Explosion Caused by Flashing Liquid in a Process Vessel

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ABSTRACT

An explosion occurred at a polyvinyl chloride resin manufacturing plant. The explosion originated at an atmospheric storage vessel when it received a slurry discharge from a suspension polymerization reactor. The pressure rise caused by the uncontrolled flashing of superheated liquid vinyl chloride resulted in the complete separation of the roof from the tank shell. A cloud of vinyl chloride vapor was released and ignited resulting in a vapor cloud explosion. The accident caused significant property damage but no serious injuries.

An investigation was conducted to determine the causes of the accident. It was discovered that the facility had experienced numerous overpressure incidents in the atmospheric storage vessels used as slurry tanks. Many of these incidents resulted in modest structural damage to these slurry tanks. It was determined by Exponent that the rapid flashing of residual liquid monomer present in the product slurry stream caused the earlier overpressure incidents. The facility operator did not adequately investigate or document these prior overpressure events nor did it communicate their findings to the operating personnel. Thus, the hazard of flashing liquid vinyl chloride was not recognized.

The overpressure protection for the slurry tanks was based on a combination of a venting system and a safety instrumentation system (SIS). The investigation determined that neither the venting system nor the SIS was adequate to protect the slurry tank from the worst credible overpressure scenario. Fundamentally, this is because the performance objectives of the venting system and SIS were not clearly defined and did not protect against the worst credible overpressure scenario.

The lessons learned from this accident include:

- Use prior incident data for recognizing process hazards
- Identify targets vulnerable to these hazards
- Explicitly define performance objectives for safeguards to protect against the worst credible overpressure scenario

The ultimate lesson learned here is that a liquid trapped under pressure above its normal boiling point represents an overpressure hazard. To avoid exceeding the design pressure of the receiving vessel, the superheated liquid must be discharged slowly so that the vapor production rate caused by flashing does not exceed the venting rate of the receiving vessel.