U.S. Chemical Safety and Hazard Investigation Board

Three Catastrophic Hydrogen Fluoride Incidents at Honeywell Geismar

Geismar, Louisiana | No. 2023-02-I-LA

Investigation Report

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SAFETY ISSUES:

OCTOBER 21, 2021
GASKET FAILURE; FATALITY
- Technology Change Implementation
- Mechanical Integrity
- Safe Work Practices

JANUARY 23, 2023
HF REBOILER EXPLOSION
- Mechanical Integrity
- Management of Organizational and Personnel Change
- Capital Project Management
- Organizational Resilience

JUNE 7, 2024
HF RELEASE; SERIOUS INJURY
- Safe Work Practices

U.S. Chemical Safety and Hazard Investigation Board

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The October 21, 2021, HF release at the
Honeywell Geismar site fatally injured:

Jason Derousselle

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ABBREVIATIONS

AMPP	Association for Materials Protection and Performance
API	American Petroleum Institute
AR	appropriations request
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
BLEVE	boiling liquid expanding vapor explosion
CCPS	Center for Chemical Process Safety
CSB	U.S. Chemical Safety and Hazard Investigation Board
CSCC	Chloride stress corrosion cracking
EPA	U.S. Environmental Protection Agency
HF	hydrogen fluoride
HFC	hydrofluorocarbon
HFIPI	Hydrogen Fluoride Industry Practices Institute
IDLH	immediately dangerous to life and health
LDAR	Leak Detection and Repair
MAWP	maximum allowable working pressure
MI	mechanical integrity
MOC	management of change
MOOC	management of organizational change
MOPC	management of personnel change
NACE	National Association of Corrosion Engineers
OSHA	U.S. Occupational Safety and Health Administration
P&ID	piping and instrumentation diagram
PPE	personal protective equipment
ppm	parts per million
psig	pounds per square inch gauge
PSM	Process Safety Management
PTFE	polytetrafluoroethylene
RMP	Risk Management Program
SES	Stress Engineering Services Inc.
STAA	safer technologies and alternatives analysis
T_{min}	minimum thickness, or required thickness
TSCA	Toxic Substances Control Act
UT	ultrasonic thickness testing
VT	visual testing

Executive Summary

Within a span of less than three years, from October 2021 to June 2024, toxic anhydrous hydrogen fluoride (HF) was released from process equipment in three separate, serious process safety incidents at the Honeywell Performance Materials and Technologies facility in Geismar, Louisiana. All three incidents occurred in Honeywell Geismar's HFC-245fa unit, which the site refers to as "the 245 unit."

The first incident occurred on October 21, 2021, as Honeywell[a] was attempting to start up a reactor in the 245 unit. A field operator ("Field Operator 1"), who was troubleshooting a no-flow condition to one of the unit's heat exchangers, smelled a leak of HF. He turned and saw a wisping HF leak from a nearby flanged piping connection. Field Operator 1 requested additional help over the radio, and another operator ("Field Operator 2") responded. While the two operators were troubleshooting the leaking flange assembly, the gasket between the flanges suddenly failed catastrophically and released toxic HF toward one of them.

Field Operator 2 was exposed to the release. His personal protective equipment (PPE) was not sufficient to protect against either skin or respiratory exposure to HF. He was transported to a local hospital, where he passed away later that day. Field Operator 1 was unharmed. Thirty-nine pounds of anhydrous HF were released during the incident, and Honeywell reported $14 million in property damage[b] resulting from the incident.

The second incident occurred on January 23, 2023, also during a startup of the 245 unit. The startup proceeded normally, until a reboiler within the unit suddenly exploded, releasing over 800 pounds of anhydrous HF and over 1,600 pounds of toxic chlorine gas. The reboiler had thinned over time due to corrosion and the failure occurred under otherwise normal operating conditions. No personnel were within the unit, and no injuries resulted from the incident. Honeywell reported $4 million in property damage resulting from this incident, and a complex-wide shelter-in-place order was initiated at the facility, which included two neighboring manufacturing companies. Local officials also temporarily closed nearby highways.

The third incident occurred on June 7, 2024.[c] Two contract workers were performing planned maintenance work in the 245 unit. The maintenance work involved opening HF piping to replace gaskets. One of the workers opened a flanged connection that, unknown to the worker or to Honeywell, was not adequately emptied of HF prior to the start of the work. Less than one pound of HF was released. Because the worker expected the piping to be empty, he was wearing the minimum level of PPE required by Honeywell. The worker was exposed to HF on his face and was seriously injured. He spent two days recovering in a local hospital.

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[a] This report uses the terms "Honeywell," "Honeywell Geismar," and occasionally, "Honeywell corporate." "Honeywell Geismar" refers to the site, specifically, and "Honeywell corporate" refers to the corporate entity as distinct from the Geismar site. "Honeywell" is used to refer to the company including the site.

[b] "Property damage" includes loss of use of the property. 40 C.F.R. § 1604.2.

[c] At the time of the October 2021 and January 2023 incidents, the CSB was engaged in eliminating a significant backlog of investigations and did not have the resources to deploy to the incidents. The CSB undertook initial information gathering actions for the first two incidents when they were reported to the CSB in accordance with the agency's Accidental Release Reporting Rule, 40 C.F.R. Part 1604, as well as began developing Incident Reports for them. Once the backlog was eliminated and investigative resources were available, the CSB sent a team to investigate the January 2023 reboiler explosion. When the third incident occurred in June 2024, the CSB investigation team began investigating the first and third incidents in addition to the second.

This document will discuss each of the three incidents separately and will conclude with an analysis of the three incidents together. The first, second, and third incidents are discussed in **Section 2**, **Section 3**, and **Section 4** of this report, respectively. The three incidents are analyzed together in **Section 5**.

SAFETY ISSUES

The U.S. Chemical Safety and Hazard Investigation Board's (CSB) investigations identified the safety issues below.

- **October 2021 Gasket Failure, HF Release, and Fatality:**
  - ***Technology Change Implementation***. Within the first five years of the 245 unit's operation, Honeywell identified corrosion problems with spiral wound gaskets in certain HF services in the unit. Fourteen years prior to the 2021 incident, in 2007, Honeywell identified a new gasket technology and conducted a Management of Change (MOC) analysis, but elected to replace the gaskets within the unit by attrition because the company believed the existing gaskets were appropriate for the process. By 2021, Honeywell had not yet fully implemented the technology change when one of these spiral wound gaskets failed catastrophically and fatally injured a Honeywell operator (Section 2.4.1);
  - ***Mechanical Integrity***. Honeywell inspected the piping segment containing the incident gasket twice within the 36 days prior to the incident. Neither inspection identified any issues with the gasket or flange assembly which Honeywell later concluded were likely already damaged by corrosion at the time of both inspections. Honeywell also did not use available technologies that could have helped its inspectors or operators detect either corrosion damage to the incident flange assembly or the HF leak prior to the incident. Such technologies included HF atmospheric monitors and acid indicating paint, both of which are strongly recommended by industry guidance documents and by Honeywell itself (Section 2.4.2); and
  - ***Safe Work Practices***. On the day of the incident, Honeywell attempted to start up equipment that was not ready for operation. Honeywell's startup attempt, which did not follow its written operating procedures, resulted in a no-flow condition within the unit. Field Operator 1 was troubleshooting the issue when he detected a nearby HF leak from the flange assembly involved in the incident. He summoned Field Operator 2 to assist him in resolving the leak. Neither of the two field operators were wearing adequately protective PPE, and when the gasket in the flange assembly failed, Field Operator 2 was exposed to the released toxic HF and was fatally injured (Section 2.4.3).
- **January 2023 HF Reboiler Explosion:**
  - ***Mechanical Integrity***. Honeywell Geismar ran the incident reboiler to failure four times since commissioning the unit in 2002. Leading up to the 2023 failure, Honeywell inspected the reboiler in October 2021, identified that the shell was nearing its minimum thickness, and initiated a capital project to procure a replacement shell. Honeywell never purchased the replacement shell, however, and the reboiler ran to catastrophic failure in January 2023 (Section 3.3.1);

- ***Management of Organizational and Personnel Change***. Only one employee at the Geismar site had working knowledge of the reboiler's condition—the 245 unit maintenance engineer, who also had responsibility for the capital project to replace the reboiler shell. After this engineer left the company in April 2022, Honeywell never reassigned the capital project to another employee. Honeywell had an existing, applicable management system entitled "Management of Organizational Change" (MOOC) that should have ensured that the maintenance engineer's key safety tasks, including the reboiler project, were accounted for and reassigned, but Honeywell did not apply the MOOC procedure in this case. Honeywell also failed to apply its MOOC processes to other significant organizational changes at the Geismar site in the years leading up to the 2023 reboiler explosion (Section 3.3.2);

- ***Capital Project Management***. Honeywell had two primary philosophies for managing capital expenditure requests and projects. Larger, more complex, and more expensive projects were handled through the company's annual and forward-looking capital expenditure budgeting process. Less expensive, less complex, though still important projects were managed and funded through what was supposed to be a faster and less administratively complex process. The project to replace the reboiler shell was approved for the faster management path and should have been funded shortly thereafter, but it was never funded. At the same time, however, the site chose to fund other projects that were either unprioritized or rated with lower priority than the reboiler shell replacement (Section 3.3.3); and

- ***Organizational Resilience***. After the October 2021 fatal incident, several adverse conditions combined to cause significant disruption to Honeywell Geismar's normal business and safety management systems. After that incident, the site focused on returning the 245 unit to safe operation. According to Honeywell personnel, this effort consumed nearly all the site's attention, manpower, and resources for several months following the October 2021 incident. Honeywell's approach to addressing the causes of the 2021 incident may have caused it to miss the conditions, disruptions, and safety management system implementation gaps that led to the reboiler explosion (Section 3.3.4).

- **June 2024 HF Release and Serious Injury:**

  - ***Safe Work Practices***. Honeywell did not adequately prepare the HF piping for maintenance, leaving a small amount of HF trapped between the incident valve plug and blind flange. Also, in the field, neither Honeywell nor personnel who worked for Honeywell's contractor, Turner Industries Group ("Turner"), identified or resolved the hazard of the closed and therefore potentially HF containing valve (Section 4.3.1).

- **Common Factors:**

  - ***Safety Management Systems Implementation and Auditing***. The three incidents at the Honeywell Geismar site revealed systemic issues with Honeywell's implementation of and adherence to its own safety management systems. Honeywell's existing safety management systems could have and should have prevented all three incidents (Section 5.1).

CAUSES

2021 Gasket Failure, Toxic HF Release, and Fatality Cause

The CSB determined that the cause of the HF release was the failure of a flanged piping connection. The gasket within the connection had deteriorated from stress corrosion cracking, and the flange assembly was likely loosened because its fastening studs were thinned from wet HF acid corrosion, resulting in the release.

Honeywell's systems for mechanical integrity, change management, and process knowledge management contributed to the incident. Honeywell's mechanical integrity systems did not identify and replace the corroded gasket prior to its failure, and its change management and process knowledge management systems allowed Honeywell to not fully implement a 2007 gasket technology change that could have prevented the gasket corrosion.

Honeywell's ineffective safe work practices contributed to the severity of the incident. Honeywell did not follow its written unit startup procedures, which caused the fatally injured operator to be in the immediate vicinity of the incident gasket. The use of inadequate personal protective equipment resulted in the operator's fatal exposure to the released toxic HF.

2023 HF Reboiler Explosion Cause

The CSB determined that the cause of the accidental release of toxic HF and chlorine was the catastrophic failure of a reboiler. The reboiler had thinned due to HF corrosion of its carbon steel shell to the point that it could no longer contain its normal operating pressure.

Contributing to the incident were Honeywell's ineffective implementation of its safety management systems for 1) mechanical integrity, 2) personnel and organizational change, and 3) capital projects. Honeywell's incomplete implementation of its organizational resilience policies and procedures, which could have enabled Honeywell to identify instability in its other management systems, also contributed to the incident.

2024 Toxic HF Release and Serious Injury Cause

The CSB determined that the cause of the accidental HF release was the partial removal of a blind flange from a valve that contained pressurized HF during a maintenance activity. Honeywell did not effectively remove all HF from the valve before turning it over to contract workers for maintenance.

Contributing to the incident were Honeywell's and Turner's ineffective implementation of safe work practices including hazard identification and mitigation.

RECOMMENDATIONS

Previously Issued Recommendations Superseded in This Report

To the U.S. Environmental Protection Agency (EPA)

2019-04-I-PA-R3 (From the CSB's Philadelphia Energy Solutions report; 2019-04-I-PA)

Per the requirements in EPA Rule *Procedures for Prioritization of Chemicals for Risk Evaluation Under the Toxic Substances Control Act*, initiate prioritization to evaluate whether hydrofluoric acid is a High-Priority Substance for risk evaluation. If it is determined to be a High-Priority Substance, conduct a risk evaluation of hydrofluoric acid to determine whether it presents an unreasonable risk of injury to health or the environment. If it is determined to present an unreasonable risk of injury to health or the environment, apply requirements to hydrofluoric acid to the extent necessary to eliminate or significantly mitigate the risk, for example by using a methodology such as the hierarchy of controls.

(Superseded by ***2023-02-I-LA-R4*** *to the EPA below)*

Previously Issued Recommendations Reiterated in This Report

To the U.S. Occupational Safety and Health Administration (OSHA)

2005-04-I-TX-R9 (from the CSB's BP Texas City report; 2005-04-I-TX)

Amend the OSHA PSM standard to require that a management of change (MOC) review be conducted for organizational changes that may impact process safety including:

a. major organizational changes such as mergers, acquisitions, or reorganizations;

b. personnel changes, including changes in staffing levels or staff experience; and

c. policy changes such as budget cutting.

New Recommendations

To Honeywell International Inc.

2023-02-I-LA-R1

Perform a comprehensive third-party audit of the Geismar facility's process safety and allied management systems as soon as practicable. The audit shall:

A. Be performed or led by an individual, firm, or team meeting the requirements outlined in paragraphs (b), (c), and (d) of Appendix E of this report.

B. Evaluate compliance with applicable federal standards (40 C.F.R. § 68 and 29 C.F.R. § 1910.119). In particular, the audit shall include the required elements that contributed to these incidents, including but not limited to:

   1. management of change;
   2. mechanical integrity;
   3. quality assurance;
   4. pre-startup safety reviews;
   5. operating procedures; and
   6. contractor management.

C. Evaluate other internal management systems that contributed to these incidents. In particular, the audit shall include but not be limited to:

   1. management of organizational and personnel change;
   2. management of safety-related capital projects;
   3. organizational resilience; and
   4. safe work practices including but not limited to:
      a. work permitting;
      b. preparation of equipment for maintenance;
      c. control of hazardous energy;
      d. line break safety; and
      e. personal protective equipment.

D. Use the Center for Chemical Process Safety's *Guidelines for Auditing Process Safety Management Systems* as guidance to verify both the suitability of these systems and their effective, consistent implementation and performance.

E. Result in the development of a comprehensive report meeting the requirements outlined in paragraphs (e) and (f) of Appendix E of this report. If any findings are rejected, the rationale for and documentation supporting the merit of the rejection shall be included. The report in its entirety shall be made available to the Honeywell workforce at the Geismar, Louisiana; Baton Rouge, Louisiana; and Metropolis, Illinois, sites.

2023-02-I-LA-R2

Require periodic reporting updates from the Geismar site regarding the closure of the audit findings. The periodic updates shall continue until all audit findings are fully closed.

2023-02-I-LA-R3

Perform a Safer Technologies and Alternatives Analysis (STAA) for the Honeywell Geismar HFC-245fa unit. The STAA shall meet the requirements outlined in paragraphs (a) and (b) of Appendix F of this report.

To the U.S. Environmental Protection Agency (EPA)

2023-02-I-LA-R4

Per the requirements in EPA Rule *Procedures for Prioritization of Chemicals for Risk Evaluation Under the Toxic Substances Control Act*, initiate prioritization to evaluate whether hydrogen fluoride, including its anhydrous and aqueous acid forms, is a High-Priority Substance for risk evaluation. If it is determined to be a High-Priority Substance, conduct a risk evaluation of hydrogen fluoride to determine whether it presents an unreasonable risk of injury to health or the environment. If it is determined to present an unreasonable risk of injury to health or the environment, apply requirements to hydrogen fluoride to the extent necessary to eliminate or significantly mitigate the risk, for example by using a methodology such as the hierarchy of controls.

(Supersedes **2019-04-I-PA-R3** *from the Philadelphia Energy Solutions Report)*

1 BACKGROUND

1.1 HONEYWELL GEISMAR

The Honeywell Performance Materials and Technologies (Honeywell) facility in Geismar, Louisiana ("the facility"), manufactures refrigerants, among other products. The facility is located within a larger complex that hosts other companies operating immediately adjacent to the Honeywell facility, including Nova Chemicals (formerly Williams Olefins[a]) and a Nutrien facility that produces various fertilizer 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 elected to operate under the Honeywell name [2].[b] All three incidents discussed in this report occurred in the same unit, which began operations in 2002 and manufactures 1,1,1,3,3-Pentafluoropropane, also known as "HFC-245fa."[c] Honeywell personnel refer to the unit as "the 245 unit."

In January 2023, the operation of the Honeywell Geismar site involved approximately 300 employees and 300 contractors. For its use of hydrogen fluoride (HF) and other regulated chemicals[d] in excess of the threshold quantities, the 245 unit, as well as other units on-site, is subject to the U.S. Occupational Safety and Health Administration's (OSHA) Process Safety Management (PSM) and the U.S. Environmental Protection Agency's (EPA) Risk Management Program (RMP) regulations. According to its 2022 RMP filing, the Geismar facility handles tens of millions of pounds of HF across its units, the vast majority of which is within the site's HF production unit. The Honeywell Geismar site is a major supplier of HF

In its RMP filings, the company states that:

> Honeywell participates in the Responsible Care program of the American Chemistry Council. Established in 1988, Responsible Care is a voluntary program focused on achieving improvements in environmental, health and safety performance beyond levels required by the U.S. government.

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[a] The Williams Olefins facility experienced a catastrophic explosion and fire in 2013, which the CSB investigated. See the CSB report here: [Williams Olefins Plant Explosion and Fire | CSB]

[b] As of the publication of this report, the Geismar facility is owned and operated by Honeywell. In October 2024, Honeywell announced its plans to spin off its Advanced Materials business unit, which includes the Geismar facility, into a separate, independent company. The spinoff is planned to occur "by the end of 2025 or early 2026" [49]. In March 2025, Honeywell announced that the new company would be named Solstice Advanced Materials [51].

[c] Refrigerant nomenclature is designated by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 34, *Designation and Safety Classification of Refrigerants.*

[d] The Geismar site also handles oleum, chlorine, hydrogen chloride, trifluorochloroethylene, boron trifluoride, vinylidene fluoride, and chloroform, all of which are regulated by RMP.

1.2 Materials Involved in the Incidents

The October 2021 and June 2024 incidents involved the release of anhydrous HF. The January 2023 incident resulted in the release of a vapor cloud that contained anhydrous HF, chlorine, HFC-245fa, and various other process intermediates.

Hydrogen Fluoride

Anhydrous HF is a colorless vapor at atmospheric conditions.[a] When dissolved in water, it is known as hydrofluoric acid, or HF acid.[b] HF and HF acid present similar hazards. HF is immediately dangerous to life and health (IDLH) at 30 parts per million (ppm) [3]. Skin contact with anhydrous 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 [3, 4]. HF is commonly used to produce refrigerants and fluoropolymers at chemical facilities and as an alkylation catalyst in the production of high-octane gasoline at petroleum refineries, among other uses. To varying degrees, both HF acid and anhydrous HF (in both liquid and vapor states) are corrosive to many metals and metal alloys [5].

Chlorine

Chlorine is a chemical with many uses in the chemical industry. At atmospheric conditions, chlorine is a vapor. Chlorine is IDLH at 10 ppm [6], and inhalation can result in burning of the nose and mouth, nausea, vomiting, pulmonary edema, and death [6, 7]. In austenitic stainless steels (such as 304 or 316 stainless steel), chlorine and chloride compounds can cause a type of corrosion called chloride stress corrosion cracking (CSCC) [8, 9].

HFC-245fa

HFC-245fa is a hydrofluorocarbon (HFC) compound with the chemical formula $CF_3CH_2CHF_2$. Honeywell sells HFC-245fa under the Genetron® [10] and Enovate® [11] brand names as a refrigerant and as a blowing agent for sprayed insulation foams, respectively. HFC-245fa, along with other HFCs, was developed in the 1990s as a replacement for ozone-depleting chlorofluorocarbon compounds [12, 13].

According to Honeywell's safety data sheet for the material, at atmospheric temperature and pressure, HFC-245fa is not flammable. Under certain temperature and pressure conditions, HFC-245fa can be flammable when mixed with air or oxygen. It is a vapor at atmospheric conditions, is heavier than air, and can cause asphyxiation by displacing the oxygen in the area of a release. Under certain conditions, HFC-245fa can decompose and produce hazardous gases.

[a] The atmospheric boiling point of HF is 67.1 °F.

[b] All three incidents discussed in this report involved the release of anhydrous HF, that is, 100% HF with no water content.

1.3 Description of Surrounding Area

Figure 1 shows the Honeywell Geismar facility and depicts the areas within approximately one, three, and five miles of the facility boundary. Summarized demographic data for the surrounding vicinity in an approximately one-mile radius of the Honeywell Geismar facility are shown below in **Table 1**. There are over 13,104 people residing in over 4,672 housing units, most of which are single units, within the census blocks within one mile of the Honeywell Geismar facility. The area within a one-mile radius is predominantly industrial and not residential. Detailed demographic information is included in Appendix D.

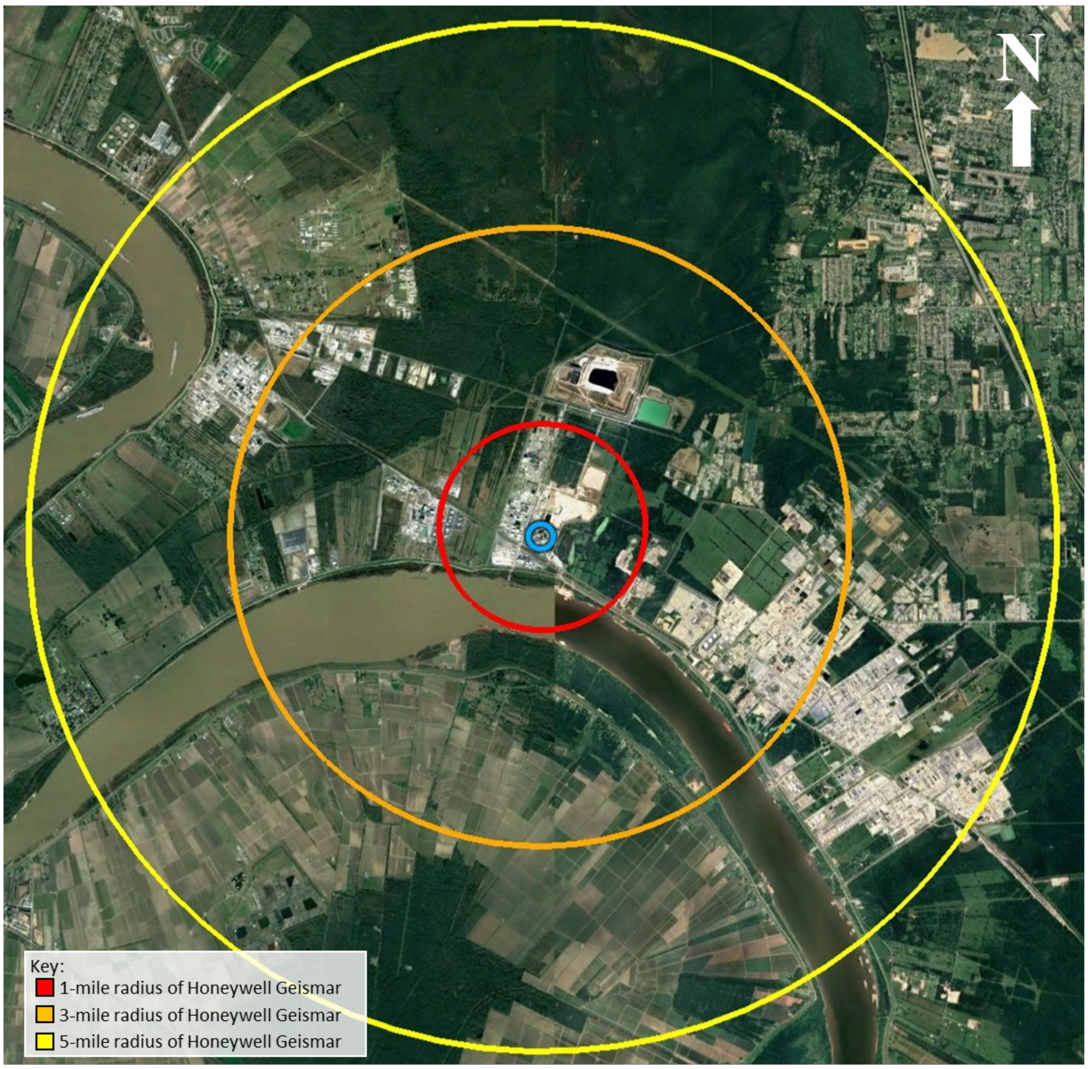

Figure 1. Overhead satellite image of the Honeywell Geismar facility and the surrounding area. (Credit: Google Earth, annotated by CSB)

Table 1. Summarized demographic data for the approximately one-mile vicinity of the Honeywell Geismar facility[a] (Credit: CSB using data obtained from Census Reporter)

Population	Race and Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Housing Units	
13,104	White	50%	$ 40,326	7%	4,672	Single Unit	78.2%
	Black	42%				Multi-Unit	7.6%
	Native	0%				Mobile Home	13.7%
	Asian	0%				Boat, RV, Van, etc.	0.5%
	Islander	0%					
	Other	1%					
	Two+	3%					
	Hispanic	4%					

[a] The Census Bureau reports that Louisiana's overall per capita income was $32,171 and that the overall per capita income for the United States was $41,804 [42].

2 GASKET FAILURE, TOXIC HF RELEASE, AND FATALITY – OCTOBER 2021

2.1 BACKGROUND

2.1.1 REACTOR HF FEED STATIONS

Honeywell's 245 unit contained multiple reactors, which were labeled alphabetically. HFC-245fa was produced by reacting HF with other materials in the reactors. Each reactor had an HF feed system that supplied the reactor with HF for the reaction.

Each reactor's HF feed system contained three "feed stations," each of which consisted of a series of manual valves, a control valve, a flowmeter, and other associated equipment. A simplified diagram of the feed stations and the HF vaporizer is shown in **Figure 2**. The three feed stations were denoted as "fresh HF," "recovered HF," and "recycle HF." The fresh HF stream was supplied by the Geismar site's HF production unit, and the recovered and recycled HF streams returned unreacted HF from other parts of the 245 process back to the beginning of the process.

Downstream of the three feed stations, the three separate HF streams combined and then flowed into a heat exchanger called the "vaporizer" which vaporized the liquid HF feed to the reactors. Each of the vaporizers was equipped with a manually operated block valve on the HF inlet piping. This incident occurred on the D reactor recycle HF feed station, which was located on the fifth deck of a structure that supported the reactors and other unit equipment. A photo of the feed stations is shown in **Figure 3**.

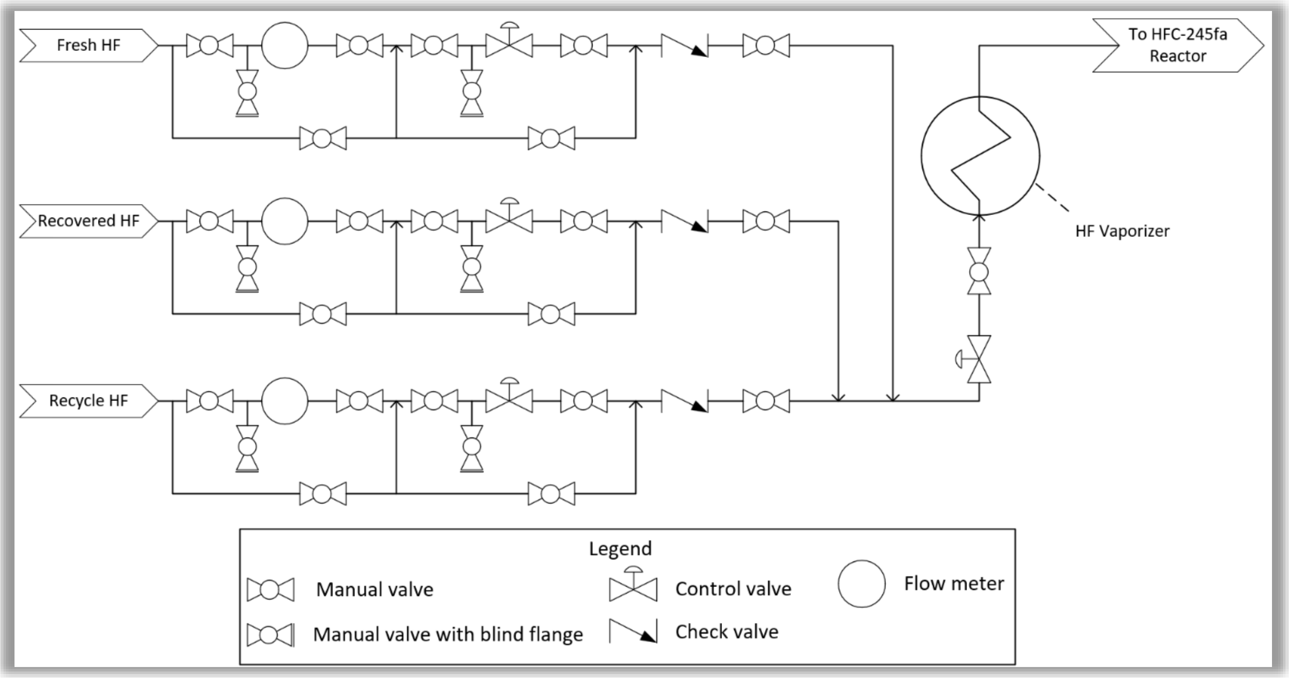

Figure 2. Simplified diagram of the 245 unit D reactor HF feed stations and vaporizer. (Credit: CSB)

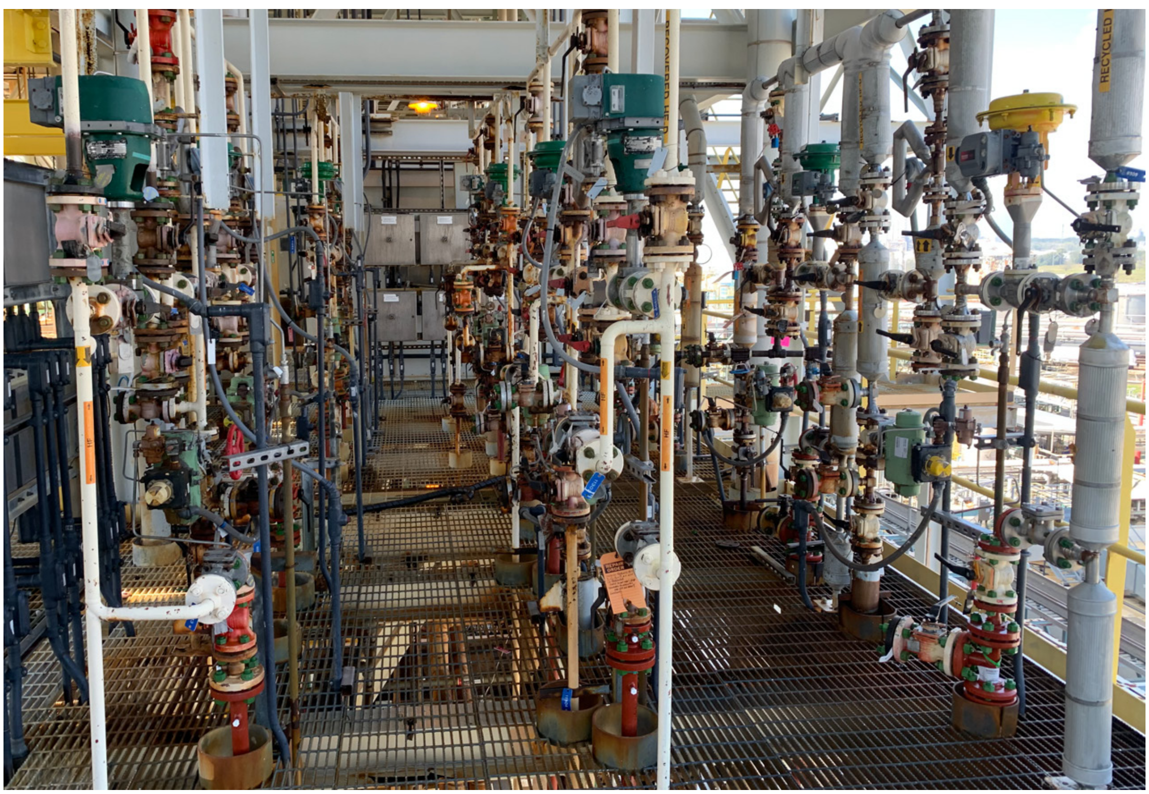

Figure 3. Photo of the D reactor Fresh HF (left), Recovered HF (center), and Recycle HF (right) feed stations.[a] (Credit: CSB)

[a] Figure 3 shows the locations of both the 2021 and 2024 incidents. The 2021 incident occurred on the D reactor recycled HF feed station, shown on the right of Figure 3. The 2024 incident occurred on the D reactor fresh HF feed station, shown on the left of Figure 3.

2.1.2 Personal Protective Equipment

Honeywell Geismar used a Personal Protective Equipment (PPE) matrix, an excerpt of which is shown below in **Figure 4** to specify differing levels of PPE required for various routine and non-routine tasks involving HF.

PLANT PPE MATRIX - MINIMUM Level of Personal Protective Equipment Requirements for Anhydrous HF and Aqueous solutions 50% and greater

NOTE: Sites may choose to wear a higher level of protection beyond that which is required

Protective Equipment

	HF Level A [5]	HF Level B	HF Level C	"Stepped Down C"	HF Level D
Suit/Clothing	Totally-encapsulating HF-resistant suit	Hooded HF-resistant chemical PPE	Hooded HF-resistant chemical PPE	HF-resistant chemical PPE	Long Sleeve Shirt/ Long Pants or Coveralls
Eye/Face and Respiratory Protection (All respiratory protection shall be NIOSH/equivalent approved)	Pressure-demand or other positive pressure mode (e.g., open/closed circuit) full-facepiece supplied air respirator with escape bottle.	[1] Pressure-demand or other positive pressure mode (e.g., open/closed circuit) full-facepiece supplied air respirator with escape bottle.	[1,2] Full facepiece Air Purifying Respirator with cartridges/canisters approved for HF. (Includes PAPRs with full facepiece, hood or helmet)	Goggles and face shield.	Safety Glasses minimum. Face shield an/or goggles as required by PPE Hazard Assessment.
Head Protection (All hard hats used shall be ANSI/equivalent approved)	Hard Hat under suit as required by PPE Hazard Assessment	Hard Hat as required by PPE Hazard Assessment	Hard Hat as required by PPE Hazard Assessment	Hard Hat as required by PPE Hazard Assessment - or - Hard Hat with wrap around cape	Hard Hat as required by PPE Hazard Assessment
Hand Protection	HF-Resistant inner gloves (HFIPI) and HF-Resistant outer gloves	HF-Resistant inner gloves (HFIPI) and HF-Resistant outer gloves	HF-Resistant inner gloves (HFIPI) and HF-Resistant outer gloves	HF-Resistant inner gloves (HFIPI) and HF-Resistant outer gloves	HF-Resistant gloves as required by PPE Hazard Assessment
Foot Protection	HF-Resistant boots, with safety toe and shank	HF-Resistant boots, with safety toe and shank	HF-Resistant boots or shoe covers over safety shoes	HF-Resistant boots or shoe covers over safety shoes	Safety shoes/boots

Figure 4. Excerpt of Honeywell's October 2021 HF PPE matrix. (Credit: Honeywell)

At the time of the 2021 incident, for routine operations such as operator rounds, Honeywell required its employees to wear Level D PPE, the least protective level of PPE prescribed in Honeywell's matrix. For other, more hazardous operations, such as leaks and releases, Honeywell required more protective levels of PPE.

2.1.3 Spiral Wound Gaskets

Spiral wound gaskets are a type of gasket used to seal piping flange faces to prevent process fluid from leaking out. Spiral wound gaskets consist of a V-shaped metal strip wound into a spiral, with a filler material inlaid between the laps (**Figure 5**).

While the filler material serves as the sealing medium, the spiral wound metal strip provides structural support to the filler. Often, the metal strip is formed from stainless steel or other alloys, and the filler material is commonly composed of materials such as graphite or PTFE.[a] However, the materials must be appropriately selected for compatibility with the process fluid and the operating conditions of the process [14, pp. 19-20].

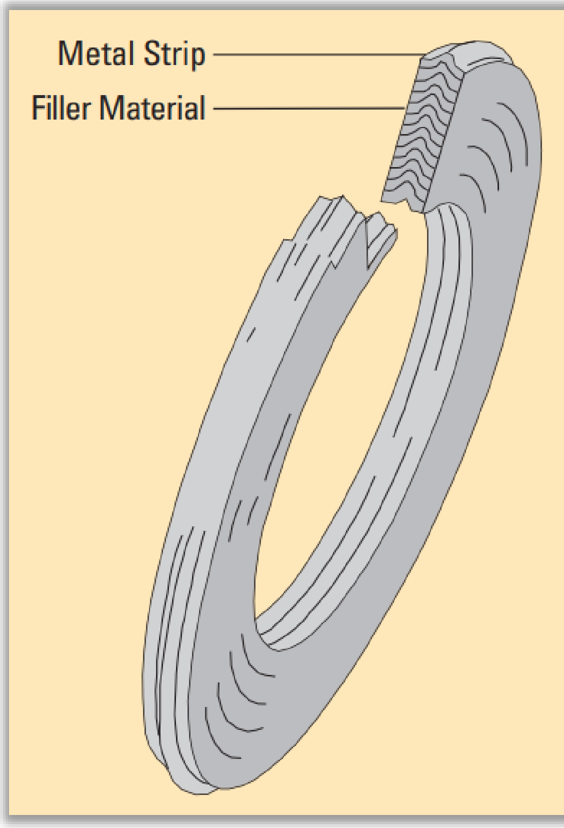

Figure 5. Diagram of a spiral wound gasket. (Credit: Flexitallic [43])

[a] PTFE is polytetrafluoroethylene, often referred to by its original trade name, Teflon.

2.2 Incident Description

On the morning of October 21, 2021, Honeywell was starting up portions of the 245 unit after a planned maintenance outage. The Board Operator had already placed reactors A and C in service and was attempting to start up reactor D, which involved charging the system with fresh HF. At this point in the reactor D startup, Honeywell intended to have flow through the fresh HF feed station but not through the recovered or recycle HF feed stations.

The Board Operator was unable to achieve fresh HF flow to the D reactor vaporizer and requested assistance from field operators. Field Operator 1 responded and proceeded to the D reactor fresh HF feed station.

After the Board Operator (from the control room) and Field Operator 1 made various unsuccessful operational moves at the fresh HF feed station to attempt to resolve the no-flow condition to the vaporizer, the Board Operator requested that Field Operator 1 check the alignment of the manual block valve on the combined HF feed to the vaporizer. Unbeknownst to either the Board Operator or Field Operator 1, the manual block valve immediately upstream of the vaporizer was closed because reactor D had not been made ready to return to service[a] (**Figure 6**).

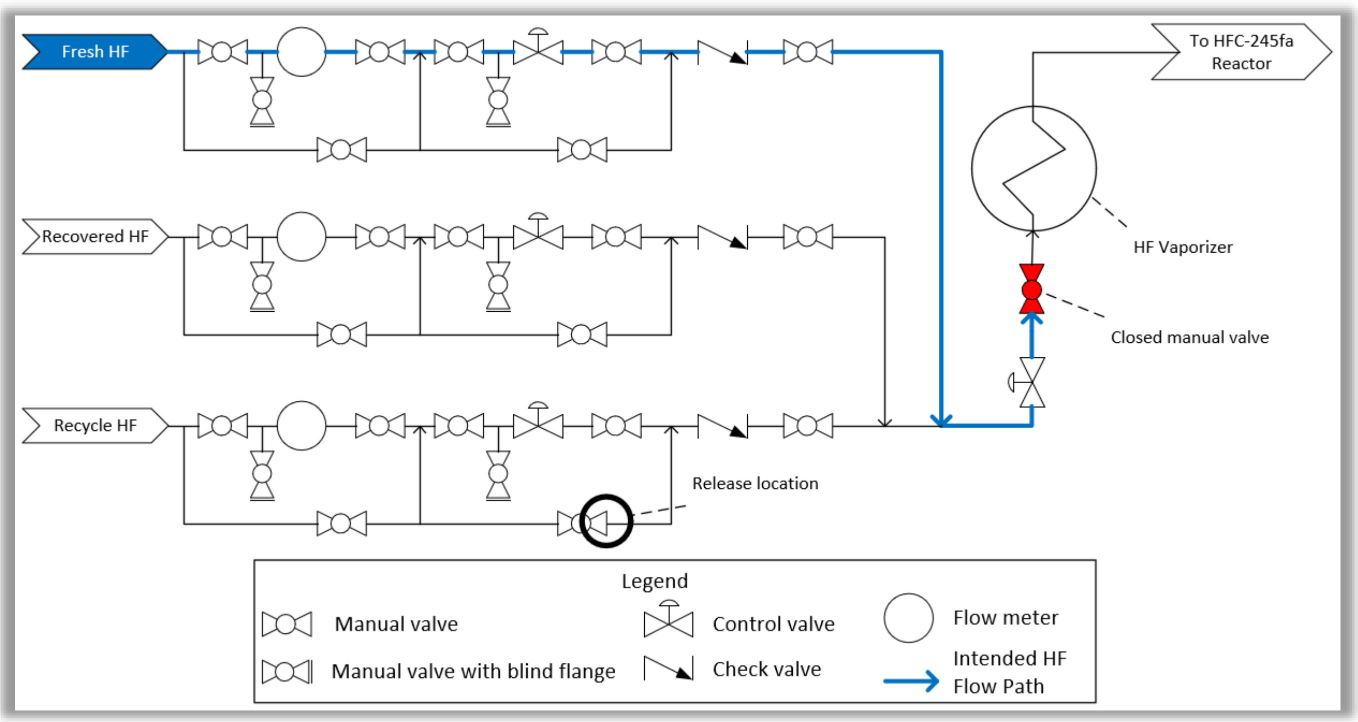

Figure 6. Intended flow path of HF during the attempted startup of HFC-245fa reactor D. (Credit: CSB)

Before moving to check the manual block valve, Field Operator 1 smelled HF coming from behind him. He turned and saw a wisping leak from one of the flanged connections of a bypass valve at the D reactor recycle HF feed station. Field Operator 1 then radioed for assistance. Field Operators 2 and 3 acknowledged over the radio,

[a] Additional detail can be found in **Section 2.4.3.1**.

and Field Operator 2 arrived to assist Field Operator 1. Field Operators 1 and 2 were both wearing Level D PPE (**Figure 4**), the least protective level prescribed by Honeywell.[a]

From roughly six to eight feet away, Field Operators 1 and 2 visually observed the leaking flange. They considered tightening the flange fasteners to attempt to stop the leak. According to statements Field Operator 1 made to the Honeywell incident investigation team, the operators decided against doing so because they observed that the fastening studs were visibly damaged from corrosion and exhibited an "hourglassed" shape between the flange faces (**Figure 7**).

At this point in the startup, the recycle HF feed station should not have been pressurized, and there should have been no HF flow to this feed station. Assuming that the HF was flowing from the upstream direction, Field Operator 1 went to check an upstream block valve to ensure that it was closed. The operators were unaware that HF was backflowing from the downstream direction because of the closed valve on the HF inlet to the vaporizer (**Figure 8**).

Figure 7. Photo of the flange assembly as found after the incident, showing the stud corrosion observed by the field operators prior to the release. (Credit: Honeywell, annotated by CSB)

[a] The Board Operator told the Honeywell incident investigation team that he instructed Field Operators 1 and 2 to "get away from it and go get a suit." Another field operator (Field Operator 5) told the Honeywell investigation team that he recalled hearing the Board Operator tell Field Operators 1 and 2 "this is not urgent, get your suit to address." Field Operator 3 told the Honeywell investigation team that he heard the Board Operator "ask if they needed their suit[s]." The CSB did not independently verify these statements. According to the Honeywell investigation team's notes from their interview with Field Operator 1, Field Operator 1 did not mention any discussion of additional PPE.

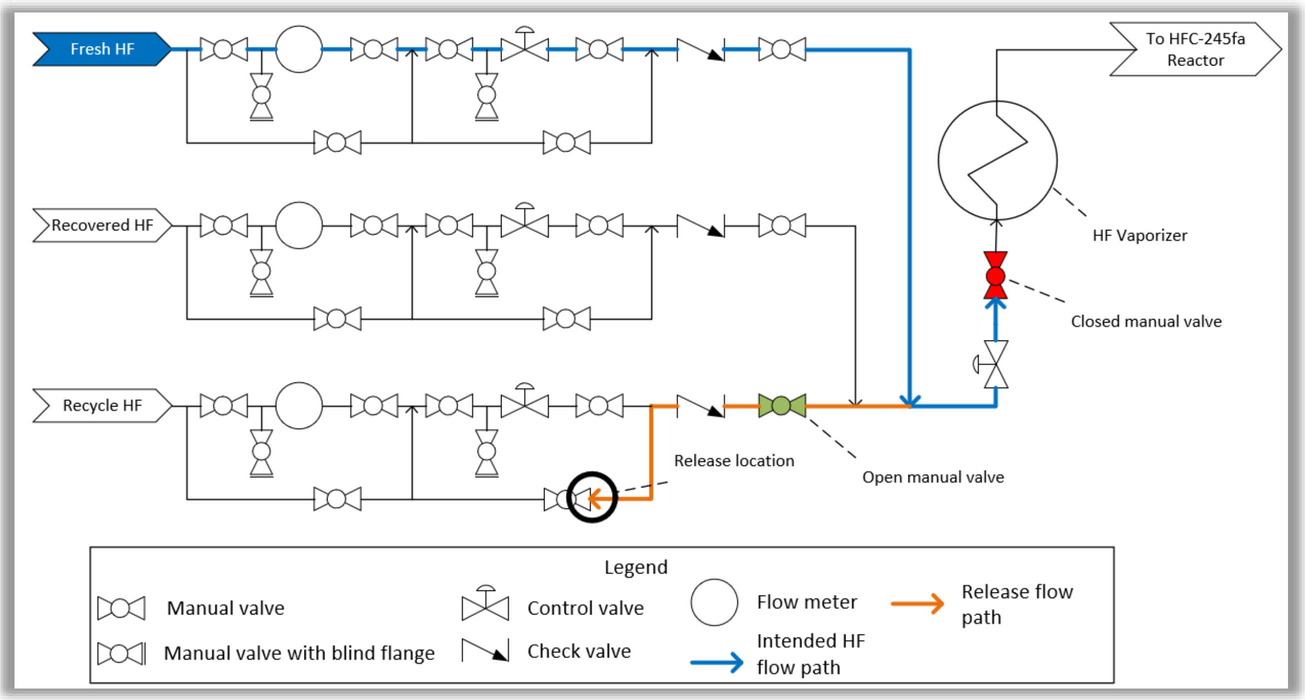

Figure 8. Simplified diagram showing the release flow path during the incident. (Credit: CSB)

Field Operator 2 remained near the leaking flange. After Field Operator 1 left the immediate vicinity, the wisping leak suddenly worsened, and HF began spraying from the flange. Field Operator 2 was exposed to the release of the toxic HF on his face, ear, and neck. Field Operator 1 heard Field Operator 2 scream, and he returned to where Field Operator 2 was located. Field Operator 1 escorted Field Operator 2 to an area safety shower away from the HF plume.

At 10:50 a.m., Field Operator 1 reported the HF leak and the injury and summoned site emergency responders. At 10:54 a.m., site medical responders arrived and began treating Field Operator 2. At 11:05 a.m., Honeywell summoned a third-party ambulance service to the facility to transport Field Operator 2 to the hospital. Field Operators 3 and 4 subsequently arrived wearing Level C PPE (**Figure 4**). At 11:07 a.m., Field Operators 3 and 4 closed the manual valve downstream of the recycle HF feed station (labelled "open manual valve" in **Figure 8**), and the leak stopped. At 11:10 a.m., site medical responders began transporting Field Operator 2 out of the 245 unit to the Honeywell administration building for ambulance transport. The ambulance arrived at the facility at 11:30 a.m. and departed for Baton Rouge General Hospital at 11:41 a.m. Field Operator 2 was alert and responsive when he departed the site via ambulance but died later that day at the hospital. Approximately 39 pounds of 100% anhydrous HF were released during the incident.

2.3 Technical Analysis

No Flow to Vaporizer

Honeywell investigated the incident and found that the cause of the no-flow condition to the D reactor vaporizer was a closed manual block valve immediately upstream of the vaporizer; the same valve that the Board Operator had asked Field Operator 1 to check before Field Operator 1 detected the HF leak from the recycle HF feed station. Honeywell isolated the vaporizer in preparation for the planned outage, but the vaporizer was never placed back into service prior to the startup. The valve was found locked closed. Honeywell determined that the closed manual valve caused the fresh HF to backflow into the recycle HF feed station through an open manual valve and a check valve[a] to the release point (**Figure 8**).[b]

Flange Assembly Failure

The release was caused by the failure of a spiral wound gasket.[c] The gasket was constructed with 304 stainless steel windings and graphite filler, which, according to Honeywell, was appropriate for the process material and conditions. A photo of the remnants of the failed gasket is shown in **Figure 9**.

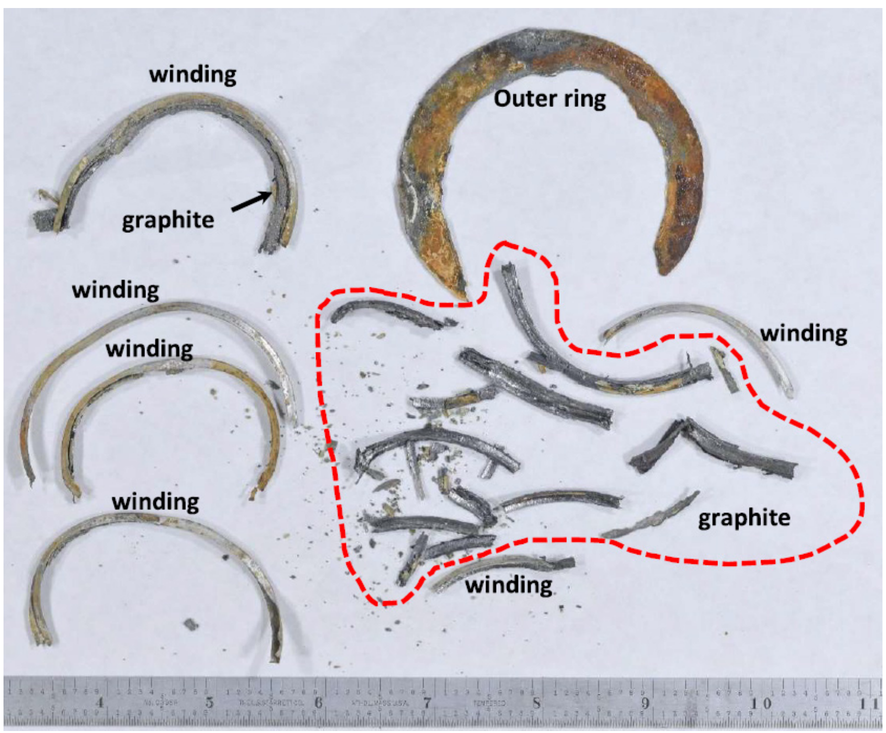

Figure 9. Photo of the failed spiral wound gasket remnants. (Credit: Honeywell via Stress Engineering Services, annotated by SES)

[a] Honeywell investigated the check valve and concluded that it failed to properly seal, allowing backflow from the downstream direction.

[b] A check valve is a type of valve that is intended and designed to allow flow in only one direction. If a check valve fails, it can allow flow in the opposite direction.

[c] Discussed below in **Section 2.4.3.1**, the no-flow condition to the vaporizer was not causal to the gasket failure. The gasket would likely have failed in the same manner regardless of the flow direction through the flange assembly. Instead, the gasket leak was causal to the two operators' presence in the field in the vicinity of the gasket when it catastrophically failed.

The fastening studs were constructed of A193 Grade B7M and had a nominal diameter of 0.50 inches. After the incident, Honeywell contracted Stress Engineering Services ("SES") to conduct metallurgical examination of the flange assembly, including the gasket and fasteners. SES measured diameter loss between 0.020 and 0.060 inches among the fastening studs installed in the incident flange. A picture of one of the corroded fastening studs is shown in **Figure 10**.

Figure 10. Post-incident examination photo of a corroded stud installed in the incident flange. (Credit: SES)

Among numerous other details, SES reported the following to Honeywell:

- The corrosion damage exhibited by the sealing faces of the incident flange, and the four fastening studs was the result of HF acid corrosion. Normally, the recycle HF and fresh HF process streams did not contain aqueous HF acid. SES concluded that the corrosion likely resulted from anhydrous HF leaking from the flange over time and mixing with ambient humidity to form aqueous HF acid.

- The degradation of the fastening studs likely resulted in a loss of sealing force, which likely led to relaxation of the flanged connection.

- SES found stress corrosion cracking in the 304 stainless steel windings of the incident gasket as well as several other nominally identical gaskets installed in other flanges in the same service of the 245 unit.[a]

[a] SES found metallurgical conditions in the incident gasket that suggest the gasket may have been susceptible to hydrogen embrittlement. Austenitic stainless steel is not normally susceptible to this failure mode. Chlorine was also found in the graphite filler of the incident gasket, which could have resulted in chloride stress corrosion cracking (CSCC). Hydrogen embrittlement can cause brittle failure in metal and could have been the reason that this gasket failed catastrophically, rather than simply leaked. Honeywell attributed this finding to a manufacturing defect in the gasket. The SES metallurgical report did not draw a conclusion as to the specific mode of stress corrosion cracking that ultimately caused the failure (CSCC versus hydrogen embrittlement).

2.4 Safety Issues

The following sections discuss the safety issues contributing to the incident, which include:

- Technology Change Implementation,
- Mechanical Integrity, and
- Safe Work Practices.

Appendix A contains the accident map (AcciMap), which provides a graphical analysis of this incident.

2.4.1 Technology Change Implementation

Shortly after the 245 unit was commissioned in 2002, Honeywell began observing corrosion damage to spiral wound gaskets and piping flange faces in recycle HF service. In 2007, 14 years before the 2021 fatal incident, Honeywell identified a different gasket technology and initiated a Management of Change (MOC) analysis for recycle HF service. The MOC documented that Honeywell planned to implement this change on an attrition basis. This meant that Honeywell elected to wait to replace the gaskets until the gaskets could either be replaced opportunistically and proactively during future maintenance efforts or when the gaskets would run to failure.[a] The MOC did not set a specific date for completion. Excerpts of the MOC are shown in **Figure 11** and **Figure 12**.

MOC Short Title: Change Gasket Specification for [redacted] Lines From Flexitallic 304 SS to Taskline

Description of Change (Provide technical justification for change): Change the approved gaskets for the [redacted] 245fa pipe specs from Flexitallic 304 SS to Taskline type gaskets. The Flexitallic 304 SS gaskets are experiencing degradation from corrosion which in turn is damaging, or allowing damage to the flange faces.

Figure 11. Excerpt from a 2007 MOC describing the change from 304 stainless steel spiral wound gaskets to PTFE-encapsulated stainless steel gaskets in recycle HF service. (Credit: Honeywell, redaction by CSB)

Gasket changes from rigid Flexitallic 304 SS to TFE encapsulated 316 SS for better flange sealing.
This change can be incorporated into the existing [redacted] specification.
Existing Flexitallic gaskets can be changed out on an attrition basis.

Figure 12. Excerpt from the 2007 MOC. (Credit: Honeywell, redaction by CSB)

The gasket that failed during this incident was the same type of gasket (304 stainless steel spiral wound) and in the same service (recycle HF) for which this 2007 MOC documented the need to change. In its investigation report, Honeywell described additional context for the gasket technology change (**Figure 13**).

[a] Allowing equipment to run to failure before replacing or repairing it is inherently reactive, and such a strategy thus cannot prevent potentially deadly process safety incidents.

[redacted] In 2007, Geismar implemented a pipe specification MOC [redacted] to change the type of gaskets in HFC-245fa service from spiral wound Flexitallic 304 stainless steel to PTFE Encapsulated Task-Line 304 stainless steel. The purpose of the change was to attempt to achieve a better flange seal as Geismar personnel had observed corrosion around the valve flanges during the first five years of HFC-245fa service. Because the spiral wound Flexitallic gaskets are appropriate for HF service, the replacements were to be made on an attrition basis.

Figure 13. Additional documented information regarding the gasket technology change. (Credit: Honeywell, redaction by CSB)

After the October 2021 fatal incident, Honeywell kept the 245 unit offline from the date of the incident until roughly December 2021 in order to inspect, replace, and change gaskets within the recycle HF portion of the unit. A former Geismar management official stated:

> Obviously, we shut down until confirmation could be made that everything was fit for service. And that pushed us into full inspections of, I would say, thousands of gaskets that were both either visually inspected while assembled or disassembled and inspected in greater detail.

The MOC did not include sufficient analysis of whether there would be a negative safety impact associated with the choice to replace the gaskets by attrition. The MOC also was not assigned a specific completion date. Any failure of a gasket in recycle HF service would result in the release of highly toxic HF. HF is IDLH at 30 ppm, and thus any leak of HF, even a small one, is potentially deadly. Honeywell should have more seriously considered the potential impact of delaying the change until the gaskets could be replaced opportunistically.

Fourteen years passed between when Honeywell documented the need to replace its 304 stainless steel spiral wound gasket technology and when a gasket of that type eventually failed catastrophically and fatally injured a Honeywell employee.

The CSB concludes that:

- Honeywell was aware of corrosion damage to 304 stainless steel spiral wound gaskets in recycle HF service beginning in the first five years of the 245 unit's operation;

- Honeywell identified a different gasket technology and documented the need to change the gasket technology in 2007, but despite ongoing gasket corrosion, Honeywell elected to replace the gaskets on an attrition basis;

- In 2021, 14 years after documenting the need to change the gasket technology, Honeywell still had not fully implemented the change. Although the MOC did not set a specific completion date, Honeywell's failure to fully implement this change contributed to the incident; and

- Had Honeywell fully implemented the gasket technology change, the loss of containment of HF may not have occurred, and the incident and the fatal injury may have been prevented.

As shown in **Figure 13**, after the incident, Honeywell maintained in its investigation report that the spiral wound gaskets were appropriate for the service in which they were installed despite also documenting that the same gaskets had been experiencing corrosion failures for nearly 20 years since the 245 unit was first commissioned (**Figure 11**, **Figure 13**). Even though Honeywell concluded that the incident gasket may have had a manufacturing defect, the prevalence of the corrosion damage for such a long time suggests that the gaskets may not have been compatible with the process materials and conditions. Regardless, the fact that Honeywell documented the need for a technology change in 2007 and had still not fully implemented the change in 2021 is indicative of serious gaps in Honeywell's PSM systems.

Neither Honeywell nor the CSB was able to determine the amount of time the incident gasket was in service. Honeywell's documentation suggests that the gasket may have been installed sometime during or after 2014, but the documentation was not conclusive. Honeywell concluded that the cause of the gasket change implementation gap was flaws in its Quality Assurance system, which is a subcomponent of Honeywell's Mechanical Integrity (MI) program. Honeywell concluded that, broadly, its maintenance personnel and contractors had not been installing the PTFE-encapsulated gaskets in accordance with the recycle HF piping specification, which the company updated in response to the 2007 MOC.

In the context of spiral wound gaskets in recycle HF service in general, Honeywell's conclusion is self-evident given the number of the gaskets that still needed to be changed at the time of the incident. Because the company could not clearly establish the service age of the incident gasket, it is not clear whether this finding applies to the incident gasket specifically. Though it is unlikely, the CSB could not rule out the possibility that the incident gasket predated the 2007 MOC.

The CSB concludes that there were serious flaws in Honeywell's systems for change management, process knowledge management, and MI. These flaws caused the Geismar site to have not fully implemented the gasket technology change 14 years after the change was initiated and may have contributed to the fatal incident.

2.4.2 Mechanical Integrity

As part of Honeywell's MI program, HF piping in the 245 unit was subject to periodic inspections. Honeywell's visual inspection checklist for piping included a direction to the inspector to "Inspect all flanges, […] valves, […] and joints for evidence of process leakage, corrosion, and damaged gaskets."

Honeywell Geismar personnel inspected the D reactor recycle HF feed station (the piping circuit that contained the incident flange and gasket) on September 15, 2021, just 36 days before the fatal incident. In the inspection report, the inspector noted "no leaks observed on line at time of inspection." On September 27, 2021, only 15 days before the incident, Honeywell again inspected the same piping circuit as part of its Leak Detection and Repair (LDAR)[a] program. Honeywell identified no nonconformities or problems during the LDAR inspection.[b,c]

[a] LDAR refers collectively to a series of work practices and regulations by the EPA, the primary goal of which is to reduce fugitive emissions through regular equipment maintenance. More information can be found in the EPA LDAR Best Practices Guide [48], which can be accessed online (Leak Detection and Repair Compliance Assistance Guidance Best Practices Guide).

[b] The intent of LDAR is the identification and prevention of fugitive emissions of volatile organic compounds and other environmental hazards [48]; its primary focus is environmental protection. It is not intended as a methodology to prevent catastrophic process safety incidents or to ensure the MI of safety-critical equipment. Nevertheless, identifying equipment leaks through an effective LDAR program could complement other, more traditional and robust MI methodologies.

[c] The 245 unit was pressurized and operating at the time of both inspections.

Neither inspection detected the issue, and the gasket in the flanged connection eventually ran to failure just a few weeks later, fatally injuring a Honeywell operator. Honeywell concluded in its investigation report that the incident gasket and flange "had been leaking […] for a period of time prior to the gasket failure." Honeywell also concluded that its piping inspection techniques were likely not robust enough to detect the problem prior to the incident.

KEY LESSON

Mechanical Integrity programs should be thorough, and companies should ensure that their testing and inspection methodologies are designed to detect expected damage mechanisms and failure modes. Mechanical Integrity programs must successfully identify and resolve equipment deficiencies prior to failure.

2.4.2.1 Acid Indicating Paint and HF Atmospheric Monitors

Acid indicating paint was notably absent from the incident flange assembly at the time of the incident (**Figure 7**). Acid indicating paint is an industrial coating with an acid-sensitive component that changes color when exposed to acid or acid vapor [15, p. 1]. An example of the paint in use can be seen in **Figure 30** in **Section 4.2**.

Honeywell is a member of the Hydrogen Fluoride Industry Practices Institute (HFIPI), an HF-focused industry trade group associated with the American Chemistry Council. HFIPI develops and issues guidelines for the use and handling of HF [16]. HFIPI states in its guidelines that "applying acid [indicating] paint to pipe and vessel flanges is very effective in highlighting HF leaks before they grow to a critical size" [17, p. 5]. A Honeywell Geismar MI expert was the chair of the task group that authored the 2021 edition of this HFIPI guidance document [17].

In addition to the HFIPI guidance, the American Petroleum Institute (API) has issued a Recommended Practice document *RP 751 – Safe Operation of Hydrofluoric Acid Alkylation Units* [15]. For HF acid alkylation units in petroleum refineries, API RP 751 requires the use of acid indicating paint on all flanges in HF acid service [15, p. 71, 18, p. 28]. API RP 751 has required the use of acid indicating paint since at least 2013.[a] Although Honeywell is not a member of API, nor does it operate a petroleum refinery, Honeywell Geismar operates a unit that manufactures and handles tens of millions of pounds of HF, which Honeywell sells to refineries that operate HF acid alkylation units. In addition, a Honeywell subsidiary, UOP, designs and licenses HF acid alkylation technology to petroleum refineries. Honeywell also adopts other API standards as part of its MI programs and thus is generally aware of API guidance and requirements.

Furthermore, in 2009, Honeywell representatives gave a presentation titled "Hydrofluoric Acid Overview" to CSB Board Members and investigative staff. The presentation contained a series of slides describing what Honeywell called "HF Safety Best Practices." The following slide advocated for the use of acid indicating paint and was included in the presentation (**Figure 14**).

[a] API RP 751 2013 ed., Section 3.5.5; API RP 751 2021 ed., Section 6.5.13. The CSB did not review API RP 751 editions earlier than the 2013 edition.

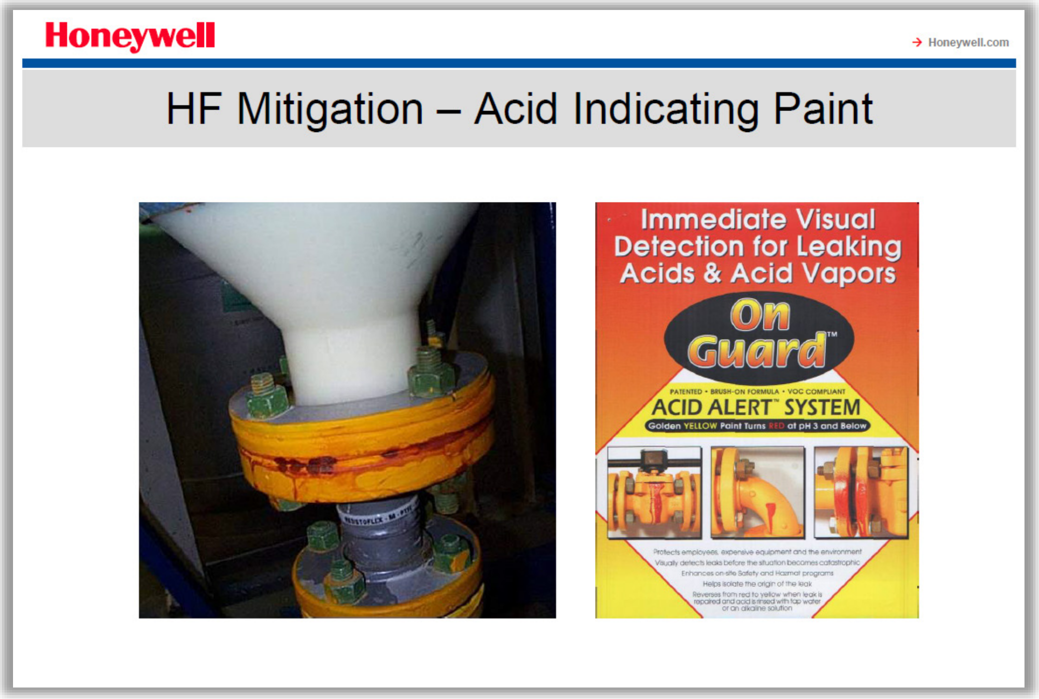

Figure 14. Slide from a 2009 presentation Honeywell made to the CSB, advocating for the use of acid indicating paint. (Credit: Honeywell)

On its website, Honeywell purports to be "the leader in HF […] safety and handling training" and offers various training and consulting services concerning the use of HF [19]. Despite marketing itself as a leader in the safe use of HF, and despite advocating for practices such as the use of acid indicating paint to its customers and to the CSB, Honeywell did not use acid indicating paint in its own 245 unit. Honeywell did not begin using the paint in the 245 unit until after a Honeywell operator was fatally injured by an HF leak in the October 2021 incident that could have been prevented by the use of the paint.

In its incident investigation report, Honeywell concluded that the incident flange was likely leaking prior to the incident and that its piping inspection techniques were not robust enough to have detected it. Therefore, acid indicating paint could have, and likely would have, helped the Honeywell inspectors or operators detect the leaking incident flange and take corrective action prior to the gasket's catastrophic failure.

While acid indicating paint would likely have aided with visual identification of the leaking flange assembly, Honeywell also lacked engineering solutions that could have remotely identified an HF leak without the risk of human exposure to HF. At the time of the incident, Honeywell Geismar was not using atmospheric monitors capable of indicating HF releases in the 245 unit. API RP 751 recommends the use of HF sensors and contains guidance on design considerations for HF detection systems.[a] Honeywell's 2009 presentation to the CSB Board and investigative staff also contained information on HF monitors (**Figure 15**).

[a] API RP 751 5th ed., Section K.3

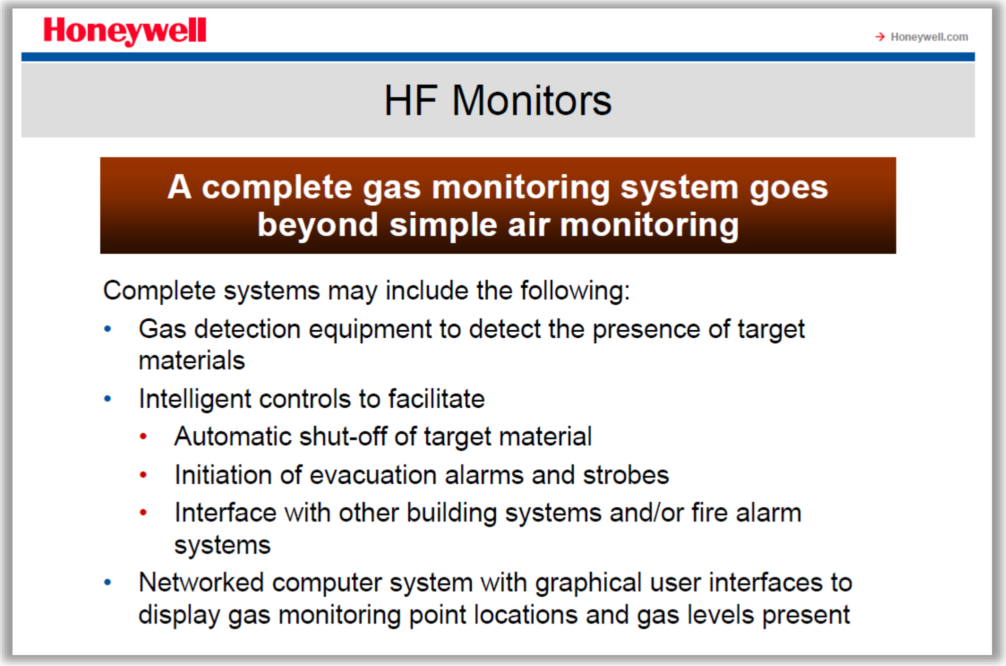

Figure 15. Slide from a 2009 presentation Honeywell made to the CSB, advocating for the use of HF monitors. (Credit: Honeywell)

The CSB concludes that Honeywell was aware of and has previously advocated for the use of technologies such as acid indicating paint and remote HF monitors. Despite Honeywell's awareness of and advocation for such technologies in HF processes, Honeywell did not use such technology in its own 245 unit prior to the October 2021 fatal incident. Acid indicating paint and remote HF monitors could have helped prevent this incident by either identifying or aiding the identification of the leaking incident flange assembly prior to the incident. Had Honeywell identified the issue prior to the incident, it could have taken effective action to resolve the leak prior to the gasket's catastrophic failure.

2.4.3 Safe Work Practices

2.4.3.1 Readiness for Operation

On the morning of the incident, Honeywell attempted to start up reactor D after a planned unit maintenance outage. Leading up to the outage, reactor D and its associated equipment, including the vaporizer, were isolated and locked out. The D reactor vaporizer was not subsequently unlocked and valved back into service prior to the startup attempt. As a result, the manual valve on the HF inlet to the vaporizer remained locked closed during the startup attempt, which caused HF to backflow through an open manual valve on the downstream side of the recycle HF feed station, through a check valve that had failed, and to the incident flange (**Section 2.3**; **Figure 8**).

Honeywell Geismar had a standard operating procedure that it used to start up the HF vaporizers, as well as a pre-startup checklist. The startup procedure directed operators to verify that the manual valve on the HF inlet to the vaporizer was open. Following the checklist would have verified that the unit was ready to accept process feeds.

During Honeywell's investigation of the incident, the company found that the Board Operator had misunderstood shift changeover notes and communication. The Board Operator believed that because the A and C vaporizers were ready for startup, so was the D vaporizer. Furthermore, in statements he made to the Honeywell incident investigation team, the Board Operator reported that his understanding of the practice was to not use the pre-startup checklist when the process being started "had not been worked on."[a] The CSB concludes that Honeywell attempted to place equipment into service that was not properly prepared for startup. This resulted in the no-flow condition to the HF vaporizer and the reverse-flow condition to the incident flange.

The incident flange was already leaking leading up to the incident (**Section 2.2**).[b] Therefore, the CSB concludes that the gasket failure did not result from the reverse-flow condition caused by the improper startup attempt. The gasket would likely have eventually failed catastrophically regardless of the direction of HF flow through the flanged connection. Following the unit startup procedure would not have prevented the gasket failure; the gasket was already leaking.

Although the improper startup was not causal to the gasket failure, the no-flow condition to the HF vaporizer was causal to the two operators' presence in the vicinity of the incident flange and thus contributed to Operator 2's fatal injury. The CSB concludes that had Honeywell ensured that the D reactor vaporizer was ready for startup by following its existing procedures and checklists, the no-flow condition to the vaporizer would have been prevented, and the two field operators would not have been called to troubleshoot the condition. Therefore, the operators would likely not have been present in the vicinity of the incident gasket when it failed, and the fatal injury to Honeywell Field Operator 2 would likely have been prevented.

2.4.3.2 Personal Protective Equipment

On the day of the incident, Field Operators 1 and 2 were both wearing Level D PPE during their troubleshooting efforts. Level D PPE was the minimum level of PPE required by Honeywell at the Geismar facility for units containing anhydrous HF (**Figure 4**). For eye, face, and respiratory protection, Honeywell's PPE matrix required only safety glasses as the minimum level of protection. Generally, Honeywell required a face shield and/or goggles only if a PPE hazard assessment was conducted and determined that they were necessary.

More specifically, for situations involving "local operation of valves," Honeywell's PPE matrix required "Stepped Down C" level PPE. This level of PPE required "HF-resistant chemical PPE," goggles, and a face shield in addition to the Level D requirements (**Figure 4**). Furthermore, the startup procedure for the HF vaporizers (which was not followed, as described previously) also directed operators to don "Stepped Down C" level PPE.

During the attempt to start up reactor D, Field Operators 1 and 2 were manipulating manual valves in their effort to resolve the no-flow condition to the D reactor vaporizer and to address the leaking incident flange assembly (**Section 2.2**). As such, they should have been wearing additional PPE. Instead, both were wearing Level D PPE during the incident.

HF is extremely hazardous and potentially fatal if splashed on any unprotected part of the body or if inhaled into the lungs. When the flange leak suddenly worsened, Field Operator 2 was exposed to HF on his face, ear, and

[a] The CSB did not examine the maintenance outage work schedule or scope and did not verify whether any maintenance work was performed on the reactor D system.

[b] The fact that Field Operator 1 detected the HF leak by both sight and smell indicates that the gasket was already leaking prior to its catastrophic failure.

neck. He was treated with calcium gluconate gel and nebulized[a] calcium gluconate by site medical responders, who arrived within five minutes of notification. Despite the quick response by the site medical team, Field Operator 2 later succumbed to his injuries and died at the hospital.

The CSB concludes that had Honeywell ensured that more protective PPE was used, Field Operator 2's exposure to HF would have been reduced, and his fatal injury could have been prevented. The CSB also concludes that both the Honeywell PPE matrix for anhydrous HF and the unit startup procedure required more protective PPE than Field Operators 1 and 2 were wearing at the time of the incident.

Once the site emergency responders were notified of the incident, additional operators (Field Operators 3 and 4) arrived on scene in Level C PPE and successfully isolated the leak, stopping the release. Significantly, although the emergency responders (Field Operators 3 and 4) were able to stop the release without additional injury, wearing Level C PPE to respond to an active emergency was also a policy deviation, according to Honeywell's PPE matrix. The PPE matrix required Level A PPE for situations that involved "working in close proximity to leaks/releases that require lines or equipment to be isolated."

This incident involved two separate instances of Honeywell personnel wearing PPE that did not match Honeywell's situational PPE requirements: 1) the field operators were wearing Level D PPE during the startup of the vaporizers, a task which required "Stepped Down C" Level PPE, and 2) the emergency responders (Field Operators 3 and 4) arrived on scene wearing Level C PPE when they should have donned Level A PPE. The CSB concludes that on the day of the incident, Honeywell did not ensure that its operators wore appropriately protective PPE on at least two separate instances leading up to and during the incident.

[a] Nebulization is a mode of medication delivery in the form of a mist inhaled into the lungs [44].

2.5 POST-INCIDENT ACTIONS

2.5.1 HONEYWELL

Honeywell investigated the incident and implemented the following changes.

Gasket Technology Change

After the October 2021 incident, Honeywell kept the 245 unit offline for several months and made a significant effort to replace the 304 stainless steel spiral wound gaskets within recycle HF service in the 245 unit. Also, in 2022, Honeywell began replacing the spiral wound gaskets in recovered and fresh HF service as well. Accordingly, the CSB makes no recommendations to Honeywell regarding the implementation of the 2007 gasket technology change.

Mechanical Integrity

After the incident, Honeywell revised its visual inspection and LDAR procedures to include additional information and inspection techniques to better identify HF leaks. Additionally, Honeywell applied acid indicating paint to the flanges and pipes within the 245 unit to better aid visual leak detection. Finally, Honeywell installed area atmospheric monitors throughout the 245 unit designed to detect and alert personnel to HF releases. The CSB makes no recommendations to Honeywell specific to its piping inspection programs and early detection and resolution of HF leaks.

Safe Work Practices

Honeywell made changes to its operating procedures, employee training, and shift communication practices. These changes were intended to eliminate or reduce shift changeover confusion, improve Board Operator awareness of equipment status, and clarify the circumstances for when pre-startup checklists are required.

Honeywell also revised its PPE matrix to include a specific requirement for elevated PPE, to include respiratory protection, when assessing incipient HF leaks. It also made related changes to its employee training program. The CSB makes no recommendations to Honeywell pertaining to the safe work practice gaps identified in this section of the report.

2.5.2 OSHA

After the incident, OSHA cited[a] Honeywell for violations of the PSM standard (29 C.F.R. 1910.119), including for the lack of HF atmospheric monitors, the lack of effectively implemented written procedures for equipment startup, and for the lack of effective MI practices. OSHA also cited Honeywell for violating the PPE Standard (29 C.F.R. 1910.132) [20].

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[a] OSHA's inspection detail can be found here: Inspection Detail | Occupational Safety and Health Administration osha.gov

3 HF Reboiler Explosion – January 2023

3.1 Background

3.1.1 The Reboiler

After HFC-245fa is produced in the reaction step of Honeywell's process, it requires purification. One of the purification steps is to remove unreacted chlorine from the process stream. This step is performed in a distillation column equipped with a kettle-style reboiler ("the reboiler").

A reboiler is a type of heat exchanger that is used to vaporize and return some or all of the liquid from the bottom of a distillation column. **Figure 16** shows a conceptual diagram of a distillation column with a kettle-style reboiler.

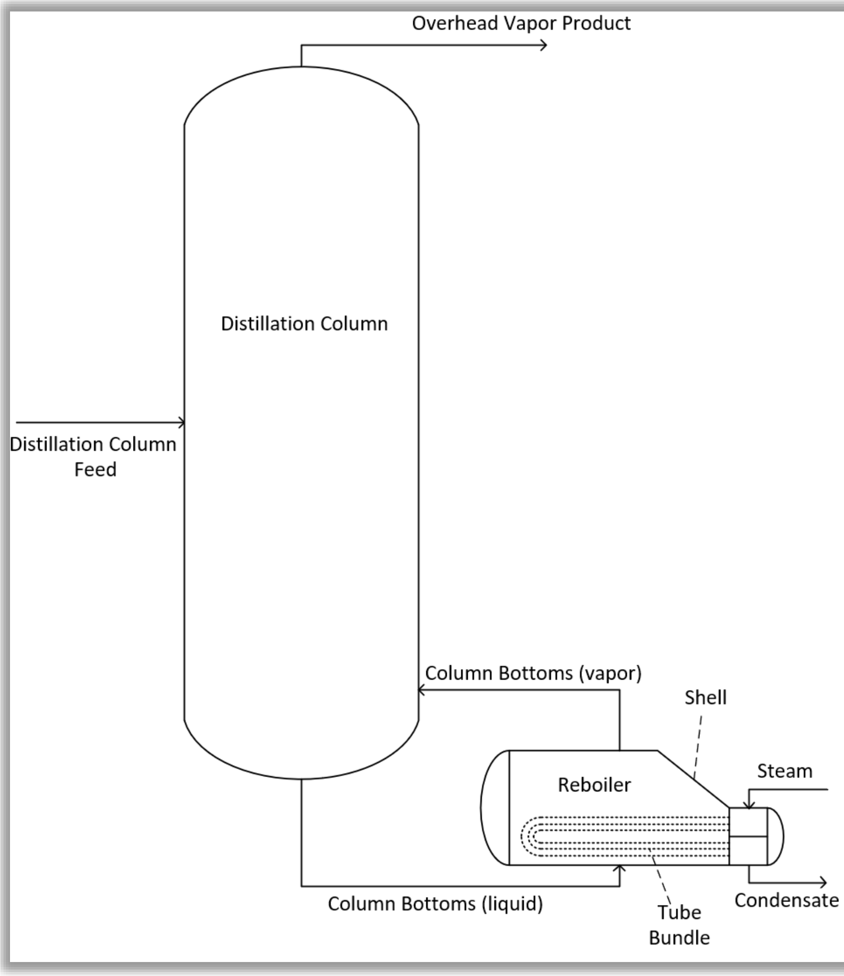

Figure 16. Simple conceptual diagram of a distillation column and a kettle-style reboiler. (Credit: CSB)

The reboiler was designed according to the 2010 edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, Division 1. As designed, the exchanger 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. The shell was constructed of SA-516 Grade 70 carbon steel.[a]

The reboiler shell normally contained a mixture of HF, HFC-245fa,[b] and smaller fractions of various process intermediates. The exchanger tubes normally contained

[a] At the time of the incident, the tube bundle was constructed of Alloy 825 (also known as Incoloy 825, Inconel 825, or Grade UNS No. N08825). Compared with carbon steel, Alloy 825 provides enhanced resistance to certain damage mechanisms, including HF corrosion [5, p. 8].

[b] 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.

steam as the heating medium. In HF service, carbon steel is subject to uniform corrosion, among other damage mechanisms [5, pp. 10-13]. Uniform corrosion is characterized by thinning occurring relatively evenly over the total surface or a large portion of the total surface of a pipe or vessel [21].

According to the design documentation, the required thickness (commonly 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.[a] T_{min} is the minimum required thickness for a pressure vessel to safely contain pressure at its specified design conditions in accordance with the ASME code [22, pp. 20-21, 404].

Honeywell installed the incident reboiler shell in December 2012. Geismar site personnel were aware that the reboiler was susceptible to HF corrosion, and the site's reliability group regularly monitored the vessel's wall thickness. More detailed information can be found in **Section 3.3.1.1**.

3.1.2 BOILING LIQUID EXPANDING VAPOR EXPLOSIONS

When a pressure vessel contains a liquid at temperatures greater than its atmospheric boiling point, the potential for a boiling liquid expanding vapor explosion (BLEVE) exists. According to the Center for Chemical Process Safety (CCPS), a BLEVE is defined as "a sudden loss of containment of a pressure-liquefied gas existing above its normal atmospheric boiling point at the moment of its failure, which results in rapidly expanding vapor and flashing liquid" [23, p. 311]. A BLEVE requires three components:

1. a liquid that exists above its normal atmospheric pressure boiling point,
2. containment that causes the pressure on the liquid to be sufficiently high to suppress boiling, and
3. a sudden loss of containment to rapidly drop the pressure on the liquid [23, p. 311].

A BLEVE can involve any liquid stored under pressure at temperatures above its atmospheric boiling point. The liquid does not need to be flammable for a BLEVE to occur [23, p. 319]. A BLEVE does not require the vessel's operating pressure to exceed either the design pressure or the rated working pressure. If the vessel is sufficiently damaged, such as from corrosion, a BLEVE can occur even at normal operating conditions. This phenomenon means that a BLEVE can occur even when the vessel's pressure relief device(s) are working correctly. Some of the consequences of a BLEVE include a blast wave due to expansion of vapor and flashing liquid and the fragmenting and propulsion of vessel pieces [23, p. 319].

[a] The site's MI records show that Honeywell utilized T_{min} values for the shell that ranged from 0.100-0.188 inches depending on the measurement location.

3.2 Incident Description

At 7:03 p.m. on January 23, 2023, Honeywell Geismar began restarting the 245 unit after the site experienced an unrelated utility outage. Operations personnel established feed to the distillation column at 7:16 p.m. At 8:12 p.m., the reboiler shell suddenly and catastrophically ruptured when the reboiler shell thinned to the point at which it could no longer contain the operating pressure (**Figure 17**).

Figure 17. 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. However, the temperature was greater than the fluids' atmospheric boiling points, and the pressure was greater than atmospheric pressure. Based upon these process conditions at the time of the failure, a BLEVE occurred. The contents of the reboiler, the distillation column, and other ancillary equipment were released into the ambient air.

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 conical section of the shell. This fragment is pictured below in **Figure 18**. The debris from the explosion was largely contained by the nearby piping and equipment collocated on the same platform as the reboiler.

Figure 18. Post-incident image showing the remnants of the reboiler. (Credit: Honeywell)

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 occurred from approximately 8:12 p.m. until approximately 9:00 p.m. An "all-clear" signal was issued for the industrial complex at 9:15 p.m.

Because the incident occurred during the night shift, there were fewer workers at the site. 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. The incident caused approximately $4 million in property damage, and the 245 unit was shut down for 47 days.

3.3 Safety Issues

The following sections discuss the safety issues contributing to the incident, which include:

- Mechanical Integrity,
- Management of Organizational and Personnel Change,
- Capital Project Management, and
- Organizational Resilience.

Appendix B contains the AcciMap, which provides a graphical analysis of this incident.

3.3.1 Mechanical Integrity

The reboiler involved in this incident ran to catastrophic failure. As discussed in this section, Honeywell's failure to adhere to its own MI requirements created the conditions that led to the failure.

3.3.1.1 Reboiler History

2002-2003 Original Stainless Steel Shell

At the time of the reboiler's original installation in July 2002, the reboiler shell was constructed of SA-240 316 stainless steel and had a design thickness of 0.250 inches. In September 2002, Honeywell discovered chlorine leaking from the reboiler's distillation column, which was also constructed of 316 stainless steel. The leaks were discovered near nozzle-to-vessel weld seams in the column. In March 2003, Honeywell discovered a leak in the reboiler shell, near the shell's rear head weld seam.

Site personnel believed that the failures were due to chloride stress corrosion cracking in the stainless steel. In response, in April 2003, Honeywell replaced the stainless steel shell with a new carbon steel shell, which was not susceptible to chloride stress corrosion cracking. The new carbon steel shell had a nominal thickness of 0.250 inches. According to documentation, the change was originally intended to be temporary while the site investigated the stainless steel failures.

2003-2008 Second Shell (First Carbon Steel Shell)

Due to concerns about corrosion failures so soon after unit commissioning, the Geismar site reliability organization placed the reboiler carbon steel shell on a monthly ultrasonic thickness testing (UT) schedule. Between April 2003 and October 2004, the site measured low corrosion rates in the carbon steel. Based on these measurements, in October 2004 Honeywell changed the shell UT inspection frequency to annual.

In May 2005, Honeywell conducted an internal inspection of the reboiler shell and found it filled with corrosion solids and debris, pictured below in **Figure 19**.

Figure 19. Picture of the inside of the reboiler shell, taken during a May 2005 internal inspection. (Credit: Honeywell)

In November 2005, Honeywell inspected the reboiler again using UT. At this point, 2.5 years into the operation of the carbon steel shell, the site measured almost no shell corrosion and estimated that the reboiler shell had greater than 20 years of remaining service life. In response, Honeywell lengthened the reboiler's UT inspection interval to three years.

According to the three-year inspection interval, the reboiler would have been due for its next UT inspection in November 2008. In April 2008, however, the reboiler shell developed a leak through the shell wall.[a] Honeywell investigated the incident and attempted to determine the cause of the apparent difference in corrosion rate from the March 2003 – November 2005 period and the November 2005 – April 2008 period.

Honeywell's investigation was ultimately inconclusive, although Honeywell identified several hypotheses. Of these hypotheses, Honeywell's investigation report indicates that the company believed the cause to be most likely related to the excessive corrosion debris accumulation that the company found in May 2005. Honeywell believed that the source of the debris in the reboiler was the corrosion and failure of the chlorine distillation column's 316 stainless steel internal components.[b]

Honeywell theorized that the difference in corrosion rate could have been the result of the corrosion debris preventing the reboiler shell from being fully wetted by the liquid HF. Alternately, the company theorized that

[a] It is unclear whether this failure was due to generalized corrosion and thickness loss, or whether the failure was or could have been a localized through-wall pit. Honeywell did not conduct a metallurgical examination of the shell and did not preserve any thickness inspection data from this shell.

[b] Honeywell Geismar has since replaced portions of the distillation column with an alloy more resistant to CSCC.

the debris could have caused a temperature gradient between the bulk of the liquid in the reboiler and the reboiler shell wall. Anhydrous HF corrodes carbon steel more slowly at lower temperatures than at higher temperatures (discussed in further detail below in **Section 3.3.1.3**). Honeywell never conclusively determined the cause of the discrepancies in the measured corrosion rate.

2008-2012 Third Shell (Second Carbon Steel Shell)

Honeywell replaced the reboiler shell in 2008 with another carbon steel shell of the same design ("replacement-in-kind"), and performed the next inspection in April 2011, three years after the April 2008 installation. Honeywell inspected the shell again in August 2012. Using the data from the August 2012 UT inspection, Honeywell estimated nine months of remaining useful life for the reboiler shell, with a projected retirement date of May 2013. At the time of the August 2012 inspection, the site had a replacement carbon steel shell available, but Honeywell elected not to replace the shell.

In December 2012, five months before the projected retirement date, Honeywell discovered that the top side of the shell had deflected and warped under the weight of attached piping. Honeywell removed the reboiler from service and found that the shell had thinned to less than 0.100 inches, which was less than the T_{min}, although no loss of containment had occurred. Honeywell conducted a 5-Whys analysis[a] of the December 2012 shell thinning event and determined that the work to replace the shell "had not been prioritized and scheduled for the 245fa Fall [2012] Outage." Honeywell did not investigate *why* the shell replacement had not been prioritized and instead stopped its analysis at the finding *that* it was not prioritized.

2012-2023 Fourth Shell (Incident Shell)

After the December 2012 shell failure, Honeywell doubled the nominal thickness of the shell to 0.500 inches. This shell (the fourth overall, and the third made of carbon steel) remained in service until it failed catastrophically in January 2023. **Table 2** below summarizes the full inspection history for the incident shell. Visual inspections and ultrasonic thickness inspections are denoted by their respective abbreviations VT and UT, which are designated by the American Society for Nondestructive Testing [24]. **Table 3** below summarizes the reboiler service history from the time of initial installation in 2002 to the January 2023 failure.

[a] The "5 Whys" incident investigation technique involves the investigation team asking the question "Why?" enough times to arrive at a management system deficiency. Teams may ask "Why?" more or fewer times than five, although the name of the technique may artificially influence an investigation team to stop at five even if further analysis would be beneficial. Further, the 5-Whys technique typically only arrives at one root cause, and many incidents involve multiple causal factors that should be identified and addressed. Accordingly, the 5-Whys technique is best suited for minor incidents rather than complex ones [47, pp. 208-211].

Table 2. Inspection history for the incident reboiler shell.

Date	Inspection Performed
December 2012	New reboiler shell installed
March 2014	External UT
October 2015	External UT & VT
April 2016	External UT & VT
May 2016	External VT
August 2016	External UT & VT
January 2017	External UT & VT
January 2018	External VT
August 2018	External UT &VT
May 2019	External VT
September 2020	External UT & VT
December 2020	External VT
October 2021	External & Internal VT
January 2023	Catastrophic reboiler shell failure

Table 3. Summarized service history of the four separate reboiler shells from initial installation date to January 2023 failure of the fourth reboiler shell.

Reboiler Shell Number	Installation Date	Failure Date	Actual Service Life	Shell Material of Construction	Shell Nominal Thickness	Failure Description
1st	July 2002	March 2003	9 months	316 Stainless Steel	0.250 inches	Failed due to chloride stress corrosion cracking. Loss of containment of HF.
2nd	March 2003	April 2008	5 years, 1 month	Carbon Steel	0.250 inches	Excessive thinning. Thinned and developed a leak near the shell/head weld seam. Loss of containment of HF.
3rd	April 2008	December 2012	4 years, 8 months	Carbon Steel	0.250 inches	Excessive thinning. Shell became sufficiently thin to warp and buckle under the weight of attached piping; no loss of containment.
4th	December 2012	January 2023	10 years, 1 month	Carbon Steel (SA-516 Gr. 70)	0.500 inches	Excessive thinning, catastrophic circumferential failure, BLEVE, loss of containment of HF, HFC-245fa, chlorine, and other materials.

3.3.1.2 Key Events Prior to the 2023 Shell Failure

In September 2020, Honeywell conducted a UT inspection of the reboiler shell. Using data from that inspection, the company estimated that the reboiler shell had 1.1 years of remaining useful life,[a] meaning that it was expected to reach its T_{min} in late 2021, over a year before the reboiler catastrophically ruptured. At Honeywell Geismar, pressure vessels with more than one year of estimated remaining life were recommended for continued operation up until their next required inspection date.[b] Vessels with less than one year of estimated remaining life were recommended for replacement. As a result, in September 2020, the reliability organization set the reboiler's next inspection date for October 2021.

The site continued operating the reboiler until October 2021, at which time it conducted external and internal visual inspections. In interviews, site reliability personnel stated that the company also conducted a UT inspection, but the company was unable to locate or produce any documentation for that inspection. For the internal visual inspection, site inspectors documented "signs of wall loss in shell, low UT reading found, recommended replacing shell," and "sealing area [across] the middle of the head in poor condition." On the same inspection form, the inspector wrote that the shell was "fit for service." The CSB found no evidence that the inspector or anyone at Honeywell conducted a fitness for service[c] evaluation of the reboiler shell, and Honeywell documented no support for the statement that the vessel was "fit for service."

As a result of the replacement recommendation, in December 2021 a site maintenance engineer obtained a quotation for a replacement shell from a local pressure vessel fabricator and initiated a capital expenditure request ("project") to replace the existing reboiler shell. The fabrication shop quoted a lead time of eight weeks to fabricate and deliver the new shell.

The project was approved by site management in February 2022. By April 2022, the project had not been funded, and the maintenance engineer in charge of the project had left Honeywell for employment elsewhere. For reasons discussed below in **Section 3.3.2**, Honeywell never assigned a new project manager to the reboiler project, and for reasons discussed below in **Section 3.3.3**, Honeywell never funded the project. Ultimately, lacking both a project manager and capital funding, the project was never completed, and the reboiler ran to failure on January 23, 2023.

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 0.030 inches, corresponding to a thickness loss of roughly 95 percent.[d]

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[a] 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 corrosion rate, which is assumed to be linear.

[b] The API standard 510 *Pressure Vessel Inspection Code* states in Section 6.5.1.1 that "whenever the remaining life is less than four years, the inspection interval may be the full remaining life up to a maximum of two years" [46].

[c] API 579 *Fitness For Service* describes a methodology that companies can use to augment their MI analyses.

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

3.3.1.3 Carbon Steel in HF Service

According to the Association for Materials Protection and Performance (AMPP, formerly the National Association of Corrosion Engineers, or NACE), under certain circumstances, the use of carbon steel is acceptable in HF service.

AMPP has published a document titled *NACE TR5A171: Materials for Storing and Handling Commercial Grades of Aqueous Hydrofluoric Acid and Anhydrous Hydrogen Fluoride* [5], which contains guidance on material selection for piping and equipment in HF service and provides HF corrosion data for selected grades and alloys of steel. The document includes the following chart (**Figure 20**) showing the corrosion performance of carbon steel in anhydrous HF service.

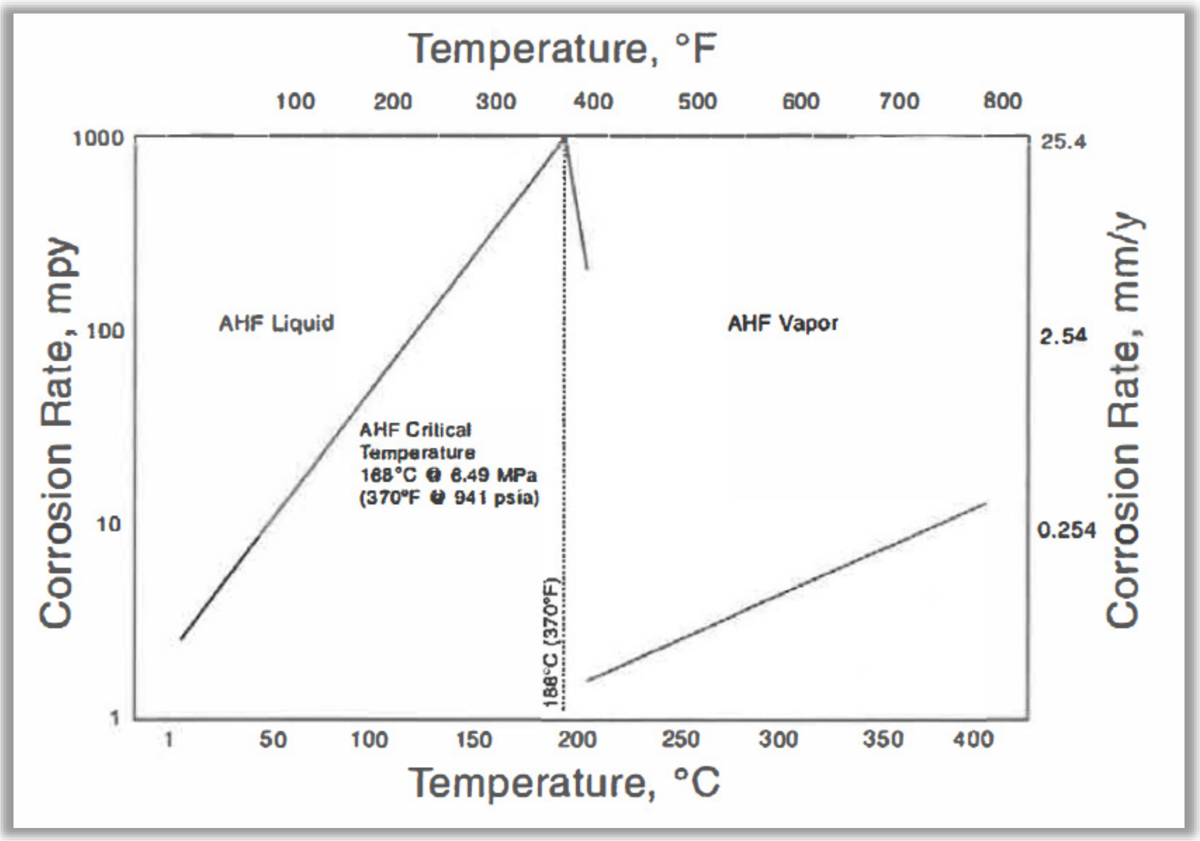

Figure 20. Corrosion rates[a] of carbon steel in anhydrous HF (abbreviated as AHF in the figure) service over a range of temperatures. (Credit: AMPP [5, p. 12])

Figure 20 shows that at the temperatures at which Honeywell operated the reboiler, Honeywell could expect a corrosion rate of roughly 30-80 mils[b] per year (mpy). Honeywell Geismar was generally aware of the data and

[a] The vertical axes of this figure show corrosion rate measured in mils per year (mpy) and millimeters per year (mm/y).

[b] A mil is equal to one thousandth of an inch, or 0.001 inches.

cited the data in its investigations of the 2008 and 2023 reboiler failures. **Table 4** below compares the theoretical and actual service life of the reboiler carbon steel shell based on the AMPP data.[a]

Table 4. Comparison of actual and theoretical service life of the Honeywell reboiler carbon steel shell

Service Dates	Nominal Thickness, Inches	Final Thickness, Inches	Theoretical Service Life[b]	Actual Service Life	Approximate Average Corrosion Rate[c]
Mar 2003 – Apr 2008	0.250	0 (shell corroded fully through)	≈ 3-8 years	5 years, 1 month	≈ 49 mpy[d]
Apr 2008 – Dec 2012	0.250	"less than 0.100"[e]	≈ 3-8 years	4 years, 8 months	≈ 32 mpy
Dec 2012 – Jan 2023	0.500	0.030	≈ 6-16 years	10 years, 1 month	≈ 47 mpy

The CSB concludes that the reboiler's carbon steel shell experienced average thickness loss that was generally consistent with published industry data. Despite being aware of the data, Honeywell Geismar allowed the reboiler's carbon steel shell to corrode to failure three times, with the final time resulting in a catastrophic BLEVE.

3.3.1.4 Mechanical Integrity Analysis

Successful MI programs must not only recognize equipment deficiencies but also manage them to safe resolution. For equipment deficiency management, the CCPS outlines six important actions that MI systems must include:

1. Acceptance criteria are established that define proper equipment performance/conditions,
2. Equipment condition is routinely evaluated,
3. Deficient conditions are identified,

[a] The theoretical service life of a pipe or pressure vessel is the projected time for it to thin to T_{min}. When a pipe or vessel is thinner than T_{min}, it can no longer be relied upon to safely contain pressure at its design conditions according to ASME code.

[b] Using an assumed corrosion rate of 30-80 mpy.

[c] Based upon CSB calculations.

[d] 49 mpy is the average corrosion rate including the first 2.5 years of service for this reboiler shell where Honeywell reported little corrosion. If that period of time is removed from the calculation, the average corrosion rate approximates to roughly 103 mpy. Because Honeywell did not preserve any of the thickness measurement data for this reboiler shell, the CSB was unable to review the information beyond what Honeywell reported qualitatively in its incident investigation report for the 2008 shell failure. Honeywell also did not investigate the cause of the two reported periods of different corrosion performance beyond developing hypotheses.

[e] Honeywell's investigation report for this failure documents "less than 0.100" inches but does not specify an exact final thickness. Honeywell also did not preserve any of the thickness measurement data for this shell. The CSB assumed a final thickness of 0.100 inches for this calculation.

4. Proper responses to deficient conditions are developed and implemented,

5. Equipment deficiencies are communicated to affected personnel, and

6. Deficient conditions are appropriately resolved [25, pp. 119-120].

The CCPS explains that acceptance criteria are qualitative or quantitative limits used to determine whether a piece of equipment's condition is acceptable for continued service, or whether the condition requires corrective action. A "deficiency" is an equipment condition that does not meet the equipment's acceptance criteria [25, pp. 120-121]. The CCPS uses **Figure 21** to illustrate the relationship between equipment condition, acceptance criteria, and deficiencies.

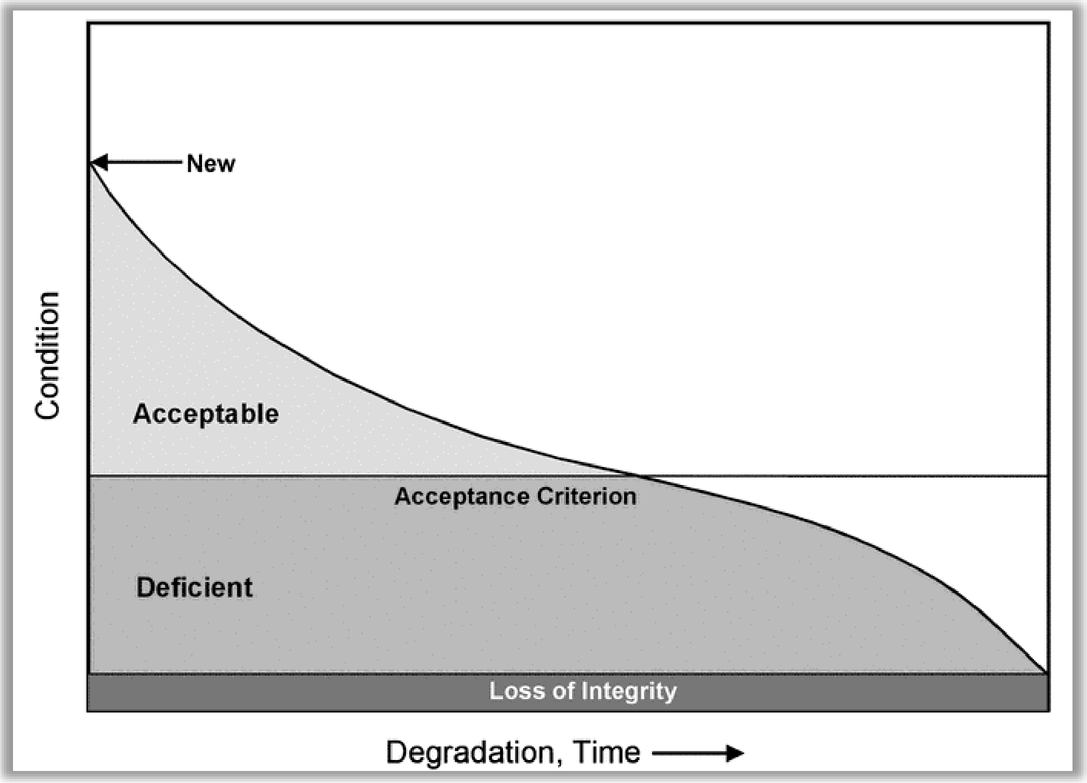

Figure 21. Conceptual diagram illustrating the relationship between equipment condition, acceptance criteria, and deficiencies. (Credit: CCPS [25])

In October 2021, the Honeywell Geismar reliability organization inspected the reboiler and determined that the shell was approaching T_{min} and required replacement. As discussed below, Honeywell did not adequately respond to this deficiency, did not fully communicate the problem to affected personnel, and did not resolve the issue before the reboiler ran to failure.

Honeywell's MI functions were highly siloed and lacked visibility to other critical site and corporate functions, including site operations personnel, site management, and corporate safety and operations management. This siloed organizational structure contributed to the incident by preventing these other important MI stakeholders from ensuring the reboiler was replaced prior to failure. These issues are discussed below.

Deficiency Management

As discussed in earlier sections, the Honeywell Geismar reliability organization established testing and inspection frequencies for the reboiler, along with acceptance criteria.

In practice, the site's acceptance criterion for pressure vessel shell thickness was set at one year of remaining life, although this criterion was not documented in any policy or procedure that the CSB reviewed during its investigation. One of the site's reliability personnel explained during an interview:

> Right, […] so we assign our T_{min} to the equipment. The way that the site works [is that] anything less than a year is what's escalated up to [the replacement process]. You need to begin getting the projects […] in place. […] Anything greater than a year, we allow the system to dictate our next inspection and we'll go back out and inspect that equipment at the next inspection that's assigned from the [system].

When the site inspected the reboiler in October 2021 and found that the shell had less than one year of remaining useful life, that finding constituted a deficiency. Site policy required the reliability organization to report any inspection deficiencies through the site's maintenance management software, SAP, and to maintain an ongoing record of corrective actions in the site's asset integrity management software, DMAPS. Accordingly, after the October 2021 inspection, when the site estimated that the reboiler shell had less than one year of remaining service life, the reliability organization should have documented the issue in SAP and DMAPS. Had the reliability organization done this, the maintenance, reliability, and operations organizations could have tracked an SAP notification or work order to completion and the reliability organization could have tracked an action item in DMAPS to completion.

Because Honeywell elected to continue operating the reboiler, the site should also have created an SAP notification for the next inspection[a] of the reboiler, even though the site intended to replace the shell. Another inspection would have presented Honeywell with another opportunity to realize the reboiler was near failure and to take appropriate action. The reliability organization did not take any of these actions after the October 2021 inspection, however.

Although the reliability organization did not document the deficiency as required by its own procedure, after the October 2021 inspection, the reliability organization informed[b] the 245 unit maintenance engineer of the deficiency. Other than the likely informal communication to the 245 unit maintenance engineer, however, the reliability organization failed to communicate the deficiency to other important stakeholders at the site. Without an inspection deficiency documented in SAP, or a notification for a subsequent inspection, there was no way for the 245 operations staff, site management, or the facility at large to maintain ongoing systemic knowledge and awareness of the reboiler's condition.

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[a] The next inspection of the reboiler shell would have been some time in 2022, but Honeywell never inspected the reboiler again after the October 2021 inspection.

[b] This communication likely occurred informally, as Honeywell was unable to produce any formal, documented communication of the inspection deficiency, such as any emails, Microsoft Teams messages, or phone or text records. Additionally, the senior reliability technician stated that "we gave our information to the engineer" for the 245 unit.

The CSB concludes that the Honeywell Geismar site did not effectively manage the thinning reboiler shell. Although the site had established acceptance criteria, inspected the reboiler, and successfully detected a deficiency prior to failure, the site did not effectively communicate the issue to all appropriate stakeholders and did not take all of its own prescribed actions for deficiency management, which ultimately allowed the reboiler to run to failure in January 2023.

KEY LESSON

Once a deficiency is identified, robust mechanical integrity programs must ensure that corrective actions are identified and tracked to completion. It is not enough to simply identify a deficiency if that deficiency goes unmanaged and unmitigated.

Siloed Organization

The CSB found that the Honeywell Geismar MI functions and stakeholders were siloed and that as a result, critical information about the condition of the reboiler was unavailable to key site decision-makers who needed to act upon it.

The CSB interviewed several management officials who could or might have known about the reboiler's condition, and all of them described being unaware of it, despite some of them having approved the replacement project. In addition to these key management officials' apparent lack of awareness of the reboiler, site personnel described a siloed site organizational structure. For example, a senior site reliability technician told the CSB that, once the reliability organization identifies a deficiency and a project is submitted to address it, the reliability organization is subsequently uninvolved in the process.

> Yeah […] Once it hits the [project] process, we are not really involved. [I shouldn't] say we. The unit inspectors and myself are not really involved in it anymore. Site leadership is.[a]

Chemical process operations departments do not typically maintain evergreen knowledge of the mechanical condition of each of their operating assets; that responsibility typically falls upon a company's maintenance and/or reliability departments. Such was the case at Honeywell Geismar, according to a 245 unit manager.

The site senior reliability technician[b] described the site's decision-making at the time:

> So at that point in time [in October 2021], the decision was made, well, it still had usable life at the time. It was not below T_{min} at the time. We have outages here fairly often, so these outages are probably every six months or so. So the ask was, 'Hey, will we be able…can we make, generate a [project], get a project in place? Will this piece of equipment last to the next outage, to where we can get it replaced?' […] So we gave our information to the engineer for [the 245 unit]. The [project] was generated and that's kind of where we kind of stepped

[a] The Honeywell Geismar site management structure included a Reliability Manager, but the position was vacant from January – November 2022.

[b] The site senior reliability technician had site-wide responsibility for the site's MI inspection programs.

> back from there. That's…kind of after that, that's really our last involvement [with that reboiler] until it BLEVE'd basically.

Given that the operations department depended on the maintenance or reliability departments to inform them of MI issues, CSB investigators asked the senior reliability technician whether the operations department could access equipment reliability information and data. According to the senior reliability technician, DMAPS was only accessible by the reliability and maintenance groups:

> DMAPS was…was a manual system that really had no visibility to the site, other than within our group, our reliability group. […] They could not see DMAPS. That was…that was strictly a mechanical integrity group's tool.

Thus, even if the operations department wanted to check on the condition of a particular piece of equipment, it could not do so independently without the assistance of the maintenance or reliability departments. Yet, the reliability department believed its involvement was complete and stopped tracking the issue once it had performed the inspection and notified the unit maintenance engineer. The 245 unit maintenance engineer's supervisor told the CSB that he could not remember there being a problem with the reboiler. The maintenance engineer thus appears to have been the only Honeywell Geismar employee with ongoing active knowledge of the reboiler, but he left the company in April 2022. After the maintenance engineer left, the project was not reassigned to anyone else,[a] and the site failed to effectively preserve, communicate, manage, or act upon critical information about the condition of the reboiler.

In summary, the site's MI systems failed in the following ways:

- Neither the reliability group nor the maintenance group created a deficiency notification in the site's maintenance management software, SAP. A deficiency notification in SAP would have been managed through the site's normal maintenance management workflow (such as maintenance scoping, planning, and scheduling). This in turn would have enabled the operations, maintenance, and/or reliability departments to track the notification (and thus the problem) to closure and maintain its visibility. Because no SAP notification was created for the inspection deficiency, once the 245 unit maintenance engineer left the company, operations and maintenance had no way of knowing, other than through ad-hoc cross-department communication, that there was a problem with the reboiler.

- No SAP notification was created for the reboiler's next inspection date, which would have been another way for the reliability, maintenance, and operations groups to maintain awareness of the situation. Because no inspection notification was created, no subsequent inspection was scheduled or performed. Another inspection, which presumably would have occurred sometime in 2022, would have been an opportunity for the site to regain awareness of the issue and take urgent action to replace the reboiler or shut it down.

- No DMAPS action item was created, which would have enabled the reliability group to track the issue to successful closure. As a result, there was no way for the reliability group to keep track of the situation other than by memory.

[a] Honeywell's ineffective management of personnel change is discussed in further detail in **Section 3.3.2**.

- While Honeywell Geismar personnel documented written information about the reboiler's condition on the written inspection forms uploaded to DMAPS and in the project form's justification section, other MI stakeholders could not access DMAPS. Consequently, even if another person or department wanted to check on the status of the reboiler, they could not independently do so.

- The information in the project form was not specific and did not clearly communicate the urgency with which the reboiler shell required replacement (See **Section 3.3.3** for more detail).

Therefore, the CSB concludes that:

- Honeywell's MI management systems did not ensure that current, active knowledge of the reboiler's condition, and the urgency with which the shell needed to be replaced, was preserved and communicated to affected stakeholders. Because Honeywell did not preserve any lasting knowledge of the reboiler in its MI management systems SAP and DMAPS, when the 245 unit maintenance engineer left the company in April 2022, the site's knowledge of the reboiler's condition was lost; and

- The Honeywell Geismar site MI function was siloed, such that key people, departments, and functions remained unaware of the reboiler's condition prior to the explosion. Honeywell Geismar's management systems relied upon individual people and informal communication. Information about the condition of the reboiler was not preserved or communicated to key personnel with the ability and authority to act upon it.

3.3.1.5 Post-Incident Actions

After the January 2023 incident, Honeywell purchased and installed a new reboiler with a shell constructed of Alloy 825 for improved corrosion performance in HF service.

Honeywell also made significant changes to the Geismar site's MI management systems. Foremost amongst these changes, the company created an asset integrity dashboard, which interfaces with both Meridium[a] and SAP. Using data from Meridium and SAP, the dashboard displays several key metrics, including currently overdue asset inspections and MI action items, inspections and action items coming due in the next week and month, and a count of assets with remaining life less than one year and between one and two years. The dashboard is accessible to anyone in the corporation and is reported daily throughout the company including up to executive level corporate leadership. These changes were aimed at increasing the visibility of the Geismar site's equipment conditions, the lack of which led to the reboiler explosion. Therefore, the CSB makes no recommendations to Honeywell regarding the Geismar site's MI functions.

KEY LESSON

Companies should ensure that their mechanical integrity systems communicate the need for corrective action to all stakeholders when safety-critical equipment is either approaching or has reached a point that requires corrective action.

[a] Honeywell Geismar changed its asset integrity management software from DMAPS to Meridium. The change was ongoing at the time of the incident.

3.3.2 Management of Organizational and Personnel Change

In its 2013 book *Guidelines for Managing Process Safety Risks during Organizational Change*, the CCPS states that:

> It has long been acknowledged that when not properly evaluated and controlled, changes in physical equipment in a facility can lead to serious incidents with potentially severe consequences. […] However, other types of changes such as changes in job responsibilities, loss of key personnel, or even changes in shift hours may not be included in an MOC program. It is less well understood that these and other nonphysical changes, collectively referred to as 'organizational changes,' can also lead to serious incidents with potentially severe consequences. Due to their focus on managing physical changes, most MOC systems have overlooked or only superficially addressed organizational change management and the impact of organizational changes that affect process safety [26, p. 1].

As discussed in **Section 3.3.1**, the Honeywell Geismar reliability team inspected the reboiler shell in October 2021 and determined that it required replacement. The reliability department informed the 245 unit maintenance engineer, who initiated a capital expenditure request to replace the reboiler shell. The project was approved by site management in February 2022. In April 2022, the maintenance engineer left the company. After the maintenance engineer left, the company never reassigned the reboiler project, and the project was never completed. Eventually, the reboiler ran to failure on January 23, 2023.

When the maintenance engineer left Honeywell in April 2022, it constituted a personnel change that should have been managed according to effective change management principles. As the CCPS points out in its organizational change *Guidelines* book, personnel changes are a type of organizational change that can present process safety risks if not managed effectively [26, p. 83].

At the time of the maintenance engineer's departure, Honeywell Geismar had a procedure called "Management of Organizational Change" (MOOC). Honeywell Geismar created the procedure in 2014. The procedure directed users to initiate an MOOC when there was "change in personnel who have key safety job functions or tasks," among other situations. The procedure defined key safety functions and tasks as those that "if done improperly would result in significant impacts to people and/or the environment."

As demonstrated by the incident, Honeywell's failure to complete the reboiler project directly caused a significant process safety event that could have resulted in multiple serious or fatal injuries. Therefore, the CSB concludes that the reboiler shell replacement project met Honeywell's definition of a "key safety task" that should have been managed using the site's existing MOOC procedure when the 245 unit maintenance engineer left the company.

Honeywell Geismar's MOOC procedure required the user to first determine whether an MOOC evaluation was required, or whether a given personnel change was a "replacement in kind." Users of the procedure were directed to a flowchart (**Figure 22**) to aid in determining whether an MOOC evaluation was necessary.

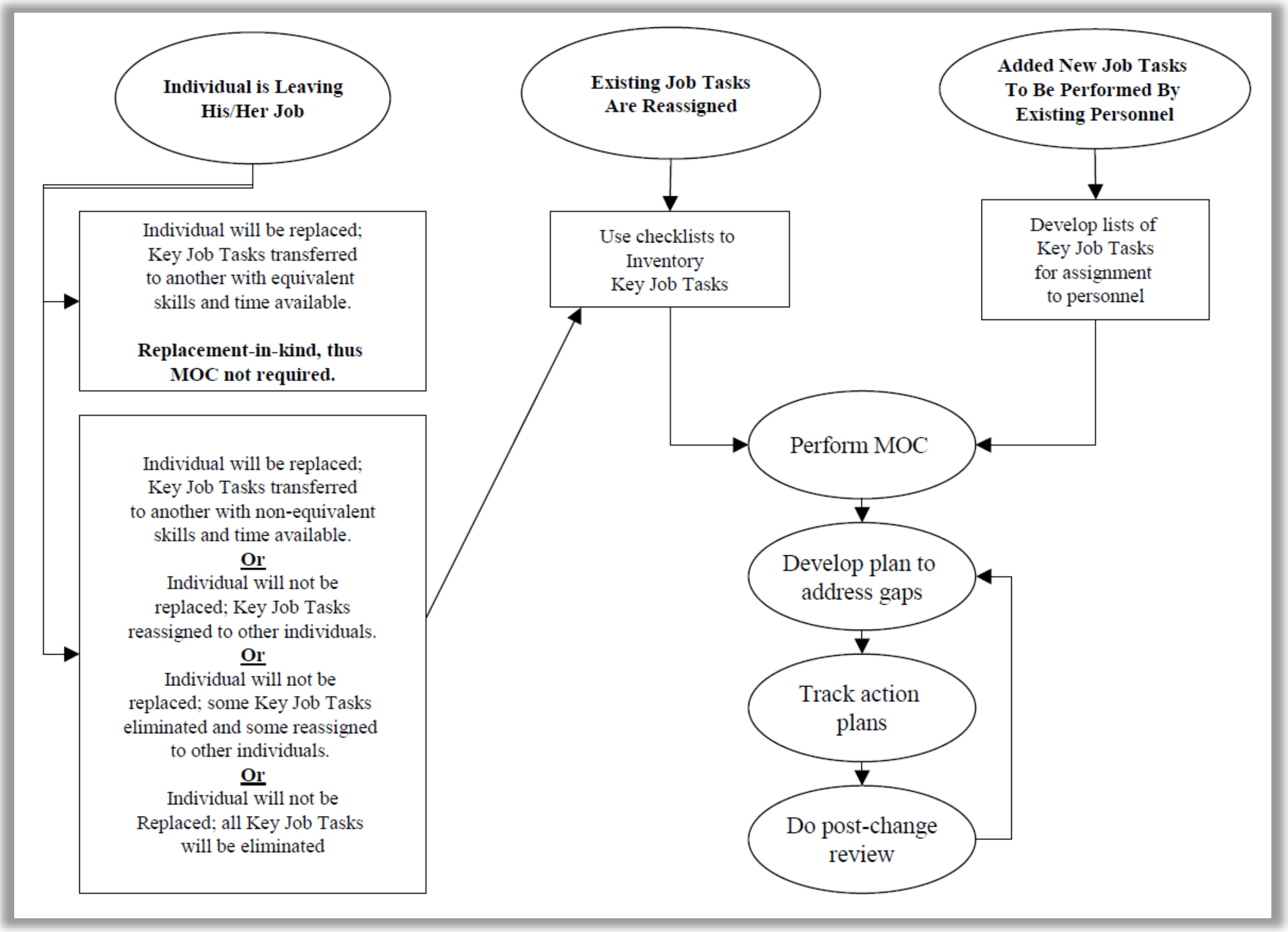

Figure 22. Honeywell flowchart to determine whether MOOC analysis was required. (Credit: Honeywell)

An MOOC analysis was either required or not[a] depending on whether Honeywell Geismar intended to replace the departing person, and whether the identified replacement possessed "equivalent skills and time" to accomplish the job.

If an MOOC was necessary, the procedure required, among other things, that the manager document the key safety job functions and skills for the person departing the site or role. The procedure stated that one objective was "to verify that no key safety functions and tasks [are] left unassigned." The procedure required an action plan to be developed and completed within six months of the change.

[a] Honeywell's procedure specified that an MOOC analysis was not required when "[a] new, similarly qualified individual is identified to replace the individual leaving and all of the original key safety functions and tasks will be transferred to the new person. […] This is essentially a 'replacement-in-kind' and thus no Management of Change (MOOC) evaluation need be done."

In interviews, the maintenance supervisor (the person to whom the 245 unit maintenance engineer reported) told the CSB that he did not perform an MOOC analysis when the 245 unit maintenance engineer departed the company.[a] Consistent with that, Honeywell Geismar was unable to produce any MOOCs completed for the site during the time period of January 2020 to January 2023. The CSB concludes that although Honeywell Geismar had a management system that was intended to manage organizational and personnel change, Honeywell did not apply its management system when the 245 unit maintenance engineer departed the company. As a result, the capital project to replace the reboiler shell was never reassigned, and the project was never completed.

KEY LESSON

Companies should develop and implement systems to manage organizational and personnel change. It is crucial to ensure that process safety-related responsibilities and tasks are not lost during such changes.

In interviews with the CSB, the maintenance supervisor described being overwhelmed with work from October 2021 (when the reboiler was last inspected and the fatality occurred) through January 2023 (when the reboiler exploded). According to company records and statements made to the CSB, during that same time the maintenance supervisor was a member of the October 2021 incident investigation team, he was heavily involved in the site's efforts to inspect and replace gaskets in the 245 unit as a result of the fatal incident (described in further detail in **Sections 2.4.1** and **Section 4.1.2**), and he experienced a personal medical emergency that required weeks of leave. He also managed the maintenance efforts that occurred during nine planned unit outages and 11 unplanned unit outages.[b]

During this time period, the maintenance supervisor was also responsible for the duties of the maintenance manager in addition to his own responsibilities. The maintenance manager position was vacant from October 2021 to August 2022. The reliability manager position, another key site management role, also was vacant from January 2022 to November 2022. These two management vacancies overlapped from January 2022 to August 2022, the key period of time during which the reboiler project was created, approved, not funded, and not transferred to a new owner.

As one former Geismar management employee stated:

> [The maintenance supervisor] was easily the most overworked. And especially once his team left, it's like […] nuts. Somebody's got to do this stuff[.]

Prior to those organizational changes, in 2020, Honeywell enacted a roughly 10% reduction in force at the Geismar site in response to economic conditions caused by the COVID-19 pandemic. Most of the positions eliminated in the 2020 reduction in force were not backfilled prior to the reboiler explosion, and the few

[a] Honeywell Geismar replaced the 245 unit maintenance engineer in June 2022, but because the site was not following its MOOC procedures, the site did not evaluate whether the replacement engineer was a "replacement in kind."

[b] According to site records, the maintenance supervisor was responsible for the maintenance of two other refrigerant units, the tank farm, and the site's utility systems in addition to the 245 unit.

backfills that did occur were not completed until 2022. The eliminated positions included process engineers, reliability engineers, process operators, and various management positions.

Honeywell Geismar did not conduct MOOC analyses for either of the maintenance and reliability management position vacancies, for the reassignment of those management duties to the maintenance supervisor and other employees, or for the 2020 reduction in force. All of these situations required MOOC analyses according to the site's existing policy. These constituted substantial changes in the distribution of responsibilities within the organization for extended periods of time. All of the changes affected positions that had some responsibility for aspects of the site's process safety management systems.

The CSB concludes that as with the 245 maintenance engineer's departure, Honeywell also did not apply its MOOC system to the extended vacancies in the maintenance and reliability manager positions, the reassignment of those management duties to other employees, or to the 2020 reduction in force. By not following its existing MOOC process, Honeywell Geismar failed to preserve critical information about the urgency of the reboiler shell replacement project. If the site had followed its MOOC policy and identified and reassigned the safety-related tasks of the departing 245 unit maintenance engineer, the necessity of the project may not have been lost, and the replacement may have been completed, thus preventing the explosion.

The CSB also concludes that the maintenance supervisor's workload likely contributed to him not conducting an MOOC evaluation when the 245 unit maintenance engineer, who reported to him, left Honeywell. By not following its MOOC process, Honeywell Geismar did not account for or address the concentration of workload upon the maintenance supervisor.

Honeywell Geismar's MOOC procedure directed users to a checklist to use for the task and skill inventory. The checklist contained a comprehensive list of occupational and process safety-related skills that an employee might be expected to possess depending on their position. It also had a matrix that listed which of the various skills were required for 19 different job types, such as Site Manager, Reliability Engineer, and others.

The checklist and matrix were comprehensive with respect to safety skills, training, and knowledge. Yet, they did not mention discrete process safety items that required a specific assignee and thus which would require the assignee to be changed during a personnel or organizational change. For example, in typical process safety management systems, such items commonly include Process Hazards Analysis action items, Pre-Startup Safety Reviews and resultant action items, MOCs and MOC action items, process safety audit action items, or incident investigation action items. Such items are discrete tasks generated by a company's various process safety management systems, are usually assigned to a specific individual, and include due dates for their implementation and/or verification.

Because such items are inherently critical to a company's risk prevention or mitigation efforts, doing them improperly, late, or not at all can result in unmitigated risks and potentially lead to serious process safety incidents. It is therefore crucial for companies to ensure that such items are transferred from one owner to a new, appropriate owner when a personnel or organizational change occurs. As discussed above, the project to replace the reboiler shell was such an item.

The CSB concludes that because Honeywell Geismar's procedure and checklist did not specifically address items such as safety-related capital projects, it is uncertain whether Honeywell Geismar would have effectively transferred the reboiler project to a new owner even if the site had followed its existing MOOC procedure.

The CSB concludes that Honeywell Geismar's management of organizational change system was not effectively implemented. Honeywell failed to analyze the risks of organizational change at all levels of the Geismar facility, from a large-scale reduction in force to individual position vacancies. Honeywell's failure to implement this system and to effectively manage organizational and personnel change directly contributed to this incident by allowing the project to replace the reboiler, a safety-related task, to go unassigned and incomplete until the reboiler exploded in January 2023.

KEY LESSON

Capital projects that are intended to address mechanical integrity deficiencies are important safety tasks. Companies must ensure that all safety-related tasks, including safety-related projects, are included in their MOOC programs so that they are properly managed, tracked, and reassigned when necessary.

3.3.2.1 Post-Incident Actions

After the 2023 incident, Honeywell Geismar modified its MOOC policy to more clearly include management of personnel change (MOPC), and now states:

> As soon as a pending personnel change is identified, the line manager or supervisor should complete a retention of critical knowledge checklist to ensure critical knowledge and responsibilities are identified with a plan for continued ownership.

The checklist specifically includes "active projects" in addition to several other specific categories of action items and tasks that could impact safety. As a result, the CSB makes no recommendations to Honeywell regarding the application of the company's MOOC/MOPC systems to capital projects.

An analysis and recommendations regarding Honeywell's implementation of its safety management systems at the Geismar site can be found in **Section 5**.

3.3.2.2 Recommendation to OSHA

On March 23, 2005, several severe explosions and fires occurred at the BP America Refinery in Texas City, Texas. The incident resulted in 15 fatalities, 180 injuries, and significant economic losses. To date, the incident remains one of the most serious incidents investigated by the CSB.[a]

The CSB identified MOOC among many significant safety issues documented during its investigation of the BP Texas City incident. The CSB issued 26 safety recommendations as a result of the investigation, one of which was made to OSHA to amend the PSM standard to explicitly require the management of organizational and

[a] The BP Texas City report can be found on the CSB's website: BP America (Texas City) Refinery Explosion | CSB

personnel changes. This recommendation is the last remaining open recommendation from the BP Texas City investigation.

Since the agency issued that report and recommendation, the CSB has investigated at least four other incidents in which the management of organizational or personnel change was identified as having contributed to the incident. **Table 5** below summarizes those incidents and their consequences.

Table 5. Summary of incidents investigated by the CSB that involved the MOOC/MOPC.

Incident Date	Company Name and Location	Incident Description	Incident Consequences	MOOC/MOPC Role in the Incident
March 23, 2005	BP; Texas City, Texas	Explosion and fire	15 fatalities; 180 injuries; significant property damage	BP had a policy that required MOOC, but it was not followed. BP ineffectively managed corporate mergers, personnel changes, and budget cuts.
August 28, 2008	Bayer CropScience; Institute, West Virginia[a]	Runaway reaction of a pesticide chemical; pressure vessel explosion	2 fatalities; 8 injuries; significant property damage	Bayer applied its MOC system to a reduction in force but did not adequately address reductions to its technical support staff and its availability during the startup of a new control system.
April 2, 2010	Tesoro; Anacortes, Washington[b]	Catastrophic heat exchanger rupture	7 fatalities; significant property damage	Tesoro required operators from other units to assist in the hazardous startup of the naphtha hydrotreater unit, but these extra operators had no defined role in the unit startup procedure. This practice resulted in an unusually high number of employees within the unit when the explosion occurred during startup. Tesoro's MOC system required MOOC, but Tesoro did not apply it to such situations.
October 9, 2012	US Ink; East Rutherford, New Jersey[c]	Combustible dust explosion	7 serious injuries; significant property damage	When a senior engineer retired from the company, US Ink lacked a system to ensure that critical knowledge regarding the dust collection system was transferred to the new engineer, who was not involved in the design of the system.

[a] The Bayer CropScience report can be found on the CSB's website: Bayer CropScience Pesticide Waste Tank Explosion | CSB
[b] The Tesoro Anacortes report can be found on the CSB's website: Tesoro Anacortes Refinery Fatal Explosion and Fire | CSB
[c] The US Ink report can be found on the CSB's website: US Ink Fire | CSB

January 23, 2023	Honeywell; Geismar, Louisiana	Catastrophic heat exchanger rupture	Significant property damage	Honeywell did not apply its existing MOOC system to the departure of a key engineer, and as a result, the project to replace the reboiler shell was never transferred to a new owner, and the reboiler ran to failure.

For 20 years, OSHA has taken little action to address the recommendation other than to issue a 2009 interpretation memo[a] to its regional administrators, stating that the MOC element within the PSM regulations includes the management of organizational and personnel change, even though it is not explicitly required in the language of the regulation [27].[b] Given that the CSB has investigated at least four additional incidents involving a total of nine fatalities, 22 injuries, and millions of dollars of property damage since the issuance of this recommendation, OSHA should take effective action to implement it. The CSB concludes that OSHA should amend its PSM regulation to explicitly require the management of organizational and personnel change.

Therefore, the CSB reiterates recommendation 2005-4-I-TX-R9 from the BP Texas City report. OSHA should amend the OSHA PSM standard to require that a management of change (MOC) review be conducted for organizational changes that may impact process safety including:

a. major organizational changes such as mergers, acquisitions, or reorganizations;

b. personnel changes, including changes in staffing levels or staff experience; and

c. policy changes such as budget cutting.

[a] Management of Organizational Change | Occupational Safety and Health Administration
[b] eCFR :: 29 CFR 1910.119 -- Process safety management of highly hazardous chemicals.

3.3.3 Capital Project Management

3.3.3.1 Honeywell's Capital Project Management Processes

Honeywell corporate procedures provided requirements for capital project management and funding. A request to obtain capital funding for a project was referred to as an appropriations request ("AR"). At the Geismar site, the process was initiated by a plant representative completing a "Project Identification Form." The form required users to assess the project's criticality[a] and complexity.[b] Projects were then managed using one of two processes based upon how they were assessed. The Geismar site used the matrix shown in **Figure 23** to assign a "block" rating to a project.

Criticality	Complexity: Low	Complexity: Medium	Complexity: High
High	(P1) Requires minimum and least sophisticated resources; execute fast w/ highest priority; utilize blanket AR if possible **Block 1**	(P2) Requires medium level of sophistication and development; resource for speed **Block 2**	(P2) Requires maximum level of sophistification and development; resource for speed and experience; special case requires discussion on how to accelerate **Block 3**
Medium	(P1) Requires minimum and least sophisticated resources; execute fast w/ highest priority; utilize blanket AR if possible **Block 4**	(P3) Requires medium level of sophistication and development; resource as available **Block 5**	(P3) Requires maximum level of sophistification and development; resource as available **Block 6**
Low	(P3) Prioritize lowest; not critical; resource/rationalize as needed **Block 7**	Don't do/Defer **Block 8**	Don't do/Defer **Block 9**

Figure 23. Matrix used to assign a "block" rating to a project. (Credit: Honeywell)

[a] A project's criticality was assessed by evaluating the business need for the project (such as whether the affected asset's production capacity would be changed), the project's safety impact, and the project's financial impact (such as the project's estimated payback time).

[b] A project's complexity was assessed by evaluating the project's engineering requirements (for example, whether it required Professional Engineer licensure or complicated front-end engineering), its "process" requirements (for example, whether a Process Hazards Analysis would be required or whether the site's material and energy balances would need to be altered), and the complexity of the project's proposed scope.

After determining the "block" to which a project would be assigned, Honeywell used the rubric shown in **Figure 24** to determine which management process to use for a project.

Honeywell had two management paths for capital projects. Higher complexity, lower criticality, higher cost projects (projects assigned to blocks 2, 3, 5, 6, and 7) were supposed to be managed through the site's annual capital budgeting process. These projects were categorized as "standalone ARs" and typically involved some level of corporate oversight. Each year, beginning generally in July, the Geismar site would aggregate a list of standalone ARs and would prioritize them for inclusion in the following year's or a future year's capital expenditure budget. Honeywell corporate officials would eventually approve the site's capital budget for the following year.

Path Forward (based on results)

Result	Capital Resource Suggestion	Capital Funding Method
Green Blocks (1 & 4)	Does not require experienced PM- assign to resource with availability to prepare AR package quickly and execute PO's	Blanket AR, or propose AR escalation through site manager and/or [redacted]
Blue Blocks (2 & 3)	Assign to resource with experience in the areas of complexity, accounting for speed requirements as needed	Stand alone AR, escalate approval process if business demands require
Yellow Blocks (5, 6, 7)	Assign to PM with capability or availability to execute, but prioritize lower than projects in blocks 1-4 in their workload	Stand alone AR (don't tie up blankets with low criticality projects), prioritize work behind other more critical projects
Red Blocks (8 & 9)	Do not submit project to capital program- not a priority investment	Do not submit project to capital program- not a priority investment

Figure 24. Rubric that Honeywell used to determine which project management process to use for a project. (Credit: Honeywell, redaction by CSB)

Projects assessed with higher criticality, lower complexity, and typically lower cost (projects assigned to blocks 1 and 4) were intended to proceed through Honeywell's "blanket" AR process. At the Geismar site, the blanket AR management path was typically used for projects similar to the one to replace the reboiler—such as projects to purchase and install pre-engineered and often replacement in-kind equipment. Generally, this process was intended to work more quickly and with less administrative oversight than the annual capital budgeting process.[a] Projects with an estimated cost of less than $150,000 required only site-level approval, whereas projects with an estimated cost of greater than $150,000 required increasing levels of corporate approvals as the amount of the estimated cost increased.

Site annual capital budget funding was not provided by the corporation until the following year, and that funding could only be used on the projects that were approved in that year's budget. In contrast, the corporation provided the site with blanket funding in advance, and the funding was intended to be used as needs arose. Honeywell normally provided funding in discrete increments. The funding was usually distributed to the site roughly each quarter, though the site could request additional funding sooner if needed. When the site's blanket funding was running low, the site capital organization would begin the approval process to request and receive the next incremental allotment from the corporation. According to Geismar personnel, approvals for additional funding allocation could often take weeks.

[a] By default, projects assigned to the annual budgeting path had to wait to receive funding and could not be completed until the specific year to which they were assigned. Blanket projects could be funded and could proceed toward completion immediately after being approved. Being assigned to the blanket path did not necessarily mean that a project would be completed quickly, but did mean that it could be.

In addition to the blanket AR process and the slower annual capital budgeting process, there was also an emergency process specified in a Honeywell corporate procedure. Using this process, the site could purchase equipment on its expense budget and capitalize the expense later.

A senior site manager described the emergency process in an interview:

> If you have something that's at end of life, you can… I can get that approved for purchase today. I could get that approval within an hour. If they come to me right now and tell me 'Hey, we just took a thickness reading on this reboiler shell and it's, you know…' […] It's as simple as sending an email. So I will send an email to my boss […], explaining what we need, explaining the cost, requesting approval to purchase. I can even purchase it on expense [and capitalize it later].

A simplified flowchart depiction of Honeywell Geismar's capital project management processes is shown below in **Figure 25**. The flowchart shows how Honeywell Geismar's capital project systems were intended to function.

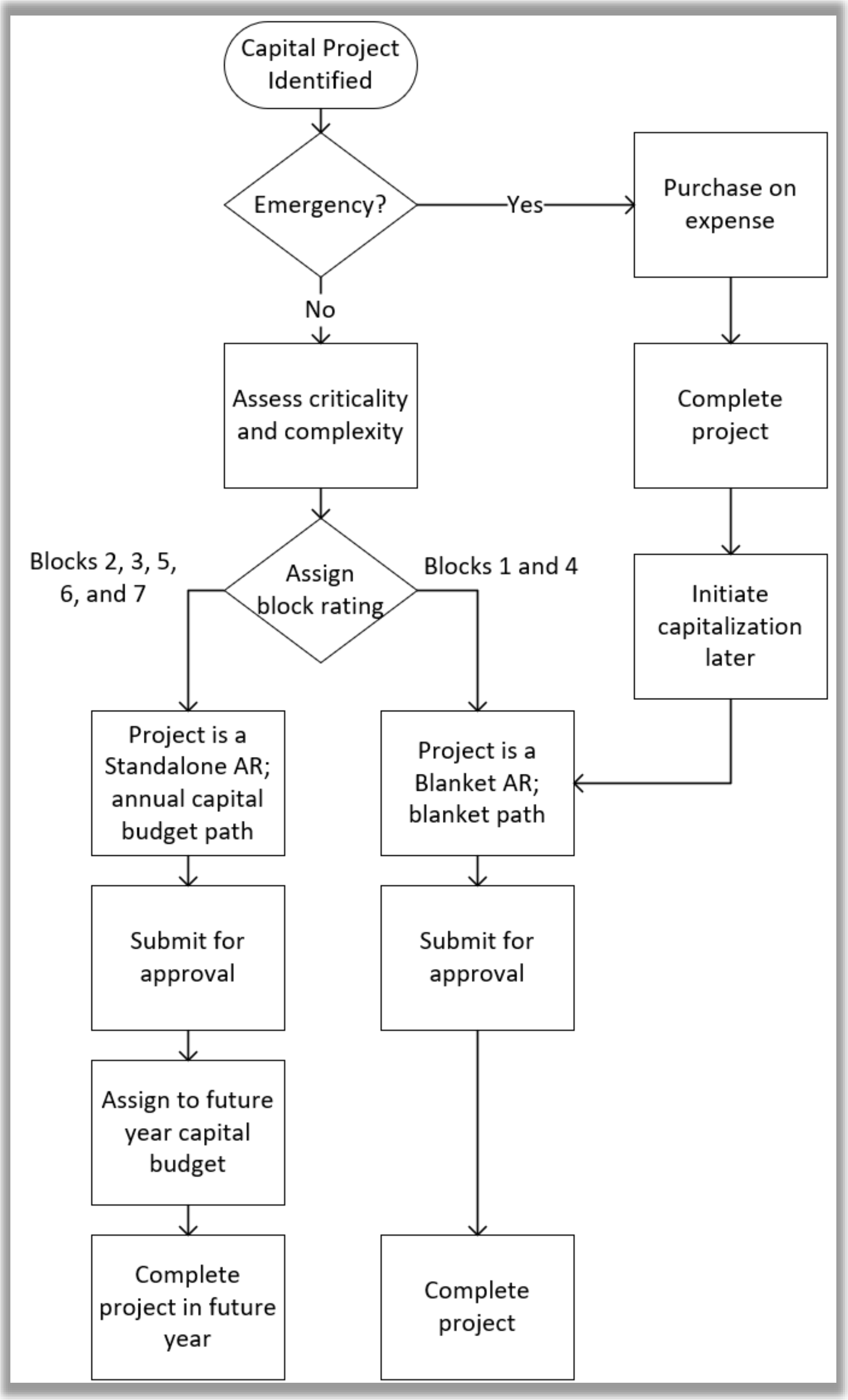

Figure 25. Simplified flowchart of Honeywell Geismar's capital project processes as they were intended to function. (Credit: CSB)

3.3.3.2 The Reboiler Project

The site reliability organization inspected the reboiler shell in October 2021 and informally communicated the need for its replacement to the 245 unit maintenance engineer (**Section 3.3.1**). For the reboiler shell replacement project, the 245 unit maintenance engineer completed the project assessment as required and determined that the project met the requirements of block 1, as shown in green in **Figure 23**.

In the project justification for the reboiler shell replacement, the engineer wrote that:

> Reliability conducted thickness readings during the inspection process and found the shell to be nearing minimum thickness allowance. Welds near the eccentric reducing head have started to wash out. It was recommended we purchase a complete shell […]. Will completely replace [the reboiler] shell […] to 'new condition.' Shell is nearing T-min. Needs to be replaced.

The 245 unit maintenance engineer submitted the project to site leadership for approval in January 2022, and it was approved as a blanket project in February 2022. Because the project was estimated to cost under $150,000, it only required site-level approvals. The project was reviewed and approved by the 245 unit operations manager, the maintenance supervisor, the site capital leader, the site technical manager, and the plant manager.

By April 2022, the project had not received funding. This condition was unusual, because blanket projects were typically funded as soon as, or shortly after, they were approved. One manager described the expectation that these projects "were just funded."

By August 2022, the reboiler shell replacement project was still neither reassigned nor funded, and site management moved the project to the site's 2023 capital budget request to the corporation. In October 2022, the corporation approved the Geismar 2023 capital budget, and the project for the reboiler shell was thereafter included in the site's 2023 capital budget, indicating that the site had abandoned efforts to complete the reboiler project in 2022.

Honeywell personnel described in interviews that during this period (roughly May to October 2022), the Geismar site was requesting more blanket funding than the corporation had allocated and at a faster rate than the corporation could quickly provide. The CSB determined that at its worst point, the average delay in blanket project funding was 88 days. As one Geismar employee described:

> We went through about a six-month period or so where we couldn't approve [blanket allocations] as fast as [the site was] spending money. So, we would have to take the list of [projects] that we had, send those back to [the site], and say 'we're getting the next [funding allocation] approved right now. When that money comes in, where do you want to spend the next $[redacted]?' So they would prioritize the list and come back to us.
>
> […]
>
> And those were happening so fast. I mean, they're sending $[redacted] back to us the day we got [the next allocation] approved. So we would start the next

> [allocation request] right then. But through the approval process, that takes time. Typically, it was taking two, three, four weeks at that period in time to get [each allocation] approved and funded.

Geismar personnel stated that having to prioritize blanket projects was abnormal, because essentially, the projects had already been prioritized by virtue of having been placed on the blanket management path (whereas other projects had to wait to be included in a future year's capital budget on the slower management path). The site was essentially having to re-prioritize projects that had already been prioritized.

The site managers who were asked to re-prioritize the project list were the same managers who told the CSB that they were unaware of the reboiler project's urgency, despite some of them having approved the project themselves. Further, project re-prioritization was done on an ad-hoc basis via email, without any formalized policy, procedure, or guidance on how to do so or which factors should be considered. **Figure 26** below shows a graphical representation of how Honeywell Geismar's capital project management systems functioned with respect to the reboiler project.

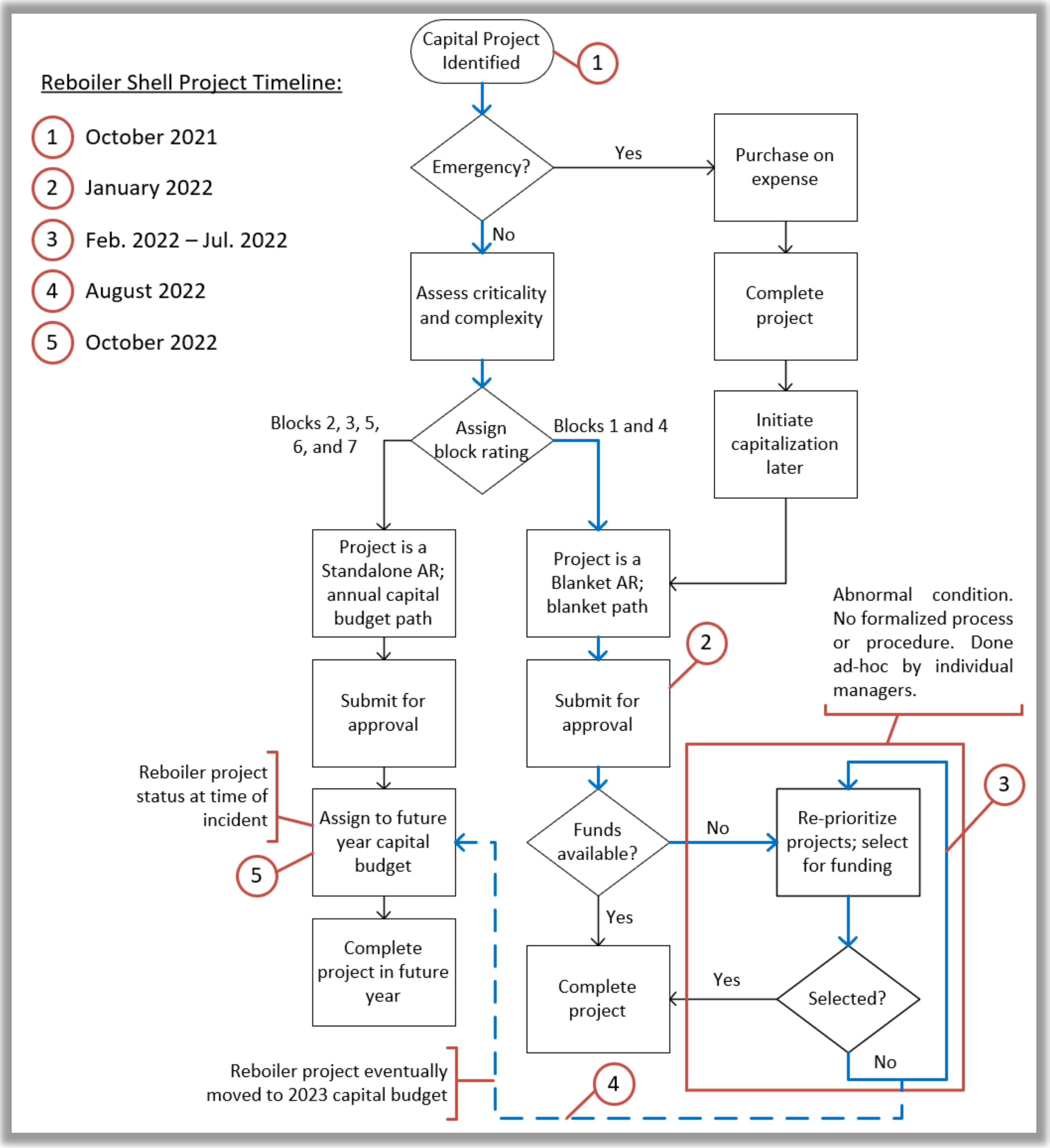

Figure 26. Flowchart showing how the reboiler project was managed. The steps through which the reboiler project progressed are highlighted with blue arrows. (Credit: CSB)

Honeywell's block rating methodology, which was applied before a project was assigned to either the annual capital budget process or to the blanket AR process, accounted for a project's impact on safety. Projects with a high or urgent potential safety impact were more likely to be assigned to the blanket path. After a project was assigned to the blanket process, however, there was no further formalized and documented consideration of a project's safety impact. To the extent that safety was considered during the re-prioritization process, it was done informally without a procedure or policy, and it was done by individual managers using their own individual judgement. Because those same managers were all unaware of the reboiler project's urgency, it was impossible for the project to be effectively prioritized under this process. The CSB concludes that Honeywell Geismar's project management systems could not appropriately accommodate periods of time during which project cost demand temporarily exceeded funding availability. This condition caused the Geismar site to have to re-prioritize its project list, but once a project was placed on the faster management path, the site had no formal process to re-prioritize projects. Because Honeywell had no formal process, the company and site had no way to ensure that projects with an urgent safety impact, such as the reboiler project, were prioritized appropriately.

3.3.3.3 Blanket Project Management

The CSB investigated why, given its urgency, the reboiler replacement project was moved from the site's blanket process to the 2023 capital budget. The CSB examined all Geismar site projects approved to proceed along the blanket management path during the period of October 21, 2021 (the date of the fatal incident described in **Section 2**), to January 23, 2023 (the date of the reboiler explosion). Honeywell's records indicated that there were 142 such projects, including the one to replace the reboiler shell. Despite short-term funding delays discussed previously, all of these projects were eventually provided with funding and completed except for two. One of these was the reboiler project, and both unfunded projects were originated by the 245 unit maintenance engineer who left Honeywell in April 2022.

Of the 140 projects that were approved for the blanket process and eventually funded, 70 of them were not given a block rating (**Figure 23**). This indicates that these 70 projects did not go through the project rating process. Additionally, of the 140 funded projects, two were rated as "block 7," and six were rated as "block 2." According to Honeywell's rubric (**Figure 24**), these eight projects should have been managed using the annual capital budget process, rather than competing with the reboiler project for blanket funding. Despite their block rating, these eight projects were still approved for the blanket process, funded, and eventually completed. In total, from October 2021 to January 2023, Honeywell funded 78 projects that either had no block rating or were assigned lower-priority block ratings than the reboiler replacement project. All 78 of these projects were selected for, and provided with, funding instead of the reboiler project.

The CSB concludes that the Honeywell Geismar site did not consistently apply its project rating methodology during the key time from October 2021 to January 2023. The reboiler project was left unfunded while at least 78 other unrated or lower rated projects were funded instead.

Additionally, despite the site's well-understood ability to use the emergency procurement method (**Section 3.3.3.1**), the site did not apply this process to the reboiler project. This process could have been used to replace the reboiler shell prior to its failure, but doing so would have required site managers with sufficient authority to understand and recognize the urgency with which the reboiler shell needed to be replaced. As discussed in **Section 3.3.1.4,** the Geismar personnel with such authority all stated to the CSB that they were not aware of the reboiler's urgency.

Of the 142 blanket projects that the CSB analyzed, at least two of them were approved and processed as emergencies, indicating that the site had working knowledge of the emergency process during the time leading up to the reboiler explosion. Therefore, the CSB concludes that in the event of temporary funding delays and disruptions in funding availability, the Honeywell Geismar site could have used its emergency process to replace the reboiler prior to its failure. Honeywell Geismar did not use this process because none of the personnel with the authority to use it were aware of the urgency with which the reboiler needed to be replaced.

The CSB found the following key facts related to the management of the reboiler project:

- Geismar management personnel stated in interviews that they were either unaware of the project to replace the reboiler, unaware that the reboiler was near failure, or both;
- Several of the managers who told the CSB that they were unaware of the reboiler's urgency had approved the project themselves;
- During the key period from October 2021 to January 2023, 78 out of 140 blanket projects that the Geismar site funded were either not assigned block ratings or were assigned block ratings that should have precluded them from the blanket AR path;
- The Geismar site used the emergency process for at least two projects during the key time period but not for the reboiler; and,
- The Geismar site delayed the project even further when it moved the project to the 2023 capital budget.

Therefore, the CSB concludes that Honeywell Geismar did not effectively manage the capital project to replace the reboiler shell. After Honeywell Geismar's MI and MOOC/MOPC systems failed to preserve crucial knowledge about the reboiler, Honeywell Geismar's project management systems failed to fund the project and funded other, lower priority or unprioritized objectives instead of the reboiler, leading to the reboiler's eventual explosion.

3.3.4 Organizational Resilience

In the 2015 book, *Risk Analysis and Control for Industrial Processes – Gas, Oil and Chemicals*, process safety author Hans Pasman describes the concept of organizational resilience as the capacity of an organization "to absorb unexpected shocks[…,] understand warning signals, minimize damage by an unforeseen threat, and to restore quickly from damage sustained" [28, p. 216]. Similarly, in their 2006 book, *Resilience Engineering – Concepts and Precepts*, authors Erik Hollnagel, David D. Woods, and Nancy Leveson wrote that organizational resilience failures at the system level occur when an organization exhibits a "temporary inability to cope effectively with complexity," resulting in the inability to "recognize, adapt to and absorb variations, changes, disturbances, disruptions, and surprises – especially disruptions that fall outside the set of disturbances the system is designed to handle" [29, p. 3].

Prior to the 2023 reboiler explosion, Honeywell was responding to significant disruption in the workforce resulting, at least in part, from the global COVID-19 pandemic. During this same time, Honeywell was beginning to develop and implement policies for organizational resilience. These systems, however, were either nascent or actively in development during and leading up to the two major process safety events that occurred at the Geismar site in 2021 and 2023. As a result, the site was unable to cope with disruptions to its management systems that were either partly caused by or occurred concurrently with the aftermath of the 2021 fatal incident.

After that incident, Honeywell needed to replace the gaskets within the recycle HF stream of the 245 unit and perform other equipment repairs and improvements, and these efforts occurred from October 2021 to roughly April of 2022.

One former plant manager stated:

> And understand that also the remaining [site] resources between October and restart were focused almost 100 percent on getting 245 back up and ensuring [its] safe operation[.] […] So, there [was] not a lot of extra folks that [were] able to look much farther than a few months down the line.

In 2022, the company decided to replace spiral wound gaskets in fresh and recovered HF service in addition to the gaskets in recycle HF service. Implementing this change caused further extensive maintenance work in addition to the work already described (see **Section 4.1.2**). This work extended into 2024.

During this time, the Geismar site experienced a significant shortage of personnel. The 2020 reduction in force resulted in dozens of site positions being eliminated or vacated by attrition. Many of these positions were never backfilled. Some of them were eventually backfilled, but not until beginning in 2022. Separately from the reduction in force, the Geismar site had vacancies in other key positions, including its maintenance and reliability managers, which were both vacant for over nine months. In addition to those key vacancies, the site experienced personnel turnover in numerous other positions during the key period of October 2021 to January 2023, including its technical manager,[a] the 245 unit manager, the 245 unit maintenance engineer, the plant manager, and the Geismar site capital leader. Honeywell did not effectively manage these organizational and personnel changes (**Section 3.3.2**), and the result was that the remaining personnel struggled to keep up with the increased workload. A senior process engineer told the CSB that:

> I think there was a lot of focus on the time around the […] fatality, really digging into the root cause of why that had happened. And I think that took away a lot of people's time and energy [from their] day-to-day job[.] And unfortunately, we didn't have the manpower [or] the staffing to have other people focus on maybe picking up their work […]. So once that investigation concluded, it seemed like those same people who now also had to do their day-to-day stuff but also had to do the day-to-day stuff of maybe three or four months [prior] as well.

Concurrently with the incident recovery efforts and the site's various position vacancies and personnel turnover, the site's normal process for managing small "replacement maintenance" projects was overwhelmed with requests that produced a roughly 88-day backlog in blanket project funding. This condition caused the need to re-prioritize blanket projects, a condition that multiple site personnel described as abnormal (**Section 3.3.3**).

This funding backlog may have been caused in part by the site's intensive efforts to resume safe operation of the 245 unit. One Honeywell manager stated that the corporation provided additional funding outside the normal capital process to enable the site to "do what [it] need[ed] to do to make it safe" after the 2021 incident. Another manager said that:

[a] The Geismar technical manager is analogous to a process engineering manager.

> It was not an open checkbook but the oversight was certainly more quick… The approval mechanisms were certainly more advanced[...]. So the funding mechanism for that typically was 'spend what you need now on an expense basis. And then we will figure out, after that, what can be capitalized using good accounting practices, and then move that over into the capital.'

Honeywell Geismar's approach to resolving the causes of the 2021 incident resulted in a significant diversion of its personnel's time and focus. Importantly, the 2021 incident occurred during the same outage during which the reboiler was last inspected. The coincidence of these two events and Honeywell's immediate focus on the resolution of the 2021 incident (which heavily involved site maintenance and reliability resources) may have contributed to Honeywell's failure to follow its normal MI deficiency management practices. That, coupled with ongoing staff shortages and turnover, resulted in disruption to the Geismar site's normal, business-as-usual tasks and routines. Although Honeywell's focus on the 2021 incident did not cause the 2023 incident, Honeywell's approach may have caused it to miss the conditions and disruptions that did cause the reboiler explosion.

The CSB concludes that beginning with the 2021 fatal incident, the Honeywell Geismar site experienced several consecutive and overlapping circumstances that caused significant disruption to the site's normal process safety and related management systems and practices. These circumstances combined to result in the catastrophic failure of the HF reboiler. Neither Honeywell nor the Geismar site recognized or resolved these disruptions to the site's normal processes prior to the explosion.

In 2017, the Geismar site began developing policies and procedures to analyze business continuity risk and develop processes to manage and respond to disruptive events. These processes were primarily intended to analyze and address the risk of disruptions to the facility's ability to manufacture its products rather than process safety risks. In January 2022, Honeywell issued new corporate policies governing what it called "Business Resilience," which included subcomponents for business continuity, crisis management, and disaster recovery. Altogether, Honeywell's intent for the program was to:

> Protect employees, assets and operational activities of the businesses[,] enhance the businesses' ability to recover following a disruption[,] reduce the likelihood […and] minimize the impact of a disruption[,] prevent […] damage to Honeywell's reputation and brand[,] and to meet business, legislative and regulatory requirements.

Honeywell's Crisis Management standard stated:

> Through the implementation of this Standard, Honeywell will achieve a robust, unified response to events that severely impact, or have the potential to impact its ability to conduct business as usual[.]

The standard included severe process safety incidents as triggers requiring such a response. Once a crisis event occurred, the standard instructed the company to assess the situation and develop and implement an action plan. The ultimate goal of the process was to restore "business as usual" function and to ensure that the "primary critical priorities of the crisis event [are resolved] and that the appropriate strategies and resources are in place to address any remaining critical priorities."

The policy and procedure included specific action plan components that could have helped the site manage the difficulties it was experiencing. For example, the policy discussed a "start, stop, continue" analysis, the purpose of which was to identify tasks and activities that were "no longer required to be performed" (stop), tasks or activities that are "currently [not performed] that […] may need to be started" (start), and tasks or activities that "should not be stopped or changed" because of the event (continue). Using this methodology, tasks and projects such as the reboiler project would likely have been categorized as tasks that should have been "continued," while other projects and efforts unrelated to safety might have been categorized as tasks that could have been temporarily "stopped."

Honeywell's organizational resilience policies were first issued in January 2022, after the 2021 fatal incident had already occurred. As a result, Honeywell Geismar did not apply these new corporate policies to the aftermath of the 2021 incident. Honeywell never convened a corporate-level crisis management team and therefore never developed or implemented a formal action plan.

KEY LESSON

To ensure that one incident does not cause or lead to another, companies should develop and implement resilience programs to recognize and prevent or minimize disruption to their routine process safety management activities and other systems that contribute to process safety, such as capital project management.

The 2023 reboiler incident resulted from disruptions—and arguably shortcomings—in several of Honeywell Geismar's safety management and related systems. The conditions that led to those disruptions occurred concurrently with Honeywell's efforts to resolve the causes of the 2021 incident. In essence, one incident caused Honeywell to miss the conditions and breakdowns that caused another. Process safety incidents occur when the "organization is unable to recognize or interpret evidence of new vulnerabilities or ineffective countermeasures until a visible accident occurs" [30, p. 24].

Honeywell's efforts to design organizational resilience systems to recognize and address disruptions such as these may have helped prevent the 2023 incident had such systems been available for use and applied to the aftermath of the 2021 incident.

Therefore, the CSB concludes that had Honeywell's resilience systems been mature and fully implemented prior to the 2021 fatal incident, Honeywell may have been able to identify and effectively resolve the conditions that led to the 2023 reboiler incident.

4 HF RELEASE AND SERIOUS INJURY – JUNE 2024

4.1 BACKGROUND

4.1.1 TURNER INDUSTRIES

Turner Industries Group ("Turner") is a diversified industrial contractor offering a variety of services, including construction, maintenance, outage work, pipefitting, and piping fabrication, among others. Turner has field offices throughout the U.S. Gulf Coast region and is headquartered in Baton Rouge, Louisiana [31].

The Honeywell Geismar site contracts a significant portion of its maintenance and reliability work to Turner, as well as some of its routine outage work such as pipefitting and flange assembly. The two workers involved in this incident were Turner employees.

4.1.2 GASKET CHANGE WORK

At the time of the incident, the 245 unit was undergoing a planned outage. Among the many scheduled tasks, the work included changing the gaskets in some of the 245 unit's HF feed stations (refer to **Section 2.1.1** and **Figure 2**). In a 2007 MOC, the Geismar site documented the need for a gasket technology change in recycle HF service in the 245 unit. The gasket corrosion hazard was originally identified shortly after Honeywell Geismar commissioned the unit in 2002.

After the fatal incident in October 2021, Honeywell Geismar initiated two MOCs in 2022 that documented the site's decision to replace the gaskets in other HF services. Honeywell Geismar decided to replace the gaskets in fresh HF and recovered HF piping, in addition to the recycle HF piping originally documented in 2007 (**Section 2.4.1**).

By June of 2024, the progress of the effort to replace spiral wound gaskets reached the D reactor fresh and recovered HF feed stations. At the time of the incident, two contract pipefitters were replacing gaskets in the D reactor fresh HF feed station. An excerpt of the scope of work involved in this incident is shown in **Figure 27**.

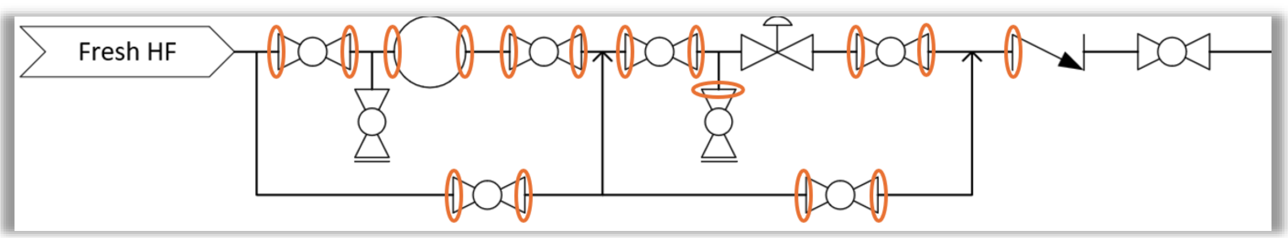

Figure 27. Excerpt of the incident job scope. In-scope flanges and gaskets are circled in orange. (Credit: CSB)

4.1.3 Preparation for Maintenance

Typically, to prepare HF piping for maintenance work, operators first used the plant's nitrogen system to push liquid HF and other material downstream for consumption in the process. Honeywell Geismar had a procedure that prescribed this practice. After purging the system with nitrogen, Honeywell would then connect piping to the site's vacuum scrubber system, which would apply a vacuum to the piping and remove HF vapors for neutralization. As part of clearing the lines, while connected to the vacuum system, operators would open a low-point bleed valve to verify airflow into the piping from the vacuum, which they believed indicated that a given portion of piping was clear and ready for maintenance.

4.1.4 Personal Protective Equipment

After the 2021 fatal incident (**Section 2**), Honeywell Geismar made changes to its PPE matrix. At the time of the 2024 incident, Honeywell's PPE requirements for HF were as shown in **Figure 28**.

Protective Equipment		HF Level A [5]	HF Level B	HF Level C	Modified Level D	HF Level D
	Suit/Clothing	Totally-encapsulating HF-resistant suit	Hooded Standard Safety HF-resistant chemical PPE (Acid Suit)	Hooded Standard Safety HF-resistant chemical PPE (Acid Suit)	Hooded HF-resistant chemical PPE	FR Long Sleeve Shirt/ Long Pants or Coveralls
	Eye/Face and Respiratory Protection (All respiratory protection shall be NIOSH/equivalent approved)	Pressure-demand or other positive pressure mode (e.g., open/closed circuit) full-facepiece supplied air respirator with escape bottle.	[1] Pressure-demand or other positive pressure mode (e.g., open/closed circuit) full-facepiece supplied air respirator with escape bottle.	[1, 2] Full facepiece Air Purifying Respirator with cartridges/canisters approved for HF. (Includes PAPRs with full facepiece, hood or helmet)	Face Shield and Safety Glasses minimum. Goggles as required by PPE Hazard Assessment.	Face Shield and Safety Glasses minimum. Goggles as required by PPE Hazard Assessment.
	Head Protection (All hard hats used shall be ANSI/equivalent approved)	Hard Hat under suit as required by PPE Hazard Assessment	Hard Hat as required by PPE Hazard Assessment	Hard Hat as required by PPE Hazard Assessment	Hard Hat as required by PPE Hazard Assessment - or - Hard Hat with wrap around cape	Hard Hat as required by PPE Hazard Assessment
	Hand Protection	HF-Resistant inner gloves and HF-Resistant outer gloves	HF-Resistant inner gloves and HF-Resistant outer gloves	HF-Resistant inner gloves and HF-Resistant outer gloves	HF-Resistant inner gloves and HF-Resistant outer gloves	HF-Resistant gloves as required by PPE Hazard Assessment
	Foot Protection	HF-Resistant boots, with safety toe and shank	HF-Resistant boots, with safety toe and shank	HF-Resistant boots, with safety toe and shank	HF-Resistant boots, with safety toe and shank	Safety shoes/boots

Figure 28. Excerpt of Honeywell's June 2024 HF PPE matrix. (Credit: Honeywell)

For work involving line breaks, Honeywell Geismar's and Turner's practices required that workers first open the line while wearing PPE sufficient to protect them from a potential release of process fluid, such as HF Level A or B. Once workers determined that "equipment/lines […] have been opened, disassembled, and fully neutralized" and "after Line Breaking activities are complete," Honeywell and Turner site policies and practices allowed workers to "downgrade" their PPE to less protective, more comfortable levels. Honeywell cited the often extreme ambient conditions (temperature and humidity) in Geismar, Louisiana, as part of its rationale for allowing workers to downgrade PPE.

4.2 Incident Description

Leading up to the incident, the 245 unit was undergoing a planned maintenance outage. The outage began on May 31, 2024. A few days before the June 7, 2024, incident, Honeywell prepared the D reactor fresh HF feed station for maintenance according to the general process described above. The piping segment was also locked out.

On the morning of the incident, two Turner pipefitters obtained a safe work permit and a line break permit from a Honeywell operator to conduct the planned gasket change work. The two Turner workers and the Honeywell operator proceeded to the unit to review the job and conduct the line break. In preparation for the line break, the two Turner workers donned Level B PPE (refer to **Figure 28**), which included wearing acid-resistant suits and supplied fresh air. The Honeywell operator wore Level D PPE. At the Honeywell operator's direction, the Turner workers opened the fresh HF feed station piping in four locations, which were intended to verify the absence of hazardous energy.

As the two Turner workers opened these flanges, the Honeywell operator monitored the piping for any signs of residual HF, such as fuming or trapped pressure. He observed none and believed that the piping was sufficiently clear of trapped HF. He then closed out the line break permit and the two Turner workers conducted the rest of the job under a safe work permit, which required Level D PPE.

As the two workers proceeded through the work, one of them loosened the blind flange[a] on one of the two bleed valves, as depicted in **Figure 29** and pictured in **Figure 30**:

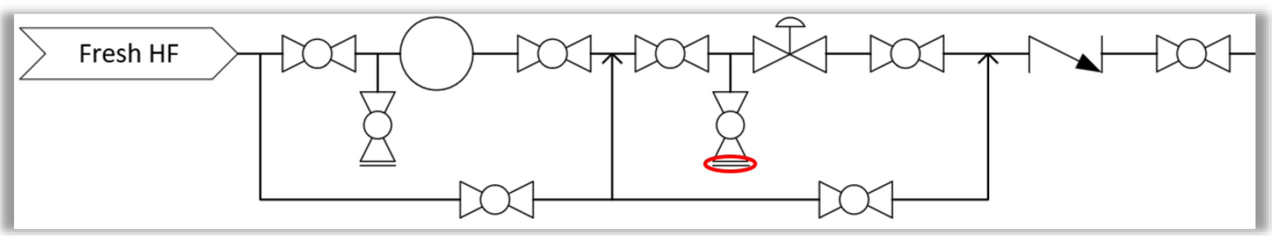

Figure 29. Simplified drawing of the fresh HF feed station. The release location is circled in red. (Credit: CSB)

[a] A blind flange is a type of pipe fitting used to close the end of a piping system or pressure vessel openings, preventing the flow of fluids or gases. Unlike other types of flanges, a blind flange has no central opening, making it a solid disk, which is normally accompanied by a gasket to provide a secure seal [45].

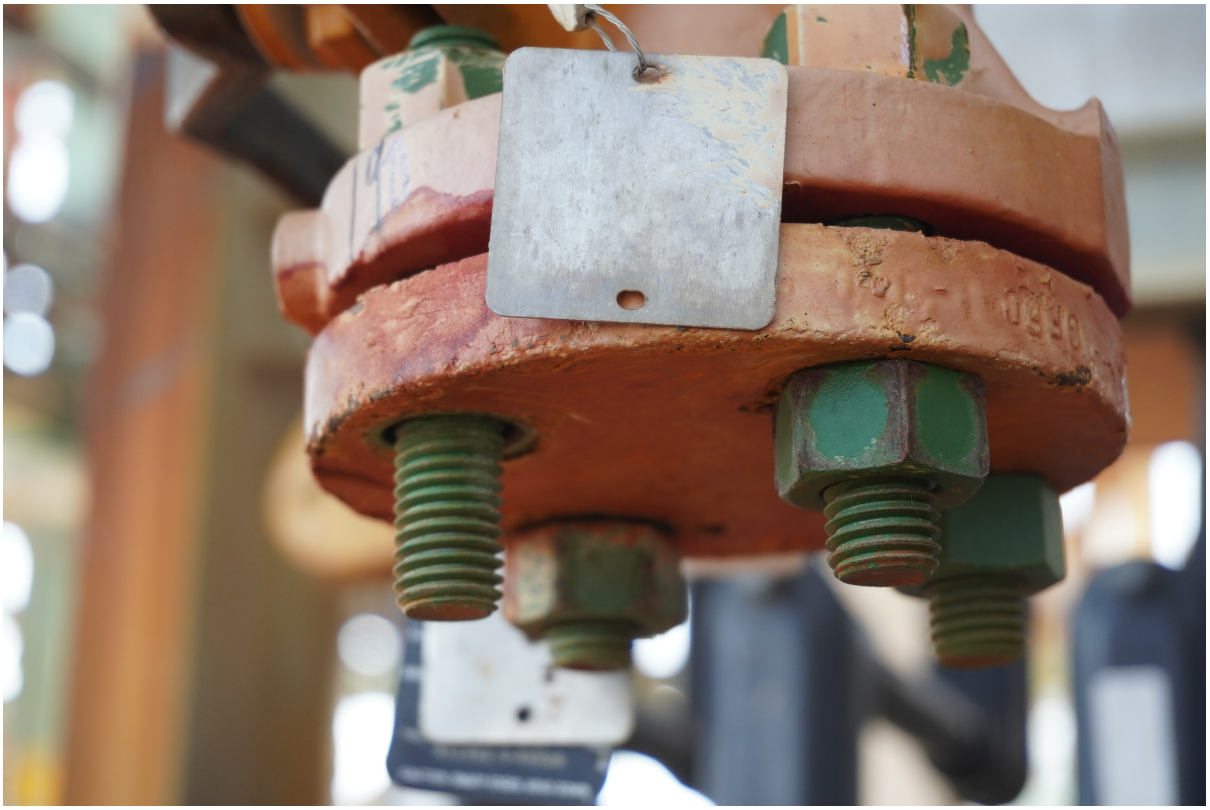

Figure 30. Blind flange as found after the incident.[a] One nut was removed (foreground left) and another (background left) was loosened to within two to three threads. (Credit: CSB)

Neither the Turner workers nor the Honeywell operator were aware that the valve had not been cleared of HF prior to the work. Less than one pound of HF was trapped between the valve plug and the blind flange. When one of the Turner workers loosened the blind flange fasteners, the trapped HF was released. The Turner worker was not wearing face or respiratory protection, and the released HF contacted him in the face, causing serious injuries.

The Turner worker was treated with nebulized calcium gluconate and was transported to a local hospital, where he was admitted and spent two days recovering as a result of his serious injury. He sustained second-degree burns from the HF exposure. According to Honeywell, the incident did not result in any property damage.

[a] Note the orange-tinted acid indicating paint. Above the stud with the missing fastening nut, the paint has turned red, indicating that it was exposed to HF.

4.3 Safety Issues

The following sections discuss Honeywell's and Turner's ineffective safe work practices that contributed to the incident.

Appendix C contains the .AcciMap, which provides a graphical analysis of this incident.

4.3.1 Safe Work Practices

4.3.1.1 Preparation for Maintenance

Process safety expert Trevor Kletz noted in the book, *Safety and Accident Prevention in Chemical Operations (2nd ed.)*, that "errors in the preparation of equipment for maintenance are one of the commonest causes of serious accidents in the chemical and allied industries" [32, p. 807].

An excerpt of the scope of the work involved in this incident is shown below in **Figure 31**.

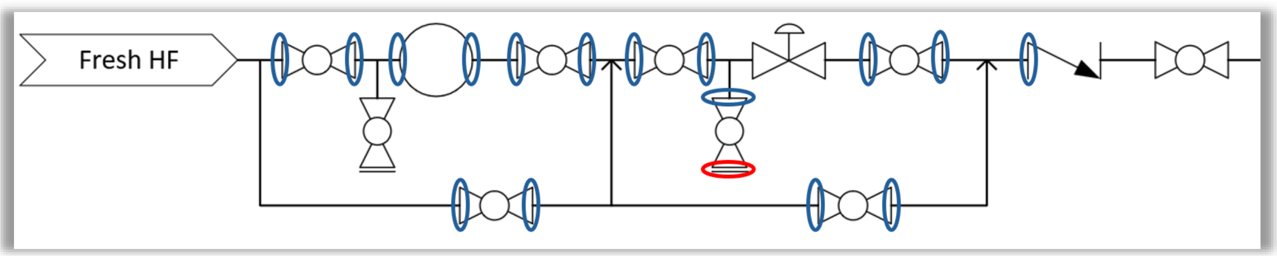

Figure 31. Partial excerpt of the incident job scope. In-scope flanges and gaskets are circled in blue. The blind flange from which the HF released was not in scope and is circled in red. (Credit: CSB)

As Honeywell concluded in its investigation of this incident, the blind flange connection from which the HF released was not within the job scope. Yet, from a safety perspective, whether that flange was in or out of scope is ultimately irrelevant; the valve was within the bounds of the lockout and should have been cleared of hazardous energy.

Moreover, even though the bottom blind flange was not in scope, the gasket within the top side flanged connection of the incident valve was in scope (as shown in **Figure 31**). Replacing this gasket would have required workers to disconnect the top side flanged connection of the incident valve in order to access the gasket. Doing so would have required the workers to handle the valve (which contained trapped HF) while they were wearing insufficiently protective PPE (because they removed their Level B PPE, believing the piping was empty). This would have been an unsafe practice regardless of whether the bottom side blind flange was in or out of scope. The best way to ensure that the trapped HF did not escape from the valve and injure a worker would have been to ensure that there was no trapped HF.

Honeywell Geismar had a policy that governed line breaking and equipment opening. In a section of the policy that prescribed preparation for line breaking and "draining, purging, and cleaning," the policy stated:

> Verify that de-pressurization of lines or equipment of material has been accomplished by opening vents and drains.
>
> […]
>
> Low points, dead legs, closed valves, or installed blinds in piping or vessel design may trap materials and prevent complete flushing/draining of the line or equipment.

Notably, the incident valve and blind flange assembly meet all four of those descriptions, as it was a local low point on a horizontally oriented section of piping, it constituted a dead leg,[a] it contained a closed valve, and it contained an installed blind. During Honeywell's preparation for maintenance, leaving the incident valve closed prevented it from being cleared during the nitrogen purge and vacuum steps of the clearing procedure. Had the valve been opened during this point of the preparation process, the valve likely would have been cleared of HF prior to the incident, and the worker would not have been exposed to HF when he mistakenly loosened the out-of-scope blind flange. A photo of the valve as found in the closed position is shown in **Figure 32**.[b]

[a] A "dead leg" is a section of piping open to the process, but through which no flow can occur.

[b] Note the orange-tinted acid indicating paint on the body of the valve and on the top and bottom flanges. On the bottom flange, the paint has turned red, indicating that it has been exposed to HF vapors. See **Section 2.4.2.1** for a discussion of acid indicating paint.

Figure 32: As-found condition of the incident valve showing that the valve was in the closed position at the time of the incident. (Credit: CSB)

The CSB concludes that Honeywell did not ensure that all piping within the bounds of the lockout was free of hazardous energy. The incident valve should have been cleared of HF as part of Honeywell's preparation for the maintenance work. Doing so would have prevented the HF release and the serious injury.

4.3.1.2 Honeywell Maintenance Planning and Hazard Identification

As part of the maintenance planning process, Honeywell prepared a work document package for each of the various gasket replacement jobs that were to be completed during the outage. The package for the D reactor fresh HF feed station included annotated piping and instrumentation diagrams (P&IDs) and annotated piping isometrics, as well as piping specifications and other materials. Both the annotated piping isometrics and the annotated P&IDs showed which flanges were in the scope of the work for the D reactor fresh HF gasket replacement work.

The Honeywell operator served as both the permit authorizer and the "standby observer" for what both Honeywell Geismar's policy and the Honeywell operator referred to as the "initial line break" for the work. The Honeywell operator reviewed the job with a P&ID prior to the initial line break. He was not provided with the annotated version that was prepared as part of the job package. He was also not provided with the annotated piping isometrics.

When the Honeywell operator proceeded to the job site to direct the two Turner workers on the initial line break, he had an opportunity to identify the potential hazard of the closed bleed valve. Because the valve was in the closed position, there was no way for the operator to know for certain whether the bleed valve had been cleared during the preparation for maintenance. Further, because the operator did not review the annotated drawings, there would have been no way for him to know with certainty that the top flange of the bleed valve was in scope and needed to be disconnected as part of the work, and thus that the valve needed to be cleared.

The CSB concludes that Honeywell Geismar did not ensure that important work scope information was provided to the operator. Because he did not review the annotated P&ID or piping isometric, the operator likely was not aware of the specific flanges that were to be changed and instead was likely only aware of the general piping segment on which the two Turner workers would change gaskets. Had the operator been provided with the correct documentation, he could have identified the potential hazard of the closed (and therefore potentially containing HF) valve, and he could have directed the two Turner workers to address the valve while they were wearing Level B PPE. Doing so would have prevented the release, the serious injury, or both.

4.3.1.3 Turner Hazard Identification

On the morning of the incident, before the work commenced, the two Turner workers went to the work location and reviewed the job with their supervisor. During this pre-job walkthrough, the Turner workers used a permanent marker to identify which flanges were in the scope of the work. The Turner supervisor had the annotated isometrics while conducting this activity, and one of the workers told the CSB that they marked the flanges according to the isometric. After the incident, the CSB confirmed that the top side flange of the incident valve was marked as in scope and the bottom side flange was not marked in scope, which matched the annotated isometric. After walking through the job with their supervisor, the Turner workers contacted the Honeywell permit authorizer and notified him that they were ready to obtain their work permits for the job. They obtained their permits and proceeded to the job site with the Honeywell operator to conduct the line break.

When the two Turner workers conducted the pre-job walkthrough with their supervisor, the workers had an opportunity to identify the potential hazard of the closed and therefore potentially HF containing incident valve. On their line opening risk assessment, the workers and their supervisor documented that "drains and bleeder valves [were] clear and open." It is evident that they did not evaluate or consider the incident valve during this risk assessment.

The CSB concludes that the Turner workers and supervisor did not consider or otherwise account for the potential hazard of the closed incident valve during their pre-job risk assessment, despite the Turner risk assessment form clearly prompting them to do so. Had they identified the potential hazard, they could have notified Honeywell of the potential hazard and addressed the risk prior to the work commencing, or during the job prior to removing their Level B PPE. Doing so would have prevented the release, the serious injury, or both.

When the HF released, the Turner worker was not wearing PPE sufficient to protect him.[a] The CSB concludes that because Honeywell and Turner closed out the line break permit, the two Turner workers removed their Level B PPE once they believed the piping segment was free of hazardous energy. Had the injured Turner worker been wearing sufficiently protective PPE, his injury would have been prevented.

As the CCPS states in its *Guidelines for Risk Based Process Safety*, "[W]hile contractors have a responsibility to monitor the action of their employees and to enforce the safety performance requirements, the ultimate responsibility for ensuring the safety of its facility rests with the company" [33, p. 376]. The CSB concludes that the number of gaps in the performance of Honeywell Geismar's and Turner's requirements during this incident is indicative of systemic problems with the site's implementation of its safe work practices including preparation of equipment for maintenance, control of hazardous energy, line break safety, and contractor management.

[a] The injured worker was wearing a face shield, but it was in the "flipped up" position and was not covering his face.

4.4 Post-Incident Actions

4.4.1 Honeywell

Honeywell investigated the incident and modified its line and equipment clearing procedures. Among other changes, Honeywell included a requirement to verify the absence of stored energy downstream of bleed valves, and included a requirement that bleed valves are either opened and cleared with the system or locked closed. Honeywell also made changes to its training programs for employees and contractors. Honeywell also revised its procedures to require that all flanges should be identified with tags and signed by operations and maintenance prior to opening.

4.4.2 OSHA

After the incident, OSHA cited Honeywell for violations of the PSM standard lockout/tagout requirements (29 C.F.R. 1910.119(f)(4)) and the Control of Hazardous Energy (Lockout/Tagout) standard (29 C.F.R. 1910.147(d)(5)(i)).[a,b] OSHA also cited Turner for violations of the PSM standard lockout/tagout requirements (29 C.F.R. 1910.119(h)(3)) and the Control of Hazardous Energy (Lockout/Tagout) standard (29 C.F.R. 1910.147(c)(8)).[c,d]

[a] Inspection Detail | Occupational Safety and Health Administration osha.gov

[b] These citations are currently contested as of the publication of this report.

[c] Inspection Detail | Occupational Safety and Health Administration osha.gov

[d] The citations are currently contested as of the publication of this report.

5 SAFETY MANAGEMENT SYSTEMS IMPLEMENTATION AND AUDITING

The CSB's investigations of the three incidents at the Honeywell Geismar facility revealed a significant number of implementation gaps in Honeywell's safety management systems. Incidents investigated by the CSB often involve safety management systems that are nonexistent, poorly developed, or that contain gaps. In contrast, Honeywell's existing systems were mature and were designed to, could have, and should have either prevented or identified and resolved the issues that led to the three incidents.

Regarding the 2021 fatal incident:

- Honeywell discovered spiral wound gasket corrosion shortly after the initial commissioning of the 245 unit. In 2007, Honeywell initiated an MOC analysis and an accompanying technology change for gaskets in recycle HF service, but Honeywell elected to replace the gaskets by attrition. Honeywell did not fully implement the change, and 14 years later, in 2021, a spiral wound gasket in recycle HF service catastrophically failed, fatally injuring a Honeywell operator (**Section 2.4.1**).

- Honeywell inspected the incident piping twice in the 36 days preceding the fatal incident. Neither inspection detected corrosion damage to the incident flange assembly. Honeywell's investigation concluded that the incident flange assembly was likely already damaged at the time of both inspections and should have been identifiable during the inspections (**Section 2.4.2**).

- In the 245 unit, Honeywell was not using HF leak detection technology and methodologies that could have helped prevent the fatal incident. Honeywell was aware of these technologies and actively advocated for its customers and industry at large to use them (**Section 2.4.2.1**).

- Honeywell did not follow its written operating procedures for starting up the 245 unit. As a result, a field operator was dispatched to resolve a no-flow condition to the 245 unit D reactor vaporizer, when he detected the nearby HF leak from the incident flange by smell. He summoned a second operator to help resolve the HF leak, and the incident gasket catastrophically failed while the two operators were in the vicinity. Failure to follow the operating procedures caused the presence of the two operators in the field near the gasket (**Section 2.4.3.1**).

- Honeywell did not ensure that its operators wore sufficiently protective PPE. While troubleshooting a known, active HF leak, two Honeywell operators wore Level D PPE. Further, Honeywell's applicable PPE requirements for starting up the 245 unit did not include respiratory protection. One Honeywell operator was fatally injured when the incident gasket failed and exposed him to anhydrous HF vapor (**Section 2.4.3.2**).

- During the emergency response to the gasket failure, Honeywell's emergency responders wore Level C PPE. Honeywell's PPE risk matrix required Level A PPE for emergency response (**Section 2.4.3.2**).

Regarding the 2023 reboiler explosion:

- Honeywell failed to effectively implement its MI systems, and as a result, ran the incident reboiler to failure four times throughout its entire service life from 2002 – 2023 (**Section 3.3.1.1**).

- Honeywell's MI procedures required three forms of deficiency documentation,[a] but when the reliability group inspected the reboiler in October 2021, no one at Honeywell created the required documentation. Instead, the reliability group informally communicated the issue to the 245 unit maintenance engineer (**Section 3.3.1.4**).

- Honeywell failed to utilize its existing MOOC systems in four significant ways: 1) when the 245 unit maintenance engineer left the company in April 2022, Honeywell failed to preserve his knowledge and safety-related tasks and action items, and the project to replace the reboiler was never reassigned to a new owner, 2) Honeywell did not apply its MOOC systems to manage the Geismar site's 2020 reduction in force, 3) the Geismar site had ongoing overlapping vacancies to two key site management positions, and the company did not apply its MOOC systems to manage those vacancies or the redistribution of those positions' duties, and 4) Honeywell failed to apply its MOOC systems to manage routine personnel turnover in numerous other process safety impacting roles (**Section 3.3.2**).

- Honeywell created and approved a capital funding request to replace the reboiler shell but never funded or completed the project. The site inconsistently applied its rating process to the various projects submitted for approval and funded and completed 78 projects that either had no priority rating or were rated lower than the reboiler project. The site applied its emergency procurement method for at least two projects, but not the reboiler project. Finally, Honeywell moved the reboiler project to the site's longer term annual capital request, a decision that further delayed the reboiler project (**Section 3.3.3**).

- In early 2022, Honeywell began implementing resilience policies and procedures designed to detect and address disruptions to the company's normal operations and management systems, including significant process safety incidents. These policies and procedures were nascent and not fully implemented during the time from October 2021 to January 2023. During this time, many of the Geismar site's routine business and safety management systems were disrupted, both partly as a result of and coinciding with the 2021 fatal incident and its aftermath (**Section 3.3.4)**.

Regarding the 2024 serious injury incident:

- Honeywell did not adequately prepare the fresh HF feed piping for maintenance. A small amount of HF was left trapped between the incident valve plug and the attached blind flange. This deviated from Honeywell's prescribed safe work practices for line breaking and equipment opening (**Section 4.3.1.1**).

[a] The required forms of documentation were 1) a deficiency notification in SAP, 2) an action item in DMAPS, and, because Honeywell elected to continue operating the reboiler, 3) an SAP notification for the reboiler's next required inspection.

- Honeywell did not identify or resolve the potential hazard of the closed incident valve and did not realize that it might have contained HF (**Section 4.3.1.2**).

KEY LESSON

No process safety management system can succeed without effective and consistent implementation. Companies must ensure that they not only develop effective systems, but that those systems are implemented, consistently followed, and validated.

The CSB concludes that all three incidents resulted from the ineffective implementation of Honeywell's existing safety management systems. Had Honeywell followed its existing normal procedures, policies, and practices, it could have, and likely would have, prevented each of the three incidents.

In its 2011 book, *Guidelines for Auditing Process Safety Management Systems*, the CCPS explained that auditing is a critical element of a process safety management system because it provides insight into the effectiveness of the existing management system and could contribute to making the system more effective [34, p. 1].

In the book, the CCPS described an audit as "a systematic, independent review to verify conformance with established guidelines or standards" [34, p. 1]. The CCPS stated that the systematic review of these management systems must "verify the suitability of these systems and their effective, consistent implementation" [34, p. 3]. The CCPS also explained how to perform an audit such that it drives improved management system effectiveness:

> A [process safety management system] audit involves examination of management system design, followed by evaluation of management system implementation. The design of the management system must be understood and then evaluated to determine if the system, when functioning as intended, will meet the applicable criteria. Then the auditor must evaluate the quality and degree of implementation since a well-designed system may not be backed up by consistent, thorough implementation [34, p. 4].

Both the EPA RMP rule and the OSHA PSM standard require companies to periodically self-assess their process safety management systems by performing compliance audits every three years.[a] In evaluating their management systems against the minimum safety requirements of the PSM standard, OSHA expects employers to verify that their procedures and practices are both adequate and followed.[b] OSHA also requires employers to develop a report documenting the audit findings and the corrective actions taken to address the audit findings.[c]

Honeywell had a corporate policy governing process safety management system auditing. The policy's stated intent was to monitor and verify "the effective implementation of [process safety management systems] at a facility." The policy also stated that the objective of the auditing program was to "provide Honeywell

[a] The EPA's RMP rule compliance audit requirements stem from 40 C.F.R. § 68.79, and the OSHA PSM standard requirement can be found under 29 C.F.R. § 1910.119(o). While the language under these two federal safety regulations is similar, the EPA places the requirements on the owner or operator of the facility and OSHA directs the requirements to the employer.

[b] See 29 C.F.R. § 1910.119(o)(1).

[c] See 29 C.F.R. § 1910.119(o)(3).

Leadership assurance regarding the maturity and performance of [Honeywell's] Process Safety Management Systems."

The policy required process safety audits every three years for covered sites, which included the Geismar site. Honeywell records show that it audited the Geismar site in 2014, 2017, 2020, and 2023.[a] Honeywell identified findings and implemented corrective actions as a result of those audits, but none of the previous audits identified or effectively addressed the implementation problems that led to the three incidents discussed in this report. A process safety auditing program must incorporate sufficient follow-up to ensure that solutions are thoroughly and sustainably implemented.

In February 2024, the EPA revised its RMP regulations, and the revisions became effective in May 2024 [35].[b] Among the changes, the EPA now requires chemical facilities that have had a prior accident to undergo third-party compliance audits instead of self-audits.[c] Specifically, a company's or site's next regularly scheduled RMP compliance audit is required to be a third-party audit if the site experiences an RMP-reportable incident. This requirement applies to the Honeywell Geismar facility, because of the June 7, 2024, incident.

Although it is a regulatory requirement[d] for Honeywell to conduct a third-party audit, Honeywell's next audit is not due to occur until 2026. In addition, RMP regulations do not cover all of the management systems that the CSB identified as causal factors to the three incidents that occurred in 2021, 2023, and 2024 (such as the management of organizational and personnel change, the management of safety-critical capital projects, and organizational resilience). Using a qualified, reputable, independent third party to audit the entirety of Honeywell's process safety management systems, including those not required by existing regulations, is likely to generate important safety benefits that will help the company prevent future incidents that could harm workers or members of the public. Furthermore, due to the weakness in Honeywell's implementation of its safety management systems at the Geismar site, Honeywell should conduct this audit as soon as practicable.

Therefore, the CSB recommends that Honeywell perform a comprehensive third-party audit of the Geismar facility's process safety and allied management systems as soon as practicable.

While such an audit is likely to generate important and helpful findings, it is crucial that those findings are appropriately implemented and that they are implemented in a timely manner. To ensure that the Geismar site takes appropriate action as a result of the third-party audit, the CSB recommends that Honeywell International require periodic reporting updates from the Geismar site regarding the closure of the audit findings. The periodic updates shall continue until all audit findings are fully closed.

[a] Exhibits 2023.162; 2023.163; 2023.164; 2023.165

[b] See Risk Management Program Safer Communities by Chemical Accident Prevention Final Rule | US EPA

[c] See 40 CFR § 68.10(g)(2);

[d] In March 2025, the EPA announced that it was "reconsidering the 2024 [RMP] rule" [50]. As of the publication of this report, the EPA has not yet taken further action in accordance with the announcement. In the event that the EPA rescinds the third-party audit requirements, the CSB has recorded the requirements in Appendix E.

6 EPA Regulations

6.1 HF Prioritization Under The Toxic Substances Control Act

In 2016, Congress amended the Toxic Substances Control Act (TSCA) by enacting the Frank R. Lautenberg Chemical Safety for the 21st Century Act [36]. The 2016 TSCA amendments required the EPA to "establish, by rule, a risk-based screening process, including criteria for designating chemical substances as high-priority substances for risk evaluations or low-priority substances for which risk evaluations are not warranted at the time."[a] For chemicals determined to "present[] an unreasonable risk of injury to health or the environment," TSCA gives the EPA the authority to apply "requirements to such substance or mixture to the extent necessary so that the chemical substance or mixture no longer presents such a risk".[b] As required by the TSCA amendments, the EPA issued a final rule, which became effective in September 2017, that "establishes the process and criteria that the EPA will use to identify chemical substances as either High-Priority Substances for risk evaluation or Low-Priority Substances for which risk evaluations are not warranted at the time" [37]. **Figure 33** depicts the EPA's chemical prioritization process.

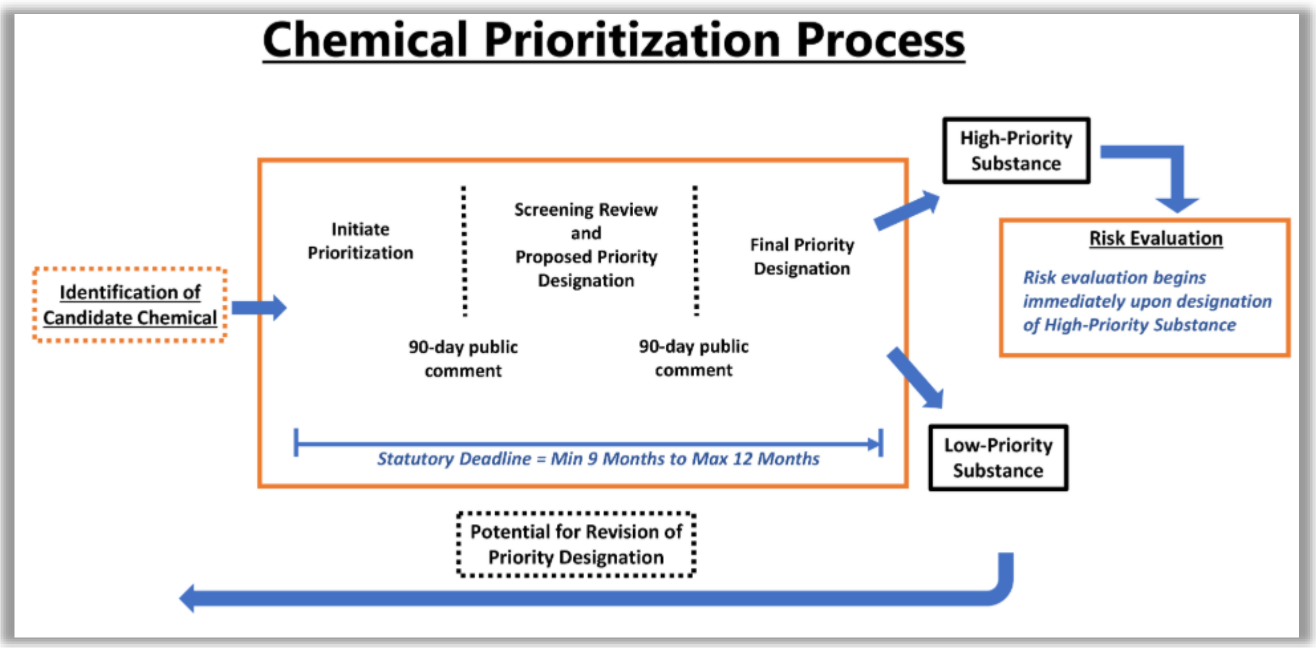

Figure 33. The EPA's chemical prioritization process. (Credit: EPA [38])

[a] The Frank R. Lautenberg Chemical Safety for the 21st Century Act, Pub. L. No. 114-182, 130 Stat. 448 (2016), codified at 15 U.S.C. § 2605(b)(1)(A)

[b] 15 U.S.C. § 2605(a)

As discussed in **Section 1.2** of this report, HF is a highly toxic chemical that can produce a vapor cloud upon release. HF is one of the eight most hazardous chemicals regulated by the RMP rule.[a][b] At the time of publication of this report, the EPA has not initiated the prioritization process for HF, but the EPA has identified HF as a potential candidate for prioritization based on the agency's screening process and has promulgated a rule requiring manufacturers of HF to submit certain health and safety information to the agency.[c] In the final rule summary, the EPA stated that the "health and safety studies sought by this action will inform EPA actions in carrying out its responsibilities pursuant to TSCA, including prioritization, risk evaluation, and risk management" [39, pp. 100,756].[d] The original deadline for submitting the health and safety information to the EPA was March 13, 2025, but the EPA extended the deadline until September 9, 2025 [40].[e]

The CSB concludes that the EPA should continue its efforts to initiate prioritization of HF under TSCA. If HF is determined to be a High-Priority Substance, the EPA should conduct a risk evaluation of HF, and implement any identified corrective actions, as required by TSCA.

In the CSB's report on the 2019 incident at the Philadelphia Energy Solutions refinery in Philadelphia, Pennsylvania,[f] the CSB recommended that the EPA initiate the TSCA prioritization process for HF (CSB recommendation 2019-04-I-PA-R3). However, the wording of that recommendation only specified the aqueous acid form of HF. Based upon the three incidents described in this report, the recommendation should apply to both the anhydrous form and the aqueous acid form. Therefore, to clarify the CSB's intent for both the anhydrous and aqueous acid forms of HF to be included in the recommendation, and to align the wording of the recommendation with recent EPA rulemaking actions, the CSB supersedes recommendation 2019-04-I-PA-R3 to the EPA by amending it to include anhydrous HF in addition to HF acid.

The CSB recommends that per the requirements in EPA Rule *Procedures for Prioritization of Chemicals for Risk Evaluation Under the Toxic Substances Control Act*, initiate prioritization to evaluate whether hydrogen fluoride, including its anhydrous and aqueous acid forms, is a High-Priority Substance for risk evaluation. If it is determined to be a High-Priority Substance, conduct a risk evaluation of hydrogen fluoride to determine whether it presents an unreasonable risk of injury to health or the environment. If it is determined to present an unreasonable risk of injury to health or the environment, apply requirements to hydrogen fluoride to the extent necessary to eliminate or significantly mitigate the risk, for example by using a methodology such as the hierarchy of controls.

[a] The RMP regulation assigns threshold quantities to chemicals that trigger coverage by the regulation. Of the 77 regulated toxic substances, HF is among the eight chemicals with the lowest threshold values triggering coverage. The EPA chose threshold quantities "based on a ranking method that considers each substance's toxicity and potential to become airborne and disperse" [52, p. 5104].

[b] The eight most toxic chemicals regulated by the EPA RMP based upon threshold quantity (listed in parentheses) are arsine (1,000 lbs.), chlorine dioxide (1,000 lbs.), chloromethyl ether (1,000 lbs.), fluorine (1,000 lbs.), hydrogen fluoride / hydrofluoric acid (1,000 lbs.), hydrogen selenide (500 lbs.), nickel carbonyl (1,000 lbs.), and phosgene (500 lbs.). See 40 C.F.R. § 68.130.

[c] See 89 Fed. Reg. 100756 (Dec. 13, 2024).

[d] 89 Fed. Reg. at 100756.

[e] See 90 Fed. Reg. 11899 (Mar. 13, 2025).

[f] The CSB's report on this incident can be found at the CSB's website here: Philadelphia Energy Solutions (PES) Refinery Fire and Explosions | CSB

6.2 Safer Technologies and Alternatives Analysis

As part of the 2024 RMP rule changes, the EPA now requires refineries and chemical manufacturers to conduct a safer technologies and alternatives analysis (STAA).[a] Among other requirements, the regulation requires that owner/operators conduct an analysis of safer technologies and alternatives, and include a practicability assessment of inherently safer technologies and designs considered as part of the analysis [41]. Although it is currently a regulatory requirement for Honeywell to conduct this analysis, the compliance deadline is not until May 2027. Furthermore, because the EPA announced in March 2025 that it was reconsidering the 2024 RMP changes, it is not clear whether Honeywell will be required to conduct this analysis.[b] In light of the findings stemming from the CSB's investigation of the three safety incidents discussed in this report, conducting such an analysis for the Honeywell Geismar 245 unit is likely to generate important safety benefits that could help Honeywell and the Geismar site prevent future safety incidents that could harm workers or members of the public, regardless of whether Honeywell is required by regulation to conduct it. Therefore, the CSB recommends that Honeywell perform a Safer Technologies and Alternatives Analysis (STAA) for the Honeywell Geismar HFC-245fa unit. The STAA shall meet the requirements outlined in paragraphs (a) and (b) of Appendix F of this report.

[a] This requirement applies to facilities and processes in NAICS Codes 324 (Petroleum and Coal Product Manufacturing) and 325 (Chemical Manufacturing). See 40 C.F.R. § 68.67(c)(9) and 68.67(h)

[b] In March 2025, the EPA announced that it was "reconsidering the 2024 [RMP] rule" [50]. As of the publication of this report, the EPA has not yet taken further action in accordance with the announcement. In the event that the EPA rescinds the STAA requirements, the CSB has recorded the relevant requirements in Appendix F.

7 Conclusions

7.1 Findings

7.1.1 2021 Gasket Failure, Toxic HF Release, and Fatality

Technology Change Implementation

1. Honeywell was aware of corrosion damage to 304 stainless steel spiral wound gaskets in recycle HF service beginning in the first five years of the 245 unit's operation.

2. Honeywell identified a different gasket technology and documented the need to change the gasket technology in 2007, but despite ongoing gasket corrosion, Honeywell elected to replace the gaskets on an attrition basis.

3. In 2021, 14 years after documenting the need to change the gasket technology, Honeywell still had not fully implemented the change. Although the MOC did not set a specific completion date, Honeywell's failure to fully implement this change contributed to the incident.

4. Had Honeywell fully implemented the gasket technology change, the loss of containment of HF may not have occurred, and the incident and the fatal injury may have been prevented.

5. There were serious flaws in Honeywell's systems for change management, process knowledge management, and MI. These flaws caused the Geismar site to have not fully implemented the gasket technology change 14 years after the change was initiated and may have contributed to the fatal incident.

Mechanical Integrity

6. Honeywell was aware of and has previously advocated for the use of technologies such as acid indicating paint and remote HF monitors. Despite Honeywell's awareness of and advocation for such technologies in HF processes, Honeywell did not use such technology in its own 245 unit prior to the October 2021 fatal incident. Acid indicating paint and remote HF monitors could have helped prevent this incident by either identifying or aiding the identification of the leaking incident flange assembly prior to the incident. Had Honeywell identified the issue prior to the incident, it could have taken effective action to resolve the leak prior to the gasket's catastrophic failure.

Safe Work Practices

7. Honeywell attempted to place equipment into service that was not properly prepared for startup. This resulted in the no-flow condition to the HF vaporizer and the reverse-flow condition to the incident flange.

8. The gasket failure did not result from the reverse-flow condition caused by the improper startup attempt. The gasket would likely have eventually failed catastrophically regardless of the direction of HF flow

through the flanged connection. Following the unit startup procedure would not have prevented the gasket failure; the gasket was already leaking.

9. Had Honeywell ensured that the D reactor vaporizer was ready for startup by following its existing procedures and checklists, the no-flow condition to the vaporizer would have been prevented, and the two field operators would not have been called to troubleshoot the condition. Therefore, the operators would likely not have been present in the vicinity of the incident gasket when it failed, and the fatal injury to Honeywell Field Operator 2 would likely have been prevented.

10. Had Honeywell ensured that more protective PPE was used, Field Operator 2's exposure to HF would have been reduced, and his fatal injury could have been prevented.

11. Both the Honeywell PPE matrix for anhydrous HF and the unit startup procedure required more protective PPE than Field Operators 1 and 2 were wearing at the time of the incident.

12. On the day of the incident, Honeywell did not ensure that its operators wore appropriately protective PPE on at least two separate instances leading up to and during the incident.

7.1.2 2023 HF Reboiler Explosion

Mechanical Integrity

13. The reboiler's carbon steel shell experienced average thickness loss that was generally consistent with published industry data. Despite being aware of the data, Honeywell Geismar allowed the reboiler's carbon steel shell to corrode to failure three times, with the final time resulting in a catastrophic BLEVE.

14. The Honeywell Geismar site did not effectively manage the thinning reboiler shell. Although the site had established acceptance criteria, inspected the reboiler, and successfully detected a deficiency prior to failure, the site did not effectively communicate the issue to all appropriate stakeholders and did not take all of its own prescribed actions for deficiency management, which ultimately allowed the reboiler to run to failure in January 2023.

15. Honeywell's MI management systems did not ensure that current, active knowledge of the reboiler's condition, and the urgency with which the shell needed to be replaced, was preserved and communicated to affected stakeholders. Because Honeywell did not preserve any lasting knowledge of the reboiler in its MI management systems SAP and DMAPS, when the 245 unit maintenance engineer left the company in April 2022, the site's knowledge of the reboiler's condition was lost.

16. The Honeywell Geismar site MI function was siloed, such that key people, departments, and functions remained unaware of the reboiler's condition prior to the explosion. Honeywell Geismar's management systems relied upon individual people and informal communication. Information about the condition of the reboiler was not preserved or communicated to key personnel with the ability and authority to act upon it.

Management of Organizational and Personnel Change

17. The reboiler shell replacement project met Honeywell's definition of a "key safety task" that should have been managed using the site's existing MOOC procedure when the 245 unit maintenance engineer left the company.

18. Although Honeywell Geismar had a management system that was intended to manage organizational and personnel change, Honeywell did not apply its management system when the 245 unit maintenance engineer departed the company. As a result, the capital project to replace the reboiler shell was never reassigned, and the project was never completed.

19. As with the 245 maintenance engineer's departure, Honeywell also did not apply its MOOC system to the extended vacancies in the maintenance and reliability manager positions, the reassignment of those management duties to other employees, or to the 2020 reduction in force. By not following its existing MOOC process, Honeywell Geismar failed to preserve critical information about the urgency of the reboiler shell replacement project. If the site had followed its MOOC policy and identified and reassigned the safety-related tasks of the departing 245 unit maintenance engineer, the necessity of the project may not have been lost, and the replacement may have been completed, thus preventing the explosion.

20. The maintenance supervisor's workload likely contributed to him not conducting an MOOC evaluation when the 245 unit maintenance engineer, who reported to him, left Honeywell. By not following its MOOC process, Honeywell Geismar did not account for or address the concentration of workload upon the maintenance supervisor.

21. Because Honeywell Geismar's procedure and checklist did not specifically address items such as safety-related capital projects, it is uncertain whether Honeywell Geismar would have effectively transferred the reboiler project to a new owner even if the site had followed its existing MOOC procedure.

22. Honeywell Geismar's management of organizational change system was not effectively implemented. Honeywell failed to analyze the risks of organizational change at all levels of the Geismar facility, from a large scale reduction in force to individual position vacancies. Honeywell's failure to implement this system and to effectively manage organizational and personnel change directly contributed to this incident by allowing the project to replace the reboiler, a safety-related task, to go unassigned and incomplete until the reboiler exploded in January 2023.

23. OSHA should amend its PSM regulation to explicitly require the management of organizational and personnel change.

Capital Project Management

24. Honeywell Geismar's project management systems could not appropriately accommodate periods of time during which project cost demand temporarily exceeded funding availability. This condition caused the Geismar site to have to re-prioritize its project list, but once a project was placed on the faster management path, the site had no formal process to re-prioritize projects. Because Honeywell had no formal process, the company and site had no way to ensure that projects with an urgent safety impact, such as the reboiler project, were prioritized appropriately.

25. The Honeywell Geismar site did not consistently apply its project rating methodology during the key time from October 2021 to January 2023. The reboiler project was left unfunded while at least 78 other unrated or lower rated projects were funded instead.

26. In the event of temporary funding delays and disruptions in funding availability, the Honeywell Geismar site could have used its emergency process to replace the reboiler prior to its failure. Honeywell Geismar did not use this process because none of the personnel with the authority to use it were aware of the urgency with which the reboiler needed to be replaced.

27. Honeywell Geismar did not effectively manage the capital project to replace the reboiler shell. After Honeywell Geismar's MI and MOOC/MOPC systems failed to preserve crucial knowledge about the reboiler, Honeywell Geismar's project management systems failed to fund the project and funded other, lower priority or unprioritized objectives instead of the reboiler, leading to the reboiler's eventual explosion.

Organizational Resilience

28. Beginning with the 2021 fatal incident, the Honeywell Geismar site experienced several consecutive and overlapping circumstances that caused significant disruption to the site's normal process safety and related management systems and practices. These circumstances combined to result in the catastrophic failure of the HF reboiler. Neither Honeywell nor the Geismar site recognized or resolved these disruptions to the site's normal processes prior to the explosion.

29. Had Honeywell's resilience systems been mature and fully implemented prior to the 2021 fatal incident, Honeywell may have been able to identify and effectively resolve the conditions that led to the 2023 reboiler incident.

7.1.3 2024 Toxic HF Release and Serious Injury

Safe Work Practices

30. Honeywell did not ensure that all piping within the bounds of the lockout was free of hazardous energy. The incident valve should have been cleared of HF as part of Honeywell's preparation for the maintenance work. Doing so would have prevented the HF release and the serious injury.

31. Honeywell Geismar did not ensure that important work scope information was provided to the operator. Because he did not review the annotated P&ID or piping isometric, the operator likely was not aware of the specific flanges that were to be changed and instead was likely only aware of the general piping segment on which the two Turner workers would change gaskets. Had the operator been provided with the correct documentation, he could have identified the potential hazard of the closed (and therefore potentially containing HF) valve, and he could have directed the two Turner workers to address the valve while they were wearing Level B PPE. Doing so would have prevented the release, the serious injury, or both.

32. The Turner workers and supervisor did not consider or otherwise account for the potential hazard of the closed incident valve during their pre-job risk assessment, despite the Turner risk assessment form

clearly prompting them to do so. Had they identified the potential hazard, they could have notified Honeywell of the potential hazard and addressed the risk prior to the work commencing, or during the job prior to removing their Level B PPE. Doing so would have prevented the release, the serious injury, or both.

33. Because Honeywell and Turner closed out the line break permit, the two Turner workers removed their Level B PPE once they believed the piping segment was free of hazardous energy. Had the injured Turner worker been wearing sufficiently protective PPE, his injury would have been prevented.

34. The number of gaps in the performance of Honeywell Geismar's and Turner's requirements during this incident is indicative of systemic problems with the site's implementation of its safe work practices including preparation of equipment for maintenance, control of hazardous energy, line break safety, and contractor management.

7.1.4 Safety Management Systems Implementation and Auditing

35. All three incidents resulted from the ineffective implementation of Honeywell's existing safety management systems. Had Honeywell followed its existing normal procedures, policies, and practices, it could have, and likely would have, prevented each of the three incidents.

36. The EPA should continue its efforts to initiate prioritization of HF under TSCA. If HF is determined to be a High-Priority Substance, the EPA should conduct a risk evaluation of HF, and implement any identified corrective actions, as required by the TSCA.

7.2 Causes

7.2.1 2021 Gasket Failure, Toxic HF Release, and Fatality

The CSB determined that the cause of the HF release was the failure of a flanged piping connection. The gasket within the connection had deteriorated from stress corrosion cracking, and the flange assembly was likely loosened because its fastening studs were thinned from wet HF acid corrosion, resulting in the release.

Honeywell's systems for mechanical integrity, change management, and process knowledge management contributed to the incident. Honeywell's mechanical integrity systems did not identify and replace the corroded gasket prior to its failure, and its change management and process knowledge management systems allowed Honeywell to not fully implement a 2007 gasket technology change that could have prevented the gasket corrosion.

Honeywell's ineffective safe work practices contributed to the severity of the incident. Honeywell did not follow its written unit startup procedures, which caused the fatally injured operator to be in the immediate vicinity of the incident gasket. The use of inadequate personal protective equipment resulted in the operator's fatal exposure to the released toxic HF.

7.2.2 2023 HF Reboiler Explosion

The CSB determined that the cause of the accidental release of toxic HF and chlorine was the catastrophic failure of a reboiler. The reboiler had thinned due to HF corrosion of its carbon steel shell to the point that it could no longer contain its normal operating pressure.

Contributing to the incident were Honeywell's ineffective implementation of its safety management systems for 1) mechanical integrity, 2) personnel and organizational change, and 3) capital projects. Honeywell's incomplete implementation of its organizational resilience policies and procedures, which could have enabled Honeywell to identify instability in its other management systems, also contributed to the incident.

7.2.3 2024 Toxic HF Release and Serious Injury

The CSB determined that the cause of the accidental HF release was the partial removal of a blind flange from a valve that contained pressurized HF during a maintenance activity. Honeywell did not effectively remove all HF from the valve before turning it over to contract workers for maintenance.

Contributing to the incident were Honeywell's and Turner's ineffective implementation of safe work practices including hazard identification and mitigation.

8 RECOMMENDATIONS

To prevent future chemical incidents, and in the interest of driving chemical safety excellence to protect communities, workers, and the environment, the CSB makes the following safety recommendations:

8.1 PREVIOUSLY ISSUED RECOMMENDATIONS SUPERSEDED IN THIS REPORT

U.S. Environmental Protection Agency (EPA)

2019-04-I-PA-R3 (From the CSB's Philadelphia Energy Solutions report; 2019-04-I-PA)

Per the requirements in EPA Rule *Procedures for Prioritization of Chemicals for Risk Evaluation Under the Toxic Substances Control Act*, initiate prioritization to evaluate whether hydrofluoric acid is a High-Priority Substance for risk evaluation. If it is determined to be a High-Priority Substance, conduct a risk evaluation of hydrofluoric acid to determine whether it presents an unreasonable risk of injury to health or the environment. If it is determined to present an unreasonable risk of injury to health or the environment, apply requirements to hydrofluoric acid to the extent necessary to eliminate or significantly mitigate the risk, for example by using a methodology such as the hierarchy of controls.

(Superseded by ***2023-02-I-LA-R4*** *to the EPA below)*

8.2 PREVIOUSLY ISSUED RECOMMENDATIONS REITERATED IN THIS REPORT

U.S. Occupational Safety and Health Administration (OSHA)

2005-4-I-TX-R9 (From the CSB's BP Texas City report; 2005-04-I-TX)

Amend the OSHA PSM standard to require that a management of change (MOC) review be conducted for organizational changes that may impact process safety including:

a. major organizational changes such as mergers, acquisitions, or reorganizations;

b. personnel changes, including changes in staffing levels or staff experience; and

c. policy changes such as budget cutting.

8.3 New Recommendations

8.3.1 Honeywell International Inc.

2023-02-I-LA-R1

Perform a comprehensive third-party audit of the Geismar facility's process safety and allied management systems as soon as practicable. The audit shall:

A. Be performed or led by an individual, firm, or team meeting the requirements outlined in paragraphs (b), (c), and (d) of Appendix E of this report.

B. Evaluate compliance with applicable federal standards (40 C.F.R. § 68 and 29 C.F.R. § 1910.119). In particular, the audit shall include the required elements that contributed to these incidents, including but not limited to:

1. management of change;
2. mechanical integrity;
3. quality assurance;
4. pre-startup safety reviews;
5. operating procedures; and
6. contractor management.

C. Evaluate other internal management systems that contributed to these incidents. In particular, the audit shall include but not be limited to:

1. management of organizational and personnel change;
2. management of safety-related capital projects;
3. organizational resilience; and
4. safe work practices including, but not limited to:
    a. work permitting;
    b. preparation of equipment for maintenance;
    c. control of hazardous energy;
    d. line break safety; and
    e. personal protective equipment.

D. Use the Center for Chemical Process Safety's *Guidelines for Auditing Process Safety Management Systems* as guidance to verify both the suitability of these systems and their effective, consistent implementation and performance.

E. Result in the development of a comprehensive report meeting the requirements outlined in paragraphs (e) and (f) of Appendix E of this report. If any findings are rejected, the rationale for and documentation supporting the merit of the rejection shall be included. The report in its entirety shall be made available to the Honeywell workforce at the Geismar, Louisiana; Baton Rouge, Louisiana; and Metropolis, Illinois, sites.

2023-02-I-LA-R2

Require periodic reporting updates from the Geismar site regarding the closure of the audit findings. The periodic updates shall continue until all audit findings are fully closed.

2023-02-I-LA-R3

Perform a Safer Technologies and Alternatives Analysis (STAA) for the Honeywell Geismar HFC-245fa unit. The STAA shall meet the requirements outlined in paragraphs (a) and (b) of Appendix F of this report.

8.3.2 U.S. Environmental Protection Agency (EPA)

2023-02-I-LA-R4

Per the requirements in EPA Rule *Procedures for Prioritization of Chemicals for Risk Evaluation Under the Toxic Substances Control Act*, initiate prioritization to evaluate whether hydrogen fluoride, including its anhydrous and aqueous acid forms, is a High-Priority Substance for risk evaluation. If it is determined to be a High-Priority Substance, conduct a risk evaluation of hydrogen fluoride to determine whether it presents an unreasonable risk of injury to health or the environment. If it is determined to present an unreasonable risk of injury to health or the environment, apply requirements to hydrogen fluoride to the extent necessary to eliminate or significantly mitigate the risk, for example by using a methodology such as the hierarchy of controls.

(Supersedes **2019-04-I-PA-R3** *from the Philadelphia Energy Solutions Report)*

9 Key Lessons for the Industry

To prevent future chemical incidents, and in the interest of driving chemical safety excellence to protect communities, workers, and the environment, the CSB urges companies to review these key lessons:

1. Mechanical Integrity programs should be thorough, and companies should ensure that their testing and inspection methodologies are designed to detect expected damage mechanisms and failure modes. Mechanical Integrity programs must successfully identify and resolve equipment deficiencies prior to failure.

2. Once a deficiency is identified, robust mechanical integrity programs must ensure that corrective actions are identified and tracked to completion. It is not enough to simply identify a deficiency if that deficiency goes unmanaged and unmitigated.

3. Companies should ensure that their mechanical integrity systems communicate the need for corrective action to all stakeholders when safety-critical equipment is either approaching or has reached a point that requires corrective action.

4. Companies should develop and implement systems to manage organizational and personnel change. It is crucial to ensure that process safety-related responsibilities and tasks are not lost during such changes.

5. Capital projects that are intended to address mechanical integrity deficiencies are important safety tasks. Companies must ensure that all safety-related tasks, including safety-related projects, are included in their MOOC programs so that they are properly managed, tracked, and reassigned when necessary.

6. To ensure that one incident does not cause or lead to another, companies should develop and implement resilience programs to recognize and prevent or minimize disruption to their routine process safety management activities and other systems that contribute to process safety, such as capital project management.

7. No process safety management system can succeed without effective and consistent implementation. Companies must ensure that they not only develop effective systems, but that those systems are implemented, consistently followed, and validated.

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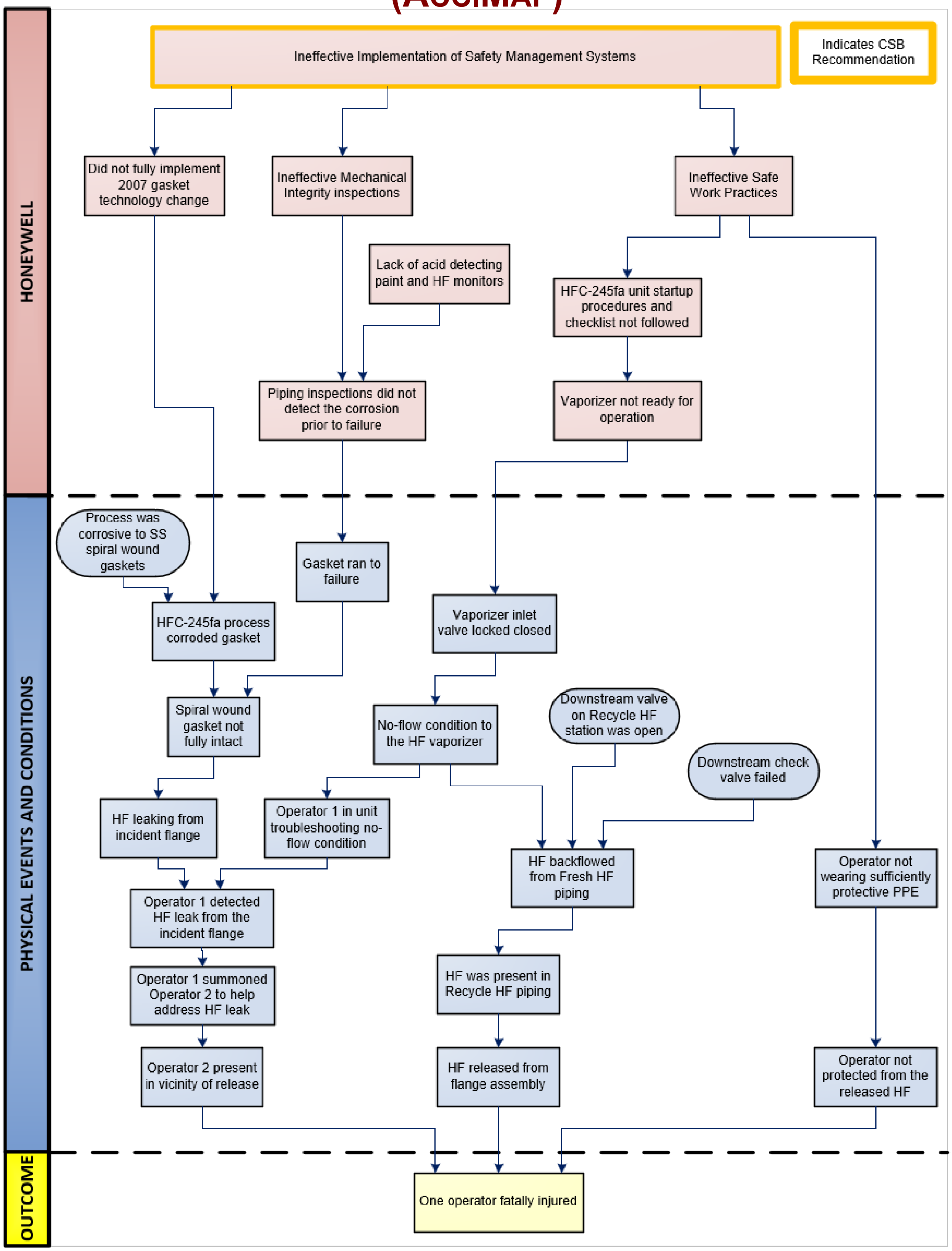
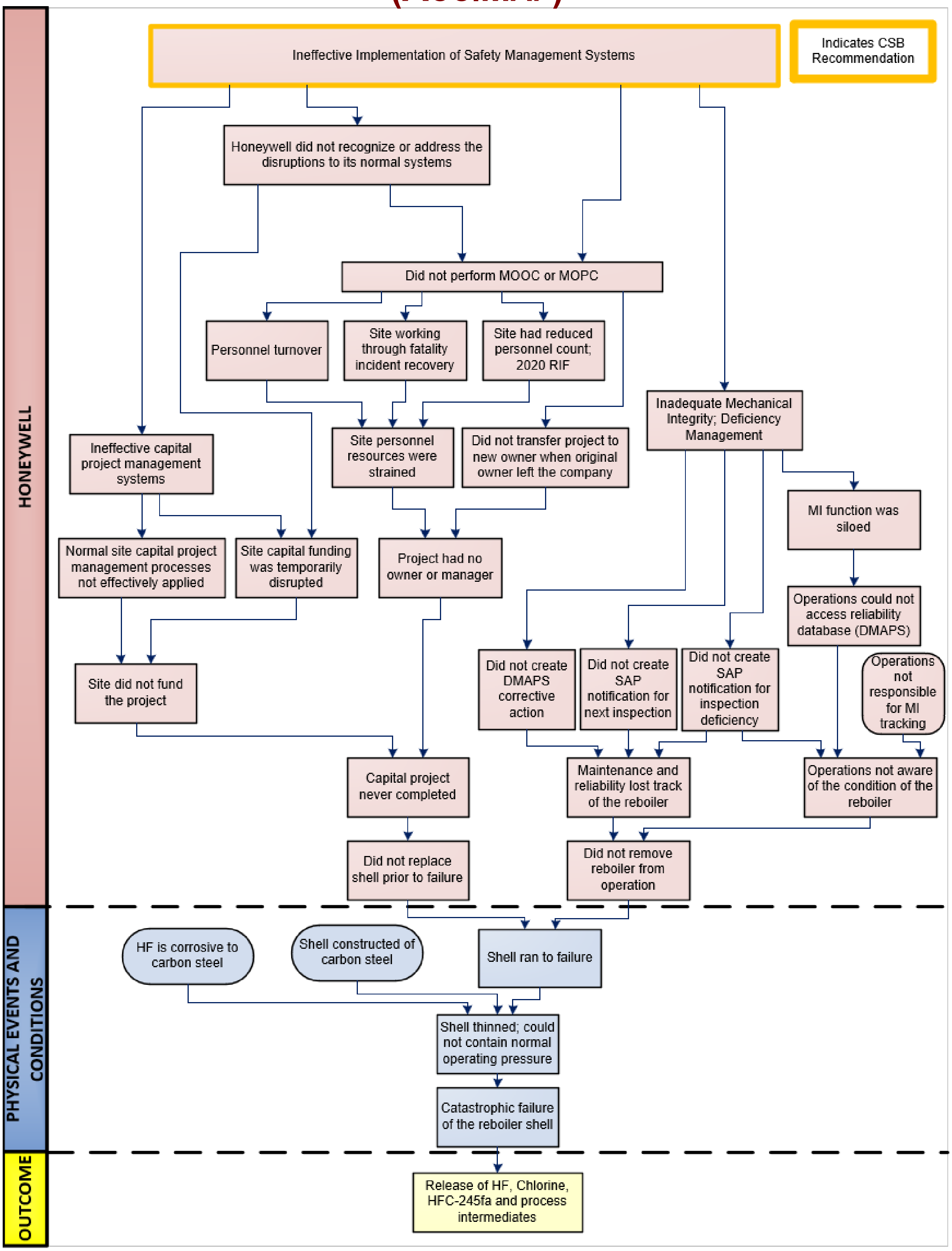
APPENDIX A: OCTOBER 2021 SIMPLIFIED CAUSAL ANALYSIS (ACCIMAP)

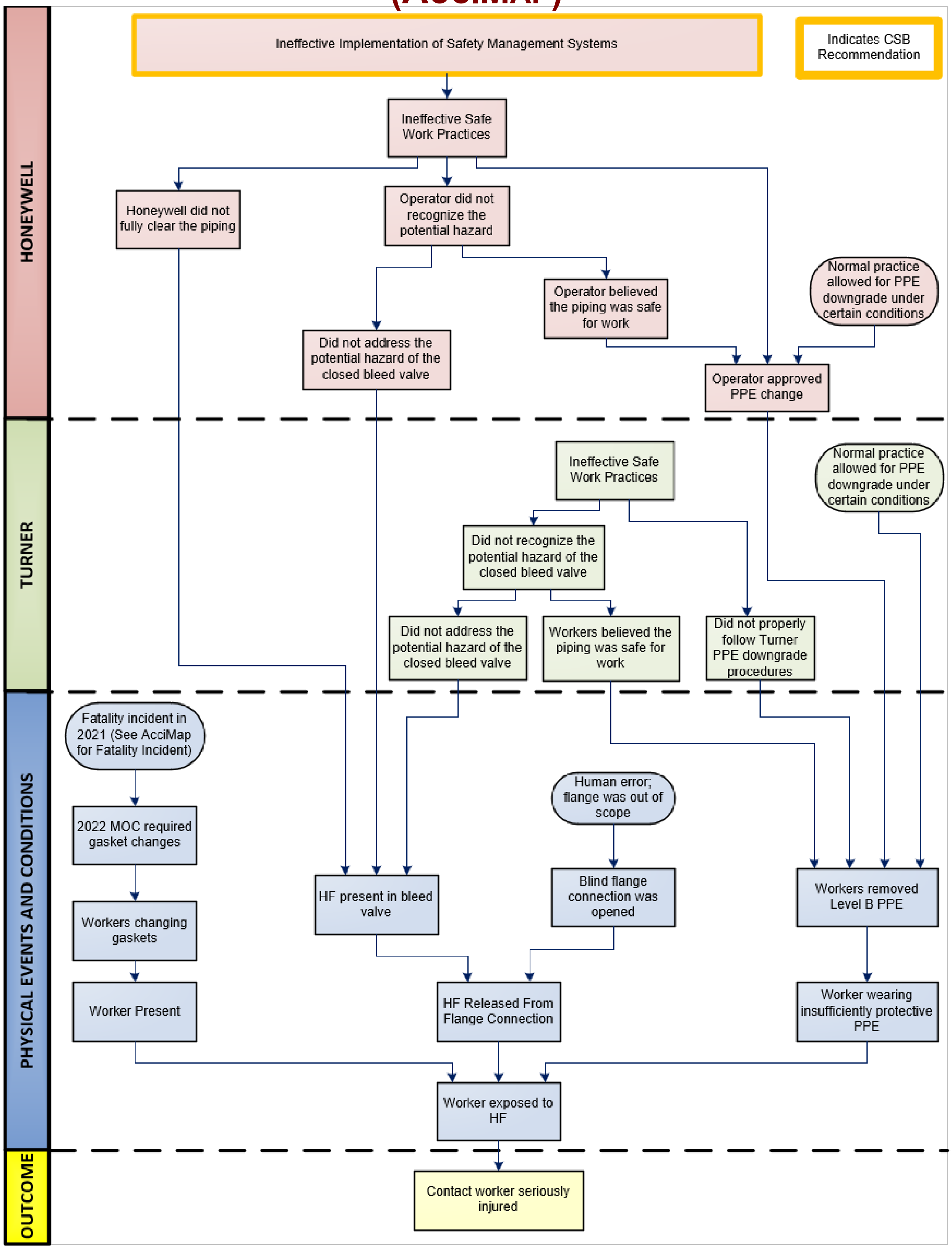


Appendix B: January 2023 Simplified Causal Analysis (AcciMap)



CSB Public Record

Appendix C: June 2024 Simplified Causal Analysis (AcciMap)



APPENDIX D: DESCRIPTION OF SURROUNDING AREA

Figure 34 shows the census blocks immediately surrounding the Honeywell Geismar facility. The census information for the blocks shown is presented in **Table 6** [42].

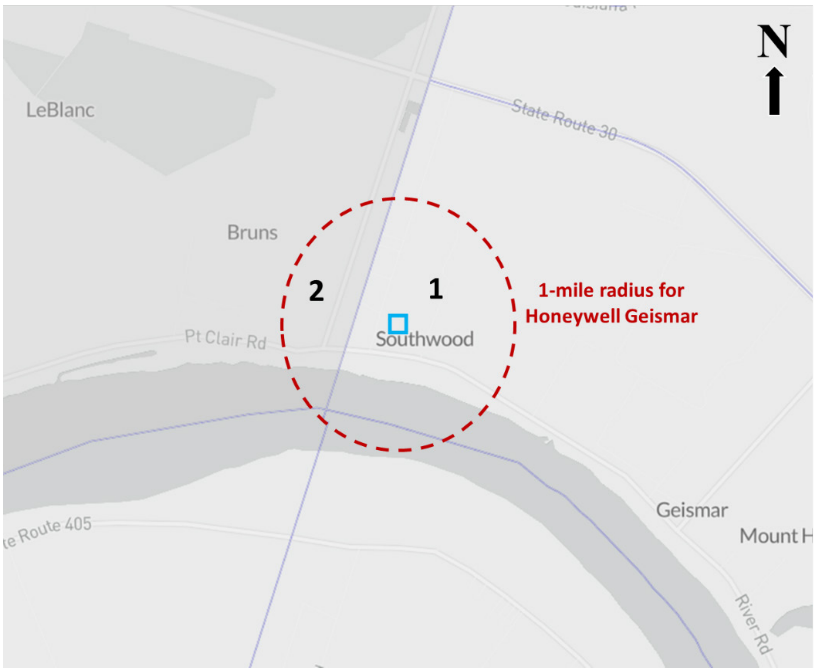


Figure 34. Census blocks within a one-mile distance from the Honeywell Geismar facility. (Credit: Census Reporter, annotated by CSB)

Table 6. Tabulation of demographic data for the populations within the census blocks shown in **Figure 34**.

Tract Number	Population	Median Age	Race and Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Structures	
1	5,814	41.5	64%	White	$ 57,951	1.4%	2,367	90%	Single Unit
			28%	Black				0%	Multi-Unit
			0%	Native				10%	Mobile Home
			0%	Asian				0%	Boat, RV, van, etc.
			0%	Islander					
			1%	Other					
			6%	Two+					
			0%	Hispanic					
2	7,290	36.9	39%	White	$ 26,269	11.2%	2,305	66%	Single Unit
			53%	Black				16%	Multi-Unit
			0%	Native				18%	Mobile Home
			0%	Asian				1%	Boat, RV, van, etc.
			0%	Islander					
			0%	Other					
			1%	Two+					
			7%	Hispanic					

APPENDIX E: THIRD-PARTY AUDIT

The CSB modeled its recommendation for Honeywell to perform an independent third-party audit using language in the EPA's RMP rule in effect in May 2024. The CSB modified the EPA's regulatory language to retain the safety improvements of using an independent third party without the legal framework imposed by the requirements of a regulation. Because this safety recommendation focuses on improving Honeywell's overall safety management systems, the CSB recommends that the third-party audit evaluate the company's program against both the OSHA PSM standard and the EPA RMP rule, and recommending that the audit include other safety management systems and allied management systems that are not required by those regulations.

(a) *Applicability.* Honeywell International Inc. shall engage a third party to conduct an audit that evaluates conformance with the provisions of the OSHA PSM standard and the EPA RMP rule.

(b) *Third-party auditors and auditing teams.* Honeywell International Inc. shall either:

(1) Engage a third-party auditor meeting all of the competency and independence criteria in paragraph (c) of this section; or

(2) Assemble an auditing team, led by a third-party auditor meeting all of the competency and independence criteria in paragraph (c) of this section. The team may include:

(i) Other employees of the third-party auditor firm meeting the independence criteria of paragraph (c)(2) of this section; and

(ii) Other personnel not employed by the third-party auditor firm, including facility personnel.

(c) *Third-party auditor qualifications.* Honeywell International Inc. shall determine and document that the third-party auditor(s) meet the following competency and independence requirements:

(1) The third-party auditor(s) shall be:

(i) Knowledgeable with the requirements of this part;

(ii) Experienced with the stationary source type and processes being audited and applicable recognized and generally accepted good engineering practices; and

(iii) Trained and/or certified in proper auditing techniques.

(2) The third-party auditor(s) shall:

(i) Act impartially when performing all activities under this section;

(ii) Receive no financial benefit from the outcome of the audit, apart from payment for auditing services. For purposes of this paragraph (c)(2)(ii), retired employees who otherwise satisfy the third-party auditor independence criteria in this section may qualify as independent if their sole continuing financial attachments to Honeywell International Inc. are employer-financed or managed retirement and/or health plans;

(iii) Ensure that all third-party personnel involved in the audit sign and date a conflict of interest statement documenting that they meet the independence criteria of this paragraph (c)(2); and

(iv) Ensure that all third-party personnel involved in the audit do not accept future employment with Honeywell International Inc. of the stationary source for a period of at least two years following submission of the final audit report. For purposes of the requirement in this paragraph (c)(2)(iv), employment does not include performing or participating in third-party audits pursuant to § 68.59 or this section.

(3) The auditor shall have written policies and procedures to ensure that all personnel comply with the competency and independence requirements of this section.

(d) *Third-party auditor responsibilities.* Honeywell International Inc. shall ensure that the third-party auditor:

(1) Manages the audit and participates in audit initiation, design, implementation, and reporting;

(2) Determines appropriate roles and responsibilities for the audit team members based on the qualifications of each team member;

(3) Prepares the audit report and, where there is a team, documents the full audit team's views in the final audit report;

(4) Certifies the final audit report and its contents as meeting the requirements of this section; and

(5) Provides a copy of the audit report to Honeywell International Inc.

(e) *Audit report.* The audit report shall:

(1) Identify all persons participating on the audit team, including names, titles, employers and/or affiliations, and summaries of qualifications. For third-party auditors, include information demonstrating that the competency requirements in paragraph (c)(1) of this section are met;

(2) Describe or incorporate by reference the policies and procedures required under paragraph (c)(3) of this section;

(3) Document the auditor's evaluation of Honeywell International Inc.'s compliance with the provisions of the PSM standard and RMP rule to determine whether the procedures and practices developed by Honeywell International Inc. under this part are adequate and being followed;

(4) Document the findings of the audit, including any identified compliance or performance deficiencies;

(5) Summarize any significant revisions (if any) between draft and final versions of the report; and

(6) Include the following certification, signed and dated by the third-party auditor or third-party audit team member leading the audit:

I certify that this RMP compliance audit report was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information upon which the audit is based. I further certify that the audit was conducted and this report was prepared pursuant to the requirements of subpart D of 40 CFR part 68 and all other applicable auditing, competency, independence, impartiality, and conflict of interest standards and protocols. Based on my personal knowledge and experience, and inquiry of personnel involved in the audit, the information submitted herein is true, accurate, and complete.

(f) *Third-party audit findings* —

(1) *Findings response report.* As soon as possible, but no later than 90 days after receiving the final audit report, the owner or operator shall determine an appropriate response to each of the findings in the audit report, and develop a findings response report that includes:

(i) A copy of the final audit report;

(ii) An appropriate response to each of the audit report findings;

(iii) A schedule for promptly addressing deficiencies; and

(iv) A certification, signed and dated by a senior corporate officer, or an official in an equivalent position, of Honeywell International Inc. of the stationary source, stating:

I certify under penalty of law that I have engaged a third party to perform or lead an audit team to conduct a third-party audit in accordance with the requirements of 40 CFR 68.80 and that the attached RMP compliance audit report was received, reviewed, and responded to under my direction or supervision by qualified personnel. I further certify that appropriate responses to the findings have been identified and deficiencies were corrected, or are being corrected, consistent with the requirements of subpart D of 40 CFR part 68, as documented herein. Based on my personal knowledge and experience, or inquiry of personnel involved in evaluating the report findings and determining appropriate responses to the findings, the information submitted herein is true, accurate, and complete. I am aware that there are significant penalties for making false material statements, representations, or certifications, including the possibility of fines and imprisonment for knowing violations.

(2) *Schedule implementation.* Honeywell International Inc. shall implement the schedule to address deficiencies identified in the audit findings response report in paragraph (f)(1)(iii) of this section and document the action taken to address each deficiency, along with the date completed.

(3) *Submission to Board of Directors.* Honeywell International Inc. shall immediately provide a copy of each document required under paragraphs (f)(1) and (2) of this section, when completed, to Honeywell International Inc.'s audit committee of the Board of Directors, or other comparable committee or individual, if applicable.

APPENDIX F: SAFER TECHNOLOGIES AND ALTERNATIVES ANALYSIS (STAA)

The CSB modeled its recommendation for Honeywell to perform a Safer Technologies and Alternatives Analysis using language in the EPA's RMP rule promulgated in May 2024. The CSB modified the EPA's regulatory language at 40 C.F.R. § 68.67(c)(9) and § 68.67(h) to retain the safety improvements of conducting such an analysis without the legal framework imposed by the requirements of a regulation.

(a) The analysis shall address:

(1) Safer technology and alternative risk management measures applicable to eliminating or reducing risk from process hazards for the Honeywell Geismar HFC-245fa unit and shall meet all of the following requirements:

(i) For the Honeywell Geismar HFC-245fa unit, consider and document, in the following order of preference, inherently safer technology or design, passive measures, active measures, and procedural measures. A combination of risk management measures may be used to achieve the desired risk reduction. Honeywell shall also determine and document the practicability of the inherently safer technologies and designs considered. Honeywell shall include in documentation any methods used to determine practicability. For any inherently safer technologies and designs implemented, Honeywell shall document a description of the technology implemented.

(ii) The analysis shall be performed by a team that includes members with expertise in the process being evaluated, including at least one member who works in the process. The team members shall be documented.

(b)

(1) For the Honeywell Geismar HFC-245fa unit, implement at least one passive measure at the stationary source, or an inherently safer technology or design, or a combination of active and procedural measures equivalent to or greater than the risk reduction of a passive measure.

(2) If no passive measures are identified or all are not practicable, and no inherently safer technology or design is implemented, then Honeywell shall implement at least one active measure. If no active measures are identified or all are not practicable, Honeywell shall implement at least one procedural measure.

(3) For passive and active measures not implemented, document sufficient evidence to demonstrate that implementing the measures is not practicable and the reasons for this conclusion. A claim that implementation is not practicable shall not be based solely on evidence of reduced profits or increased costs.

U.S. Chemical Safety and Hazard Investigation Board

Members of the U.S. Chemical Safety and Hazard Investigation Board:

Steve Owens
Chairperson

Sylvia E. Johnson, Ph.D.
Member

Catherine J. K. Sandoval
Member