U.S. Chemical Safety and Hazard Investigation Board

Fatal Coke Oven Gas Explosion at U.S. Steel Clairton Coke Works

Clairton, Pennsylvania | *Incident Date: August 11, 2025* | **No. 2025-03-I-PA**

Investigation Report

Published: August 2026

SAFETY ISSUES:

- **Procedures and Hazard Analysis**
- **Facility Siting**
- **Process Safety Management Systems**

U.S. Chemical Safety and Hazard Investigation Board

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The August 11, 2025, explosion at the U.S. Steel Clairton Coke Works facility fatally injured two people:

Steven Menefee
Timothy "TQ" Quinn

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ABBREVIATIONS

°F	degrees Fahrenheit
ACHD	Allegheny County Health Department
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
C.F.R.	Code of Federal Regulations
CCPS	Center for Chemical Process Safety
CSB	U.S. Chemical Safety and Hazard Investigation Board
EDC	Electrical Distribution Center
EPA	U.S. Environmental Protection Agency
HJM	Hazardous Job Meeting
HJP	Hazardous Job Procedure
JHA	Job Hazard Analysis
LOI	Letter of Interpretation
NFPA	National Fire Protection Association
OSHA	U.S. Occupational Safety and Health Administration
PHA	Process Hazards Analysis
PHMSA	Pipeline and Hazardous Materials Safety Administration
psig	Pounds per Square Inch Gauge
PSM	Process Safety Management standard
RBPS	Risk Based Process Safety
RMP	Risk Management Program

EXECUTIVE SUMMARY

On August 11, 2025, at 10:47 a.m., approximately 19 pounds of coke oven gas, a toxic and flammable gas mixture, were released at the U.S. Steel Clairton Coke Works ("U.S. Steel Clairton") facility in Clairton, Pennsylvania. The released coke oven gas exploded and fatally injured two U.S. Steel employees, injured 11 people, five of them seriously, and caused an estimated $52.5 million in property damage.

The release occurred during a maintenance operation in which U.S. Steel employees and contractors were attempting to fully close and reopen a double disc gate isolation valve in the piping that supplied coke oven gas to one of U.S. Steel's coke oven batteries, called Battery 13. During this maintenance operation, the workers also attempted to wash the valve's seats[a] using pressurized water from a contractor's pump truck, as instructed by a U.S. Steel supervisor (who was described to the CSB as the facility's "water washing expert"). U.S. Steel had no procedure for how to safely conduct this operation, but for at least three years prior to the incident, U.S. Steel employees had utilized pressurized water to clean valve seats on an ad hoc basis despite the lack of a formal procedure prescribing it. While applying pressurized water to the valve's seats, the workers closed or nearly fully closed the valve's double gates, creating an enclosed space between the two gates.[b] The pressurized water filled this space inside the cast iron valve and caused the pressure inside the valve to increase beyond the valve's ability to contain it. The valve then failed catastrophically, allowing toxic and flammable coke oven gas to release into the surrounding area.

After the valve failed, the workers began evacuating the area of the release and over the next one to two minutes alerted other workers of the need to evacuate. Twenty-four seconds after an evacuation order was issued via radio, the released coke oven gas ignited and exploded.

The area in which the explosion occurred, called the "transfer area," was located in between Batteries 13 and 14 and contained multiple buildings that were routinely occupied by people. At the time of the explosion, the two fatally injured workers were each in or near separate control rooms and two of the five seriously injured workers were inside a break room. All three buildings were located in the transfer area, less than 20 feet directly above the coke oven gas piping system that was the source of the release. None of the buildings were designed or constructed to withstand an explosion. All three buildings suffered catastrophic damage.

[a] A valve's seat is the internal surface against which the valve seals.

[b] A gate valve stops flow by lowering one or multiple gates into the path of the fluid and sealing against the seat or seats.

Safety Issues

The CSB's investigation identified the safety issues below.

- **Procedures and Hazard Analysis.** On the day of the incident, the valve washing operation was performed in a way that directly caused the catastrophic failure of the Battery 13 coke oven gas isolation valve. U.S. Steel occasionally utilized water washing to address valves that could not otherwise fully close, but the company never developed a formal procedure for water washing valves despite relying on it to prepare isolation valves for maintenance outages. Additionally, neither U.S. Steel nor its contractor, MPW Industrial Services, Inc, (MPW), identified or addressed the hazards created by applying pressurized water to the valve at a pressure greater than the valve's design rating. (Section 4.1)

- **Facility Siting.** The buildings in the Battery 13/14 transfer area were located less than 20 feet directly above the coke oven gas piping system. The buildings were routinely occupied by U.S. Steel personnel and were neither designed nor constructed to withstand an explosion. Prior to the explosion, four U.S. Steel employees were occupying three buildings in the transfer area. All three buildings were destroyed by the explosion, which caused the deaths of two employees and seriously injured two other workers who were in or near the buildings, thereby increasing the severity of this incident. In the years leading up to the explosion, U.S. Steel had multiple opportunities to evaluate and address the inherent hazards resulting from the co-location of occupied buildings and the hazardous coke oven gas piping. However, U.S. Steel affirmatively chose not to do so, based on the company's belief that it was not required to do so. (Section 4.2)

- **Process Safety Management Systems.** Effective process safety management systems are crucial for facilities where hazardous chemicals are produced and handled. U.S. Steel did not have sufficiently robust process safety management systems that could have prevented or reduced the severity of this incident. (Section 4.3)

Cause

The CSB determined the cause of the incident was the overpressurization of a double disc gate valve constructed of cast iron, which resulted in the release of flammable coke oven gas that ignited and exploded. The valve design was such that, when the valve was fully closed, an enclosed volume of space existed between the valve's two gates. This enclosure was pressurized with water during an operation in which U.S. Steel and its contractor, MPW, were attempting to wash the valve with high-pressure water.

Contributing to the incident was U.S. Steel's and MPW's lack of a procedure detailing how to safely perform the valve washing operation, along with U.S. Steel's and MPW's failure to identify or adequately address the potential hazards of the operation. Additionally, U.S. Steel lacked effective process safety management systems that could have prevented or reduced the severity of this incident.

Contributing to the severity of this incident was U.S. Steel's inadequate siting and construction of occupied buildings within its coke battery unit, which enabled catastrophic building damage that in turn caused both of the fatal injuries and two of the five serious injuries.

RECOMMENDATIONS[a]

To U.S. Steel

2025-03-I-PA-R1 (issued as an interim recommendation in December 2025)

Conduct a siting evaluation for all occupied and potentially occupied buildings at the Clairton Coke Works facility. Utilize the guidance contained in the Center for Chemical Process Safety's *Guidelines for Evaluating Process Plant Buildings for External Explosions, Fires, and Toxic Releases*, the American Petroleum Institute's Recommended Practices 752, 753, and 756, and other industry good practice guidance documents.

2025-03-I-PA-R2 (issued as an interim recommendation in December 2025)

Using the results from the evaluation performed in **2025-03-I-PA-R1**, ensure that all documented facility siting hazards are mitigated in accordance with the guiding principles contained in the American Petroleum Institute's Recommended Practices 752, 753, and 756.

2025-03-I-PA-R3

Develop a written procedure in accordance with industry guidance such as NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, for washing valve seats with pressurized water. Ensure that the procedure includes steps and other controls, including overpressure protection, to minimize the hazards of the operation. Ensure that workers who will or might perform the operation are involved in the development of the procedure and are trained on the procedure.

2025-03-I-PA-R4

Conduct a hazard analysis or safety validation of the written valve washing procedure in accordance with NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*. Ensure that workers who will or might perform the operation are involved in the analysis or validation.

2025-03-I-PA-R5

Develop a comprehensive process safety management system, incorporating guidance from the Center for Chemical Process Safety's *Guidelines for Risk Based Process Safety* and other industry good practice guidance publications, and apply it to all coke oven gas processes at the Clairton facility.

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[a] The CSB is not making any recommendations to the American Society of Mechanical Engineers (ASME). However, as discussed in Appendix C to this report, the ASME B31.3 standard, titled *Process Piping*, lacks clarity regarding the use of cast iron in coke oven piping. ASME B31.3 is a broadly applicable standard and is widely used in the chemical process industries, but it does not explicitly prohibit the use of cast iron in piping except for what it defines as "severe cyclic conditions," although it cautions that the "lack of ductility and…sensitivity to thermal and mechanical shock" of cast iron "should be evaluated" in piping systems. The ASME has informed the CSB that it has approved revisions to B31.3 to expressly include requirements for hydrogen piping, which will be incorporated in the 2026 edition of ASME B31.3.

To Nippon Steel North America, Inc.

2025-03-I-PA-R6

Develop and implement a corporate process safety governance program to ensure the implementation of process safety management at applicable facilities. At a minimum, this program shall:

a. include regular audits of subordinate facilities throughout the organization;
b. require the documentation of process safety deficiencies, when identified, and prompt corrective action; and,
c. incorporate industry guidance, such as the Center for Chemical Process Safety's (CCPS) *Guidelines for Implementing Process Safety Management*, the CCPS's *Process Safety – Leadership from the Boardroom to the Frontline*, and other industry good practice guidance publications.

To MPW Industrial Services, Inc.

2025-03-I-PA-R7

Develop written policies and procedures in accordance with industry guidance such as NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, governing cleaning piping systems containing flammable or toxic gas. Ensure that all workers who will or might participate in such operations are trained on the policies and procedures.

1 BACKGROUND

1.1 UNITED STATES STEEL

United States Steel Corporation ("U.S. Steel") was formed in 1901, when a business group headed by John Pierpont ("J.P.") Morgan, which owned the Federal Steel Company, purchased the Carnegie Steel Company, then owned by Andrew Carnegie [1]. In the 1980s, U.S. Steel entered the energy industry and acquired several oil companies, including Marathon Oil Company. As a result, the company changed its name to USX Corporation. In the 2000s, USX reorganized, splitting its steel-related businesses from its petroleum-related businesses. The steel-related businesses became U.S. Steel, and the petroleum-related businesses became the Marathon Oil Corporation [2].[a]

In June 2025, Nippon Steel North America, Inc.[b] acquired U.S. Steel [3]. U.S. Steel retained its name and headquarters in Pittsburgh, Pennsylvania [4] and operates several facilities across the United States [5].

1.2 MPW INDUSTRIAL SERVICES, INC.

MPW Industrial Services, Inc. ("MPW") is headquartered in Columbus, Ohio. MPW provides industrial cleaning services, water treatment, and various management services throughout North America [6]. U.S. Steel regularly contracted MPW to provide industrial cleaning services at the Clairton facility.

1.3 THE CLAIRTON FACILITY

The Clairton Coke Works facility (**Figure 1**) is located in the City of Clairton in Allegheny County, Pennsylvania, and is the largest coke manufacturing facility in the Western Hemisphere [5, 7, p. 6]. The site is located approximately 20 miles south of Pittsburgh, on 392 acres, sitting along a roughly 3-mile portion of the Monongahela River bank [7]. The plant was built by the St. Clair Steel Company in 1901 and bought by U.S. Steel in 1904 [8]. The facility began producing coke for steel production in 1918 [9, 10, p. 7], and at the time of the incident employed approximately 1,150 people, including employees represented by the United Steelworkers union, as well as non-represented employees [11]. The site has about 350 resident contractors.

[a] In 2011, Marathon Oil split into Marathon Petroleum, which retained the downstream refining business, and Marathon Oil, which retained the upstream production business [67]. Marathon Oil was eventually acquired by ConocoPhillips in 2024, while Marathon Petroleum continues operating refineries [68].

[b] Nippon Steel North America, Inc. is a wholly owned subsidiary of Nippon Steel Corporation, a Japanese corporation.

Figure 1. The U.S. Steel Clairton facility. (Credit: The Center for Land Use Interpretation)[a]

The Clairton facility converts raw metallurgical coal into coke, a carbon-rich substance used, in part, as fuel in blast furnaces for iron and steel production [12, p. 1]. Metallurgical coal, also called "met coal" or "coking coal," is coal that is used for steel production and typically has a lower ash and sulfur content than steam coal, which is used to generate electricity [13, 14].

The coking process occurs in equipment called "coke ovens." A "coke battery" is a series of coke ovens connected by common walls and operated as one unit (**Figure 2**) [15].

[a] *See* Clairton Works Coke Plant | The Center for Land Use Interpretation

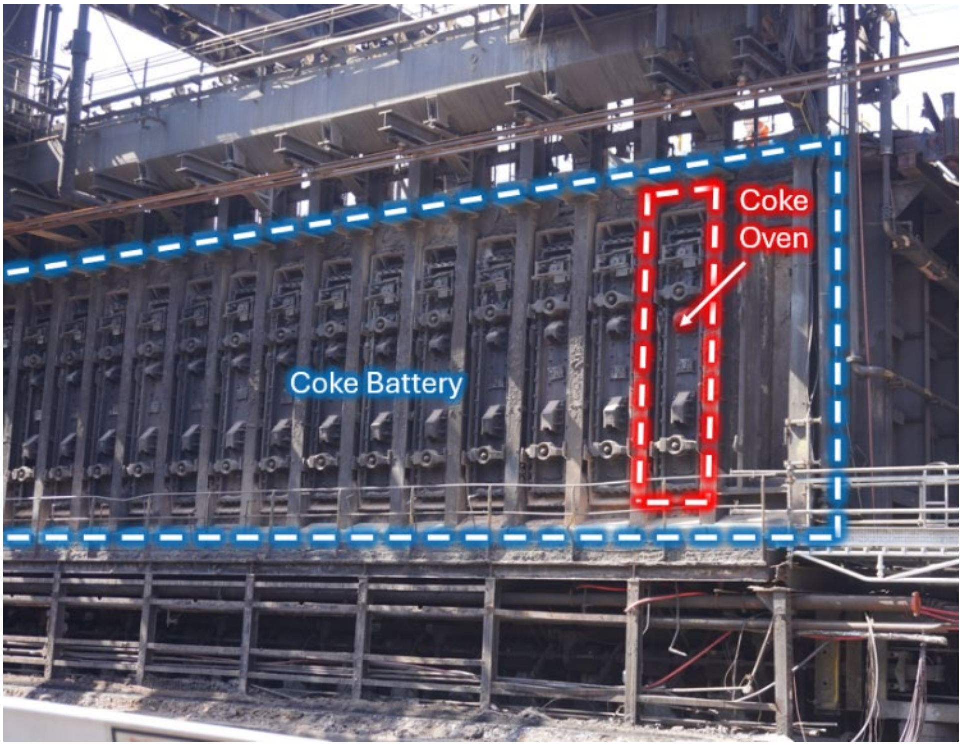

Figure 2. Post-incident picture of one of U.S. Steel's coke batteries. (Credit: CSB)

The Clairton facility reached its maximum production capacity in 1948, operating 22 coke batteries with a total of 1,482 coke ovens. During the peak production years of the 1940s, some 7,200 workers were employed at the Clairton site [16]. The facility currently operates six coke batteries, designated as Batteries 13, 14, 19, 20, B, and C, with a total of 455 ovens. The August 11, 2025, incident occurred between Batteries 13 and 14.

1.4 The Clairton Coke Process

Bituminous[a] coal is delivered to the Clairton facility in barges. The coal is crushed and blended, then moved to coal storage bunkers located on each coke battery unit. The coal is transferred from the coal storage bunker to each oven by a coal charging railcar called a "Larry car," which runs along a track atop of each coke battery and deposits the coal into each oven via chutes.

In the coke ovens, coal is heated to approximately 2,000 degrees Fahrenheit (°F) for a minimum of 18 hours [7, p. 14]. During that time, gases are driven off by heat into an off-gas piping system [17, pp. 2-3]. These gases are known collectively as "coke oven gas."

At the Clairton facility, the off-gas piping system routes raw coke oven gas to the facility's byproduct recovery unit for processing, which removes tar, ammonia, light oil (benzene, toluene, and xylene), and elemental sulfur from the gas. The processed coke oven gas produced by the byproduct recovery unit is a mixture of hydrogen (55 to 61 volume percent), methane (22 to 23 volume percent), nitrogen (9 to 10 volume percent), and carbon

[a] Bituminous coal contains 45%–86% carbon. Bituminous coal in the United States is between 100 million and 300 million years old. Bituminous coal is the most abundant coal found in the United States, and it accounted for about 46% of total U.S. coal production in 2022. *See* Coal explained - U.S. Energy Information Administration (EIA).

monoxide (4 to 5 volume percent), along with smaller amounts of other compounds. Approximately 45 percent of the processed coke oven gas is burned as fuel to heat the Clairton facility's coke ovens, while the remaining 55 percent is sent downriver in pipelines and used as fuel at U.S. Steel's Irvin and Edgar Thomson steel plants in Pennsylvania [7, pp. 20-21].

Coke oven gas is highly flammable, toxic, colorless, and has a sulfurous odor. It has a lower explosive limit[a] of about 4.4 percent and is less dense than air. The autoignition temperature of hydrogen, the most prominent component of coke oven gas, is 1,065 °F [18]. Coke oven gas also contains residue that can accumulate in low points, such as at the bottom of piping and in valve seats. U.S. Steel describes the coke oven gas pipeline residue as containing sulfur, iron, and other trace components [19].

The nearly pure carbon that remains in the oven after the 18-hour heating cycle is called "coke." When heating is completed, a "pusher" machine pushes the coke into a railcar (**Figure 3**), which transports the coke to a "quench tower" where it is showered with water to cool it. The coke is then transported to U.S. Steel's nearby facilities (**Figure 4**).

[a] The lower explosive limit, or lower flammable limit, is defined as the concentration of a combustible material in air below which ignition will not occur [73].

Figure 3. Coke, after being pushed from a coke oven and in transit to a quench tower at the U.S. Steel Clairton facility (Credit: CSB)

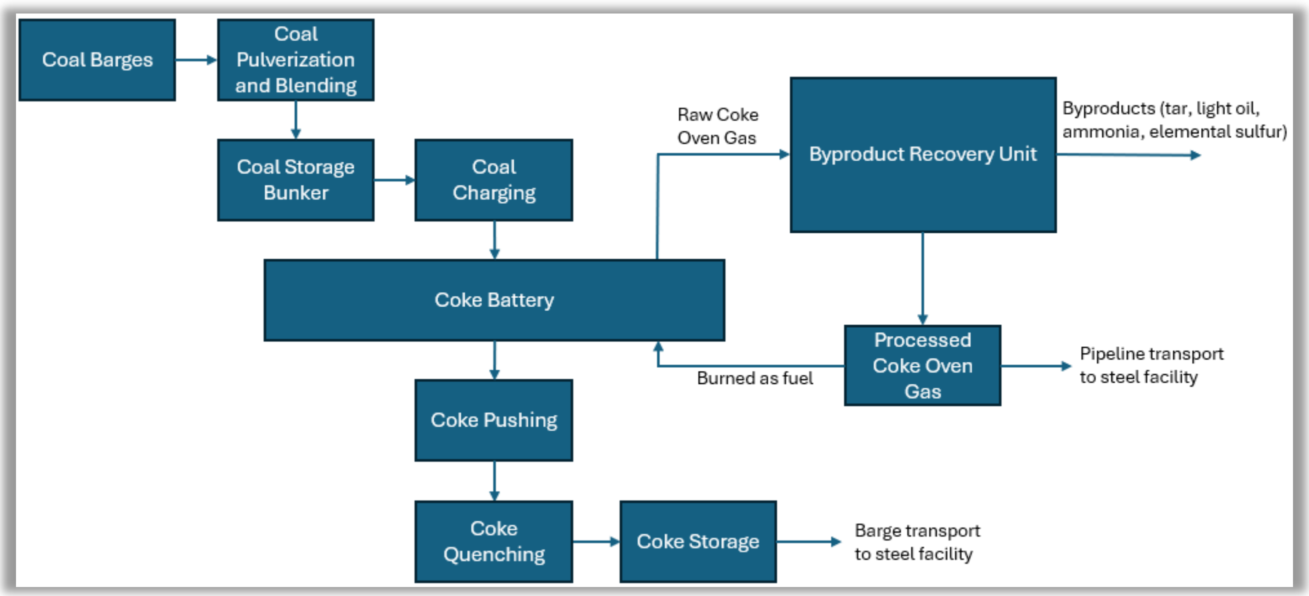

Figure 4. Simplified block flow diagram of the Clairton coking process. (Credit: CSB)

1.5 Coke Production in the United States

The U.S. Energy Information Administration's *Quarterly Coal Report*, which provides data on U.S. coke production, has reported that 10.2 million tons of coke were produced in the United States in 2025 [20, p. 11].

In 2024, the United States Environmental Protection Agency (EPA) reported that there were 11 active coke facilities in the United States, with a total annual capacity of 12.4 million tons [21, p. 18]. **Table 1** lists the six of these facilities that are byproduct recovery facilities, meaning they produce coke using coke ovens and recover chemicals from coke oven gas in an on-site chemical plant [21, p. 19, 22, p. 42]. The U.S. Steel Clairton facility has the largest capacity of these facilities, according to the EPA.

Table 1. U.S. Byproduct Recovery Coke Facilities (Credit: EPA [21, p. 18], modified by CSB)

Ultimate Parent Company	Facility	Capacity (tons)
Cleveland-Cliffs Inc.	Burns Harbor, Indiana	1,400,000
Cleveland-Cliffs Inc.	Monessen, Pennsylvania	350,000
Cleveland-Cliffs Inc.	Warren, Ohio	550,000
DTE Energy Company	River Rouge, Michigan	800,000
Drummond Company	Tarrant, Alabama	730,000
Nippon Steel North America Inc.[a]	Clairton, Pennsylvania	3,200,000[b]

1.6 The Battery Transfer Area

Within the Battery 13/14 unit, the batteries are separated by a "transfer area." The transfer area is an open-air space between the two batteries consisting of three levels: the "basement," the "bench," and the top level. The bench level of the Battery 13/14 transfer area included control rooms (known as "reversing rooms"), a break room, and an electrical distribution center (**Figure 5**). The reversing rooms contained physical equipment used

[a] At the time the EPA published the report containing this table in May 2024, Nippon Steel North America had not yet completed its purchase of U.S. Steel. The EPA report identifies the ultimate parent company of the facility as U.S. Steel.

[b] In May 2024, the EPA reported the Clairton facility's capacity to have been 4.3 million tons of coke. After the EPA published this information, U.S. Steel decommissioned one of its coke batteries in June 2024, and the company has informed the CSB that the facility uses 3.2 million tons per year "for planning purposes."

to control the gas flow to the battery ovens and computer stations from which operators could monitor the conditions of the battery and the ovens.

Below the bench level is the basement level, where the processed coke oven gas supply piping is located. The transfer area also has staircases leading to the top level of the battery, where a "lidding shanty"[a] is located. None of the rooms or shanties in the Battery 13/14 transfer area were designed or constructed to withstand an explosion.[b] The buildings in the transfer area were routinely occupied by workers.

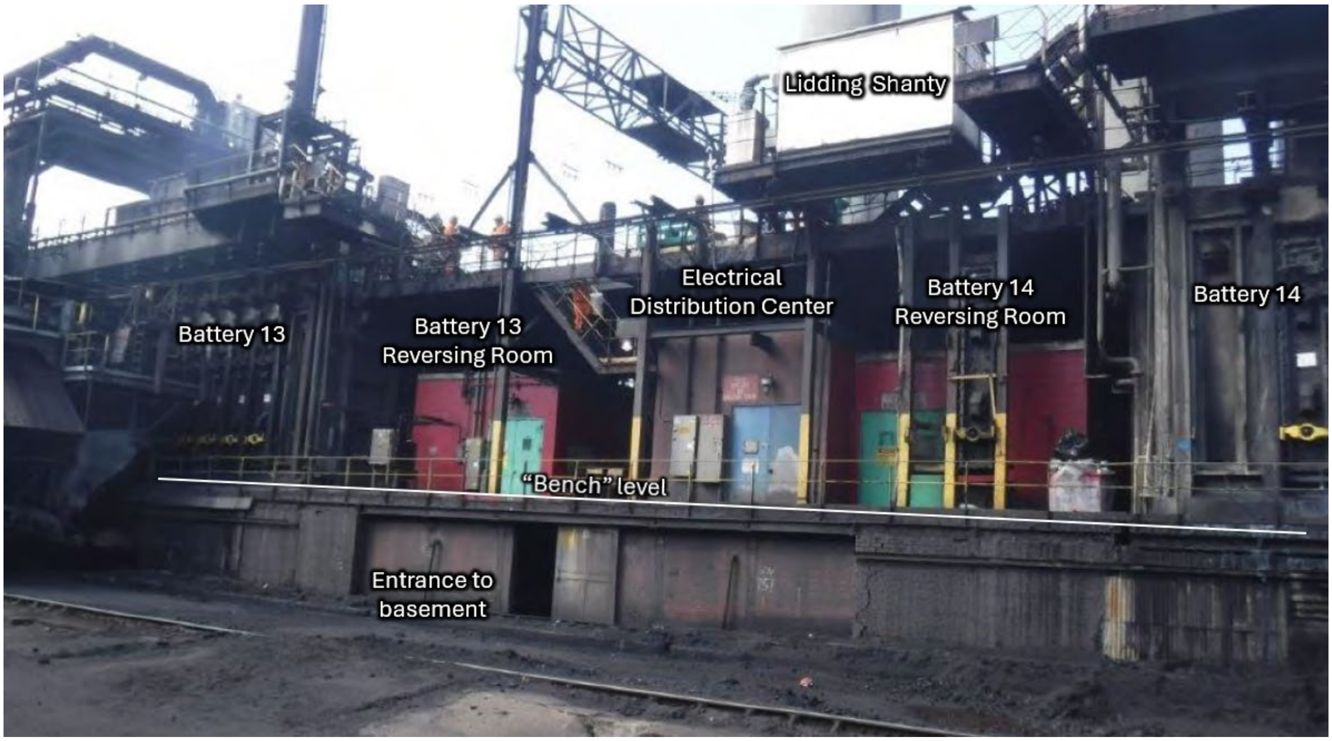

Figure 5. Pre-incident photo of the Battery 13/14 Transfer Area, showing the reversing rooms and other buildings. The break room is not pictured because it was located on the bench level behind the buildings shown here. (Credit: U.S. Steel, annotated by CSB)

[a] The lidding shanty was a small building located on the top level of the transfer area where operators would take breaks and cool off.

[b] Both the BP U.S. Refineries Independent Safety Review Panel report and the CSB's investigation of the 2005 BP America Refinery explosion in Texas City, Texas, discussed the importance of using blast-resistant buildings when buildings and personnel are located near hazardous chemical processes [63, 64].

1.7 Coke Battery Gas Supply

At the Clairton facility, the coke oven gas byproduct recovery unit supplies processed coke oven gas to all the batteries through a piping system containing both above- and underground segments. The coke oven gas system is operated as a low-pressure system at around one pound per square inch gauge (psig) at a temperature of around 85-95 °F.

At Battery 13/14, the coke oven gas flow splits at a tee, with one branch going to each battery. Past the tee, each battery is equipped with a manually operated isolation valve. Past the isolation valve, the flow of the coke oven gas splits into two parallel streams, each of which flows down one side of the battery (**Figure 6**). The processed coke oven gas is burned within a series of heating flues inside each wall separating adjacent coke ovens. The combustion of the processed coke oven gas inside the heating flues provides the heat required to produce coke and raw coke oven gas inside the ovens.

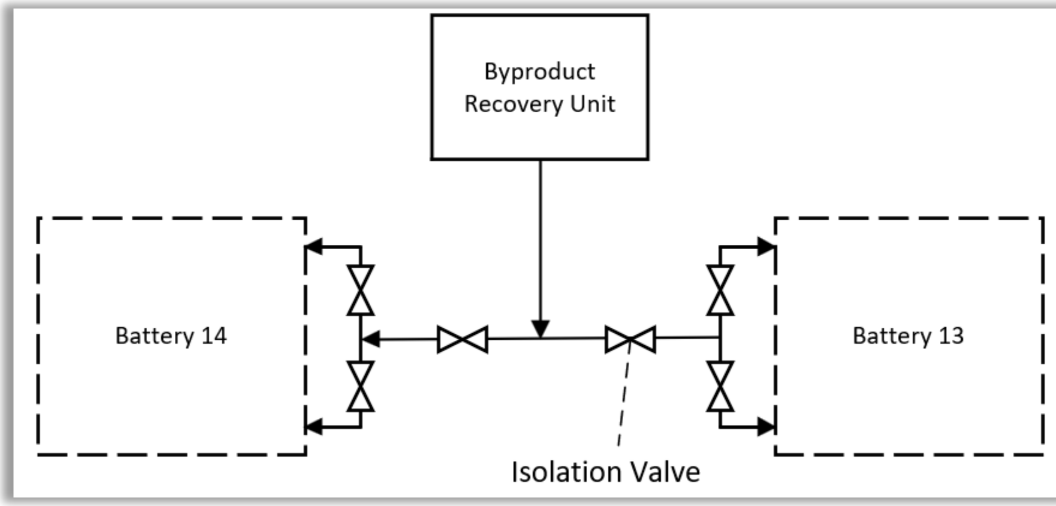

Figure 6. Simplified process flow diagram of the Battery 13 and 14 coke oven gas supply systems. (Credit: CSB)

1.8 Battery 13 Gas Isolation Valve

The Battery 13 isolation valve was an 18-inch double disc gate valve, fabricated by Chapman[a] in 1953 and rated for 50 psig (**Figure 7**).[b] It was located in a basement area beneath Batteries 13 and 14.

On the bottom of the isolation valve, between the parallel disc gates, were two "cleanout ports."

[a] In 1953, the company was known as Chapman Valve Manufacturing Company.

[b] Maintenance records show that U.S. Steel last sent the valve to a local vendor for repair in 2013. At that time, both gates in the valve were found cracked, and they were subsequently replaced.

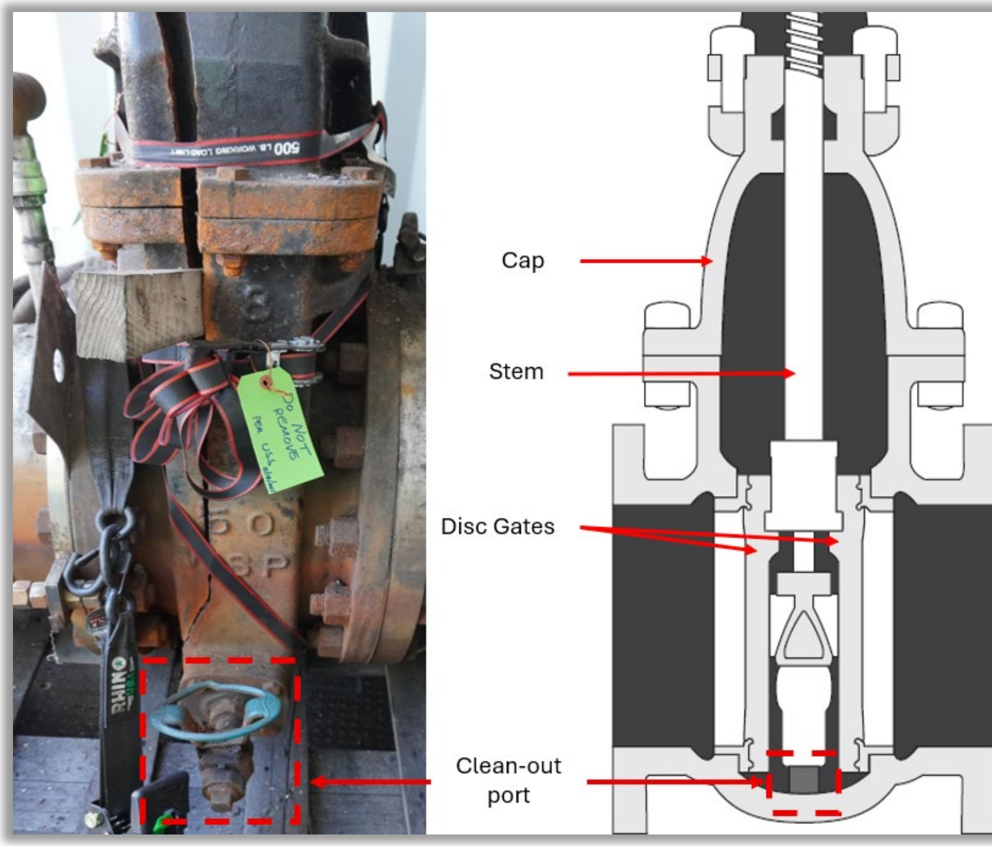

Figure 7. Post-incident photo of the isolation valve involved in the incident (left) and a diagram of the valve internals (right). (Credit: CSB)

1.9 Valve Exercising

U.S. Steel maintained an operating procedure for "exercising" the Battery 13 coke oven gas isolation valve, as well as other valves at the Clairton facility. Exercising a valve involved closing it, then reopening it to ensure it could successfully operate through its full range. In an interview with the CSB, a U.S. Steel employee who was primarily assigned to exercising valves explained that exercising valves was "to make sure that they move properly, make sure that they raise properly, and that they're not deficient."

U.S. Steel employees reported that they occasionally had difficulty fully closing a valve when exercising it. According to the employees, this was likely due to the accumulation of coke oven gas residue in the valve seat over time. Employees described injecting steam or water into a valve's cleanout port when valves were found not to close fully. This practice was used to attempt to remove or displace accumulated coke oven gas residue from the valve seat to enable full valve closure.

U.S. Steel's valve exercise procedure specified a maximum steam pressure of 10 psig. The procedure did not mention using water to clean the valve seat. U.S. Steel did not provide this procedure to MPW prior to the incident.

1.10 Coke Battery Personnel

1.10.1 U.S. Steel

At the time of the incident, at least 22 U.S. Steel employees were working at Batteries 13 and 14. In addition to the normally assigned workers for coke production, a U.S. Steel supervisor and valve operator were working at Battery 13/14 at the time of the incident.

1.10.2 MPW

Three MPW Industrial Services, Inc. (MPW) contractor employees were working at Batteries 13 and 14 at the time of the incident.

1.10.3 Allegheny County Health Department

At the time of the incident, one Allegheny County Health Department (ACHD) Field Compliance Engineer was on top of Battery 14, inspecting the unit for compliance with air quality regulations. Another ACHD Field Compliance Engineer was inspecting Batteries 19 and 20.

ACHD has duties that include enforcing the Clairton Title V Permit to control emissions from the facility.[a] ACHD staffs a full-time team of air quality inspectors at the Clairton facility to supplement electronic monitoring and company oversight. The Clairton Title V operating permit identifies over 50 emission points. The health department deputy director who oversees the Bureau of Environmental Health explained to the CSB, “Coke facilities are the only facilities where we have [assigned daily] inspectors” [16].

1.10.4 Veolia

At the time of the incident, one Veolia North Water North America Operating Services, LLC (Veolia) employee was working at Batteries 13 and 14. This Veolia employee, U.S. Steel's contracted safety escort, was accompanying the ACHD compliance engineer and filming the inspected areas with a GoPro camera supplied by U.S. Steel. Veolia provides various environmental services [23].

1.11 U.S. Steel Clairton Regulatory Coverage

1.11.1 OSHA Process Safety Management

The U.S. Occupational Safety and Health Administration’s (OSHA) Process Safety Management (PSM) standard, found at 29 C.F.R. 1910.119 [24], sets forth requirements for preventing or minimizing the

[a] A Title V Permit is an operating permit that is required for certain facilities by Title V of the Clean Air Act. An operating permit is a legally enforceable document designed to improve compliance by clarifying what a facility must do to control air pollution. The permit includes pollution control requirements from federal or state regulations that apply to the facility. *See* [Basic Information about Operating Permits | US EPA]

consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals. The standard applies to any process containing 10,000 or more pounds of flammable gas or liquid.[a] As discussed in Section 1.4, coke oven gas is a flammable gas. Therefore, the PSM standard applies to processes containing 10,000 or more pounds of coke oven gas.

In its 2025 EPCRA Tier II report,[b] U.S. Steel reported, for emergency preparedness purposes, that it handles an estimated maximum potential daily inventory of 2.5 million pounds of coke oven gas at the Clairton facility.

The Clairton facility's coke oven gas process is potentially covered by PSM. This topic is covered in further detail in **Section 4.2.6**.

1.11.2 EPA Risk Management Program

The EPA Risk Management Program (RMP) rule, found at 40 C.F.R. part 68, sets forth requirements for preventing and minimizing the consequences of catastrophic releases of hazardous chemicals. Like the OSHA PSM standard, the RMP rule contains lists of regulated substances with threshold quantities.[c] Ammonia is listed with a threshold quantity of 10,000 pounds. The portion of U.S. Steel's process containing ammonia are covered by the RMP rule at Program Level 3. U.S. Steel's most recent RMP submission was in February 2026.

Coke oven gas is not listed for coverage in the RMP rule. However, hydrogen is, with a threshold quantity of 10,000 pounds.[d] For flammable substances that exist within mixtures, such as hydrogen in coke oven gas, the RMP rule requires that the total weight of the mixture be counted against the threshold quantity of the substance, unless 1) the regulated substance in the mixture is present at a concentration of less than one percent by weight, or 2) the mixture does not have a National Fire Protection Association (NFPA) flammability rating of 4.[e] Hydrogen is the largest component of coke oven gas and makes up roughly 40-60 percent of U.S. Steel's coke oven gas by volume, and the mixture has an NFPA flammability rating of 4. U.S. Steel is therefore required to consider the entire weight of the coke oven gas mixture in its RMP threshold quantity determination.

In its 2025 EPCRA Tier II report, U.S. Steel reported, for emergency planning purposes, that it had an estimated maximum potential daily inventory of 2.5 million pounds of coke oven gas at the Clairton facility.

The Clairton facility's coke oven gas process is potentially covered by the RMP rule. This topic is covered in further detail in **Section 4.2.7**.

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[a] 29 C.F.R. §1910.119(a)(1)(ii)

[b] EPCRA is the Emergency Planning and Community Right-to-Know Act, which was passed in 1986 in response to the 1984 Union Carbide chemical disaster in Bhopal, India. That incident involved the accidental release of methylisocyanate (MIC) and killed or severely injured thousands of people. EPCRA requires facilities that handle hazardous materials to submit inventories of those chemicals, among many other requirements [66]. A facility covered by EPCRA must submit an annual Tier II inventory report to the State Emergency Response Commission (SERC), Local Emergency Planning Committee (LEPC), and local fire department.

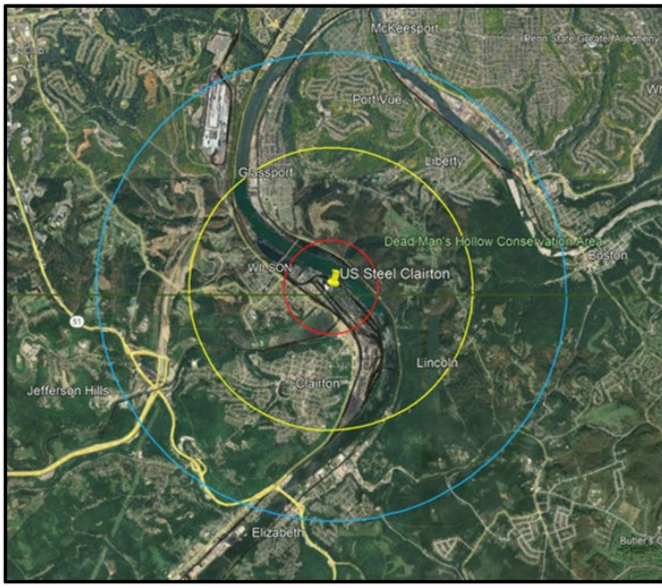
[c] 40 C.F.R. §68.130

[d] 40 C.F.R. §68.130, Table 3

[e] 40 C.F.R. §68.115(b)(2)(i)

1.12 DESCRIPTION OF SURROUNDING AREA

Figure 8 shows the U.S. Steel Clairton facility and depicts the area within one, three, and five miles of the facility boundary. Summarized demographic data for the approximate three-mile vicinity of the U.S. Steel Clairton facility is shown below in **Figure 8**.[a] There are over 20,000 people residing in over 10,000 housing units, most of which are single-family units, within three miles of the U.S. Steel Clairton facility. The population of the city of Clairton was 5,945 in 2024, but peaked at 19,652 in 1950 [25, p. 19, 26]. There are seven public schools within three miles of the facility. Detailed demographic data is included in **Appendix D**.



Population	Race & Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Housing Units	
20,830	White	76%	$34,841	15%	10,146	Single Unit	82%
	Black	15%				Multi-Unit	16%
	Native	0%				Mobile Home	2%
	Asian	1%				Boat, RV, Van, etc.	1%
	Islander	0%					
	Other	0%					
	Two+	3%					
	Hispanic	4%					

Figure 8. Overhead satellite image of the U.S. Steel Clairton facility and summarized demographic data for the approximately three-mile vicinity of U.S. Steel Clairton facility (Credit: Google Earth, annotated by CSB [left]; Census Reporter data [right])

[a] Census Reporter reports that the approximately five-mile vicinity of U.S. Steel Clairton Facility per capita income was $34,841. The Census Bureau reports that the overall per capita income for the United States from 2020-2024 was $44,673.

2 Incident Description

2.1 U.S. Steel Discovers a Coke Oven Gas Leak

On July 8, 2025, five weeks before the incident, a U.S. Steel employee identified a coke oven gas leak from a valve downstream of the Battery 13 isolation valve. The company found that the valve had a hairline crack near one of its flanges (**Figure 9**). U.S. Steel applied a metal repair composite onto the crack as a temporary repair. Subsequent monitoring by U.S. Steel determined that coke oven gas had stopped leaking from the temporarily repaired valve. As a precaution, U.S. Steel placed air movers[a] near the valve, intended to exhaust air outside to prevent the accumulation of flammable gas in the basement.

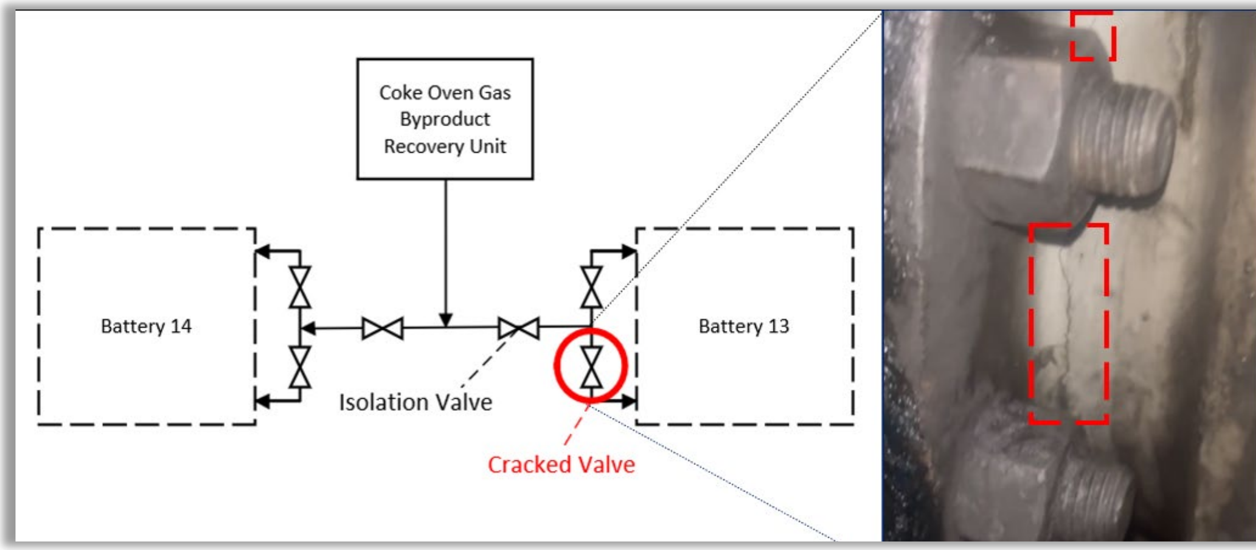


Figure 9. Cellphone photograph of cracked valve, with diagram showing valve's relative position in the coke oven gas piping. (Credit: Photo by U.S. Steel, diagram and annotations by CSB)

U.S. Steel began developing a plan to remove and replace the cracked valve by isolating and purging Battery 13's coke oven gas supply. In addition, U.S. Steel planned to opportunistically replace at least three other valves in the Battery 13 coke oven gas supply piping system while the gas to the battery was isolated and purged from the piping.

2.2 U.S. Steel Holds a Job Planning Meeting

On July 28, 2025, two weeks before the incident, U.S. Steel held a "Hazardous Job Meeting" (HJM) to review and plan the scope of work for replacing the cracked valve. The job was planned for August 19, 2025. The objective of the HJM was to have a team approve a "Hazardous Job Procedure" (HJP) developed to address hazards associated with isolating and purging the coke oven gas system at Battery 13. The HJP was a step-by-

[a] An air mover is a portable industrial fan.

step written procedure intended to safely accomplish the tasks required to isolate and purge the Battery 13 coke oven gas system.

The team assembled for the HJM included nine U.S. Steel employees and supervisors familiar with Battery 13 operation, maintenance, and safety practices. Three contractors also attended the meeting. Two of the contractors were there to assist U.S. Steel if any asbestos abatement would be needed, and the other was from a mechanical contracting firm.[a]

The team approved isolating Battery 13 from the coke oven gas supply using the double disc gate valve and subsequently purging the coke oven gas from the Battery 13 piping to allow for removing and replacing the cracked valve. The plans made during the meeting did not include exercising, steaming, or washing the Battery 13 isolation valve. None of the workers or contractors who exercised and washed the isolation valve on the day of the incident were present at the meeting.

2.3 U.S. Steel Exercises Battery 13 Isolation Valve

On Monday August 11, 2025, the day of the incident, a U.S. Steel supervisor decided to exercise the Battery 13 gas isolation valve, to confirm the valve's isolation capability, in preparation for the upcoming Battery 13 outage. The supervisor had arranged for MPW to provide a pump truck to flush the Battery 13 isolation valve, and specified the equipment for MPW to use to assist with the task.

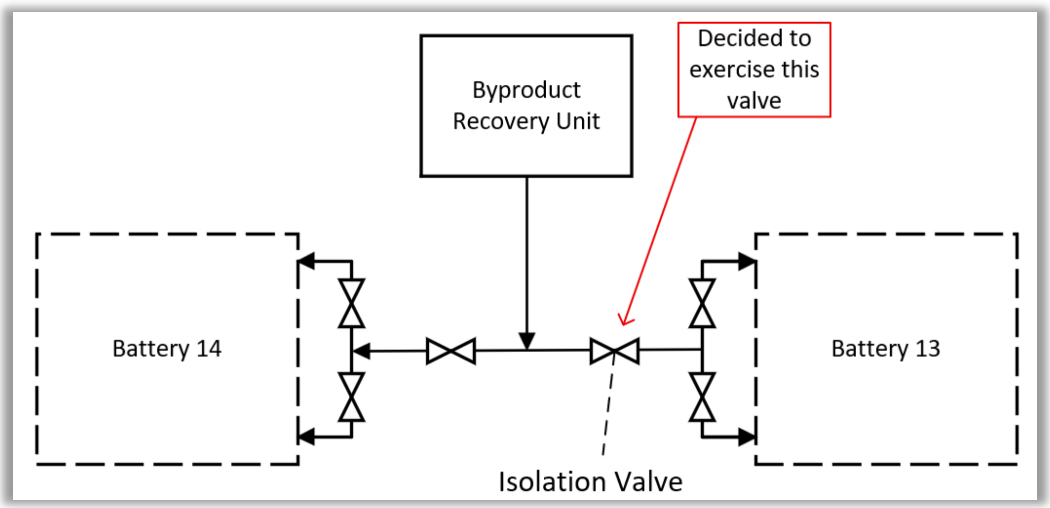


Figure 10. Simplified process flow diagram of the Battery 13 and 14 coke oven gas supply systems. (Credit: CSB)

The MPW pump truck arrived at the Battery 13/14 transfer area, and by approximately 8:00 a.m., two MPW employees had connected water from a nearby hydrant to the pump truck. At 10:35 a.m., a U.S. Steel employee and an MPW employee connected a hose from the pump truck to a cleanout port on the bottom of the isolation valve. At 10:39 a.m., U.S. Steel personnel shut off the flow of coke oven gas to the individual Battery 13 ovens.

[a] These contractors worked for JT Thorpe (*See* JT Thorpe) and SSM Industries (*See* SSM).

MPW then began pumping water into the valve body through the cleanout port. Once water was introduced into the valve, the U.S. Steel employees began to exercise it.

At this time there were three U.S. Steel employees (two operators and one supervisor) and two MPW contractors present at the scene. Each of the workers had personal carbon monoxide monitors, and one of the MPW employees carried a four-gas monitor to detect oxygen, carbon monoxide, hydrogen sulfide, and flammable gas. One worker recounted:

> And then we started the water pressure through, turned on the valve to the bottom, ran it down, ran the gate[s] down, and it gets to a certain point, and you raise it back up a little bit, lower it down, to just wash it out.
>
> Anyway, we got to a point where the valve wouldn't turn anymore, and we were [almost fully closed], and the monitor started to go off, so we tried to raise it. We couldn't raise it. There was three or four of us on the wrench trying to pull it back up to raise it.

2.4 Isolation Valve Failure and Coke Oven Gas Release

One worker told the CSB that they observed water leaking from the valve. Another worker described the moment the valve failed:

> We heard a pop. It sounded like when you overinflate a tire. It just went ["pop"], and in my mind, I felt like it was a breach. And I ran, and everybody ran out with me. And [the supervisor] was like, 'What…what was that?' And I said, 'I don't know if that was the hose or if that was the valve.' And [the supervisor] stuck his head back in and he said, 'I smell gas.' And he wanted me to shut it off from outside of the battery. There's no shutoff outside of the battery for it.

Because they could smell gas and their personal gas monitors began alarming, four of the workers quickly evacuated the basement to the ground level adjacent to the batteries.[a] One of the U.S. Steel operators ran up the stairs from the basement to the bench level and informed another U.S. Steel employee located there that the workers needed to evacuate, then ran to the Battery 13 reversing room and informed an operator there of the situation.

A worker, who was located on the bench level at the time of the incident, told the CSB that they could smell coke oven gas and could hear the audible alarm from their personal gas monitor, indicating that the releasing coke oven gas had risen to the bench level. This worker then called for the evacuation of Batteries 13 and 14 by radio, addressing the call to another U.S. Steel employee located on the top of the batteries.

On the top level of the battery, a group of three workers consisting of a U.S. Steel employee, the ACHD environmental inspector, and the Veolia contractor, heard the radio evacuation call and began evacuating, but

[a] Data recovered from the workers' carbon monoxide monitors and the four-gas monitor demonstrate that the monitors alarmed around this time, indicating that coke oven gas was releasing from the piping system.

ran toward the Battery 13/14 transfer area instead of away from it. Twenty-four seconds after the radio evacuation call, at 10:47 a.m., the released coke oven gas ignited and exploded (**Figure 11**).

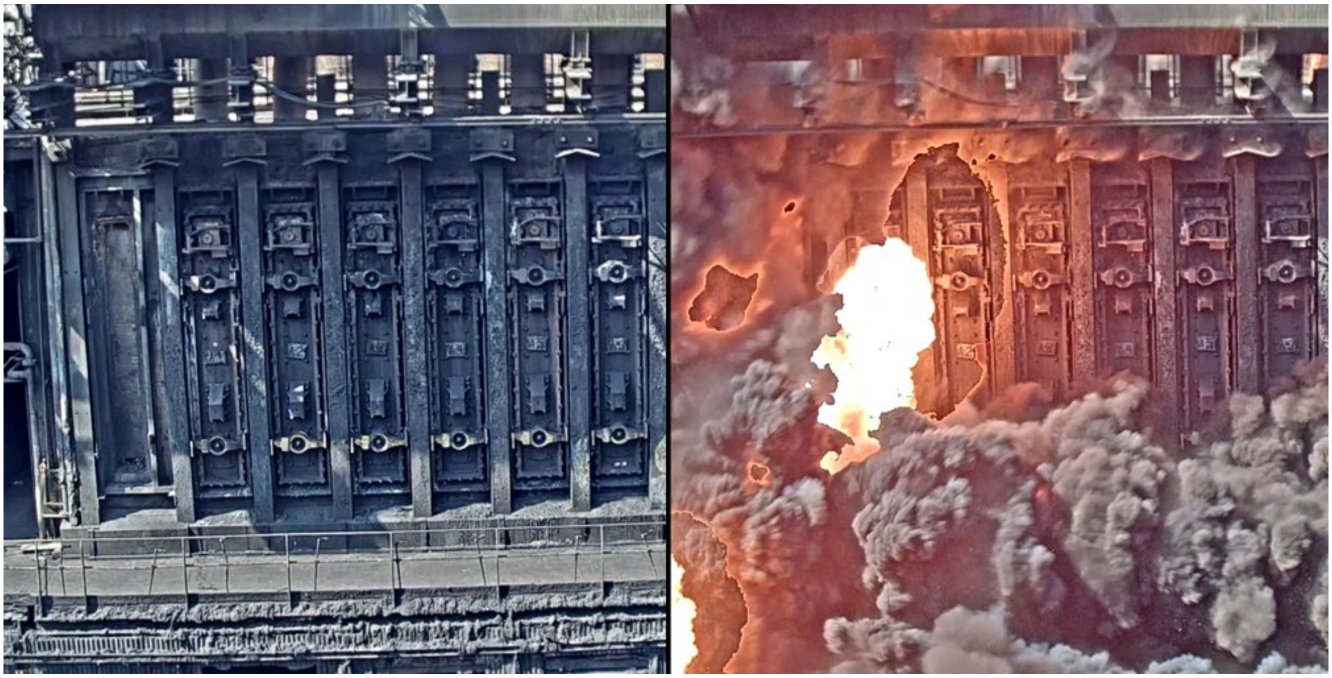


Figure 11. Surveillance images showing Battery 14 immediately before and after the ignition of the coke oven gas leaking from the basement. (Credit: U.S. Steel)

At the time of the explosion, four workers were still on top of the transfer area (**Figure 12**).

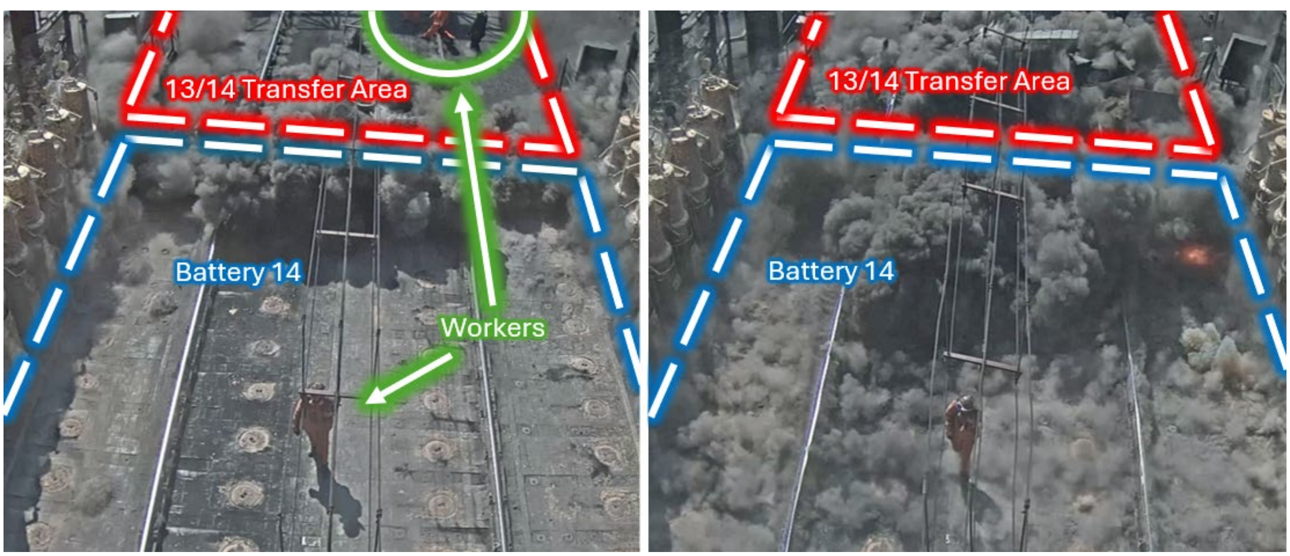


Figure 12. Surveillance images of the initial moments of the explosion, overlooking the top of Battery 14 and the Battery 13/14 transfer area. (Credit: U.S. Steel, annotated by CSB)

2.5 CONSEQUENCES

The incident at the U.S. Steel Clairton facility resulted in two fatalities, five serious injuries, six other injuries, and an estimated $52.5 million in property damage.[a,b]

The two fatally injured workers were each in or near one of the two reversing rooms immediately preceding the explosion. One of them was found shortly after the explosion, but the other was not found until approximately 7:30 p.m. on August 11, roughly 9 hours after the explosion. This employee was found buried in debris by a Pennsylvania Urban Search and Rescue Strike Team, which was called in to assist responders in the recovery.[c]

Four U.S. Steel employees were seriously injured and were hospitalized. Two of the four were located in the 13/14 transfer area break room. One of these two employees was trapped under debris from the explosion and was found alive around 2:45 p.m., roughly four hours after the explosion. The other of these two was able to crawl away from the debris and locate help.

The supervisor in charge of the valve washing operation was located on the ground level adjacent to the batteries at the time of the explosion and was seriously injured. The worker, who was located between the two reversing rooms on the bench level of the transfer area and who made the radio evacuation call, was also seriously injured.

The fifth seriously injured person, who was the Veolia employee performing environmental monitoring on top of Battery 14 (**Figure 12**), required inpatient hospitalization.

Six other workers were transported to offsite medical facilities but did not require inpatient hospitalization. Of these six, five were U.S. Steel employees, and one was an MPW employee.

The explosion heavily damaged the buildings within the Battery 13/14 transfer area, including both the Battery 13 and Battery 14 reversing rooms (**Figure 13**).

[a] On the day of the incident, approximately 650 U.S. Steel employees and 290 contractors were on site.
[b] U.S. Steel estimated that approximately 19 pounds of coke oven gas were released prior to the explosion.
[c] *See* Pennsylvania Urban Search & Rescue | Strike Team 1

Figure 13. Post-incident photo, showing the damage to the Battery 13/14 transfer area. (Credit: CSB)

As a result of the incident, OSHA issued citations and fines totaling $118,214 for U.S. Steel and $61,473 for MPW, the details of which are included in **Appendix B**.[a]

On August 14, 2025, three days after the explosion, Batteries 19 and 20 were returned to operation on a reduced operating schedule. On August 29, 2025, 18 days after the explosion, Batteries 19 and 20 were returned to producing coke at full production.[b] On August 22, 2025, Batteries 13 and 14 were successfully placed on hot idle[c] to maintain their temperature after all the coke had been removed from the ovens and the damaged coke oven gas supply piping had been repaired [27, 28]. Battery 14 was repaired and restarted on October 23, 2025, 74 days after the explosion [29]. Battery 13 required additional downtime, as the overhead structure of the transfer area for delivering coal to the Battery 13 ovens needed to be replaced. Battery 13 was restarted on February 5, 2026 [30], 178 days after the incident.

[a] Both U.S. Steel and MPW have formally contested OSHA's citations. The resolution has not yet been determined as of the date of this report.

[b] *See* Updates - monvalley.uss.com

[c] If a coke battery is shut down and cools down, the refractory lining the walls of the ovens can fail, potentially causing the loss of structural integrity in the coke battery structure, as well as damage to the ovens. This can cause the need for significant repairs or replacement before the battery can be returned to operational status, which is the reason why coke batteries are instead put in hot idle mode when not producing coke. During hot idle, coke oven gas is supplied and burned, and the coke ovens are heated to maintain the refractory lining integrity, but no coal is charged into the ovens for coke production [70, p. 124].

3 Technical Analysis

Battery 13 Isolation Valve Failure Analysis

After the incident, the Battery 13 coke oven gas isolation valve was found to have failed catastrophically (**Figure 14**).

Figure 14. Photo of the Battery 13 gas isolation valve, as found after the incident. (Credit: Allegheny County Fire Marshal, annotated by CSB)

The Battery 14 isolation valve was found intact after the incident. The CSB conducted non-destructive testing and examination of the failed Battery 13 coke oven gas isolation valve. The examination included external and internal visual inspection and photography, ultrasonic thickness inspection, magnetic particle inspection, three-dimensional laser imaging, and X-ray fluorescence analysis. Each of these examinations and tests were also performed on the Battery 14 isolation valve for comparison.

The ultrasonic thickness testing showed no evidence of significant corrosion-related thickness loss, and the thickness of the Battery 13 isolation valve was consistent with that of the Battery 14 valve. Magnetic particle inspection did not detect any crack or failure indications in the Battery 13 valve, indicating that there was likely not any pre-incident cracking or loss of metal integrity. Internal visual inspection did not identify any evidence of severe, localized corrosion-related thickness loss. Three-dimensional laser imaging showed that the overall geometry of the failed Battery 13 valve was consistent with the Battery 14 valve, with no obvious macroscopic differences. X-ray fluoroscopy confirmed that the elemental composition of the valve was consistent with cast iron.

External visual examination determined that the crack in the body of the Battery 13 gas isolation valve was fully circumferential, and was visually consistent with sudden, brittle fracture (**Figure 15**). Internal visual examination confirmed that the double gates of the valve were in the fully lowered or nearly fully lowered position.

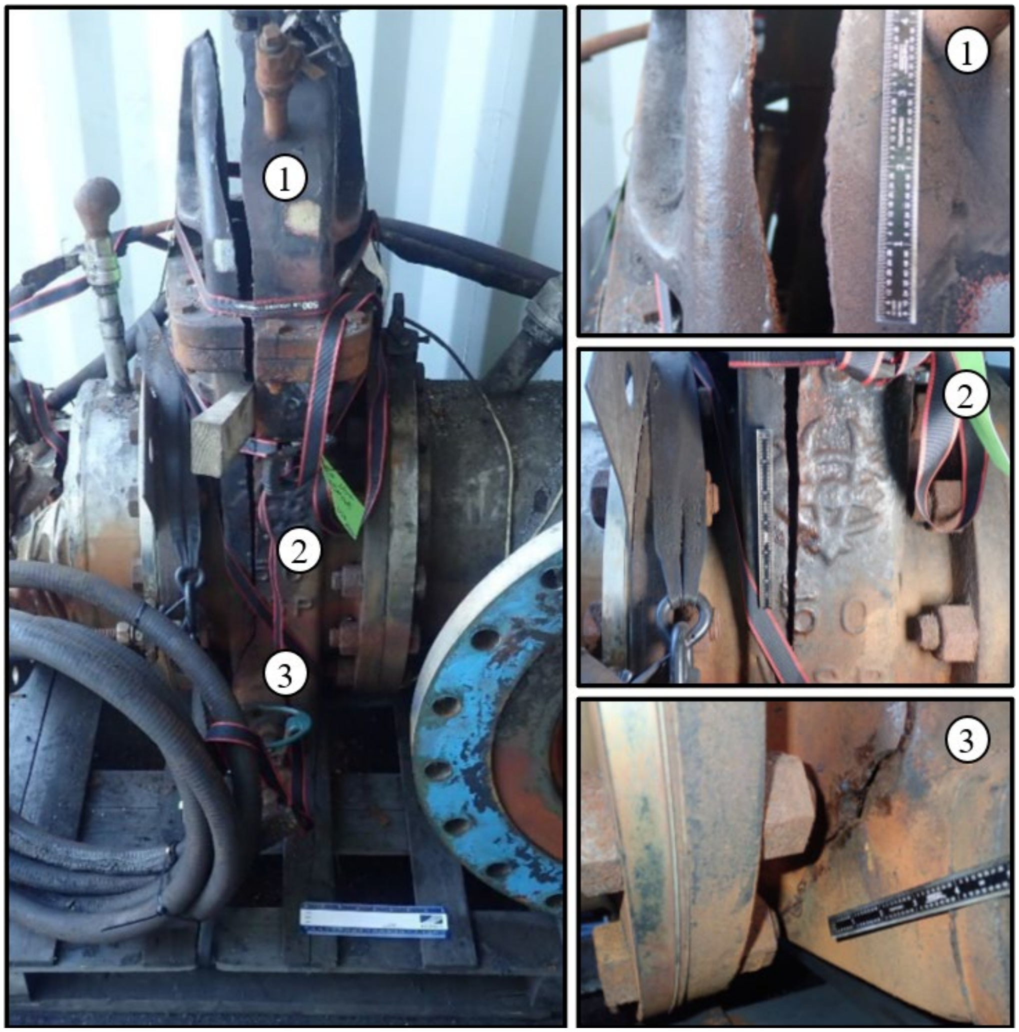


Figure 15. Photos of the Battery 13 coke oven gas isolation valve, taken during post-incident examination. (Credit: CSB)

Visual examination of the valve determined that the failure was consistent with overpressurization of the valve body and cap. The CSB concludes that the Battery 13 coke oven gas isolation valve was subjected to internal pressures greater than the valve was designed to withstand, causing it to catastrophically fail.

The failed Battery 13 valve was made from cast iron and was over 70 years old. The valve was originally manufactured in 1953 and had been refurbished in 2013. Cast iron is widely recognized as a brittle material. Numerous publications that provide safety guidance either warn against or outright prohibit the use of cast iron equipment in certain hazardous applications, including for flammable substances like coke oven gas. See **Appendix C** for further information on cast iron in hazardous service.

Pressure at Time of Incident

There were no pressure gauges or sensors attached to the valve at the time of the incident, and the CSB was unable to establish the pressure supplied to the valve from witness testimony. The pump truck that U.S. Steel and MPW used to wash the valve included a positive displacement pump that was mechanically connected to the truck's engine. MPW workers told the CSB that they set the truck to operate "at 3,000" in "third gear," which means that they set the truck's transmission gearing to the third gear and operated the truck's engine at 3,000 revolutions per minute. The CSB did not correlate those mechanical settings to any specific output pressure or flowrate from the pump. However, the pump was a piston-style positive displacement pump and was thus mechanically capable of producing pressures significantly greater than the valve's 50 psig design, especially when the discharge of the pump was ultimately blocked, as it was when the valve's gates were closed during the washing operation.

Valve Failure Sequence

Normally, with the valve gates raised, pumping water into the valve would not cause the valve to fail, as the water would simply flow through the piping in either the upstream or downstream direction. For the valve to fail due to overpressurization, water had to have been pumped into the valve without an adequate path to flow out.

The CSB could not fully determine the precise sequence of actions taken by the workers during the incident. There was no surveillance video in the 13/14 transfer area basement and no process data for the MPW pump truck, and the Battery 13 coke oven gas isolation valve was manually operated, not equipped with pressure sensors, and had no remote position indication or other data that would aid in determining the precise incident sequence. Therefore, to determine the likely incident sequence, the CSB relied upon available witness testimony, surveillance video from outside the 13/14 transfer area basement, and the non-destructive examination of the failed valve. The likely incident sequence is illustrated below in **Figure 16**:

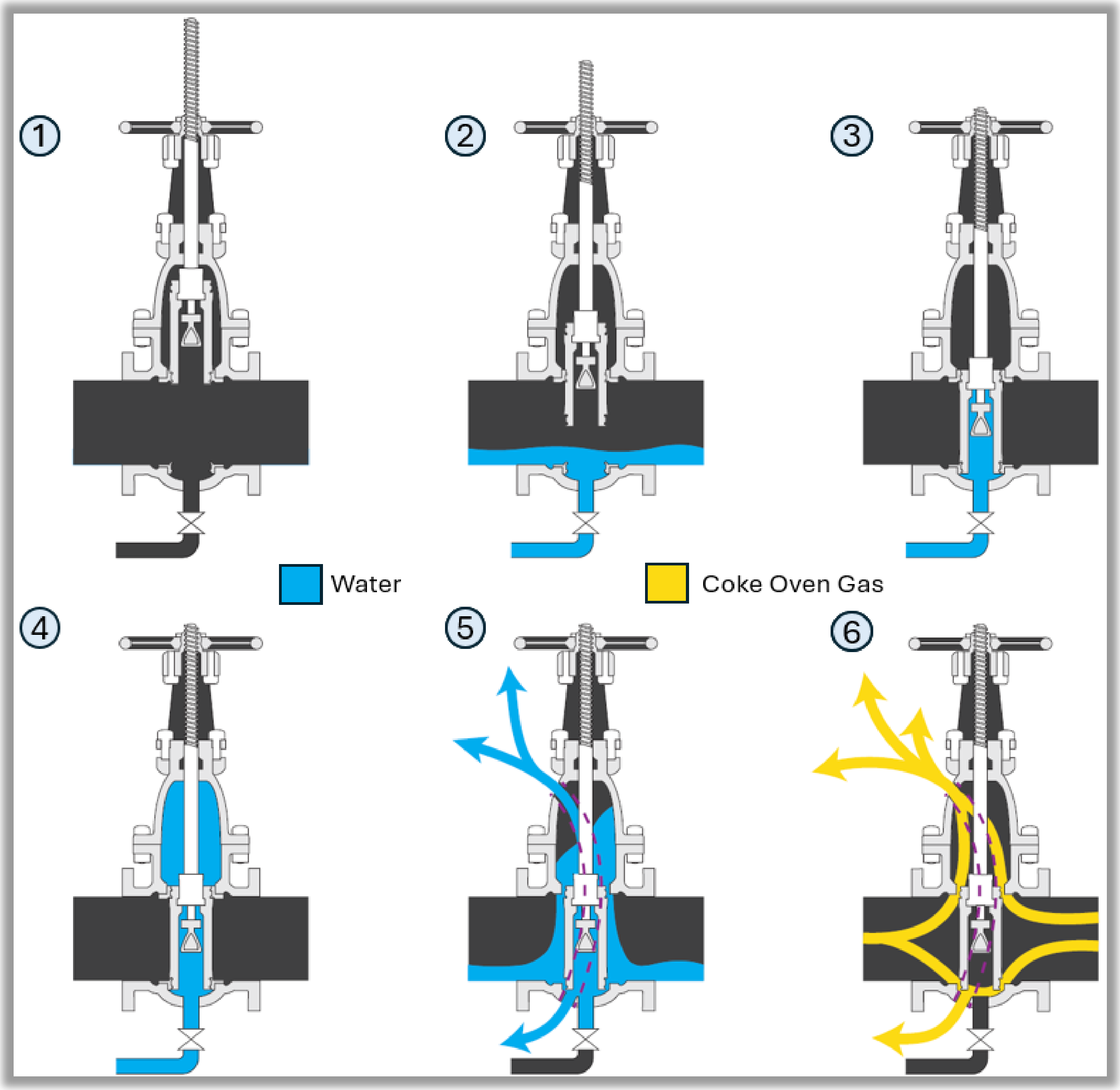


Figure 16. Diagram illustrating the likely incident sequence. (Credit: CSB)

1. The valve exercising operation began with the valve gates fully open.

2. Workers partially lowered the gates. Then workers began applying water to the valve seats through the cleanout port. Workers began further lowering the valve's gates.

3. The gates reached the fully closed, or nearly fully closed position, while water was still being pumped into the valve. The cleanout port was positioned directly between the valve's two gates. With the gates closed, water began filling up the space between the two gates.

4. Water continued filling the inside of the valve into the cap and increased the pressure on the inside of the valve body and cap.

5. The internal pressure exceeded the valve's strength and the valve fractured, releasing the water witnessed by the workers during the incident.

6. Workers turned off the pump truck. With the valve body split open, there was sufficient horizontal clearance in the valve to enable the gates not to seal fully against the seats. As a result, coke oven gas was able to flow around the valve gates, through the fracture in the valve's body, and out into the transfer area basement.

The CSB concludes that fully closing, or nearly fully closing, the gates created an enclosure within the valve from which the water being pumped in could not flow out, causing the water to fill and pressurize the valve's cap. This caused the pressure exerted on the inside of the valve body and cap to increase until the valve could no longer contain it, resulting in the catastrophic overpressurization of the valve and the subsequent release of coke oven gas.

Explosion Ignition Point

After the coke oven gas released, it began filling the basement and eventually reached the bench level. The worker who made the radio evacuation call did so after one of the workers on the valve washing job informed them of the emergency, and after their own personal gas monitor began alarming (**Section 2.4**). Surveillance video captured the ignition point, shown below in **Figure 17**:

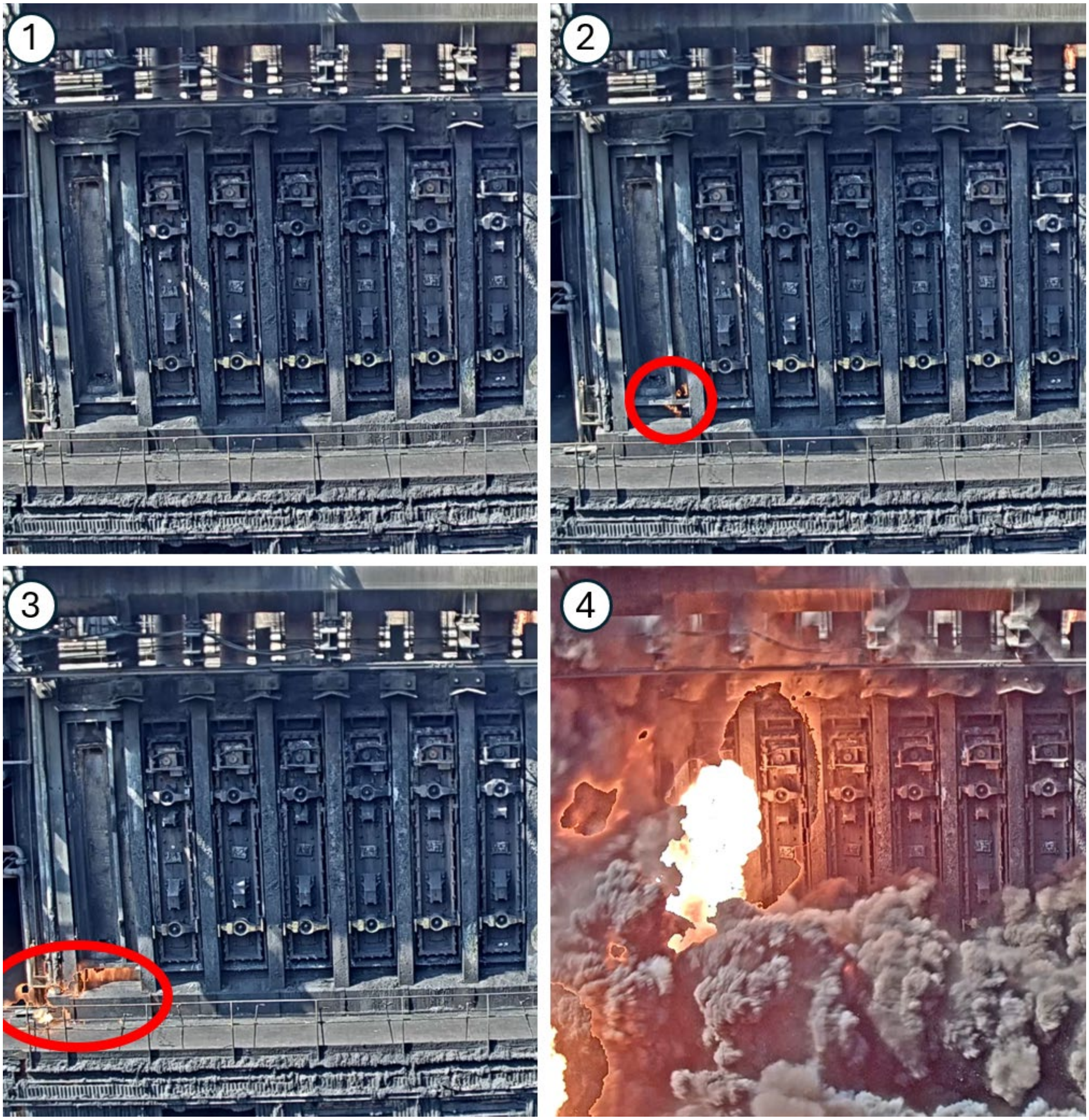


Figure 17. Frame-by-frame surveillance images showing the ignition of the coke oven gas cloud. (Credit: U.S. Steel, annotated by CSB)

The CSB concludes that the coke oven gas cloud ignited at or near the Battery 14 coke oven closest to the transfer area.

4 Safety Issues

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

- Procedures and Hazard Analysis
- Facility Siting
- Process Safety Management Systems

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

4.1 Procedures and Hazard Analysis

Standardized safe work procedures help mitigate hazards by facilitating consistency in performed work, preventing deviations that can greatly affect the safety of workers [31, p. 246]. In addition, well written procedures can clearly identify the hazards of deviating from the procedure and enable more thorough pre-job planning efforts.

The Center for Chemical Process Safety's (CCPS) *Guidelines for Risk-Based Process Safety* state that procedures should reflect the proper way to complete a task and should be verified to ensure that actual practice conforms to intended practice [31, p. 256]. If there are challenges within a system that current procedures fail to address, then those procedures need to be revised accordingly or new procedures need to be developed. If the procedures are not revised or new procedures are not developed, workers may begin to deviate from established procedures and develop their own methods to address the challenges in the system. A company's tolerance or endorsement of using alternatives to approved procedures can lead to unpredictable and unsafe operation [31, p. 257].

Because U.S. Steel's existing procedures were ineffective in addressing the accumulation of coke oven gas residue in the seats of isolation valves, employees used pressurized water instead of the company's existing procedures. U.S. Steel did not proceduralize the use of water washing, allowing hazards to exist without being identified and mitigated.

4.1.1 Lack of a Formalized Procedure

At the U.S. Steel Clairton facility, coke oven gas piping and valves often contain coke oven gas residue that accumulates in the seats of the double disc isolation valves. The residue can create problems during routine maintenance tasks, such as exercising valves, as it may prevent personnel from fully closing the valves (**Section 1.9**).

In the past, prior to the August 11, 2025, incident, U.S. Steel had experienced instances during the purging process where gas samples taken from the piping after an attempted purge would have a consistent concentration of coke oven gas because the isolation valve would not fully close. During an interview with the CSB, a supervisor gave an example:

> …we had an issue with a valve that we couldn't get [closed]. And basically, we were doing a purge job and we could not get the readings down to be able to put the blank in. So, you know, even though the valve stem was down to nothing, when we did our sweep, no matter what we did, we couldn't get the readings below 10% [of the lower explosive limit]. So there was a leak through with the valve.

Because of this, U.S. Steel management would sometimes call for an isolation valve to be exercised to prepare for an upcoming purge to ensure that the valve would be able to successfully isolate the piping. U.S. Steel had a procedure for exercising various types of valves in the facility, including the isolation valve that was being exercised on the day of the incident. The procedure did not provide any guidance on cleaning valve seats to mitigate the accumulation of coke oven gas residue, but it did mention the use of steam as a method to pre-heat the valves. However, the procedure did not address what circumstances would warrant the use of steam (beyond "if steam is needed"), nor did it explicitly state that steam was to be used to clean the valve seats. When the CSB asked a U.S. Steel supervisor why a valve would need steam, the supervisor stated:

> Because a lot of the matter that's in our valves is known to be kind of like tar based. You know, we have some matter in there that you can move with steam…The steam will heat it up and allow you to remove it. So that's when you would particularly warm a valve… A warm valve will sometimes allow some of the deposits to move out of the way.

The CSB concludes that U.S. Steel did not have a written procedure to remove coke oven gas residue from valve seats.

Even with the use of steam to clean the valve seat, employees occasionally struggled to fully seat and close isolation valves. When that happened, the facility would have to cancel or extend the purge, leading to either delays in production or delays in maintenance activities. Because the employees would occasionally be unable to achieve full valve closure, they began applying pressurized water on an ad hoc basis, instead of low pressure steam, directly to the valve seat, despite the lack of a formal procedure prescribing the use of water. The water and dislodged coke oven gas residue would then flow out and accumulate at low points downstream of the double disc isolation valve, where it could be drained out. A U.S. Steel operator told the CSB:

> There's been a couple of times that they've gone to do a purge to purge out the battery, that they couldn't get good contact to get their double block and bleed, and they had to cancel the work. So [water washing] is something they added to it because of that to make sure that the valve [closes].

The CSB concludes that U.S. Steel's use of steam to remove coke oven gas residue from valve seats was occasionally ineffective. The CSB further concludes that the lack of a consistently effective method to remove coke oven gas residue caused U.S. Steel to utilize high-pressure water washing on an ad hoc basis to clean the seat of isolation valves.

Over time, water washing became the preferred method for workers to remove coke oven gas residue from valve seats to prepare for purges. Another worker told the CSB that water washing valves "[has] become the status quo [for] when we go to do these purges, to wash out the [isolation] valve."

Based on interviews conducted by the CSB, water washing had been conducted as a method to prepare for purges for at least three years before the day of the incident. Despite the facility's use of high-pressure water to remove coke oven gas residue, it was never proceduralized. When the CSB requested a written procedure for the use of water to clean valve seats, U.S. Steel was unable to provide one and instead referred the CSB to the valve exercising procedure, which does not address water washing valve seats.

In addition, U.S. Steel had a procedure that governed isolating the battery from the coke oven gas piping. This procedure briefly mentions the use of high-pressure water as a technique "to address isolation valve issues," (**Figure 18**) but does not include any guidance or instruction on how to perform it.

The following are common isolation valve issues. These need to be considered and planned for when considering isolation method options.

5.3.1 Valve Seat Deposits

5.3.2 Valve Seat and Disc Degradation

5.3.3 Stem and Bushing Failure

5.3.4 Plug Valve Lubrication (prior to isolation)

5.4 Techniques to Address Isolation Valve Issues

5.4.1 Utilize clean out ports located on valve seating (For seat deposits)

5.4.1.1 Steam

5.4.1.2 High-pressure water wash (with packing gland)

5.4.1.3 Chemical injection

Figure 18. A part of U.S. Steel's purge procedure that mentions high-pressure washing. (Credit: U.S. Steel)

The battery isolation procedure shown in **Figure 18** above was approved and implemented by Clairton management, indicating their knowledge and endorsement of the water washing practice. In addition, on the day of the incident, the valve washing job was initiated by a U.S. Steel supervisor who was described to the CSB as the "water washing expert."

The CSB concludes that washing a valve seat with water was never proceduralized, despite: 1) U.S. Steel management being aware of and endorsing the practice; 2) the practice being referenced in U.S. Steel's battery isolation procedure; and 3) U.S. Steel conducting the practice multiple times before the incident.

On the day of the incident, closing the valve gates while washing the valve seat created an enclosed cavity inside the valve body that was able to fill with water and become pressurized (**Section 3**). The pressure exceeded what the valve could withstand, causing a catastrophic failure that released coke oven gas. The lack of a procedure detailing the correct order of operations allowed the water washing practice to be performed in a way that caused the valve to fail catastrophically, causing the incident.

KEY LESSON

If a task can be performed incorrectly and in a way that could result in harm to people, property, the environment, or the community, there should be a detailed written procedure prescribing the correct way to perform the task, and workers should be trained on the procedure.

The CSB concludes that had the water washing practice been proceduralized, the work performed on the day of the incident could have been accomplished in a manner that would not have caused the valve to catastrophically fail, thereby preventing the incident.

4.1.2 Lack of Hazard Analyses

The CCPS's *Guidelines for Risk-Based Process Safety* state that, to manage risk, hazards must first be identified and the risks evaluated and determined to be tolerable or not [31, p. 211]. Writing an effective procedure provides an opportunity to identify risks and hazards before performing the work [32]. In addition, well-written procedures describe the hazards and controls within an operation in sufficient detail so that operators understand the hazards and ensure that more effective controls are in place [31, pp. 245-246].

KEY LESSON

The potential for overpressure should always be considered and appropriately controlled when connecting an external pressure source to piping or equipment containing hazardous chemicals.

Applying an external pressure source to equipment containing flammable gas introduces dangerous hazards if the work is not effectively controlled. U.S. Steel did not identify the process safety hazards of washing a valve seat with water, such as working on energized equipment or potential overpressurization. In addition, MPW did not conduct a hazard analysis, either independently or in conjunction with U.S. Steel, despite having performed the practice multiple times in the past.[a]

The CSB concludes that U.S. Steel and MPW did not consider, identify, or address the hazards created by washing a valve seat with high-pressure water. Had either company conducted a hazard analysis and addressed the hazards appropriately, the incident could have been prevented.

[a] MPW performed a Job Hazard Analysis (JHA) on the day of the incident. However, the JHA was associated with the occupational hazards of MPW's typical tasks, such as water blasting, lancing, "gun work", and wet/dry vacuuming, and did not address the potential process safety hazards of connecting an external pressure source to an energized piping system containing hazardous chemicals.

4.1.3 Industry Guidance

On February 7, 2010, six workers were killed and at least 50 were injured when an explosion occurred during planned cleaning of fuel gas piping at the Kleen Energy facility in Middletown, Connecticut. Following this incident, the CSB issued an urgent recommendation to the National Fire Protection Association (NFPA) to update its standards to address fuel gas piping cleaning activities. In response to the recommendation, NFPA published *NFPA 56, Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*. This standard "provides minimum safety requirements for the cleaning and purging of flammable gas piping systems, including cleaning new or existing piping systems, and purging piping systems into or out of service" [33]. **Table 2** lists some of the general requirements outlined in NFPA 56 for cleaning equipment in piping systems containing flammable gas, and relates them to the August 11, 2025, incident at the U.S. Steel Clairton facility.

Table 2. NFPA 56 requirements that are relevant to the U.S. Steel Clairton incident [33].

NFPA 56 Requirement	Day of Incident Correlation
The delivered temperature and pressure of cleaning or purging media shall be compatible with the flammable gas piping systems.	The MPW pump truck used to clean the Battery 13 isolation valve was capable of producing pressures greater than the valve's 50 psig design rating. Neither U.S. Steel nor MPW protected the valve from overpressure during the work.
Written cleaning and purging procedures shall be developed and implemented by a competent person.	As discussed in **Section 4.1.1**, there was no procedure for washing valves with high-pressure water. The lack of a procedure led to the work being conducted in a way that caused the valve failure.
A written safety validation shall be performed for cleaning and purging procedures. [a]	As discussed in **Section 4.1.2**, neither U.S. Steel nor MPW conducted a hazard analysis on water washing valves prior to or on the day of the incident.
Prior to initiation of a cleaning or purging activity, the safety validation shall be affirmed by a designated individual who is competent and knowledgeable in the procedure(s) and hazards.	Because there was no procedure or hazard analysis, there was nothing to affirm prior to the start of the hazardous water washing conducted on the day of the incident.
Personnel in the affected area(s), as determined by the cleaning or purging procedure, shall be informed of the hazards associated with the activity prior to the initiation of any such activity.	Uninvolved personnel in the 13/14 transfer area were not informed that the work was taking place, nor of the hazards of the work.
Personnel not involved in cleaning or purging activities shall be evacuated from the affected area(s) as determined by the procedure.	Because no cleaning procedure was developed or implemented, uninvolved personnel were not removed from the transfer area prior to the valve cleaning operation.

[a] NFPA 56 states that "[t]he safety validation shall be conducted independently after the procedure has been written and shall evaluate hazards, errors, and malfunctions related to each step in the procedure to validate the measures prescribed in the procedure or make recommendations for additional hazard mitigation measures if necessary [33]."

The CSB concludes that had either U.S. Steel or MPW implemented the safety guidance contained in NFPA 56, the incident could have been prevented or reduced in severity.

Therefore, the CSB recommends that U.S. Steel:

- Develop a written procedure in accordance with industry guidance such as NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, for washing valve seats with pressurized water. Ensure that the procedure includes steps and other controls, including overpressure protection, to minimize the hazards of the operation. Ensure that workers who will or might perform the operation are involved in the development of the procedure and are trained on the procedure; and,

- Conduct a hazard analysis or safety validation of the written valve washing procedure in accordance with NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*. Ensure that workers who will or might perform the operation are involved in the analysis or validation.

The CSB also recommends that MPW develop written policies and procedures in accordance with industry guidance such as NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, governing cleaning piping systems containing flammable or toxic gas. Ensure that all workers who will or might participate in such operations are trained on the policies and procedures.

4.2 FACILITY SITING

Two U.S. Steel employees were fatally injured and two others were seriously injured when the blast wave created by the coke oven gas vapor cloud explosion caused occupied buildings located in the 13/14 transfer area to collapse upon the workers. None of the buildings were designed or constructed to be blast resistant,[a] and the buildings were situated less than 20 feet directly above the coke oven gas piping where the release occurred.

The concept of facility siting in the chemical and petrochemical industries concerns the analysis, documentation, and mitigation of risk resulting from the location of occupied buildings in relation to fire, explosion, and toxic hazards. In the years leading up to the incident, U.S. Steel did not conduct any facility siting evaluation for its coke battery units and did not take sufficient action to address the inherent risk posed by co-located buildings and coke oven gas piping.

4.2.1 FACILITY SITING BACKGROUND

It is widely known and well understood in the chemical process industry that explosions can damage or destroy occupied buildings, causing or failing to prevent harm to building occupants. In the late 20th century, the chemical industry experienced a series of prominent catastrophic incidents involving occupied buildings located near hazardous processes, including:

- **Nypro Limited, Flixborough, United Kingdom (1974).** Approximately 73,000 pounds of cyclohexane were released from process equipment and formed a large vapor cloud. The vapor cloud contacted an ignition source, which caused an explosion that, among other consequences, killed 28 people, injured 36 others, and demolished a block of offices and a control room. Eighteen of the 28 people killed were located in the control room at the time of the explosion. None of the buildings were designed to protect their occupants from such an explosion [34].

- **Phillips 66, Pasadena, Texas (1989).** A vapor cloud was released from process equipment at the Phillips 66 facility in Pasadena, Texas. The vapor cloud contained approximately 85,000 pounds of a mixture of ethylene, isobutane, hexene, and hydrogen. The cloud contacted an ignition source, exploded, and set off a chain of subsequent explosions that ultimately killed 23 people, some of whom were located within buildings at the time of the explosion. In its 1990 report on the incident, OSHA concluded that "buildings containing personnel […] were not separated from process units in accordance with accepted engineering principles or designed with sufficient resistance to fire and explosion" [35].

After these and other prominent safety incidents, OSHA and EPA took regulatory action in the 1990s and promulgated the PSM standard (1992) and the RMP rule (1996), respectively. Both regulations include facility siting as a mandatory consideration for covered processes.

Around the same time, industry groups began issuing guidance on the topic. In 1995, the American Petroleum Institute (API) published the first edition of its Recommended Practice (RP) 752 *Management of Hazards*

[a] Blast resistant buildings are "structurally designed to withstand an explosion generated load (pressure and impulse) while sustaining a predetermined amount of damage" [62].

Associated with Location of Process Plant Buildings, and in 1996, the CCPS issued the first edition of its book *Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires*. In 2003, the CCPS supplemented its 1996 guidance with another book, titled *Guidelines for Facility Siting and Layout*.

In 2005, flammable hydrocarbons were released from process equipment at the British Petroleum (BP) Texas City Refinery, in Texas City, Texas, and then vaporized, contacted an ignition source, and exploded. Fifteen people were killed and 180 were injured in the explosion. Among other consequences, the explosion destroyed nearby temporary office trailers. All of the fatalities occurred in or near the temporary trailers, which were located as close as 120 feet from the release point [36].

In response to a CSB recommendation resulting from that investigation, API supplemented its guidance in RP 752 by publishing the first edition of RP 753 in 2007.[a] In 2012, API published RP 756. RP 753 covers siting for temporary buildings, such as the ones destroyed in the BP Texas City incident, and RP 756 covers siting for process plant tents. These events and developments in the field of facility siting are depicted on a timeline below in **Figure 19**:

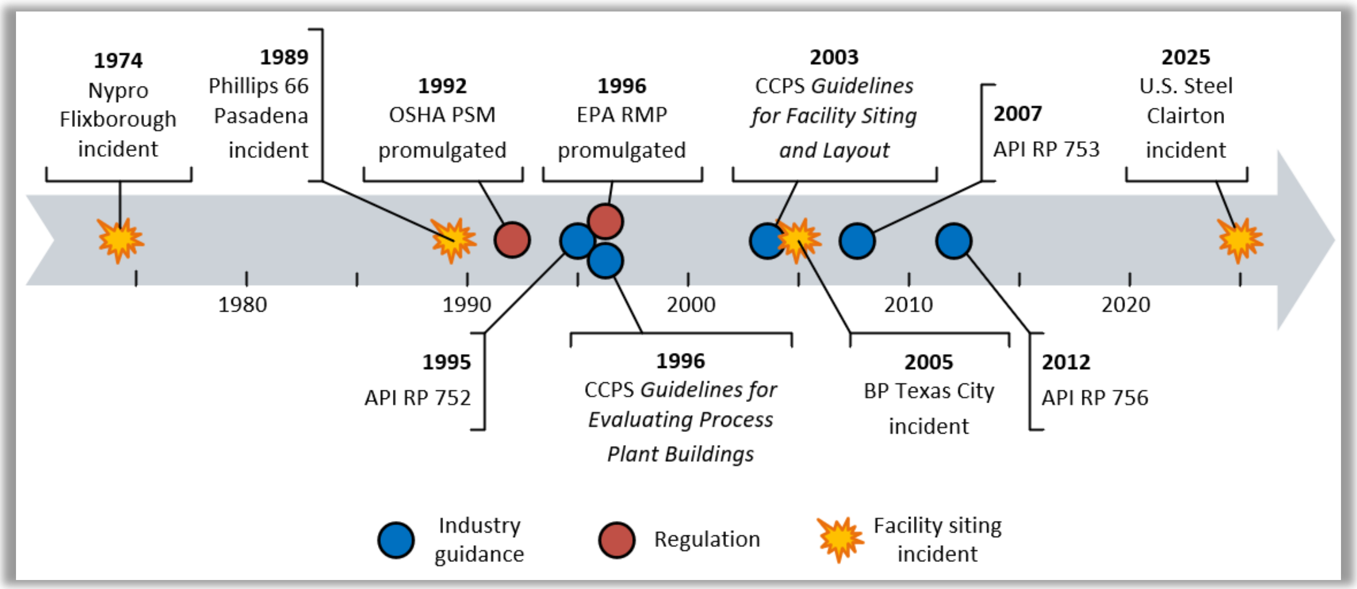


Figure 19. Timeline of selected significant facility siting events. (Credit: CSB)

In addition to the selected events depicted in **Figure 19** above, since beginning operations in 1998, the CSB has investigated at least 10 incidents involving fatal and serious injuries that resulted from damage to on-site buildings (**Table 3**). Together, these incidents resulted in 35 fatalities and over 220 injuries.

[a] With Recommendation 2005-4-I-TX-2, the CSB recommended that API either revise RP 752 or develop a new Recommended Practice concerning the safe placement of trailers and other temporary structures.

Table 3. Selected CSB investigations involving on-site facility siting consequences.

Year	Investigation	Consequences	Facility Siting Summary
1998	Sierra Chemical; *Mustang, NV*	4 fatalities, 6 injuries	An explosion destroyed Sierra's explosives manufacturing facility. Sierra's process hazards analysis (PHA) for the facility did not consider the safe siting of buildings, and the facility was constructed with insufficient separation between different operations, resulting in an additional fatality and additional property damage that could have been prevented with appropriate facility siting.
2002	First Chemical; *Pascagoula, MS*	3 injuries	At the time of the explosion, three employees were located in the control room, which was not blast resistant and was located roughly 50 feet away from the release point. Debris from the explosion impacted the employees.
2002	Concept Sciences; *Hanover Township, PA*	5 fatalities, 14 injuries	Four Concept Sciences employees and a manager of an adjacent business were fatally injured by the explosion. Two other Concept Sciences employees were trapped underneath building debris and later rescued by responders.
2004	Sterigenics; *Ontario, CA*	4 injuries	All four injured workers were located in the control room at the time of the explosion. All four were injured by debris from the control room, which was not blast resistant and was located roughly 75 feet from the explosion.
2005	BP; *Texas City, TX*	15 fatalities, 180 injuries	All 15 fatalities occurred in temporary trailers located 120 feet away from the release point. The trailers were destroyed by the explosion.
2009	Veolia; *West Carrolton, OH*	4 injuries	The explosion seriously injured workers who were in a building that was not blast resistant and that was located only 25 feet away from the hazardous process. Veolia did not conduct a facility siting evaluation prior to the incident.
2011	Carbide Industries; *Louisville, KY*	2 fatalities, 2 injuries	Two workers located in the control room were fatally injured by hot gases and explosion debris. The control room was not blast resistant and was located roughly 12 feet away from the explosion.
2018	Pryor Trust; *Pittsburg County, OK*	5 fatalities	All five fatalities occurred in a drilling rig control room, in which the workers were trapped and prevented from escaping by the fire that resulted from a wellhead blowout.
2024	Givaudan; *Louisville, KY*	2 fatalities, 3 injuries	Both fatalities occurred in the facility's control room, which was not blast resistant and was located near the source of the explosion.
2025	U.S. Steel; *Clairton, PA*	2 fatalities, 5 injuries	This incident is the subject of this report. Two workers were killed and two more workers were seriously injured when the buildings they were occupying were damaged by the explosion. None of the buildings were blast resistant. The buildings were located less than 20 feet directly above the release point.

4.2.2 INDUSTRY GUIDANCE

The CCPS states in its *Guidelines for Evaluating Process Plant Buildings for External Fires, Explosions, and Toxic Releases* that:

> For accidents affecting process plant buildings, the potential for serious or fatal injury to building occupants is the foremost concern. Additionally, in cases where buildings house critical controls or equipment, proper design and siting may also help reduce indirect safety impacts…as well as business interruption costs and property loss from such events [37].

Both the CCPS and API provide guidance on how to conduct facility siting analyses.

The CCPS, in *Guidelines for Evaluating Process Plant Buildings for External Explosions, Fires, and Toxic Releases*, defines a "building siting evaluation" as "the procedures used to evaluate the hazards and establish the design criteria for new buildings and the suitability of existing buildings at their specific locations" [38, p. xviii].

According to the CCPS, the purpose of a facility siting evaluation is to "address the explosion, fire and toxic impacts to process plant buildings and occupants occurring as a result of hazards associated with operations external to the building" [38, p. 5].

API RP 752 defines a "siting evaluation" similarly as "the procedures…used to site buildings/tents given their performance characteristics and the hazards at the specific location" [39, p. 4]. API's guiding principles for facility siting, listed in order from most effective to least effective, are to:

- Eliminate either the occupancy or the hazards by locating personnel away from process areas;
- Reduce either the occupancy or the severity of the hazards by minimizing the use of buildings in close proximity to process areas;
- Increase the distance between building occupants and the hazards;
- Increase the resistance of the building to the hazards by considering and accounting for fire, explosion, and toxic hazards in a building's design; and,
- Administratively manage the occupancy [39, p. 1].

Broadly, both CCPS's and API's guidance follows the same process:

- Determine which buildings are in the scope of the siting evaluation by identifying buildings that are either intended for occupancy, or which experience intermittent occupancy.
- Determine whether those buildings could be impacted by fire, explosion, or toxic hazards.
- Perform a consequence assessment on those buildings.
- For existing buildings, mitigate the potential consequences, and for new buildings, incorporate the consequence analysis into the building's design [38, p. 5, 39, p. 10].

Although both API's and CCPS's facility siting guidance take into account whether a building is *intended* for occupancy, API RP 752 cautions that "the basis for a building's exclusion [from the evaluation] should consider the number and frequency of visiting personnel and the cumulative level of occupancy among all occupants"

[39, p. 9]. Thus, even though a building may not be *intended* for occupancy, if it *is* occupied, even occasionally, it should be considered for inclusion in a siting evaluation.

4.2.3 FACILITY SITING AT U.S. STEEL

Within the Battery 13/14 transfer area, there were at least five buildings: two reversing rooms (one for each battery),[a] a break room, a lidding shanty,[b] and a room that housed electrical and motor control equipment, which U.S. Steel called the "Electrical Distribution Center" (EDC). A photo of the 13/14 transfer area prior to the incident is shown in **Figure 20**, and a post-incident photo is shown in **Figure 21**:

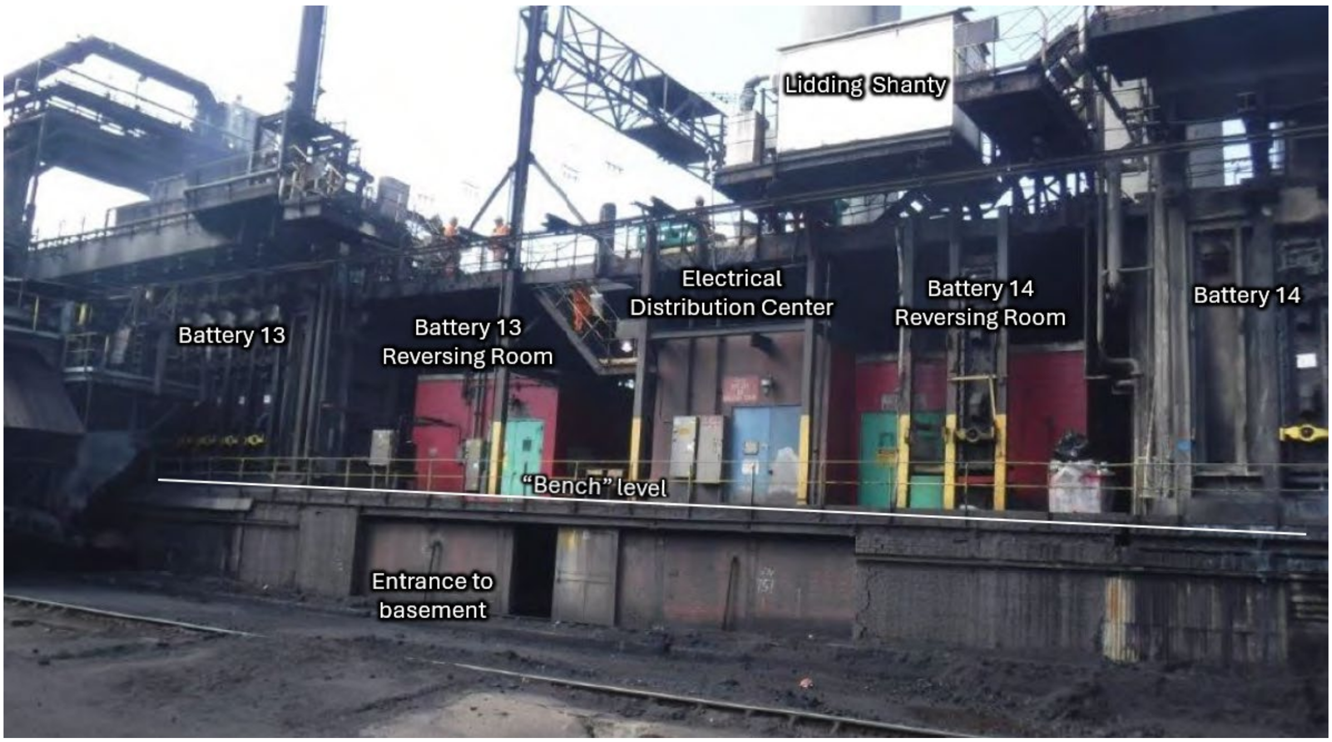


Figure 20. Pre-incident photo, date unknown, of the 13/14 transfer area. The break room is not pictured, as it was located behind the EDC and the Battery 14 reversing room. (Credit: U.S. Steel, annotated by CSB)

[a] Reversing rooms are akin to control rooms and contained both physical and computerized equipment for controlling and monitoring the battery.

[b] The lidding shanty was a small, rudimentary building located on the top level of the transfer area.

Figure 21. Post-incident photo of the 13/14 transfer area. The break room was located behind the EDC and the Battery 14 reversing room. (Credit: CSB)

Before the explosion, four U.S. Steel employees were inside the buildings in the 13/14 transfer area. One employee was in or near the Battery 13 reversing room, one in or near the Battery 14 reversing room, and two in the break room.[a] The two workers in or near each of the reversing rooms were both fatally injured. One of them was propelled by the force of the explosion and was found underneath rubble by emergency responders on the ground level adjacent to the coke batteries. The other fatally injured worker was buried in debris and was found by an urban search and rescue team roughly nine hours after the explosion.

Both of the workers in the break room at the time of the explosion were seriously injured by debris from the room's walls and ceiling. One of them suffered burns, broken ribs, broken vertebrae, and a broken tibia, and the other worker suffered explosion shrapnel to his face, burns, and broken bones in his spine, ankle, lower legs, knees, and hands. One of these two workers freed himself from the rubble, crawled out of the debris, and found help. The other worker was trapped under debris and was unable to free himself. Emergency responders located him, alive, roughly four hours after the explosion.

In Battery 13/14, the coke oven gas supply piping was located underneath the 13/14 transfer area, in the basement. The construction of the two batteries and the transfer area was such that the rooms within the transfer

[a] The workers in the reversing rooms were responsible for monitoring and controlling the conditions of the ovens, among other duties.

area were located roughly less than 20 feet directly above the coke oven gas supply piping, and the release point for this incident (**Figure 20**).

The CSB concludes that:

- the buildings in the Battery 13/14 transfer area were not designed or constructed to prevent the catastrophic damage caused by the explosion. Had the buildings in the transfer area been designed and constructed to withstand the explosion, the two fatal injuries and two of the five serious injuries could have been prevented or reduced in severity; and,

- the proximity of the buildings in the transfer area to the hazardous coke oven gas piping and the explosion increased the severity of the damage the buildings sustained. Had the buildings in the transfer area been located sufficiently distant from the hazardous process, the catastrophic damage to the buildings, and thus the two fatal injuries and two of the five serious injuries, would have been prevented or reduced in severity.

4.2.4 U.S. Steel Did Not Consider Facility Siting

Facility Siting Excluded from Process Hazards Analyses

U.S. Steel conducted its first process hazard analysis (PHA) of the Battery 13/14 coke oven gas supply system in 1998 and conducted revalidation PHAs in 2003, 2008, 2013, and 2018. Prior to the incident, U.S. Steel had not conducted a PHA of the system since 2018.

However, despite conducting PHAs on its coke oven gas systems, U.S. Steel did not evaluate facility siting in its coke battery units. Documents from the company's 1998, 2003, and 2008 PHAs specifically state that the PHA teams did not consider the topic. The 2018 PHA team stated in its PHA report that the subject was addressed "qualitatively" and that "specific discussion relative to facility siting is documented throughout the [PHA] worksheets." Other than that brief statement, however, the topic was not discussed anywhere else in the PHA documentation, and U.S. Steel could not provide any other documentation to support the PHA team's statement.

As discussed in **Section 4.2.2**, ample industry guidance exists for how to evaluate facility siting and address risk. Both the CCPS and API guide companies to perform a risk assessment for occupied buildings in proximity to potential sources of fire, explosion, or toxic releases, and to reduce and/or mitigate that risk accordingly.

KEY LESSON

When buildings are occupied by personnel or contain equipment critical for safe operations, they must be adequately designed or located to protect the personnel or equipment from fires, explosions, or toxic releases. Companies should conduct facility siting analyses of normally occupied spaces, such as control rooms, and make design changes as appropriate, to protect people and critical equipment from process hazards. Ensure workers who occupy those buildings are involved in the analyses.

Any combination of the risk reduction methods recommended by the CCPS and API could have prevented or reduced the severity of the injuries to the four workers located inside transfer area buildings at the time of the explosion.

Management Rejected Facility Siting PHA Recommendation

U.S. Steel's 2003 PHA team issued a recommendation to site management to conduct a facility siting study of the coke batteries, but Clairton management rejected the recommendation, writing:

> The [coke oven gas] system is not explicitly covered by OSHA's [PSM] regulation. Accordingly, elements of PSM are selectively applied to this system as deemed necessary and appropriate by Clairton Works management. Elements applied are considered adequate to ensure employee safety and operational integrity. Therefore, management does not consider it necessary to conduct the activities as recommended[.]"

2010 Coke Oven Gas Explosion Did Not Prompt Facility Siting Evaluation

On July 14, 2010, U.S. Steel Clairton experienced a similar coke oven gas explosion to the one that occurred on August 11, 2025.

U.S. Steel was attempting to clean a heat exchanger in the coke oven gas supply system to Battery B. To attempt to isolate the coke oven gas flow to the heat exchanger, U.S. Steel planned to open a flanged piping connection (without fully isolating the coke oven gas flow prior to doing so) and insert a piping blind. After workers opened the flanged connection, coke oven gas began releasing into the Battery B basement. Fixed gas monitors in the area began alarming, and shortly thereafter, the released coke oven gas contacted an ignition source and exploded. Coke oven gas continued burning for several hours until U.S. Steel emergency responders stopped the flow of coke oven gas by fully closing the Battery B coke oven gas isolation valve and purging the then-isolated coke oven gas piping with nitrogen.

The explosion injured 14 U.S. Steel employees and six contractors. A dozen workers were hospitalized with severe injuries. One suffered burns on nearly a third of their body, and several were intubated with breathing machines because flames and smoke had damaged their respiratory airways.

The 2010 incident shows that a coke oven gas explosion in a battery basement was a credible scenario potentially serious enough to cause severe injury, property damage, production interruption, and fatality. In the aftermath of the 2010 incident, U.S. Steel could have evaluated facility siting at Battery B and its other coke oven batteries and addressed the issues prior to the August 2025 explosion, but it did not.

U.S. Steel's investigation of the 2010 incident did not identify the potential facility siting issues and instead focused primarily on the company's attempt to open a piping segment without having first isolated it from the hazardous process. The company's investigation report recommended identifying the tasks that could generate hazardous atmospheres and defining appropriate actions to eliminate the potential hazard. In response to this incident, U.S. Steel published an HJM governance document to ensure that the HJM Committee has a comprehensive understanding of the potential hazards associated with a job and that each hazard is thoroughly addressed by applying all U.S. Steel, local, state, and Federal rules, regulations, and procedures. U.S. Steel also developed an Isolation, Purging, and Blanking Program in response to the incident.

The CSB concludes that:

- The 2003 PHA recommendation and the 2010 coke oven gas explosion both presented key opportunities for U.S. Steel to address facility siting risks in its coke battery units, but neither event prompted the company to do so;
- U.S. Steel chose not to conduct a facility siting evaluation of its coke oven batteries prior to the incident. By not doing so, it accepted the inherent risks posed by the location of occupied buildings near highly hazardous processes in its Battery 13/14 unit; and,
- U.S. Steel did not take actions that could have prevented or reduced the severity of the two fatal and two serious injuries that resulted from catastrophic building damage. U.S. Steel operated its Battery 13/14 unit while routinely occupied non-blast resistant buildings were located less than 20 feet directly above a hazardous piping system.

4.2.5 Post-incident Actions

In December 2025, the CSB issued two interim safety recommendations to U.S. Steel regarding facility siting. At that time, the company was in the process of rebuilding the facilities and equipment that were destroyed or damaged in the August 2025 explosion. The company had already chosen not to relocate the coke oven gas piping from the basement and had already rebuilt the damaged piping in generally the same location and layout as it was prior to the explosion, with a few minor changes. The company also informed the CSB that it planned to rebuild the reversing rooms and EDC in their existing locations but intended to relocate the Battery 13/14 control equipment and personnel to a building located approximately 100 feet away from the transfer area. The company stated that it selected this building because it was not physically affected[a] by the August 11, 2025, explosion. Additionally, the company informed the CSB that it had chosen not to rebuild the 13/14 transfer area break room and that it would administratively require employees to take breaks in other locations away from the 13/14 transfer area.

Figure 22 below shows the building to which U.S. Steel has relocated Battery 13 and 14 control equipment and workers and its proximity to the coke oven gas process.

[a] One incident witness, who was inside this building at the time of the explosion, told the CSB in an interview that the explosion "blew the windows out," and that he was "thrown out of [his] chair." Another witness, who was also in the building at the time, told the CSB that "glass was flying all over the place. The light fixtures blew off the ceilings. […] The explosion was so violent that it ripped our entry door open[, which is] usually a locked door." A third employee in the room corroborated these accounts.

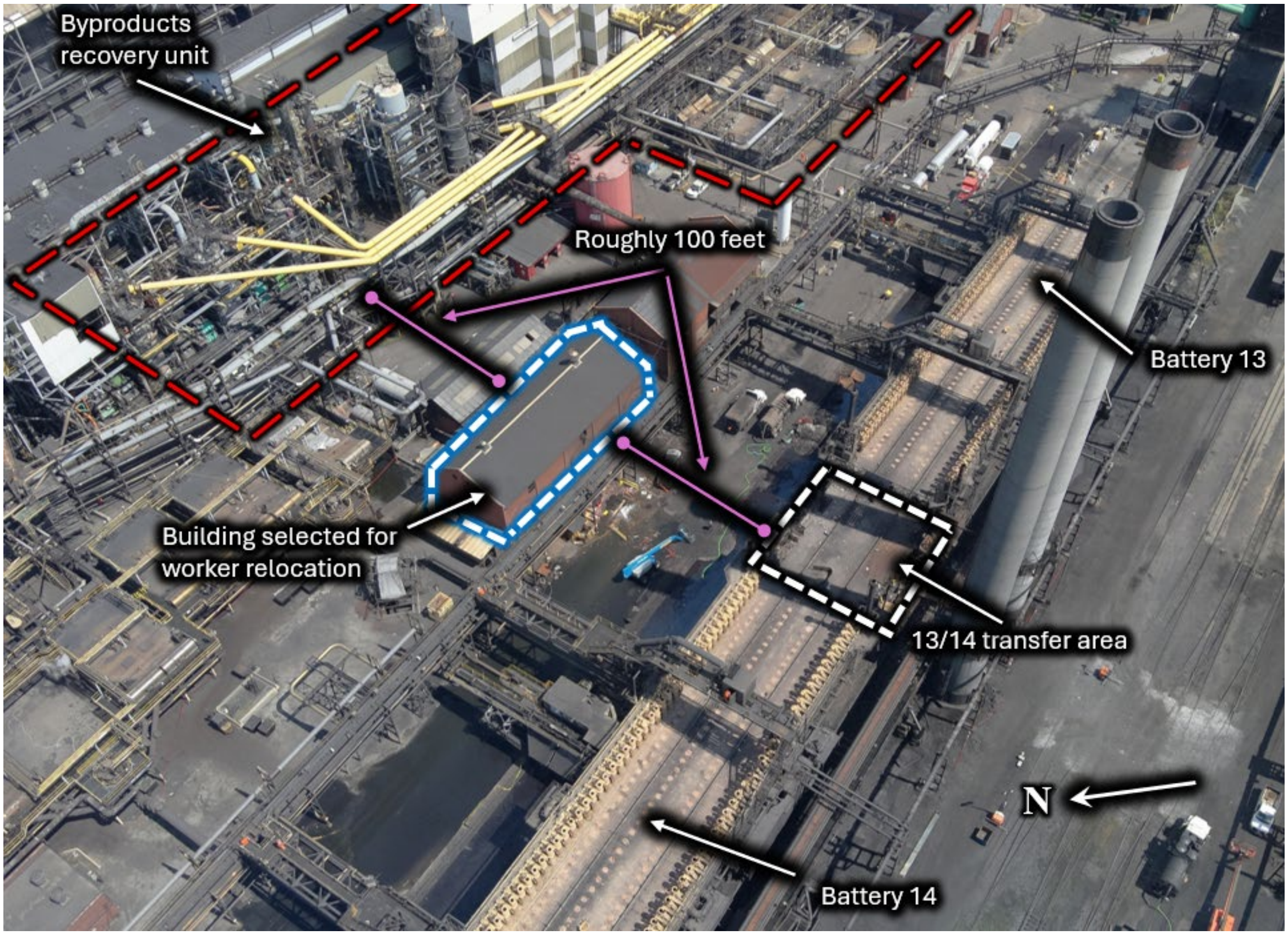


Figure 22. Aerial drone photograph of a portion of the U.S. Steel Clairton facility. The building to which the company is relocating workers is close to processes containing raw and processed coke oven gas. (Credit: Allegheny County Fire Marshal, annotated by CSB)

Like the buildings within the 13/14 transfer area, this building is also not constructed to be blast resistant. Additionally, the building is located approximately just 100 feet away from portions of the coke oven gas byproduct recovery unit, another major potential source of toxic, fire, and explosive releases. The fact that this building was not substantially affected by the August 11, 2025, incident, does not preclude the building from being substantially affected by some potential future toxic, fire, or explosive incident. U.S. Steel informed the CSB that it had not conducted a building or facility siting evaluation to inform its efforts to relocate its personnel to this building or to reconstruct the transfer area rooms destroyed by the explosion.

Furthermore, U.S. Steel operates four other battery units, all of which contain reversing rooms and other routinely occupied buildings. All of these buildings are in proximity to the batteries' coke oven gas piping. As a result of these circumstances, the CSB concluded in December 2025 that without conducting a facility siting evaluation and mitigating the possible consequences of an incident appropriately, U.S. Steel could not be sure that its personnel and facilities are safely located. The CSB also concluded that conducting a comprehensive, facility-wide siting evaluation and implementing any resulting recommendations could reduce the severity of potential future fire, explosion, or toxic release incidents at the Clairton facility.

As a result, the CSB issued recommendations **2025-03-I-PA-R1** and **2025-03-I-PA-R2** in December 2025.[a] The CSB recommended that U.S. Steel:

- Conduct a siting evaluation for all occupied and potentially occupied buildings at the Clairton Coke Works facility. Utilize the guidance contained in the Center for Chemical Process Safety's *Guidelines for Evaluating Process Plant Buildings for External Explosions, Fires, and Toxic Releases*, the American Petroleum Institute's Recommended Practices 752, 753, and 756, and other industry good practice guidance documents.
- Using the results from the evaluation performed in **2025-03-I-PA-R1**, ensure that all documented facility siting hazards are mitigated in accordance with the guiding principles contained in the American Petroleum Institute's Recommended Practices 752, 753, and 756.

4.2.6 PSM Applicability

As discussed in **Section 1.11**, the OSHA Process Safety Management (PSM) standard requires that companies operating covered processes consider facility siting as part of their PHAs. The standard applies to processes containing more than 10,000 pounds of flammable gases and liquids such as coke oven gas.

Notably, the PSM regulation exempts "hydrocarbon fuels used solely for workplace consumption as a fuel (e.g., propane used for comfort heating, gasoline for vehicle refueling)."[b] OSHA refers to this exemption as the "fuels exemption."

In 1992, shortly after OSHA promulgated the PSM standard, the agency issued a Letter of Interpretation (LOI),[c] called the "King Letter." In the King Letter, OSHA wrote that coke oven gas used as fuel is included within the fuels exemption, as long as the process using coke oven gas does not also use another PSM-covered substance [40]. U.S. Steel's process collects raw coke oven gas from the coke oven batteries and sends the gas to the byproduct recovery unit, which processes the gas by removing tar, light oils, and other compounds, including ammonia.

Since the 1992 King Letter, U.S. Steel has treated its coke oven gas process that is outside the boundaries of the byproduct recovery unit as being not covered by the PSM standard. In February 2013, however, OSHA issued another LOI, called the "Wilkins Letter," in which OSHA explicitly rescinded the 1992 King Letter, stating that coke oven gas does not qualify for the hydrocarbon fuels exemption because it does not meet the definition of "hydrocarbon," which OSHA defined as "an organic compound consisting exclusively of carbon and hydrogen" [41]. Coke oven gas is a mixture of multiple components including hydrogen, methane, nitrogen, carbon monoxide, ammonia, hydrogen sulfide, and other trace constituents (**Section 1.4**) [42].

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[a] The CSB's December 2025 Interim Recommendations document can be found on the CSB's website here: [United States Steel Corporation Clairton Plant Coke Oven Explosion | CSB]

[b] 29 C.F.R. §1910.119(a)(1)(ii)(A)

[c] OSHA Letters of Interpretation are OSHA's "[explanation] of…requirements and how they apply to particular circumstances" [60]. LOIs "respond to questions posed by an employer or worker, or an issue encountered by a field inspector during a site visit. They explain how standards apply in special or unique situations not explicitly explained in the regulatory text" [61].

The 2013 Wilkins Letter has not been rescinded or archived by OSHA. Therefore, since 2013, the PSM standard covers coke oven gas processes if the process contains 10,000 or more pounds of coke oven gas. Despite OSHA's 2013 interpretation, U.S. Steel has not applied its process safety management systems to its coke oven gas process outside of the byproduct recovery unit.

The CSB found that U.S. Steel's reason for never conducting a facility siting evaluation of its coke oven batteries has been the company's belief that it is not required to do so. From 1992-2013, U.S. Steel's choice may have been consistent with OSHA's interpretation of the PSM standard. Since 2013, however, it has been clear that the PSM standard applies to coke oven gas, even when used as fuel, if the process contains more than 10,000 pounds of coke oven gas. Despite this, even after the incident, U.S. Steel has insisted that the rescinded 1992 LOI exempted its coke oven gas process. U.S. Steel wrote to the CSB in September 2025 (a month after the incident) that:

> The U.S. Steel Clairton Coking Plant is exempt from PSM coverage under the hydrocarbon fuel exemption, even if the threshold quantity of coke oven gas was present. […] Per the clear interpretation of [the PSM standard] provided from [OSHA] in the June 19, 1992 Letter of Interpretation, U.S. Steel treats coke oven gas as an exempt hydrocarbon fuel[.]

Company management, including the Clairton PSM manager, were unaware of the 2013 Wilkins Letter. Even after the CSB made company personnel aware of the 2013 LOI, the company wrote to the CSB in December 2025 that:

> U.S. Steel advises that based on information it had at the time of the explosion, the threshold quantity of coke oven gas for the [PSM] standard to apply was not present in the system.

The CSB requested that U.S. Steel provide documentation supporting the company's statement. In response, U.S. Steel submitted calculations from 2010 that included only the parts of the coke oven gas process outside the bounds of the byproduct recovery unit. The company estimated the inventory of these parts of the process to be roughly 7,000 pounds. Along with the calculations, U.S. Steel noted that, since 2010, the company had decommissioned four coke batteries and had commissioned just a single new one. The company reasoned that as a result, the Clairton coke oven gas system contained less inventory in 2025 than it did in 2010. However, the 2010 calculations were incomplete and excluded the entire coke oven gas byproduct recovery unit,[a] as illustrated below in **Figure 23**:

KEY LESSON

Companies have an obligation to be aware of when and how regulations that affect or may affect them change over time.

[a] It is not clear to the CSB why U.S. Steel has excluded the byproduct recovery unit from these calculations. The OSHA PSM standard states that "any group of vessels which are interconnected and separate vessels which are located such that a highly hazardous chemical could be involved in a potential release shall be considered a single process." 29 C.F.R. § 191.119(b). Given that all of U.S. Steel's coke oven gas piping and process vessels are interconnected from the point at which the raw coke oven gas is generated at the coke batteries, to the point at which the processed coke oven gas is eventually burned as fuel, the CSB believes that U.S. Steel's calculations should include the inventory of the process both inside and outside the byproduct recovery unit together.

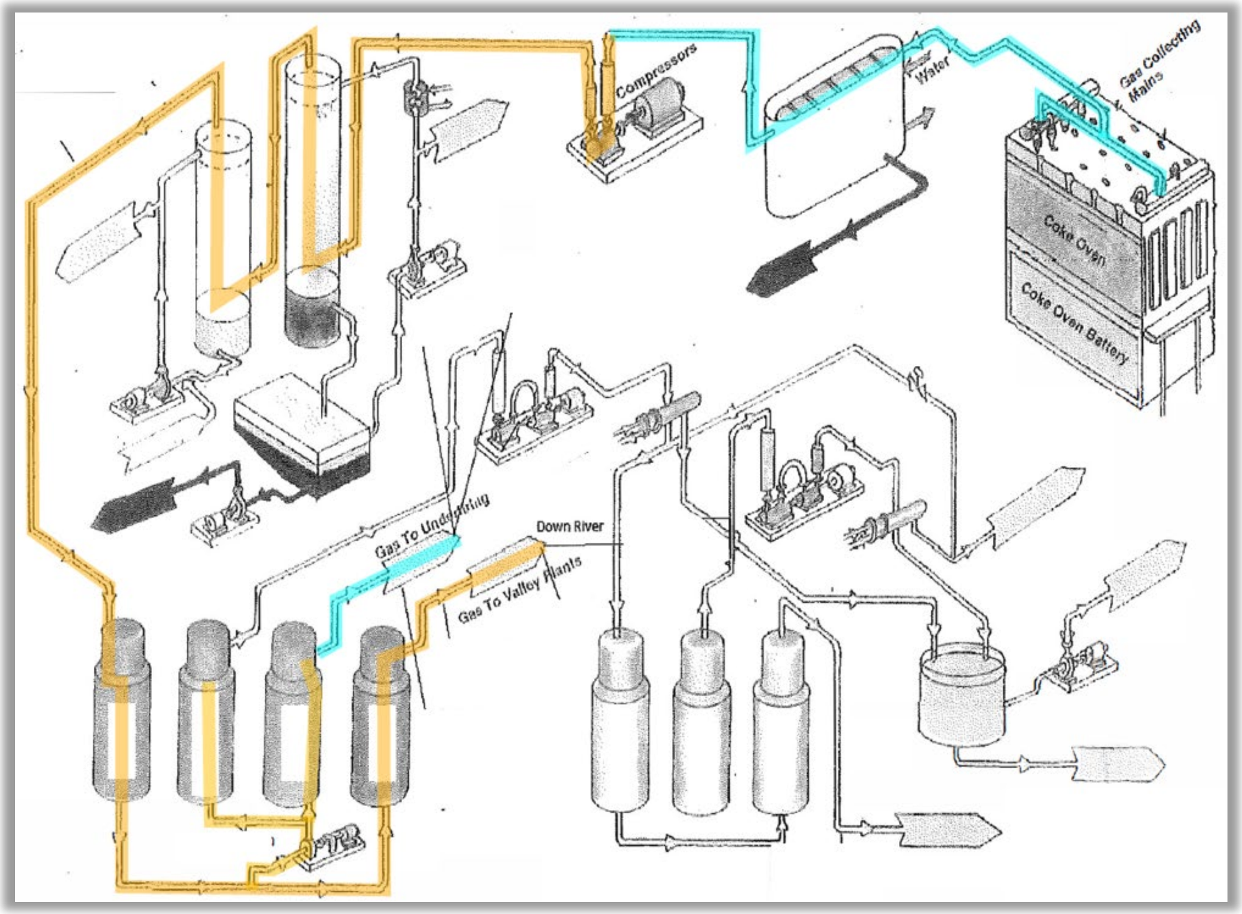

Figure 23. Illustrative diagram of the Clairton coke oven gas process. Portions highlighted in blue were included in the 2010 calculations; orange-highlighted portions were excluded. Only one coke battery is shown rather than six. (Credit: U.S. Steel, redacted and annotated by CSB)

When the CSB requested calculations for the excluded byproduct recovery unit, U.S. Steel responded that it had no documents indicating the quantity of coke oven gas in those portions. The company also stated that it had no calculations that were more recent than the 15-year old calculations from 2010 and that the company was "assessing the feasibility of updating the […] 2010 calculations."

The CSB concludes that, based on information currently available to the CSB, the OSHA PSM standard appears to apply to U.S. Steel's coke oven gas process. If the PSM standard applies, U.S. Steel would have been required to address facility siting in its PHAs since 2013.

After the incident, OSHA cited U.S. Steel for violations of the PSM standard (**Appendix B**). Consequently, it appears to be OSHA's conclusion that the PSM standard applies. However, U.S. Steel has contested OSHA's citations, and the final resolution has not yet been determined as of the date of this report.

4.2.7 RMP Applicability

During the investigation, the CSB conferred with the EPA to determine whether the EPA Risk Management Program (RMP) rule applies to the U.S. Steel Clairton coke oven gas process. According to the EPA, RMP applicability generally depends, like the PSM standard, on the quantity of coke oven gas handled at the Clairton facility. The EPA also indicated, however, that there are several other considerations that differ between determining PSM and RMP applicability.

For example, although the RMP rule contains a fuel exclusion that is similar to the OSHA PSM fuels exemption,[a,b] the RMP rule's exclusion is broader than OSHA's fuels exemption. While OSHA's fuels exemption applies to any "hydrocarbon" fuel, the RMP exclusion applies to any flammable substance covered by the RMP rule that is used or held for sale as a fuel. Unlike the PSM exemption, the RMP exclusion is not limited to substances meeting the definition of "hydrocarbon."

As discussed above in **Section 1.11.2**, hydrogen, and by extension coke oven gas, is a regulated flammable substance under the RMP rule that U.S. Steel produces, processes, and uses as a fuel. By interpreting the RMP fuels exclusion broadly to exclude all of its coke oven gas, U.S. Steel has not included its coke oven gas process in its RMP program. U.S. Steel stated in its 2026 RMP submission that "coke oven gas and its associated processes are exempt from [RMP] because all coke oven gas is used as a fuel."

However, the EPA has issued guidance that may be contrary to U.S. Steel's interpretation:

> …if you hold a listed flammable substance for purposes **other than on-site use as fuel**, you are potentially covered by [the RMP Rule]. For example, if you **manufacture a listed flammable fuel,** [or] **use it as a chemical feedstock**, […] you may be covered by the rule [43, p. 3]. (*emphasis added*)

This guidance is consistent with the preamble to the 2000 RMP rule amendment that revised the list of regulated flammable substances to exclude those substances when used or held for sale as a fuel. In the final rule preamble, EPA stated that flammable substances "are sometimes used as feedstock chemicals instead of fuel" [44].

Consequently, according to EPA's guidance document and the 2000 RMP rule amendment preamble, the raw coke oven gas that is produced in the Clairton facility's coke batteries and sent to the byproducts recovery unit for processing may be covered by RMP (because the gas is manufactured at the coke batteries and is used as a chemical feedstock within the byproduct recovery unit), and the portion of the processed coke oven gas that is

[a] 40 C.F.R. §68.126

[b] The fuel exclusion in the RMP rule is mandated by the Chemical Safety Information, Site Security, and Fuels Regulatory Relief Act of 1999, which amended Section 112(r) of the Clean Air Act to remove the EPA's authority to regulate a flammable substance used as fuel or held for sale as a fuel at a retail facility based solely on the substance's explosive or flammable properties (*See* Public Law 106-40—Aug. 5, 1999). The statute does not define "fuel," but EPA uses the common definition for the purposes of the RMP rule exclusion: "a material used to produce heat or power by burning" [69].

sent off-site to U.S. Steel's Irvin and Edgar Thomson facilities[a] elsewhere in Pennsylvania may also be covered by RMP[b] (because it is not burned as a fuel on-site at Clairton).

The portion of the processed coke oven gas that leaves the byproduct recovery unit and is burned on-site at the Clairton coke batteries might be the only portion of coke oven gas that arguably can be excluded from RMP threshold quantity determination. According to the company's 2010 inventory calculations discussed above, this quantity of coke oven gas at that time was approximately only 1,600 pounds, and is likely to have only decreased since 2010.

The threshold quantity for coverage of a flammable mixture containing hydrogen, and thus coke oven gas by extension, is 10,000 pounds. Given these considerations, it is possible that a threshold quantity of coke oven gas is present that would make the RMP rule applicable to U.S. Steel's coke oven gas process. The CSB concludes that, based on information currently available to the CSB, it appears that the EPA RMP rule applies to U.S. Steel's coke oven gas process. If the RMP rule applies, U.S. Steel would have been required by regulation to consider facility siting in its PHAs.

As of the publication of this report, the CSB is not aware of whether the EPA has cited U.S. Steel for any violations of the RMP rule.

[a] U.S. Steel documents show that of all the coke oven gas produced by the coke batteries at the Clairton facility, only roughly 40 percent is burned as a fuel at the Clairton facility. The remaining roughly 60 percent is sent via pipeline to separate U.S. Steel facilities, outside the Clairton facility property line.

[b] This portion of coke oven gas is probably covered under RMP, but would only be covered up to the point where the piping transitions from being considered a stationary source to a non-stationary source, or pipeline. At that point, regulatory responsibility for the coke oven gas would switch from EPA and OSHA to PHMSA and other agencies.

4.3 PROCESS SAFETY MANAGEMENT SYSTEMS

In 2007, the CCPS wrote that “process safety management is widely credited for reductions in major accident risk and improved process industry performance,” but also observed that “after an initial surge of activity, process safety management activities appear to have stagnated within many organizations” [31, p. 1]. The CCPS identified many potential causes of such stagnation, the first of which was that:

> In the U.S., process safety management has become synonymous with OSHA’s PSM regulation, 29 [Code of Federal Regulations (CFR)] 1910.119, resulting in a minimum cost, compliance-based approach to managing process safety[.] ‘If [it] isn’t a regulatory requirement, I’m not going to do it!’ [31, p. 2]

The CCPS further observed that “some companies have done everything they reasonably could to minimize PSM regulatory coverage, but failed to address their general duty obligations to protect workers, the public, and the environment” [31, p. 9].

Coke oven gas is hazardous regardless of whether U.S. Steel handles more than the regulatory threshold quantity under the PSM standard or RMP rule and regardless of how and whether regulatory exemptions apply. The CCPS, in its book *Process Safety – Leadership from the Boardroom to the Frontline*, wrote that:

> [A]s a leader, you need to understand that compliance with regulations and standards alone will not manage the barriers that control your hazards […]. Leaders who believe that compliance alone makes their company safe are often sadly mistaken. Here’s why: Your hazard may not be regulated. […] If you have unregulated hazards, your facility may be in complete compliance, but fail to manage those hazards sufficiently [45, pp. 39-40].

To guide companies to move from a compliance-based accident prevention approach to a risk-based one, the CCPS issued its *Guidelines for Risk Based Process Safety* (“RBPS”) [31]. The CCPS outlines four foundational blocks that together support 20 elements for its RBPS framework and uses the diagram below in **Figure 24** to illustrate the concept:

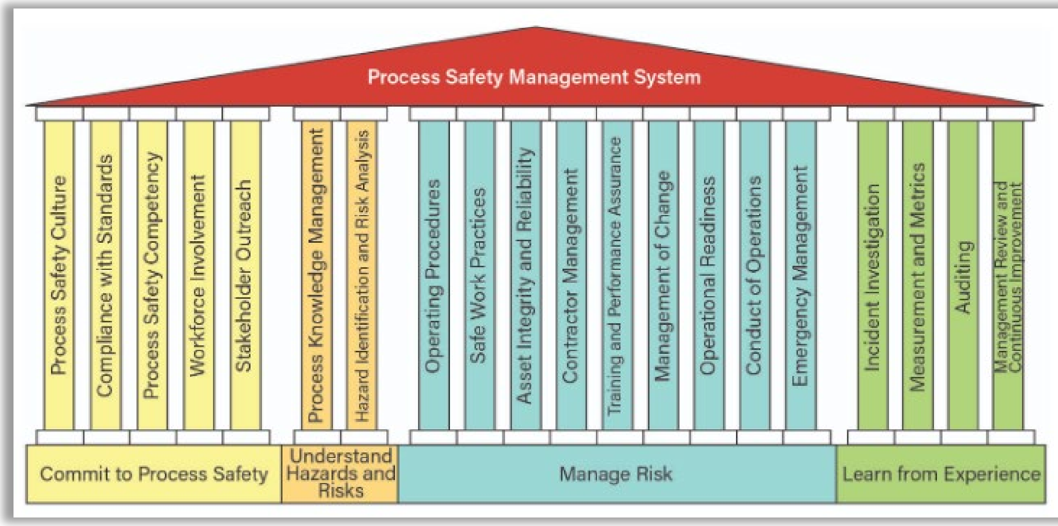

Figure 24. The CCPS risk-based process safety model. (Credit: CCPS)

During the CSB's investigation of the August 11, 2025, explosion at the U.S. Steel Clairton facility, the agency identified numerous RBPS elements that U.S. Steel did not adequately address, and which could have either prevented the incident or reduced its severity. The paragraphs below discuss the elements applicable to this incident, in the order of RBPS element number, and how each element applies to the August 11, 2025, incident.

Compliance with Standards (Element #2)

An effective system establishes a formal process for maintaining institutional awareness about new and existing applicable standards, codes, regulations, and laws, and ensures ongoing compliance as those standards change over time [31, pp. 67-73].

U.S. Steel Clairton used cast iron piping system components despite U.S. Steel's own internal guidance and prevailing industry guidance either cautioning against or outright prohibiting the use of cast iron in flammable service. (**Appendix C**)

U.S. Steel's use of high-pressure water to wash piping components containing flammable materials did not conform to NFPA 56, an applicable industry standard. (**Section 4.1.3**)

U.S. Steel's regulatory compliance strategy relied upon an out-of-date understanding of the PSM fuels exemption and a potentially incorrect interpretation of the RMP fuels exclusion. The company was not aware that OSHA's interpretation of the PSM standard had changed in February 2013, more than 12 years prior to the incident. The company lacked sufficiently robust regulatory review systems. (**Section 4.2.6**; **Section 4.2.7**)

Process Knowledge Management (Element #6)

An effective knowledge management system will maintain accurate, complete, and up-to-date information required to support process safety activities [31, pp. 169-173].

U.S. Steel used flawed calculations to determine PSM and RMP applicability and did not maintain accurate and up-to-date calculations of its coke oven gas inventory. (**Section 4.2.6**)

Hazard Identification and Risk Analysis (Element #7)

To effectively manage risk, companies must first identify it. The incorrect perception of risk could lead to the acceptance of risks that exceed the true tolerance of a company or community [31, pp. 209-213].

U.S. Steel did not identify or account for the potential overpressure hazard created by connecting an external pressure source (the MPW pump truck) to a low-pressure piping component (50 psig rated cast iron valve). (**Section 4.1.2**)

U.S. Steel conducted PHAs on its coke oven gas systems but chose not to evaluate or address facility siting risks resulting from the co-location of occupied buildings and hazardous process piping. Site management rejected a PHA recommendation to evaluate coke battery facility siting, thereby accepting the risks. (**Section 4.2.6**)

Operating Procedures (Element #8)

An effective operating procedures system will produce and maintain current, accurate, and useful written instructions that apply to normal, abnormal, and high-hazard tasks [31, pp. 245-251].

On the day of the incident, the valve washing operation was performed in a manner that directly caused the catastrophic failure of the Battery 13 coke oven gas isolation valve. U.S. Steel management was aware of the valve washing practice and endorsed the practice by referring workers to it in the facility's battery isolation procedure. However, the company never formally proceduralized the practice, and as a result, no formal procedure existed to guide users on the correct, safe, order of operations. (**Section 4.1.1**)

Safe Work Practices (Element #9)

This element helps manage the risk of nonroutine work, and typically covers activities such as hot work, control of hazardous energy (lockout/tagout), opening process vessels or piping, and similar operations [31, pp. 285-287].

U.S. Steel did not adequately control hazardous energy during the valve cleaning operation, a task that caused the release of a flammable vapor cloud and a subsequent explosion. Both the August 2025 incident and the 2010 incident represent situations in which U.S. Steel attempted maintenance on operating processes that were not isolated from hazardous energy. (**Section 2**)

Asset Integrity and Reliability (Element #10)

Successful asset integrity systems ensure that equipment is properly designed, installed, maintained, remains fit for service, and that trained maintenance workers use the right tools in accordance with written maintenance procedures [31, pp. 317-326].

A month prior to the incident, U.S. Steel detected a hairline crack in a cast iron valve in coke oven gas service that resulted in the loss of containment of coke oven gas. U.S. Steel's asset integrity systems did not prevent the premature failure of this cast iron valve. The failure of this valve ultimately led to the events on the day of the incident (**Section 2.1**).

U.S. Steel applied high-pressure water into a low-pressure valve and did not protect the valve from overpressure during the task (**Section 2.3**; **Section 2.4**; **Section 3**).

<u>Contractor Management</u> (Element #11)

An effective contractor management program should ensure that contract workers are prepared to safely provide their services. The program should ensure that contractors understand relevant risks and facility safety controls and procedures [31, pp. 365-368].

On the day of the incident, neither U.S. Steel nor MPW identified or mitigated the potential overpressure hazard presented by washing low-pressure valves with high-pressure water. The practice originated when U.S. Steel began contracting MPW to perform the valve washing practice, a practice that MPW did not question, and its workers had no procedure for and were not trained to perform. U.S. Steel did not involve MPW in the meeting when it planned the upcoming Battery 13 maintenance outage. (**Section 1.9**; **Section 2.2**)

<u>Training and Performance Assurance</u> (Element #12)

Effectively managing process safety risk depends in part on human workers performing their work consistently, to an acceptable standard, and in accordance with established procedures [31, pp. 395-396].

On the day of the incident, U.S. Steel and MPW workers inadvertently performed the valve washing operation in a manner that directly caused the valve to catastrophically fail. Neither U.S. Steel nor MPW workers were trained on the correct sequence of steps to safely conduct the valve washing operation.

<u>Conduct of Operations</u> (Element #15)

An effective Conduct of Operations system ensures that operational and management tasks are conducted in a deliberate and structured manner. Conduct of operations ensures reliable performance by establishing standards of behavior for all levels of an organization, including management. An effective system will document what activities are prohibited, what activities are permitted with no special controls, and what procedures govern all other activities [31, pp. 469-472].

Leading up to the incident, U.S. Steel developed a plan for the upcoming Battery 13 maintenance outage, but the plan did not include washing or exercising the Battery 13 coke oven gas isolation valve, and none of the workers who participated in the valve washing operation on the day of the incident were included in the planning meeting. (**Section 2.2**)

U.S. Steel's management systems were such that a U.S. Steel supervisor was enabled to arrange and direct the valve washing operation without prior planning, a procedure, training, a work permit, or sufficient hazard analysis and mitigation. (**Section 2.3**; **Section 4.1**)

<u>Incident Investigation</u> (Element #17)

Effective incident investigation can help facilities and companies learn from previous incidents in order to prevent future ones. Limited investigations may only provide feedback concerning a specific incident scenario, rather than discovering lessons that might apply to broad categories of incidents [31, p. 554].

U.S. Steel missed a key opportunity after the July 2010 incident, which injured 20 people, to recognize that a coke oven gas explosion in a coke battery basement was not only possible but could be extensive enough to cause severe consequences. The incident did not prompt U.S. Steel to evaluate or address facility siting in its coke battery units, and the company's incident investigation did not identify the risk. (**Section 4.2.4**)

The CSB concludes that U.S. Steel's policies, procedures, and practices for managing process safety were ineffective. Had U.S. Steel developed a robust process safety system and applied it to its coke oven gas systems, U.S. Steel could have prevented or reduced the severity of this incident.

Regulations such as the OSHA PSM standard and the EPA RMP rule only establish minimum requirements. Nothing prevents a company from voluntarily taking appropriate, sound safety action, above and beyond the minimum expectations established by regulation. However, as former CSB Chairperson Carolyn Merritt once stated [46],

KEY LESSON

Companies should develop and apply robust process safety management principles to all hazardous processes. Regulation only establishes minimum expectations. There is no prohibition from exceeding minimum requirements.

> The problem with voluntary programs is that not everyone volunteers.

The CSB concludes that U.S. Steel could prevent or reduce the severity of future coke oven gas incidents by developing and implementing a comprehensive process safety management system in accordance with industry good practice guidance, regardless of whether any regulation requires it to do so. Therefore, the CSB recommends that U.S Steel develop a comprehensive process safety management system, incorporating guidance from the Center for Chemical Process Safety's *Guidelines for Risk Based Process Safety* and other industry good practice guidance publications, and apply it to all coke oven gas processes at the Clairton facility.

It has long been understood in the process industries that successful process safety management starts in the boardroom. The CCPS wrote that:

> When producing or handling hazardous materials, there is an obligation of the CEO and the Board of Directors, as leaders of the organization, to protect employees and the community, and to properly prepare for and respond to emergencies. In other words, leaders are obliged to uphold their company's implicit social license-to-operate [45, p. 31].

Following the CSB's investigation of the 2010 Macondo Blowout and Explosion,[a] the CSB issued guidance[b] for corporate boards of directors and executives to help prevent major accidents in the oil and gas industry, including the following actions:

- Ensure that a robust safety management system is in place that integrates internal safety requirements with regulatory requirements to control major accident hazards and that identifies, prevents, and mitigates identified process safety deficiencies.
- Communicate process safety policies and their importance as well as the crucial role of workers in risk identification and management.
- Institute a cross-industry approach to learning and sharing of lessons from significant process safety incidents.
- Ensure the following items are in place:
  - Consistent corporate policies
  - Procedures for hazard identification, risk assessment, and controls
  - Clear management structure with established responsibilities
  - An audit system, management reports, and management reviews.

Although the CSB's guidance focused on executive leadership in the offshore oil and gas industry, the recommended actions are equally applicable to many industries, or companies, including U.S. Steel and its parent company, Nippon Steel North America.

Therefore, the CSB recommends that Nippon Steel North America develop and implement a corporate process safety governance program to ensure the implementation of process safety management at applicable facilities. At a minimum, this program shall:

a. include regular audits of subordinate facilities throughout the organization;
b. require the documentation of process safety deficiencies, when identified, and prompt corrective action; and,
c. incorporate industry guidance, such as the Center for Chemical Process Safety's (CCPS) *Guidelines for Implementing Process Safety Management*, the CCPS's *Process Safety – Leadership from the Boardroom to the Frontline*, and other industry good practice guidance publications.

[a] Macondo Blowout and Explosion | CSB

[b] CSB Best Practice Guidance for Corporate Boards of Directors and Executives in the Offshore Oil and Gas Industry for Major Accident Prevention

5 Conclusions

5.1 Findings

Valve Failure Analysis

1. The Battery 13 coke oven gas isolation valve was subjected to internal pressures greater than the valve was designed to withstand, causing it to catastrophically fail.

2. Fully closing, or nearly fully closing, the gates created an enclosure within the valve from which the water being pumped in could not flow out, causing the water to fill and pressurize the valve's cap. This caused the pressure exerted on the inside of the valve body and cap to increase until the valve could no longer contain it, resulting in the catastrophic overpressurization of the valve and the subsequent release of coke oven gas.

3. The coke oven gas cloud ignited at or near the Battery 14 coke oven closest to the transfer area.

Procedures and Hazard Analysis

4. U.S. Steel did not have a written procedure to remove coke oven gas residue from valve seats.

5. U.S. Steel's use of steam to remove coke oven gas residue from valve seats was occasionally ineffective.

6. The lack of a consistently effective method to remove coke oven gas residue caused U.S. Steel to utilize high-pressure water washing on an ad hoc basis to clean the seat of isolation valves.

7. Washing a valve seat with water was never proceduralized, despite: 1) U.S. Steel management being aware of and endorsing the practice; 2) the practice being referenced in U.S. Steel's battery isolation procedure; and 3) U.S. Steel conducting the practice multiple times in the past.

8. Had the water washing practice been proceduralized, the work performed on the day of the incident could have been accomplished in a manner that would not have caused the valve to catastrophically fail, thereby preventing the incident.

9. U.S. Steel and MPW did not consider, identify, or address the hazards created by washing a valve seat with high-pressure water. Had either company conducted a hazard analysis and addressed the hazards appropriately, the incident could have been prevented.

10. Had either U.S. Steel or MPW implemented the safety guidance contained in NFPA 56, the incident could have been prevented or reduced in severity.

Facility Siting

11. The buildings in the Battery 13/14 transfer area were not designed or constructed to prevent the catastrophic damage caused by the explosion. Had the buildings in the transfer area been designed and

constructed to withstand the explosion, the two fatal injuries and two of the five serious injuries could have been prevented or reduced in severity.

12. The proximity of the buildings in the transfer area to the hazardous coke oven gas piping and the explosion increased the severity of the damage the buildings sustained. Had the buildings in the transfer area been located sufficiently distant from the hazardous process, the catastrophic damage to the buildings, and thus the two fatal injuries and two of the five serious injuries, would have been prevented or reduced in severity.

13. The 2003 PHA recommendation and the 2010 coke oven gas explosion both presented key opportunities for U.S. Steel to address facility siting risks in its coke battery units, but neither event prompted the company to do so.

14. U.S. Steel chose not to conduct a facility siting evaluation of its coke oven batteries prior to the incident. By not doing so, it accepted the inherent risks posed by the location of occupied buildings near highly hazardous processes in its Battery 13/14 unit.

15. U.S. Steel did not take actions that could have prevented or reduced the severity of the two fatal and two serious injuries that resulted from catastrophic building damage. U.S. Steel operated its Battery 13/14 unit while routinely occupied non-blast resistant buildings were located less than 20 feet directly above a hazardous piping system.

16. Based on information currently available to the CSB, the OSHA PSM standard appears to apply to U.S. Steel's coke oven gas process. If the PSM standard applies, U.S. Steel would have been required to address facility siting in its PHAs since 2013.

17. Based on information currently available to the CSB, it appears that the EPA RMP rule applies to U.S. Steel's coke oven gas process. If the RMP rule applies, U.S. Steel would have been required by regulation to consider facility siting in its PHAs.

Process Safety Management Systems

18. U.S. Steel's policies, procedures, and practices for managing process safety were ineffective. Had U.S. Steel developed a robust process safety system and applied it to its coke oven gas systems, U.S. Steel could have prevented or reduced the severity of this incident.

19. U.S. Steel could prevent or reduce the severity of future coke oven gas incidents by developing and implementing a comprehensive process safety management system in accordance with industry good practice guidance, regardless of whether any regulation requires it to do so.

5.2 Cause

The CSB determined the cause of the incident was the overpressurization of a double disc gate valve constructed of cast iron, which resulted in the release of flammable coke oven gas that ignited and exploded. The valve design was such that, when the valve was fully closed, an enclosed volume of space existed between the valve's two gates. This enclosure was pressurized with water during an operation in which U.S. Steel and its contractor, MPW, were attempting to wash the valve with high-pressure water.

Contributing to the incident was U.S. Steel's and MPW's lack of a procedure detailing how to safely perform the valve washing operation, along with U.S. Steel's and MPW's failure to identify or adequately address the potential hazards of the operation. Additionally, U.S. Steel lacked effective process safety management systems that could have prevented or reduced the severity of this incident.

Contributing to the severity of this incident was U.S. Steel's inadequate siting and construction of occupied buildings within its coke battery unit, which enabled catastrophic building damage that in turn caused both of the fatal injuries and two of the five serious injuries.

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6 RECOMMENDATIONS[a]

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:

6.1 U.S. STEEL

2025-03-I-PA-R1 (previously issued as an interim recommendation in December 2025)

Conduct a siting evaluation for all occupied and potentially occupied buildings at the Clairton Coke Works facility. Utilize the guidance contained in the Center for Chemical Process Safety's *Guidelines for Evaluating Process Plant Buildings for External Explosions, Fires, and Toxic Releases*, the American Petroleum Institute's Recommended Practices 752, 753, and 756, and other industry good practice guidance documents.

2025-03-I-PA-R2 (previously issued as an interim recommendation in December 2025)

Using the results from the evaluation performed in **2025-03-I-PA-R1**, ensure that all documented facility siting hazards are mitigated in accordance with the guiding principles contained in the American Petroleum Institute's Recommended Practices 752, 753, and 756.

2025-03-I-PA-R3

Develop a written procedure in accordance with industry guidance such as NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, for washing valve seats with pressurized water. Ensure that the procedure includes steps and other controls, including overpressure protection, to minimize the hazards of the operation. Ensure that workers who will or might perform the operation are involved in the development of the procedure and are trained on the procedure.

2025-03-I-PA-R4

Conduct a hazard analysis or safety validation of the written valve washing procedure in accordance with NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*. Ensure that workers who will or might perform the operation are involved in the analysis or validation.

2025-03-I-PA-R5

[a] The CSB is not making any recommendations to the American Society of Mechanical Engineers (ASME). However, as discussed in Appendix C to this report, the ASME B31.3 standard, titled *Process Piping*, lacks clarity regarding the use of cast iron in coke oven piping. ASME B31.3 is a broadly applicable standard and is widely used in the chemical process industries, but it does not explicitly prohibit the use of cast iron in piping except for what it defines as "severe cyclic conditions," although it cautions that the "lack of ductility and…sensitivity to thermal and mechanical shock" of cast iron "should be evaluated" in piping systems. The ASME has informed the CSB that it has approved revisions to B31.3 to expressly include requirements for hydrogen piping, which will be incorporated in the 2026 edition of ASME B31.3.

Develop a comprehensive process safety management system, incorporating guidance from the Center for Chemical Process Safety's *Guidelines for Risk Based Process Safety* and other industry good practice guidance publications, and apply it to all coke oven gas processes at the Clairton facility.

6.2 NIPPON STEEL NORTH AMERICA, INC.

2025-03-I-PA-R6

Develop and implement a corporate process safety governance program to ensure the implementation of process safety management at applicable facilities. At a minimum, this program shall:

a. include regular audits of subordinate facilities throughout the organization;
b. require the documentation of process safety deficiencies, when identified, and prompt corrective action; and,
c. incorporate industry guidance, such as the Center for Chemical Process Safety's (CCPS) *Guidelines for Implementing Process Safety Management*, the CCPS's *Process Safety – Leadership from the Boardroom to the Frontline*, and other industry good practice guidance publications.

6.3 MPW INDUSTRIAL SERVICES, INC.

2025-03-I-PA-R7

Develop written policies and procedures in accordance with industry guidance such as NFPA 56 *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, governing cleaning piping systems containing flammable or toxic gas. Ensure that all workers who will or might participate in such operations are trained on the policies and procedures.

7 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. If a task can be performed incorrectly and in a way that could result in harm to people, property, the environment, or the community, there should be a detailed written procedure prescribing the correct way to perform the task, and workers should be trained on the procedure.
2. The potential for overpressure should always be considered and appropriately controlled when connecting an external pressure source to piping or equipment containing hazardous chemicals.
3. When buildings are occupied by personnel or contain equipment critical for safe operations, they must be adequately designed or located to protect the personnel or equipment from fires, explosions, or toxic releases. Companies should conduct facility siting analyses of normally occupied spaces, such as control rooms, and make design changes as appropriate, to protect people and critical equipment from process hazards. Ensure workers who occupy those buildings are involved in the analyses.
4. Companies have an obligation to be aware of when and how regulations that affect or may affect them change over time.
5. Companies should develop and apply robust process safety management principles to all hazardous processes. Regulation only establishes minimum expectations. There is no prohibition from exceeding minimum requirements.

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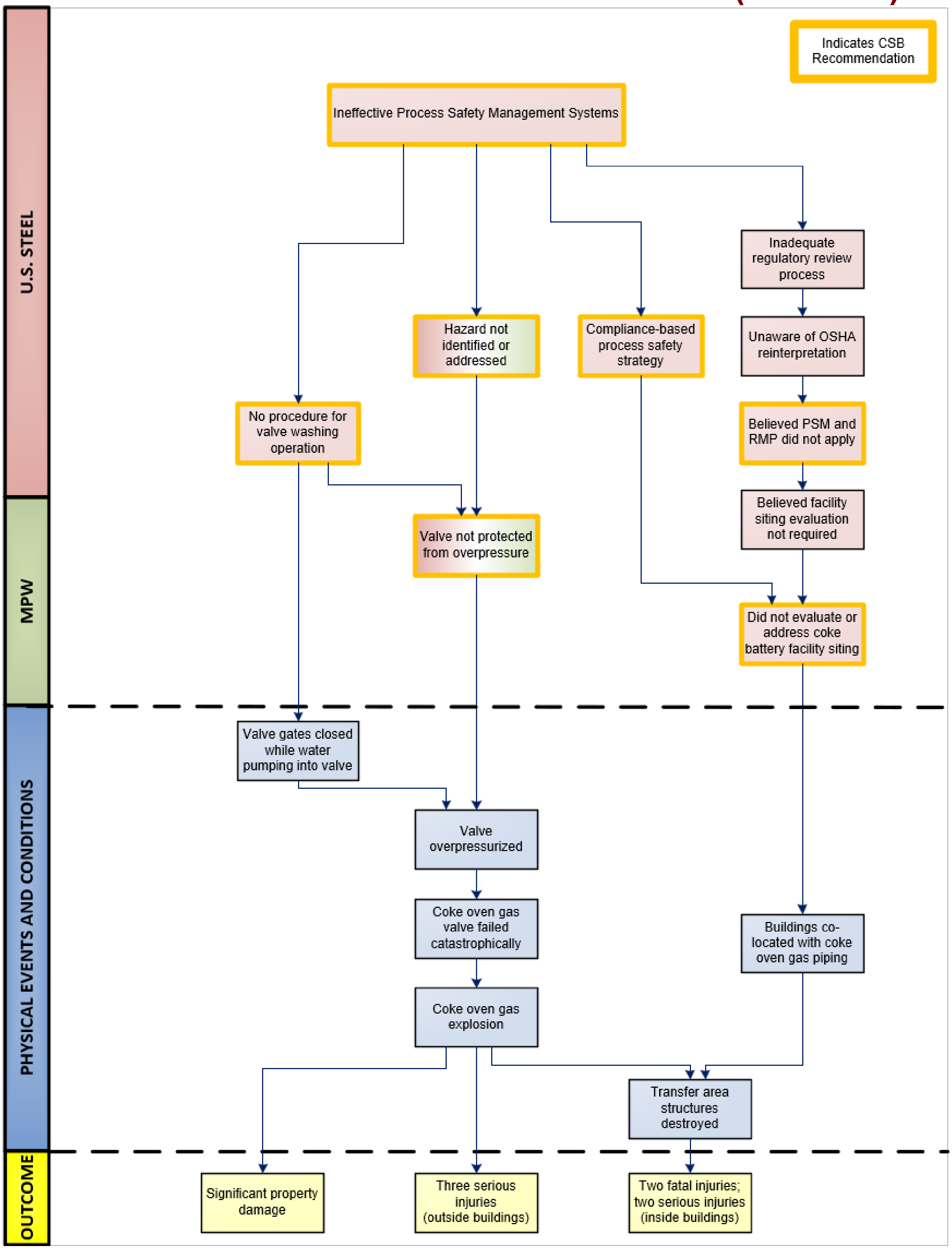
Appendix A – Simplified Causal Analysis (AcciMap)



APPENDIX B – OSHA ENFORCEMENT ACTIONS

On February 9, 2026, OSHA issued citations to U.S. Steel stemming from the August 11, 2025, incident with a proposed penalty of $118,214 [47]. These citations included the following:

- U.S. Steel's information on the technology of the process did not include the maximum intended inventory of coke oven gas. (29 C.F.R. § 1910.119(d)(2)(i)(C))
- U.S. Steel did not update and revalidate a process hazards analysis for coke oven gas at least every five years. (29 C.F.R. § 1910.119(e)(6))
- U.S. Steel did not develop and implement safe work practices, such as lockout/tagout, for the control of chemical energy, while employees cleaned the seat of Battery 13 isolation valve with water when coke oven gas was present in the valve and coke oven gas piping. (29 C.F.R. § 1910.119(f)(4))
- U.S. Steel's procedures for the control of hazardous energy did not clearly and specifically outline the scope, purpose, authorization, rules, and techniques to be used to control chemical energy when cleaning the seat of Battery 13 isolation valve with water when coke oven gas was present in the valve and coke oven gas piping. (29 C.F.R. § 1910.147(c)(4)(ii))
- U.S. Steel did not establish written procedures to maintain the on-going integrity of the Battery 13 isolation valve. (29 C.F.R. § 1910.119(j)(2))
- U.S. Steel did not train each employee involved in maintaining the on-going integrity of the Battery 13 isolation valve in the procedures applicable to washing the valve with water to ensure that the employee can perform the wash in a safe manner. (29 C.F.R. § 1910.119(j)(3))
- U.S. Steel did not ensure that the knowledge and skills required for the safe application and usage of U.S. Steel's energy control program were acquired by employees who cleaned the seat of the 13 Battery isolation valve with water when coke oven gas was present in the valve and coke oven gas piping. (29 C.F.R. § 1910.147(c)(7)(i))
- U.S. Steel did not ensure energy isolating devices were operated in a manner to isolate the 13Battery isolation valve Pad Valve from coke over gas while employees cleaned the seat of the valve with water when coke oven gas was present in the valve and coke oven gas piping. (29 C.F.R. § 1910.147(d)(3))
- U.S. Steel did not inform MPW of their Battery 13 isolation valve lockout or tagout procedures when MPW employees engaged in cleaning the seat of the valve with water when coke oven gas was present in the valve and coke oven gas piping. (29 C.F.R. § 1910.147(f)(2)(i))
- U.S. Steel failed to provide an authorized government representative with the OSHA Form 301 Injury and Illness Incident Reports[a] for calendar years 2023, 2024, and 2025 within the four business hours from when requested for the eight injuries resulting from the August 11, 2025, explosion in the Battery

[a] *See* OSHA Forms for Recording Work-Related Injuries and Illnesses

13/14 Transfer Area recorded on the 2025 OSHA 300 Log of Work-Related Injuries and Illnesses until February 5, 2026. (29 C.F.R. § 1904.40(a))

OSHA also issued citations to MPW stemming from the August 11, 2025, incident, with a proposed penalty of $61,473 [48]. These citations included the following:

- MPW did not furnish employment and a place of employment that was free from recognized hazards that were causing or likely to cause death or serious physical harm to employees created by using high-pressure water jetting equipment to wash a gate valve that contained flammable coke oven gas. (Occupational and Safety Health Act of 1970 Section 5 (a)(1))

- MPW used a Butterworth (Legacy product line under Gardner Denver Water Jetting Systems) brand water jetting system (Model Number: TF-450MB) to wash a Chapman Valve Manufacturing Company 18" cast iron gate valve (Model Number: L58 1/2) containing flammable coke oven gas. The gate valve ruptured during this exercise process, causing an uncontrolled release of coke oven gas and a subsequent explosion. (Occupational and Safety Health Act of 1970 Section 5 (a)(1))

  Among other methods, feasible and acceptable abatement methods include, but are not limited to, following the guidance provided in the following documents: 1. ASTM E1575-12 Standard Practice for Pressure Water Cleaning and Cutting, which references automatic shutoff and dump devices. 2. WaterJet Technology Association (WJTA) Industry Best Practice Practices for the Use of High Pressure Waterjetting Equipment – 2021.

- MPW did not identify and evaluate the hazards of entering the Battery 13/14 gas isolation valve pit, a permit-required confined space, before employees accessed the pit. The pit was classified by U.S. Steel as a permit-required confined space. (29 C.F.R. § 1910.146(d)(2))

- MPW did not develop and implement the means, procedures, and practices necessary for safe permit-required space entry operations prior to an employee entering the Battery 13/14 gas isolation valve pit. The pit was classified by U.S. Steel as a permit-required confined space. (29 C.F.R. § 1910.146(d)(3))

- MPW did not test conditions in the Battery 13/14 gas isolation valve pit to determine if acceptable entry conditions existed prior to an employee entering the pit. The pit was classified by U.S. Steel as a permit-required confined space. (29 C.F.R. § 1910.146(d)(5)(i))

- MPW did not ensure an entry permit was completed prior to an employee entering the Battery 13/14 gas isolation valve pit. (29 C.F.R. § 1910.146(e)(1))

- MPW did not maintain a written certification of permit-required confined space training for each employee who entered the Battery 13/14 gas isolation valve pit. 29 C.F.R. § 1910.146(g)(4)

- MPW and U.S. Steel did not inform each other of their respective lockout/tagout procedures prior to the washing of a Chapman Valve Company brand double gate valve with high-pressure water jetting equipment. The valve, which was neither isolated nor purged of flammable coke oven gas, split open during the washing process, resulting in an uncontrolled release of coke oven gas and a subsequent explosion. (29 C.F.R. § 1910.147(f)(2)(i))

- MPW did not certify that employee training related to MPWs' Energy Control Program had been accomplished and up to date. Training records maintained by MPW showed that MPW did not certify that each employee who participated in the washing of a Chapman Valve Company brand double gate valve had completed training related to MPW's Energy Control Program. (29 C.F.R. § 1910.147(c)(7)(i))

APPENDIX C – CAST IRON IN HAZARDOUS SERVICE

On the day of the incident, the Battery 13 gas isolation valve, constructed in 1953 with a cast iron body, suffered a catastrophic fracture resulting in the release of flammable coke oven gas. As an equipment design philosophy, it is often desirable for equipment to leak before it breaks ("leak-before-break"). Among other things, a leak-before-break approach strives to provide workers the opportunity to discover a smaller leak and then take corrective action before a fracture can occur, which would likely result in a larger release [49]. Material that exhibits ductile failure typically experiences significant stretching or deformation before separation or breaking occurs.

As a result, equipment made using a ductile material may provide a warning before breaking, such as by bulging, stretching, or leaking [50, p. 92]. Brittle materials typically do not provide such a warning and tend to fracture catastrophically [51, p. 56]. Constructing equipment from a ductile material (such as carbon or stainless steel) rather than a brittle material (such as cast iron) is typically in alignment with the leak-before-break design philosophy [52, p. 55]. For example, carbon steel would exhibit ductile behavior at the temperatures and pressures of U.S. Steel's coke oven gas systems.

Cast iron is widely recognized as a brittle material. Numerous publications that provide safety guidance either warn against or outright prohibit the use of cast iron equipment in certain hazardous applications, including for flammable substances like coke oven gas.

<u>General Industry and Regulatory Guidance</u>

Numerous industry guidance publications recognize the brittle nature of cast iron and have prohibited or recommended against its use in piping systems containing hazardous materials. The CSB Investigation Report, *Fatal Equipment Rupture, Explosion, and Fire at the KMCO Chemical Facility*,[a] includes numerous references recommending against the use of cast iron in pressure-retaining components [53, pp. 37-38], including the following:

- American Petroleum Institute (API) Recommended Practice (RP) 574, *Inspection Practices for Piping System Components*: "Cast iron piping is generally used for nonhazardous service, such as water, it is generally not recommended for pressurized hydrocarbon[b] service because of its brittle nature" [54, p. 13].

- API Standard 2510, *Design and Construction of LPG[c] Installations*: "Low-ductility material such as cast iron, semisteel, malleable iron, and cast aluminum shall not be used in any pressure-retaining accessory parts" [55, p. 19].

- *Chemical Process Safety: Learning from Case Histories*: "Cast iron is undesirable (and prohibited by certain flammable liquid codes) because a brittle fracture can lead to a massive leak" [56, p. 286].

[a] The April 2, 2019, incident at the KMCO facility involved the catastrophic failure of a cast iron Y-strainer in isobutylene service. The incident resulted in one fatal injury, two serious injuries, and at least 28 other injuries [53]. The CSB's final investigation report can be found here: [KMCO LLC Fatal Fire and Explosion | CSB]

[b] Although coke oven gas is not a hydrocarbon, it exhibits similar flammability and explosive characteristics to hydrocarbons.

[c] Although coke oven gas is not a liquefied petroleum gas (LPG), it exhibits similar hazard characteristics.

Safety concerns about using cast iron equipment for chemicals such as coke oven gas have been raised for decades. In addition to industry guidance, the Pipeline and Hazardous Materials Safety Administration (PHMSA), which develops and enforces regulations for the safe and reliable operation of pipeline transportation, has published numerous alerts and advisories regarding the use of cast iron in pipelines. Two alerts were published as a result of a National Transportation Safety Board (NTSB) recommendation following a fatal natural gas explosion in Allentown, Pennsylvania in August 1990. The alerts, issued in 1991 and 1992, recommended that operators identify segments of cast iron pipelines and develop procedures to monitor and replace them. In 2012, PHMSA issued an Advisory Bulletin asking operators to, among other things, monitor their cast iron replacement programs [57].

Since 2005, the number of cast iron gas distribution pipelines[a] in the United States has decreased by over 80 percent, and the number of miles of cast iron gas distribution pipelines has decreased by over 60 percent.[b] Similarly, PHMSA reports that 24 states and one territory have eliminated cast iron from their natural gas distribution pipelines [57].

U.S. Steel is subject to PHMSA regulation because it is a pipeline operator that transports processed coke oven gas via pipeline from the Clairton facility to its other facilities. Although the Clairton coke oven gas piping systems are not "pipelines" in the regulatory sense, there is no reason that the safety guidance for pipelines should not also be applied to U.S. Steel's stationary source piping systems. U.S. Steel currently uses carbon steel piping in its pipelines that transport coke oven gas to its Edgar Thomson and Irvin facilities elsewhere in Pennsylvania, as well as its above-ground coke oven gas piping within the Clairton facility. Despite using carbon steel piping, U.S. Steel used cast iron for its coke oven gas valves.

U.S. Steel Piping Specifications

At the CSB's request, U.S. Steel provided documents regarding piping and valve specifications, including materials of construction. For 18-inch gate valves in coke oven gas service, U.S. Steel engineering documents specify an American National Standards Institute (ANSI) Class 150 gate valve with a carbon steel body. As discussed in **Section 1.8**, the Battery 13 gas isolation valve was a 50 psig-rated gate valve with a cast iron body. The Battery 13 coke oven gas isolation valve did not conform to U.S. Steel's own internal guidelines regarding valves in coke oven gas service.

The documents provided to the CSB were dated from 1993 to 1999 with no revisions and no designated owner for the specifications. The CSB spoke with senior engineering personnel at U.S. Steel about these documents, and the engineering staff informed the CSB that U.S. Steel did not maintain, implement, or enforce the documents, and that the documents were used primarily, if at all, as reference documents and guidelines rather than specifications. Given U.S. Steel's statements that the company relies on its engineering contractors to follow consensus industry standards, the CSB examined several prominent standards, discussed below.

[a] The PHMSA definition of "pipeline" includes "all parts of those physical facilities through which gas moves in transportation, including…valves…" [65].

[b] Data was determined from PHMSA's public portal at https://portalpublic.phmsa.dot.gov/analytics/saw.dll?PortalPages.

NFPA Standard 54 National Fuel Gas Code

The piping and valve guideline documents that U.S. Steel provided to the CSB state that the National Fire Protection Association's (NFPA) *National Fuel Gas Code* (NFPA 54) shall apply to coke oven gas piping with system pressures less than 125 psig, which includes the Battery 13 coke oven gas piping system. However, NFPA 54 states that it does not apply to "industrial gas applications using such gases as…hydrogen, ammonia, [or] carbon monoxide…," (all of which coke oven gas contains) and that it further does not apply to "fuel gas systems using hydrogen as a fuel" (which is the largest component of coke oven gas and thus which U.S. Steel burns as a fuel) [58, pp. 54-7].

Nevertheless, section 5.5.2 of NFPA 54 states that "cast-iron pipe shall not be used," where pipe is defined as "a rigid conduit used to convey fuel gas or other fluids" [58]. Beyond pipe, this definition does not appear to include components such as fittings, flanges, or valves. NFPA 54 does permit cast-iron flanges, but fittings larger than six inches "shall not be used unless approved." NFPA 54 also addresses valves, but the Battery 13 gas isolation valve does not fall within any of the categories described by NFPA 54. For example, NFPA 54 explicitly discusses pressure regulators (a type of control valve), overpressure protection (pressure relief valves), back pressure protection (check valves and three-way valves), and shutoff valves. Under these general categories, the only type potentially applicable to the Battery 13 gas isolation valve is the shutoff valve category. However, within this category, NFPA 54 defers to either American Society of Mechanical Engineers (ASME) B16.33, ASME B16.44, or ANSI LC 4, none of which address a valve such as the Battery 13 gas isolation valve.

ASME B31.3

ASME B31.3 *Process Piping* is a broadly applicable standard and is widely used in the chemical process industries. It describes, among other things, requirements and recommendations for design and construction of process piping, including materials and components. Regarding materials of construction, ASME B31.3 does not explicitly prohibit the use of cast iron except for what it defines as "severe cyclic conditions."[a] The CSB found no evidence that the Battery 13 coke oven gas supply piping system was subjected to severe cyclic conditions.

Therefore, ASME B31.3 does not expressly prohibit the use of cast iron for the Battery 13 gas isolation valve despite it being used in flammable service. However, ASME B31.3 does caution users that the "lack of ductility and…sensitivity to thermal and mechanical shock" of cast iron "should be evaluated" in piping systems.[b] Thus, with respect to the use of cast iron, U.S. Steel's coke oven gas piping systems were compliant with ASME B31.3.

ASME B31.3 states that "it is the owner's responsibility to select the Code Section that most nearly applies" to a piping system. In an informal response, ASME informed the CSB that Code Sections B31.1 (Power Piping), B31.3 (Process Piping) or B31.12 (Hydrogen Piping and Pipelines) all are "logical choices" for coke oven gas service.

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[a] ASME B31.1 defines "severe cyclic conditions" as when the computed displacement stress range exceeds 0.85 times the allowable stress range, and the equivalent number of cycles exceeds 7000 [72, p. 419].

[b] ASME B31.3 Section F.323.4

ASME further informed the CSB that it has moved the requirements for hydrogen piping from B31.12 to a new chapter within B31.3. These changes were approved by the B31.3 committee in March 2026 and have been incorporated in the 2026 edition of ASME B31.3. Lastly, ASME informed the CSB that it will withdraw B31.12 in a future revision cycle.

<u>Post-Incident Actions</u>

The August 11, 2025, explosion caused extensive damage to both Battery 13's and Battery 14's coke oven gas supply piping systems, including at least five cast-iron double disc gate valves. After the explosion, U.S. Steel replaced some of the damaged cast iron valves, including the Battery 13 gas isolation valve, with in-kind replacements constructed of cast iron.

Appendix D - Description of Surrounding Area

Figure D-1 shows the census blocks immediately surrounding the U.S. Steel Clairton facility. The census information for the blocks shown is presented in **Table D-1** [59].

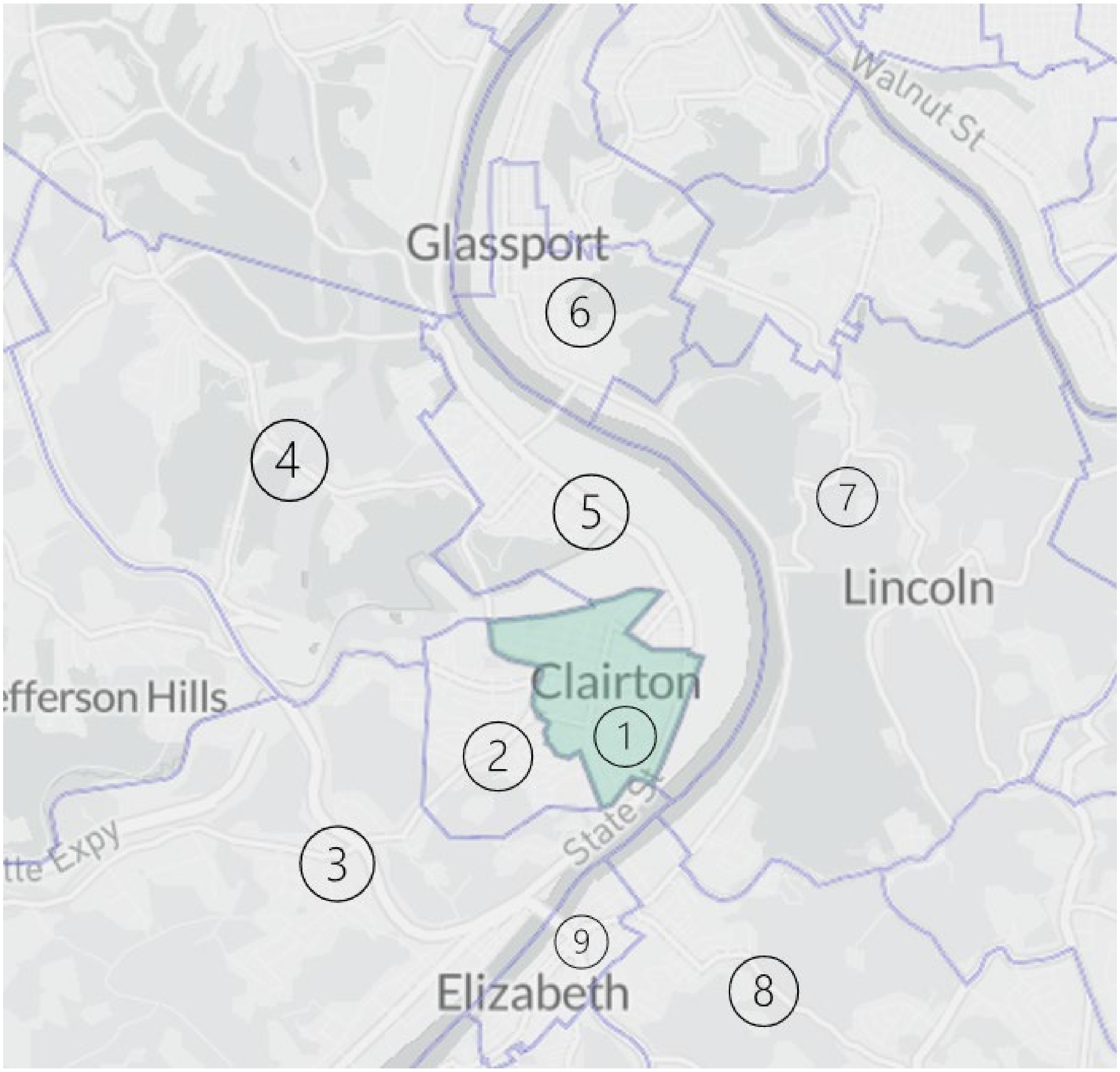

Figure D-1. Census blocks within a three-mile distance from the U.S. Steel Clairton facility. (Credit: Census Reporter, annotated by CSB)

Table D-1. Tabulation of demographic data for the populations within the census blocks shown in **Figure D-1**.

Tract Number	Population	Median Age	Race and Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Structures	
1	2,656	37.2	27.0%	White	$24,334	30.8%	1,230	74%	Single Unit
			61.0%	Black				21%	Multi-Unit
				Native					Mobile Home
				Asian				5%	Boat, RV, van, etc.
				Islander					
				Other					
			9.0%	Two+					
			3.0%	Hispanic					
2	1,613	43.2	57.0%	White	$29,555	27.4%	1,210	77%	Single Unit
			40.0%	Black				22%	Multi-Unit
				Native				1%	Mobile Home
				Asian					Boat, RV, van, etc.
				Islander					
				Other					
			1.0%	Two+					
			3.0%	Hispanic					
3	2,997	43.2	92%	White	$41,248	3.6%	1,312	91%	Single Unit
			1%	Black				2%	Multi-Unit
				Native				7%	Mobile Home
			1%	Asian					Boat, RV, van, etc.
				Islander					
				Other					
			1%	Two+					
			5%	Hispanic					
4	2,163	48.8	81%	White	$50,244	3.9%	1,046	69%	Single Unit
			11%	Black				28%	Multi-Unit
				Native				3%	Mobile Home
			1%	Asian					Boat, RV, van, etc.
				Islander					
				Other					
			6%	Two+					
			1%	Hispanic					

Tract Number	Population	Median Age	Race and Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Structures	
5	1,836	42	67%	White	$26,806	30.7%	1,056	78%	Single Unit
			25%	Black				22%	Multi-Unit
				Native					Mobile Home
				Asian					Boat, RV, van, etc.
				Islander					
				Other					
			6%	Two+					
			2%	Hispanic					
6	2,858	37	85%	White	$23,635	14.1%	1,331	81%	Single Unit
			5%	Black				19%	Multi-Unit
				Native					Mobile Home
				Asian					Boat, RV, van, etc.
				Islander					
				Other					
			2%	Two+					
			9%	Hispanic					
7	962	49.8	94%	White	$46,887	5.0%	441	95%	Single Unit
			1%	Black				1%	Multi-Unit
				Native				4%	Mobile Home
				Asian					Boat, RV, van, etc.
				Islander					
				Other					
			1%	Two+					
			4%	Hispanic					
8	4,367	48.7	93%	White	$41,150	7.7%	1,874	97%	Single Unit
				Black				2%	Multi-Unit
				Native				1%	Mobile Home
			3%	Asian					Boat, RV, van, etc.
				Islander					
			2%	Other					
			1%	Two+					
			1%	Hispanic					

Tract Number	Population	Median Age	Race and Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Structures	
9	1,378	38.1	84%	White	$28,719	18.9%	646	70%	Single Unit
			2%	Black				30%	Multi-Unit
				Native					Mobile Home
			1%	Asian					Boat, RV, van, etc.
				Islander					
				Other					
			5%	Two+					
			8%	Hispanic					

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