Investigation Update

July 2024

On January 23, 2023, at 8:12 p.m., a reboiler catastrophically ruptured at the Honeywell Performance Materials and Technologies facility in Geismar, Louisiana. The rupture resulted in the release of hydrogen fluoride (HF) gas, chlorine gas, and other process fluids. Honeywell estimated that approximately $4 million of property damage resulted from the incident. No injuries occurred as a result of the release, but a complex-wide shelter-in-place was initiated at the facility. Local officials also closed nearby highways. This document provides an update on the ongoing CSB investigation of this incident.

Background Information

- The Honeywell Performance Materials and Technologies ("Honeywell") facility in Geismar, Louisiana, manufactures refrigerants, among other products. The facility was constructed in 1967 [1] by the Allied Chemical and Dye Corporation. In 1985, Allied merged with Signal Companies and became AlliedSignal, and in 1999, AlliedSignal acquired Honeywell and retained the Honeywell name [2]. The unit involved in the incident began operating in 2003 [3] and manufactures 1,1,1,3,3-Pentafluoropropane, also known as "HFC-245fa."

- As of January 2023, the operation of the Honeywell site involved approximately 300 employees and 300 contractors. At the time of the incident, approximately 40 Honeywell employees and 46 contractors were present on site during the night shift.

- During the incident, after the release caused by the reboiler rupture, a vapor cloud engulfed part of the Honeywell site. The cloud contained anhydrous HF, chlorine, HFC-245fa, and various process intermediates.

- HF is a colorless vapor at atmospheric conditions. When dissolved in water, it is known as hydrofluoric acid. HF is highly toxic,[a] and skin contact with liquid HF or HF acid can result in severe burns, deep tissue and bone damage, and death. If inhaled, HF vapor can cause severe lung injury and death. In the chemical industry, HF is commonly used to produce refrigerants and as an alkylation catalyst in the production of high-octane gasoline at petroleum refineries, among other uses [4, 5].

- Chlorine is a chemical element with many uses in the chemical industry. At atmospheric conditions, chlorine is a vapor with a yellow-green color. Chlorine is highly toxic,[b] and inhalation can result in burning of the nose and mouth, nausea, vomiting, and death [6, 7].

- HFC-245fa is a hydrofluorocarbon compound with the chemical formula $CHF_2CH_2CF_3$. It is sold by Honeywell under the Genetron® [8] and Enovate® [9] brand names as a refrigerant and as a blowing agent for

[a] HF is immediately dangerous to life and health (IDLH) at 30 parts per million (ppm) [4].

[b] Chlorine is IDLH at 10 ppm [6].

sprayed insulation foams, respectively. HFC-245fa, along with other hydrofluorocarbons, was developed in the 1990s as a replacement for ozone-depleting chlorofluorocarbon compounds [10, 11].

- The Honeywell HFC-245fa unit contains a distillation column that includes a kettle-style reboiler. A reboiler is a type of heat exchanger that is used to vaporize and return to the column some or all of the liquid bottoms product within a distillation column. **Figure 1** below shows a simple conceptual diagram of a distillation column with a kettle-style reboiler.

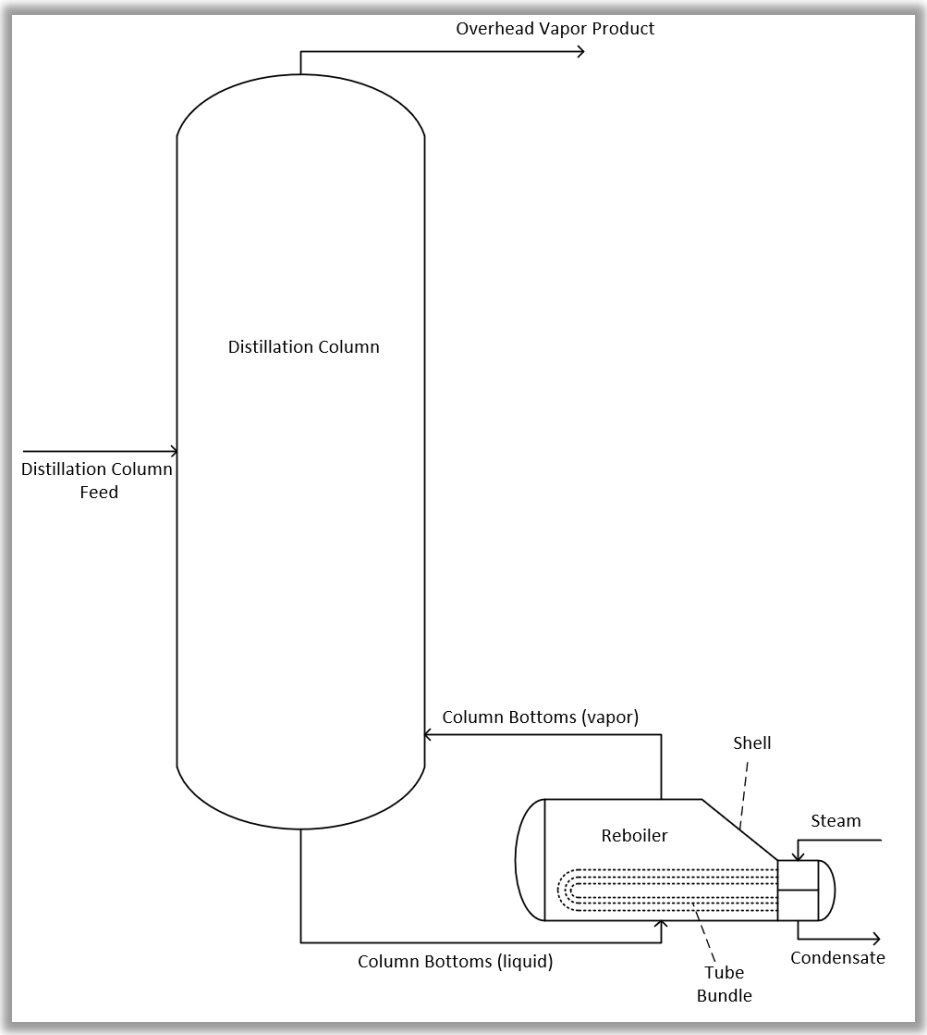

Figure 1. Conceptual diagram of a distillation column and a kettle-style reboiler. (Credit: CSB)

- The reboiler shell normally contained a mixture of HF, HFC-245fa,[a] and smaller fractions of various process intermediates. The exchanger tubes normally contained steam as the heating medium.
- At the time of the incident, the reboiler tube bundle was constructed of Alloy 825[b] and the shell was constructed of SA-516 Grade 70 carbon steel.
- In HF service, carbon steel is subject to uniform corrosion, among other damage mechanisms [12, pp. 10-13]. Uniform corrosion is characterized by thinning taking place relatively evenly over the total surface or a large portion of the total surface of a pipe or vessel [13]. Compared to carbon steel, Alloy 825 provides enhanced resistance to certain damage mechanisms, including HF corrosion [12, p. 8].
- The reboiler was designed according to the 2010 edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1.
- As designed, the shell had a maximum allowable working pressure (MAWP) of 200 pounds per square inch gauge (psig) at a maximum temperature of 300 °F. The shell had a nominal thickness of 0.500 inches with a corrosion allowance of 0.125 inches.
- According to the design documentation, the required thickness (sometimes referred to in industry as the minimum thickness, or "T_{min}") for the reboiler shell ranged from 0.0792 inches to 0.1614 inches depending upon the location. This value is the minimum required thickness for a pressure vessel to safely contain pressure at its specified design conditions in accordance with the ASME BPVC [14, pp. 20-21, 404].
- The site's mechanical integrity records show that Honeywell utilized T_{min} values for the shell ranging from 0.100-0.188 inches depending on the measurement location.
- Honeywell records show that the reboiler shell was last replaced in December of 2012 because HF corrosion had thinned the reboiler shell wall to the point where it required replacement.
- The most recent mechanical integrity inspections of the reboiler prior to the incident were in September 2020 (in which Honeywell used ultrasonic thickness testing), and in October 2021 (in which Honeywell conducted an internal visual inspection of the reboiler).
- Using data from the September 2020 ultrasonic thickness inspection of the reboiler, Honeywell estimated 1.1 years of remaining service life[c] for the reboiler shell. After the October 2021 visual inspection, Honeywell personnel recommended that the shell be replaced at the next shutdown opportunity. Generally, the site had a practice of shutting down the HFC-245fa unit twice per year, once roughly in the spring and once again roughly in the fall of each year.

[a] The reboiler shell typically does not contain substantive amounts of chlorine during normal operation. Chlorine was released during the incident because once the reboiler shell failed, the contents of the distillation column, which normally contains chlorine, were released through the failed exchanger and piping.

[b] Otherwise known as Incolloy 825, or Grade UNS No. N08825

[c] Estimations such as this are typically accomplished by calculating the difference between the current measured thickness and the T_{min} and dividing that difference by a calculated linear corrosion rate.

- In January 2022, Honeywell initiated a project to purchase a replacement reboiler shell. Management approved the project but did not purchase or install a replacement shell before it failed on January 23, 2023.

Incident Description

- At 7:03 p.m. on January 23, 2023, Honeywell began restarting the HFC-245fa unit after the site experienced a utility outage. Operations established feed to the distillation column at 7:16 p.m. At 8:12 p.m., the reboiler shell catastrophically ruptured (**Figure 2**).

Figure 2. Surveillance images immediately before (left) and four seconds after (right) the reboiler rupture. (Credit: Honeywell)

- The process conditions in the reboiler shell at the time of the incident were within the normal as-designed safe operating limits of the reboiler. The temperature and pressure in the reboiler shell at the time of the incident were greater than the fluids' atmospheric boiling points.
- Based upon the temperature and pressure[a] in the reboiler at the time of the failure, a boiling liquid expanding vapor explosion (BLEVE) occurred. The contents of the reboiler, the distillation column, and other ancillary equipment were released into the ambient air.
- In total, the incident resulted in the release of 871 pounds of HF, 1,684 pounds of chlorine, 1,754 pounds of HFC-245fa, and 220 pounds of various process intermediates.
- The release continued from approximately 8:12 p.m. until approximately 9:00 p.m. An "all-clear" signal was given for the industrial complex at 9:15 p.m.

[a] Honeywell asserted that the temperature and pressure in the reboiler at the time of the incident are confidential business information.

- No workers were in the vicinity of the unit at the time of the explosion and thus no injuries occurred as a result of the release. Honeywell procedures require the removal of personnel from the unit during certain phases of operation, including startup.
- The incident caused approximately $4 million in property damage, and the HFC-245fa unit was shut down for approximately 47 days.

Reboiler Shell Failure

- After the incident, Honeywell contracted metallurgical testing and examination of the failed reboiler shell. The examination found that the reboiler shell had severely thinned due to HF corrosion of the carbon steel. Honeywell found at least two locations on the shell to be as thin as 0.03 inches, corresponding to a thickness loss of roughly 95 percent.[a]
- The reboiler shell ruptured into at least nine fragments, which were propelled up to 35 feet away. The largest fragment contained the tube side head, the complete tube bundle, and the eccentric conical section of the shell and is pictured below in **Figure 3**. This fragment was located about 35 feet from the reboiler's original location, and it was the furthest ejected fragment that Honeywell documented. The debris from the explosion was largely contained by the nearby piping and equipment collocated on the same platform as the reboiler.

[a] The T_{min} for both locations was 0.156 inches

Figure 3. Post-incident image showing the remnants of the reboiler. (Credit: Honeywell)

Path Forward

- The CSB is continuing to gather facts and analyze several key areas, including:
    - Honeywell's mechanical integrity policies and practices
    - Honeywell's project management policies and practices
    - Relevant facility, corporate, and industry standards
- The investigation is ongoing. Complete findings, analyses, and recommendations, if appropriate, will be detailed in the CSB's final investigation report.

References

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