



U.S. Chemical Safety and
Hazard Investigation Board

Explosion and Fire at KMCO Chemical Facility

Crosby, Texas | Incident Date: April 2, 2019 | No. 2019-02-I-TX

Factual Update

Published: September 17, 2019



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U.S. Chemical Safety and Hazard Investigation Board

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U.S. Chemical Safety and Hazard Investigation Board

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Acronyms and Initialisms

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
CCPS	Center for Chemical Process Safety
CSB	U.S. Chemical Safety and Hazard Investigation Board
EPA	Environmental Protection Agency
FNPT	Female National Pipe Thread
LLC	Limited Liability Company
LPG	Liquefied Petroleum Gas
NOAA	National Oceanic and Atmospheric Administration
ORG	Owner Resource Group
OSHA	Occupational Safety and Health Administration
PSM	Process Safety Management
PTFE	Polytetrafluoroethylene
RMP	Risk Management Plan
SDS	Safety Data Sheet

1.0 Incident Summary

On Tuesday, April 2, 2019, just before 10:46 am, a vapor cloud of isobutylene formed at the KMCO, LLC (“KMCO”) facility in Crosby, Texas after a three-inch gray iron (a type of cast iron) y-strainer, a piping component, failed.¹ Shortly after 10:50 am, the vapor cloud found an ignition source and ignited, causing an explosion. The explosion killed one KMCO worker [1]² and seriously burned two others. On the day of the incident, more than 200 KMCO employees, contract workers, and visitors were onsite. The incident injured at least 30 workers—seven KMCO employees³ and 23 contract workers [2], [3], [4], [5], and [6]. A shelter-in-place was issued to community members within one mile of the KMCO facility. The incident interrupted normal business operations at KMCO and resulted in two rounds of employee layoffs, reducing the number of employees at the Crosby facility from more than 180 [7, p. 4] to less than 50.⁴

2.0 Background

2.1 KMCO

The [KMCO](#)⁵ facility in Crosby, Texas manufactures specialty chemicals and operates tolling facilities [7, p. 2] (**Figure 1**). Tolling is “[a]n arrangement in which a company (which has specialized equipment) processes raw materials or semi-finished goods for another company [8].”⁶ KMCO purchased the Crosby plant on July 1, 2012 and has owned and operated the facility since.⁷



Figure 1. KMCO. Photo showing the KMCO facility in Crosby, Texas. Equipment and buildings shown date this photo between 2015 and 2016. (Source: [KMCO](#)).

2.2 Isobutylene

Isobutylene⁸ is a highly flammable, colorless gas, with a sweet gasoline odor [9]. Under certain (temperature and pressure) conditions, isobutylene can be a liquid.⁹ Among other things, isobutylene is used in the production of aviation fuel, resins, chemicals, packaging, plastics, and antioxidants for food [9]. Isobutylene is typically transported and stored in a liquefied form, and it is among the gases

- 1 The isobutylene storage tank level decreased during the incident, but the amount of isobutylene released is not yet known. KMCO’s computer control system records process data in a proprietary format. The manufacturer of the system helped KMCO secure the process data and to extract the data for the various investigation parties, including the CSB. The CSB received this information on August 23, 2019. The inventory (level) of isobutylene in KMCO’s isobutylene storage tank, before and after the incident, is part of this data. The isobutylene storage tank has two level devices and preliminary evaluation revealed differences that will require further analysis.
- 2 The Harris County Institute of Forensic Sciences autopsy report shows the KMCO worker died from “sharp force injuries of the right upper extremity with transection of the right brachial artery and vein” resulting from an “accident” [1].
- 3 KMCO records show seven employee injuries resulting from the incident. Two employees sustained second and third degree burn injuries all over their body, one employee suffered from a blood clot, one employee experienced a lower back strain, and three employees developed respiratory issues.
- 4 According to a KMCO manager, less than 50 employees remained at the Crosby facility at the end of July 2019.
- 5 Artie McFerrin founded a company that built the plant at the Crosby site in 1975 [31]. In July 2012, the McFerrin family’s company sold the plant to KMCO, LLC.
- 6 The Center for Chemical Process Safety (CCPS) defines tolling as “[p]roviding manufacturing services for a fee by a contractor (the toller), to a company issuing (letting) a contract for those services. Tolloed services can include, reaction processes, formulation, blending, mixing or size reduction, separation, agglomeration, packaging/repackaging, and others or a combination of the above [19].”
- 7 ORG Chemical Holdings owns KMCO. ORG Chemical Holdings also owns the KMTEX, LLC (“KMTEX”), which operates a facility in Port Arthur, Texas. Similar to KMCO, KMTEX is a tolling and specialty chemical manufacturing facility [7, p. 2].
- 8 Isobutylene has a vapor density of 1.94, making it heavier than air [22, p. 9]. Isobutylene’s lower explosive limit is about 1.8 volume percent and its upper explosive limit is about 9.6 volume percent [22, p. 8].
- 9 Isobutylene is a gas at atmospheric pressure and typical outdoor air temperatures. Liquefying isobutylene takes increased pressure, significant cooling, or a combination of increased pressure and cooling. At atmospheric pressure, isobutylene will be a liquid if it is colder than its boiling point of 19.6 degrees Fahrenheit [21]. Liquefying isobutylene at 20 degrees Celsius (68 degrees Fahrenheit) requires pressures greater than 2,560 hectopascal (37.1 pounds per square inch) [22, p. 8]. Liquefying isobutylene requires more pressure at warmer temperatures and less pressure at cooler temperatures.



Figure 2. Isobutylene Storage Tank. KMCO's 70,000-gallon isobutylene storage tank was built in 2014 and the tank was commissioned and began operating in 2015. The tank is made from SA-516-70 carbon steel, has an inner diameter of 12 feet, and is 80 feet long (seam-to-seam). The tank's 2:1 elliptical heads add to the overall length. The maximum allowable working pressure is 200 pounds per square inch at 150 degrees Fahrenheit. The isobutylene storage tank was designed to meet the 2013 edition of the American Society of Mechanical Engineers (ASME) code, Section VIII, Division 1. (Credit: CSB).

referred to as LPG, or liquefied petroleum gas [10].¹⁰ KMCO received isobutylene shipments as a liquid, stored it as a liquid, and fed the isobutylene to its batch reaction system as a liquid.

2.3 KMCO Isobutylene System

KMCO used isobutylene as a raw material in its batch reaction process (**Figure 4**) to manufacture sulfurized isobutylene lubrication additive products.^{11, 12} On the day of the incident, this reaction system was producing HiTEC® 3315 [11], a lubrication additive.¹³

The equipment used to produce sulfurized isobutylene at KMCO includes an isobutylene storage tank (**Figure 2**) and a batch reactor (**Figure 3**).¹⁴ This report is using the "batch" term because KMCO manufactures its sulfurized isobutylene products in batches rather than in a continuous operation.



Figure 3. Batch Reactor. This photo shows the post-incident condition of the batch reactor KMCO used to manufacture sulfurized isobutylene products. (Credit: CSB).

¹⁰ Other LPG's include propane, propylene, and butane.

¹¹ Sulfurized isobutylene is an extreme pressure lubrication additive [20, p. 120].

¹² KMCO filed a Risk Management Plan (RMP) with the EPA on February 23, 2018 [37]. KMCO included isobutylene in its RMP and the company identified the isobutylene as being a Program Level 3 process [37, p. 33]. KMCO's RMP submission also clarifies that the isobutylene system is regulated by both the EPA RMP rule and the OSHA Process Safety Management (PSM) standard [37, p. 33].

¹³ The HiTEC® 3315 safety data sheet refers to sulfurized isobutylene as alkyl polysulfides.

¹⁴ KMCO replaced its isobutylene storage and piping system between 2014 and 2015.

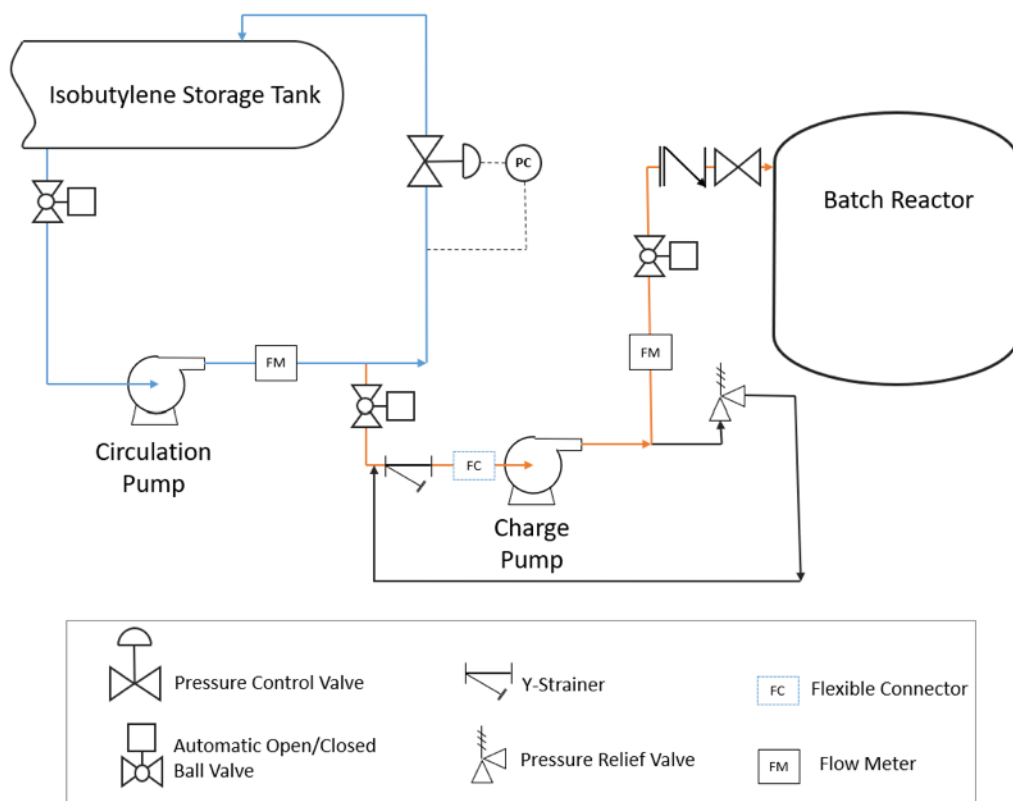


Figure 4. KMCO Isobutylene System. This simplified schematic shows the isobutylene system used to supply (charge) the batch reactor. The circulation pump keeps a steady supply of isobutylene to help provide reliable operation of the charge pump. The failed y-strainer is located on the inlet (suction) piping to the charge pump. (Credit: CSB).

valves, the isobutylene system has several automatic valves. Of these automatic valves, board operators, working inside the control room, could only control the pressure control valve shown in Figure 4. The automatic ball valves could only be opened or closed by operators in the field.¹⁵

3.0 The Incident

On the morning of April 2, 2019, KMCO operations staff was making a batch of sulfurized isobutylene. Before 7:00 am, operators completed the isobutylene charge to the batch reactor that night shift operators started. After completing the isobutylene charge, the unit operator closed several valves on the isobutylene charge pump outlet (discharge) piping to the sulfurized isobutylene reactor.¹⁶

Later in the morning, an operator was walking by the sulfurized isobutylene batch reactor when there was a loud “pop” sound followed by a loud whooshing noise similar to “an air hose coming off.”

The operator described seeing a white cloud of vapor hovering near the ground with three to four feet of a wavy, hazy vapor above it, that looked “like a water mirage over hot pavement” or “like if you’re filling up a gas tank and you see the fumes coming out.

Figure 4. shows a simplified schematic of the process used to charge the batch reactor periodically with isobutylene to make sulfurized isobutylene.

There are two pumps in the isobutylene system; an isobutylene circulation pump and an isobutylene charge pump. Operators can only start or stop these pumps from the field. The isobutylene circulation pump circulates isobutylene through more than 1,200 feet of piping, from the storage tank to the sulfurized isobutylene reactor unit and back to the isobutylene storage tank. The isobutylene charge pump then feeds the sulfurized isobutylene reactor when the proper step in the batch reaction procedure calls for adding isobutylene. As shown, the inlet piping to the isobutylene charge pump includes a y-strainer and a flex hose.

In addition to manually operated

15 The automatic ball valve on the inlet (suction) piping to the isobutylene circulation pump was equipped with a fusible link. This design should allow the valve to automatically close under certain fire conditions [30, p. 97]. The April 2, 2019 incident did not expose this valve to fire conditions.

16 A scrubber pump needed repair and the sulfurized isobutylene batch was holding until that maintenance work was completed. While waiting for the maintenance on the scrubber pump, the unit operator performed other tasks, such as helping a coworker connect a railcar for a different process.

In describing the release, a KMCO supervisor said it was like seeing “a two-foot river” of isobutylene vapor “going all the way down the road.”

After identifying the leak as isobutylene, a KMCO operator used the all-call¹⁷ feature on the plant radio system, which allows simultaneous communication on all the KMCO radio channels, to announce: “Attention KMCO, evacuate the reaction area.” Based on KMCO surveillance video, which shows many people suddenly acting with concern and purpose, this radio call to evacuate the reaction area took place at about 10:46 am.

KMCO operators and supervisors then took actions, including:

- Ordering a plant-wide evacuation;
- Turning on fire water monitors;
- Turning off equipment;
- Instructing people using motorized equipment to shut the equipment down and evacuate; and
- Closing vehicle gates near the release to prevent workers from driving into the vapor cloud.

Despite these efforts, the isobutylene vapor cloud exploded. Workers already heading to rally points hurried their evacuation (**Figure 5**). KMCO surveillance cameras visibly shook just after 10:50 am, capturing the time of the explosion.¹⁸

Emergency responders to the KMCO incident included KMCO’s Emergency Response Team, the Crosby Fire Department, Mutual Aid Mont Belvieu, and Harris County. Harris County responders included the Sheriff’s office and the Harris County Fire Marshal’s Office. KMCO also brought in U.S. Fire to help with the firefighting. The incident triggered a shelter-in-place order for community members within a one-mile radius [12].¹⁹



Figure 5. Evacuation. This surveillance camera image shows workers evacuating after the explosion. (Credit: KMCO).

¹⁷ An all-call is a call from an individual radio to every radio on the channel and to multiple talk groups. It is used to make important announcements requiring the user’s full attention [23].

¹⁸ Based on KMCO surveillance video, about four minutes and 29 seconds elapsed between the operator’s radio call and the explosion.

¹⁹ Officials lifted the shelter-in-place at 3:15 pm, more than five hours after the explosion.



Figure 6. Plant Building (North Side). This post-incident photo shows the path KMCO workers commonly took to enter the plant building. With process units on the left and right, this walkway led to the entrance on the north side of the plant building, where emergency responders recovered the operator. (Credit: CSB).



Figure 7. Plant Building (South Side). This post-incident photo shows the south side of the plant building. (Credit: CSB).



Figure 8. Plant Building (Top View). This photo, taken from the top of adjacent equipment, shows the post-incident condition of the plant building. (Credit: CSB).

KMCO conducted a headcount of its employees, contractors, and visitors and found that one KMCO employee, an operator, was missing. Emergency responders recovered the missing operator near the entrance a building in the plant (“plant building”) that was previously a control room. At 12:07 pm, medical responders evaluated the operator and did not try to resuscitate him. The Harris County Institute of Forensic Sciences autopsy report shows the operator died from “sharp force injuries of the right upper extremity with transection of the right brachial artery and vein” resulting from an “accident” [1].

One of the responders described what the plant building now looked like, saying:

Shrapnel. ... There was nothing left of it. Wires, there was nothing there. There wasn't a building there anymore
(**Figure 6**, **Figure 7**, and **Figure 8**).

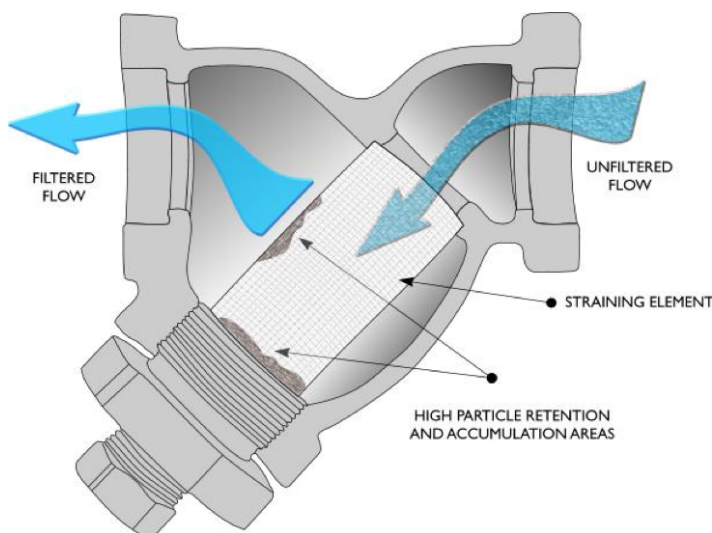


Figure 9. Generic Y-Strainer. This graphic shows a generic depiction of a typical y-strainer application—used to remove solid particles from a liquid stream. (Credit: [13]).



Figure 10. Y-Strainer (East Side). This post-incident photo shows the top and east side of the three-inch y-strainer on the inlet piping to the isobutylene charge pump. The orientation of the y-strainer was such that the straight through flow was headed north. (Credit: CSB).



Figure 11. Y-Strainer. This photo shows west side of the failed y-strainer involved with the April 2, 2019 incident. (Credit: CSB).



Figure 12. Y-Strainer Piece. This photo shows the single piece that likely separated from the failed y-strainer. (Credit: CSB).

4.0 The Y-Strainer

KMCO installed a filtration strainer (y-strainer) on the inlet (suction) piping to the isobutylene charge pump. A typical application for a y-strainer is to remove solid particles from a liquid stream (**Figure 9**). The three-inch y-strainer had threaded ends, and KMCO added flange-to-threaded connections to allow the y-strainer to connect to the isobutylene piping flanges (**Figure 10**).

Post-incident, the source of the isobutylene release was identified as the three-inch y-strainer on the inlet (suction) piping to the isobutylene charge pump. The y-strainer was found with a hole, which is roughly 3-inches by 5.5-inches, on its west side (**Figure 11**). A KMCO operator (who saw the release) confirmed that the location of the hole was consistent with where he saw the isobutylene escaping.

A metal fragment that appears to be consistent with the piece missing from the y-strainer was found on the ground, near the sulfurized isobutylene reactor, and to the west of the y-strainer (**Figure 12**).



Figure 13. Exemplar Y-Strainer. The CSB purchased an exemplar y-strainer (left image) using the inventory information available in KMCO’s warehouse. The image on the right is the y-strainer involved in the April 2, 2019 KMCO incident. (Credit: CSB).

Technical Specs			
Item	Y Strainer	Width	10"
Pipe Size	3"	Screen Material	Stainless Steel
Connection Type	FNPT x FNPT	Mesh	1/16"
Housing Material	Cast Iron, Stainless Steel, PTFE	Gasket Material	PTFE
Max. Pressure	400 psi @ 150 Degrees F, 250 psi @ 406 Degrees F	Blow-off Port	1-1/2"
Height	6"	Standards	ASTM A126 Class B

Figure 14. Y-Strainer Technical Specifications. (Credit: [15]).

The y-strainer involved in the incident appears physically consistent with the standard three-inch gray iron y-strainer KMCO stocks in its warehouse. Using the KMCO warehouse inventory information, the CSB purchased an exemplar y-strainer that also appears physically consistent with the y-strainer involved in the incident (**Figure 13**).

The supplier’s technical specifications (**Figure 14**) confirm that the exemplar y-strainer has a gray iron²⁰ (cast iron) body with an internal stainless-steel strainer. Gray iron is a type of cast iron [14].

5.0 Next Steps

The CSB investigation is ongoing. Investigators will continue developing the incident causal analysis based on evidence collected during the investigation. A final report, consisting of facts, analysis, conclusions, and recommendations will be issued at the completion of the investigation.

20 The technical specifications show that the y-strainer was manufactured to ASTM A126 Class B [15]. ASTM 126 is a “Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings [38].” ASTM 126 covers three classes (A, B, and C) “for castings intended for use as valve pressure retaining parts, pipe fittings, and flanges [38].”



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