	12/15/18	6	**Level:** Procedural **Strategy:** Moderate
9	Add the 1" block valve connecting the quill outlet line to V-205B (Knock Out pot) to the locked open valve list.	5/15/18	7	**Level:** Procedural **Strategy:** Simplify

10	Perform a PHA in regards to manual operation of wet gas compressor isolation valves and protection from liquid accumulation in the suction header given the hazard's probability has changed. Consider installation of remotely operated valves.	7/15/18	8	**Level:** Procedural **Strategy:** Moderate