Incident Record

Title: **Fuel Station 1000 bar ASME Vessel PRV Activation and Vent System Failure**
Incident Date: **Fall 2024**
Record Revision Date: **22 August 2025**
Incident Location: **United States**

Description

A bank of eight 1000 bar hydrogen storage vessels located at a private fueling station was being refilled from a compressor. A pressure relief valve (PRV) activated and released hydrogen into the storage system vent stack. During the activation, there was a separation of a 3/4" press-fit joint at the exit of the relief valve which led to deformation of the discharge manifold and a horizontal release into an outdoor open area. The PRV failed to reseat. Emergency responders secured the area and allowed the hydrogen to vent as the system gradually decreased to atmospheric pressure over a period of three days.

There were no injuries. Property damage was limited to the PRV and vent piping network. There was no ignition and approximately 194 kg was released during the incident.

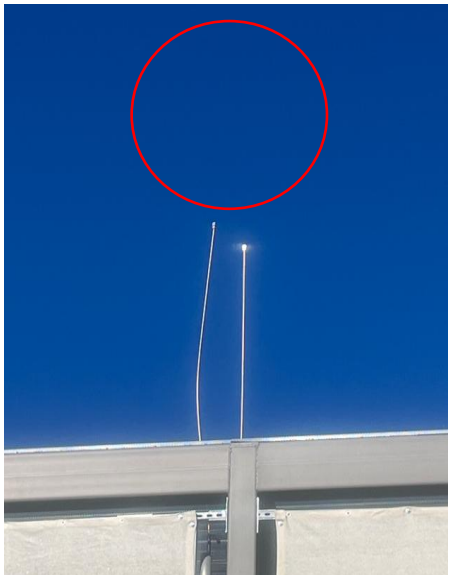
Investigation

The process control system permitted the discharge pressure of the compressor to exceed the set point of the PRV that was protecting the high-pressure storage vessels. This caused the initial activation of the PRV.

The valve was an ASME certified valve designed and built per the ASME Boiler and Pressure Vessel Code (Sec VIII, Division 1). These valves have a "pop action" where they will open quickly to full flow and remain open until a specific "blowdown" pressure is reached. These valves are commonly used to protect ASME pressure vessels from overpressure. However, proper operation is sensitive to the inlet and discharge piping, and the piping must be adequately designed to keep pressure drop within prescribed limits to ensure proper operation. If there is too much pressure drop on either the inlet or the outlet, then the valve is susceptible to opening and closing repeatedly in what is referred to as "valve chatter". Valve chatter creates large hammering forces on the valve internals and the vent system piping and often leads to damage. In this incident, valve chattering caused internal damage to the valve which prevented it from reseating. In addition, valve chattering also contributed to the failure and separation of the press-fit joint.

The investigation observed that a contributing factor to the valve chatter was that the original ¾" diameter X 30' long vent discharge manifold design deviated from the original manufacturer's design of 1½" x 20'. The smaller size and longer length created excessive pressure drop which caused the chattering condition. In addition, the use of an engineered vent stack cap which was not sized properly for the flow rate unintentionally restricted the outlet flow of the PRV. While not confirmed, it is likely that the back-pressure from the small piping and the vent stack cap resulted in exceeding the pressure rating of the fitting at the immediate outlet of the PRV. The combination of the overpressure and the hammering action from the chattering led to the separation of the fitting.

The separation of the fitting resulted in the hydrogen being released in an uncontrolled manner at grade level instead of the intended 30' elevation.



Root Causes

- Repeated high pressure operation of the system exceeded the cracking pressure of the PRV due to overlapping control setpoints.
- Vent discharge piping design (3/4" x 30') deviated from the station OEM design (1½" x 20') and was inadequate to prevent valve chatter.
- PRV internal damage from chattering prevented the valve from reseating or sealing.
- Use of an engineered vent stack vent cap contributed to restricting the flow of released gas from the PRV.
- The vent system design was not adequately designed to withstand the forces from the venting gas pressure and valve chatter.
- The PRV had exceeded its 5-year maintenance recertification interval.

Lessons Learned

- Operating procedures detailing desired operating pressure of the system controls and safety equipment, along with potential deviations and mitigations, were not created.
- PRV inlet piping, discharge piping, and vent design requirements should be in accordance with CGA G-5.5 and CGA S-1.3 per NFPA 2. API 521 should also be referenced as a recommended guideline.
    - Excessive pressure drop on the inlet and outlet piping are proximate causes.
- Appropriate vent discharge topworks should have been sized and implemented instead of the vent cap which served as a flow restrictor.
- Modifications to the vent piping design should have been documented using a Management of Change procedure.
- While not directly pertinent to the incident, the PRV should have been recertified prior to the expiration of its 5-year operating certificate.

Primary reference

This incident was reported by the system owner who requested to remain anonymous.

Secondary reference

This incident was not reported in the media.

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