



Figure 1. Fire at Kuraray EVAL Plant. The photo on the left shows the fire from a local road. The photo on the right is an image from a [video](#) of the fire. Credit: Houston Chronicle (left) Tiffany Craig, KHOU TV, courtesy of Edward Ross (right).

On May 19, 2018, at approximately 10:30 a.m., during preparations for startup activities following a turnaround,¹ a fire occurred at the Kuraray America EVAL facility in Pasadena, Texas. At the time of the incident, 266 employees and contract workers were onsite. During pre-startup pressure-testing activities of a chemical reactor, an abnormal high-pressure condition occurred and over 2,000 pounds of ethylene² were released to the atmosphere from a pressure relief valve. The ethylene vapors ignited (**Figure 1**), resulting in worker injuries. Twenty-one injured workers were transported to off-site medical facilities for treatment.³

The Kuraray America EVAL Plant (“EVAL Plant”) is a chemical production facility located in the Bayport Industrial District⁴ near Pasadena, Texas. The EVAL Plant produces ethylene-vinyl alcohol copolymers.⁵ This plant has four production lines. Production began in 1986 with two production lines, 1100 and 1200. The 1300 line began production in 1997. The fourth line, 1400, started commercial production in 2006. The 1200 production line, one of the original lines, was involved in the incident. Each of these production lines has a pressurized chemical reactor that uses ethylene in its polymerization⁶

1 A [turnaround](#) is a site-wide routine maintenance activity.

2 [Ethylene](#) gas is extremely flammable. It has a relative vapor density of 0.98, making it slightly lighter than air.

3 Workers suffered from burns or were injured from jumping from heights or from falling while running to escape the fire. One contract worker remained in critical condition for several days from life-threatening burns.

4 The [Bayport Industrial District](#) covers 12 square miles and has over 70 specialty chemical companies with more than 15,000 employees.

5 [Ethylene-Vinyl Alcohol Copolymers](#) are used as a vapor and gas barrier in containers and packaging ranging from food storage to automotive gasoline tanks. Kuraray has been manufacturing and marketing ethylene-vinyl alcohol copolymers (EVOH) under the name [EVAL™](#) since 1972. Kuraray also [produces EVAL™](#) in Okayama, Japan and Antwerp, Belgium.

6 [Polymerization](#) is a chemical process where one or more small molecules, monomers, react to form larger molecules, polymers.



Figure 2. The pressure relief system that activated and discharged ethylene horizontally across the road. Credit: CSB.

process. This process is highly dependent on temperature and pressure. The polymerization reaction generates heat that is controlled using two cooling systems: a reactor jacket⁷ that uses cooling water, and reactor cooler system that uses a refrigerated solution of water and methanol, commonly referred to as “brine” by Kuraray EVAL personnel.⁸

The EVAL Plant was previously shut down for a turnaround and for the installation of various equipment upgrades. One of the equipment upgrades included the commissioning of a new brine refrigeration compressor that would replace an existing ammonia-based system with one utilizing Freon™. The compressor would chill brine that would then be circulated through various pieces of process equipment to provide cooling. In April 2018, EVAL personnel began to commission the Freon™ compressor. As a part of this commissioning, personnel circulated refrigerated brine through the 1200 line reactor coolers prior to startup because the installation layout of the new compressor differed from that of the old ammonia-

7 A [reactor jacket](#) is a second shell surrounding a reactor vessel, creating a cavity around the outside of a reactor between the outer wall of the reactor and the inner wall of the jacket. Cooling or heating fluid can be circulated in this gap, i.e., through the jacket, as a method for controlling the temperature of the reactor.

8 The EVAL reactor coolers are a specialized type of [heat exchanger](#) device used to transfer heat from the reactor into a circulating cold “brine” fluid. Reactor vapors travel through tubes in the reactor cooler, and cold brine is circulated on the outside of the tubes.

based compressor. By normal startup practice, brine is not circulated through the reactor coolers until the reactor startup sequence is completed and the reactor is in normal operation mode.

On May 18, 2018, the day before the incident, the site began preparations to begin startup of the 1200 production line, pressure-testing the chemical reactor using ethylene gas. At about 11:20 p.m., 11 hours before the incident occurred, the abnormal low temperature conditions in the reactor coolers caused by the circulating chilled brine created conditions that could condense the ethylene gas into a liquid. During this time, the reactor temperature began to decrease as liquid ethylene accumulated inside.

After the day shift took over on the morning of May 19, 2018, at approximately 7:00 a.m., one of the supervisors checked on the status of the process. During this review, he recognized the low reactor temperature. The supervisor requested that the control room operator close the brine valves to stop circulating brine through the reactor coolers. In addition, the operations staff began to warm up the reactor contents by circulating steam-heated water through the reactor jacket. Closing the brine valves and adding heat to the reactor jacket began vaporizing the ethylene liquid in the reactor, increasing both the reactor temperature and pressure. Over the next three and one-half hours, Kuraray operators made a number of process adjustments, but at 10:28 a.m. the reactor pressure relief system⁹ (**Figure 2**) activated.

When the reactor’s pressure relief valve opened, reactor vapor ejected horizontally out of the relief valve’s atmospheric discharge piping, over a road adjacent to the reactor structure inside the EVAL Plant. The flammable gas ignited, resulting in a large flash fire,¹⁰ which then propagated back to the relief valve outlet and became a jet fire¹¹ (right photo **Figure 1**). The Harris County Fire Marshal

9 The reactor’s pressure relief system consists of a rupture disc and pressure relief valve. When the pressure relief system is activated, the disc will burst, opening a path to the relief valve. Then the relief valve will open, discharging vapor and/or liquid horizontally, until the pressure in the reactor decreases enough for the valve to close.

10 A [flash fire](#) is a fire that spreads by means of a flame front rapidly through a diffuse fuel—in this case ethylene—without the production of damaging pressure.

11 A [jet fire](#) is a fire type resulting from the discharge of liquid, vapor, or gas into free space from an orifice—in this case, ethylene through the reactor relief valve—the momentum of which induces the surrounding atmosphere to mix with the discharged material.

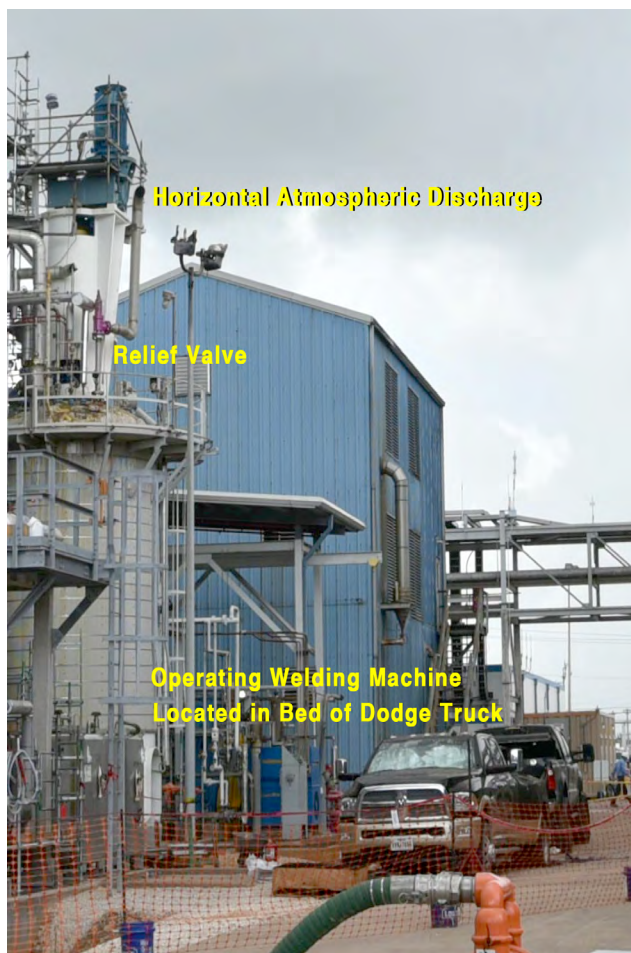


Figure 3. The welding machine that was the source of ignition, located under the relief valve's horizontal discharge. Credit: CSB.

Office identified the ignition source as “located in or around the operating welder [welding machine] located in the back of the Dodge pickup” (right photo in **Figure 3**), located adjacent to the reactor structure, under the relief valve discharge piping (left photo in **Figure 3**). Contract workers in the vicinity of the fire were performing a variety of activities including welding, insulating, and painting. These workers immediately evacuated when the fire erupted. Some workers suffered burns or were injured by jumping from heights or falling while running to escape the fire. The fire burned for

just short of three minutes, until enough vapor was released to reduce the reactor pressure, allowing the spring-loaded pressure relief valve to close.

The CSB investigation is ongoing. Investigators continue to collect data and evidence from the site. Investigators will conduct an analysis of this incident based upon evidence collected during the course of the investigation. A final report, including facts, analysis, conclusions, and recommendations will be issued at the conclusion of the investigation.