U.S. Chemical Safety and Hazard Investigation Board

Understanding And Addressing Operational Risk

RefComm 2024
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Galveston, TX

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Executive Director
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CSB Statutory Authority

Background

- independent Federal agency
- authorized by the Clean Air Act of 1990
- became operational in January 1998
- Not a regulator
- Not an enforcement agency

CSB Statutory Authority

42 U.S.C. 7412(r)(6) Chemical Safety Board

The Board shall:

1. investigate (or cause to be investigated),
2. determine and report to the public in writing the facts, circumstances, and conditions
3. determine the cause or probable cause

of any accidental release resulting in a fatality, serious injury, or substantial property damages.

Notification of an Accidental Release Event

- 40 CFR Part 1604 - Reporting of Accidental Releases

- The owner or operator of a stationary source must report any accidental release of a regulated substance or other extremely hazardous substance resulting in a fatality, serious injury, or substantial property damage.

Notification of an Accidental Release Event

- Serious injury - injury or illness that results in death or inpatient hospitalization.
- Stationary source - fixed facility.
- Substantial property damage - estimated property damage at or outside the stationary source equal to or greater than $1,000,000.

What Does Good Look Like?

What Does Good Not Look Like?

Common Causes of Process Incidents

- Management System Deficiencies
  - poor program to implement PHA action items
  - ineffective procedures
  - hazards not understood or controlled at company level
  - poor control of reactive hazards
- Equipment Failures Due to Damage Mechanisms
  - sulfidation corrosion
  - HF corrosion
  - high temperature hydrogen attack

Philadelphia Energy Solutions
Philadelphia, PA

- June 21, 2019
- Fire and Multiple Explosions
- 6 Injuries

Incident Summary

- A pipe elbow in the hydrofluoric acid (HF) alkylation unit ruptured.
- A large vapor cloud (95% propane, 2.5% HF, and other hydrocarbons) engulfed the unit.
- The vapor cloud ignited about two minutes after the start of the release, causing a large fire followed by multiple explosions.

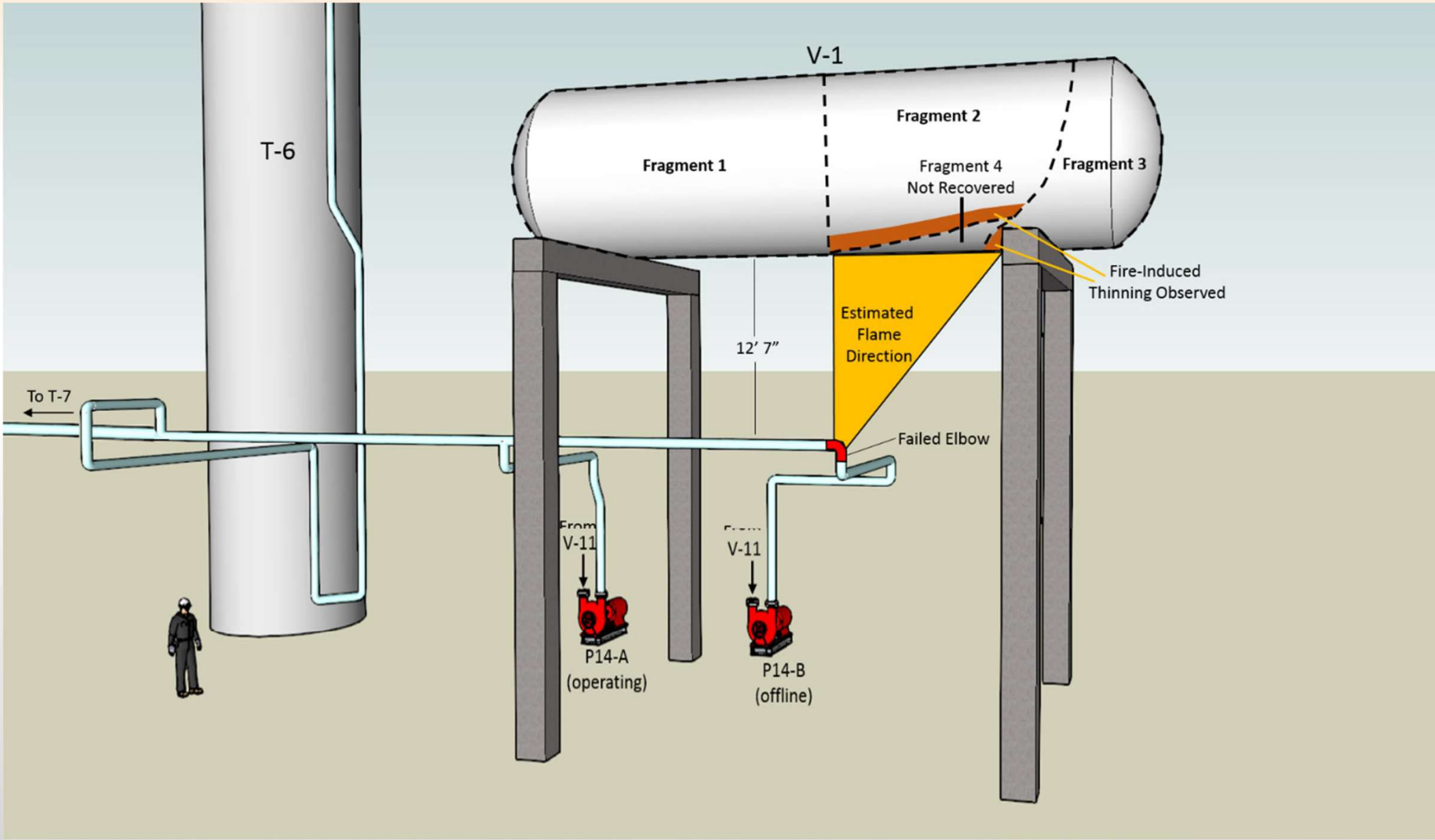

6/21/2019 4:01:40.169 AM

Incident Summary

- The control room operator then activated the Rapid Acid Deinventory (RAD) system.
- The activation of the RAD system successfully drained about 339,000 pounds (43,260 U.S. gallons) of hydrofluoric acid from the unit to the RAD drum.
- The control room operator then tried to remotely turn on the water pumps that fed the HF mitigation water cannons that are designed to reduce airborne HF through vapor suppression.
- The water pumps did not turn on.

Incident Summary

- The water mitigation system was activated manually approximately 40” after the incident occurred.
- PES estimated that 5,239 pounds of HF released from piping and equipment during the incident.
- It estimated that 3,271 pounds of HF released to the atmosphere and was not contained by water spray.
- PES also estimated that about 676,000 pounds of hydrocarbons released during the event, of which an estimated 608,000 pounds were combusted.


V-1
T-6
Fragment 1
Fragment 2
Fragment 3
Fragment 4
Not Recovered
Fire-Induced
Thinning Observed
Estimated
Flame
Direction
12' 7"
To T-7
Failed Elbow
From
V-11
P14-A
(operating)
From
V-11
P14-B
(offline)

Safety Issues

1. Mechanical Integrity
2. Verifying Safety of Equipment after Changes to RAGAGEP
3. Remotely Operated Emergency Isolation Valves
4. Safeguard Reliability in HF Alkylation Units
5. Inherently Safer Design

Cause

The rupture of a steel piping component with high nickel and copper content that had corroded from HF and thinned faster than adjacent piping components with lower nickel and copper content.

Cause

Contributing to the incident was the lack of requirements by the American Petroleum Institute, Sunoco, and PES, to inspect all existing carbon steel piping circuit components to ensure they could safely operate in HF service.

The industry began quantifying the levels of nickel and copper in steel that could be considered safe for use in HF alkylation units in 2003.

Cause

Contributing to the severity of the incident was the absence of remotely operated emergency isolation valves to isolate large sources of hydrocarbons, and incident-induced damage to the water mitigation system that limited PES's ability to suppress released HF during the incident.

Recommendations

EPA

- 3 Recommendations

API

- 2 Recommendations

ASTM

- 1 Recommendation

TPC Group
Port Neches, TX

- November 27, 2019
- Multiple Explosions and Fires
- 3 Injuries

Incident Summary

A process pump in the butadiene unit was taken out of service for maintenance 114 days prior to the incident.

During this lengthy offline period, popcorn polymer developed and expanded in the dead leg piping section of the unit.

The popcorn polymer continued to accumulate and expand until the internal piping pressure increased to the point that the piping ruptured, releasing butadiene from the process unit.

Incident Summary

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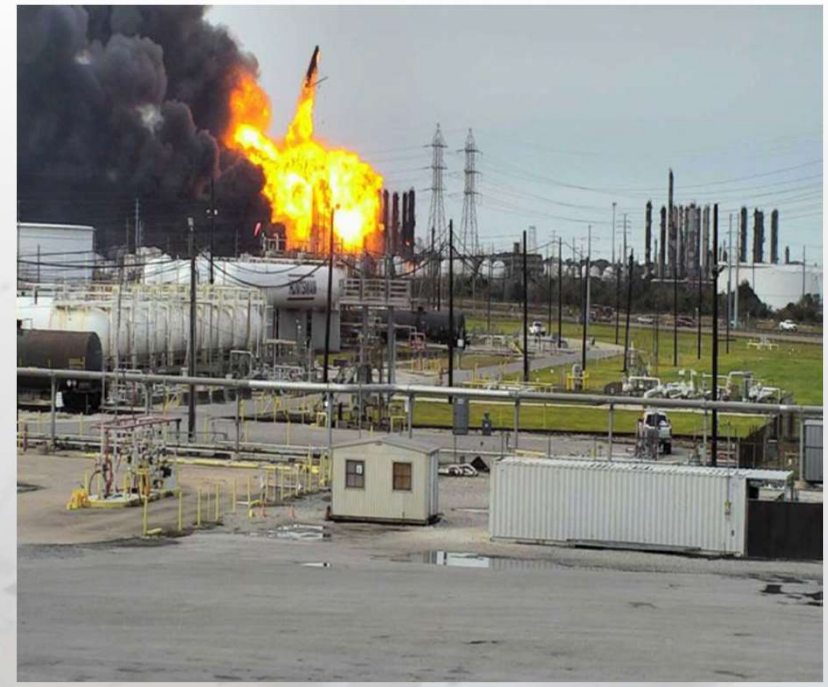
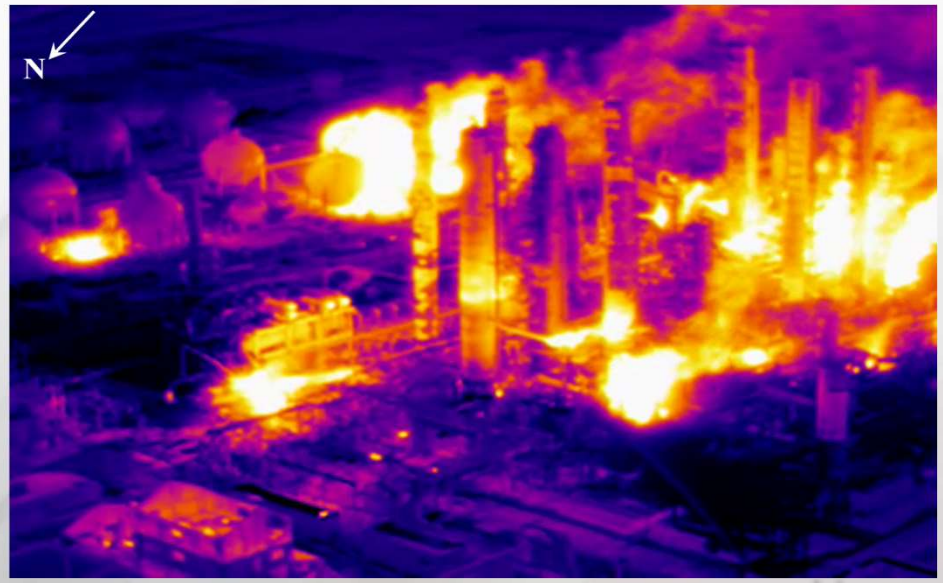
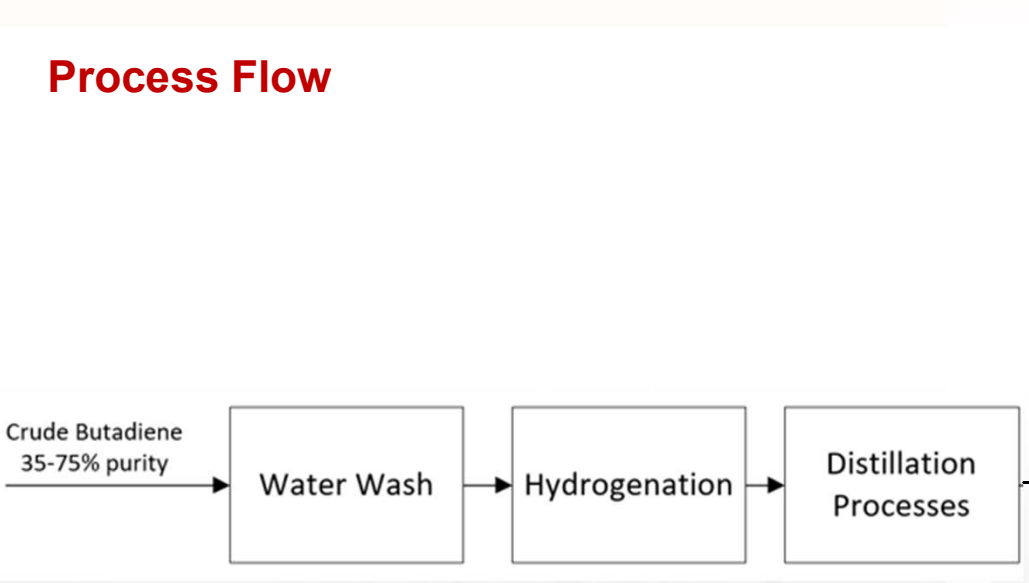


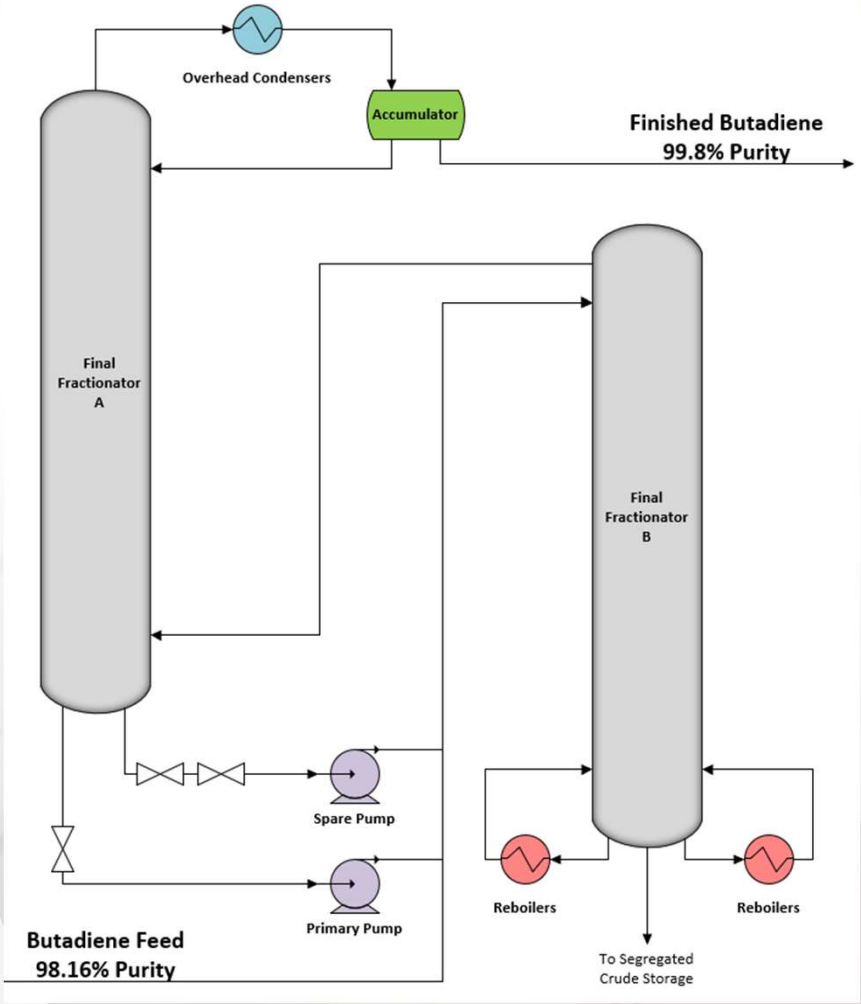


BACKGROUND INFORMATION

U.S. Chemical Safety and Hazard Investigation Board

Process Flow





Safety Issues

- Dead Leg Identification and Control
- Process Hazard Analysis Action Item Implementation
- Control and Prevention of Popcorn Polymer
- Remotely Operated Emergency Isolation Valves

Cause

The failure to identify that an out-of-service pump within the butadiene unit caused a temporary dead leg allowing popcorn polymer to develop and exponentially expand in the piping section until the piping ruptured.

Contributing to the incident was the inadequate prevention and control of popcorn polymer within its process units and the inadequate implementation of the 2016 PHA action item.

Contributing to the severity of the incident was the lack of remotely operated emergency isolation valves within the butadiene process unit.

Recommendations

TPC Group

2 Recommendations

American Chemistry Council (ACC)

3 Recommendations

Husky Superior Refinery
Superior, WI

- April 26, 2018
- Explosion and Asphalt Fire
- 36 Injuries

Incident Summary

Operators were shutting down the FCC unit for a planned turnaround.

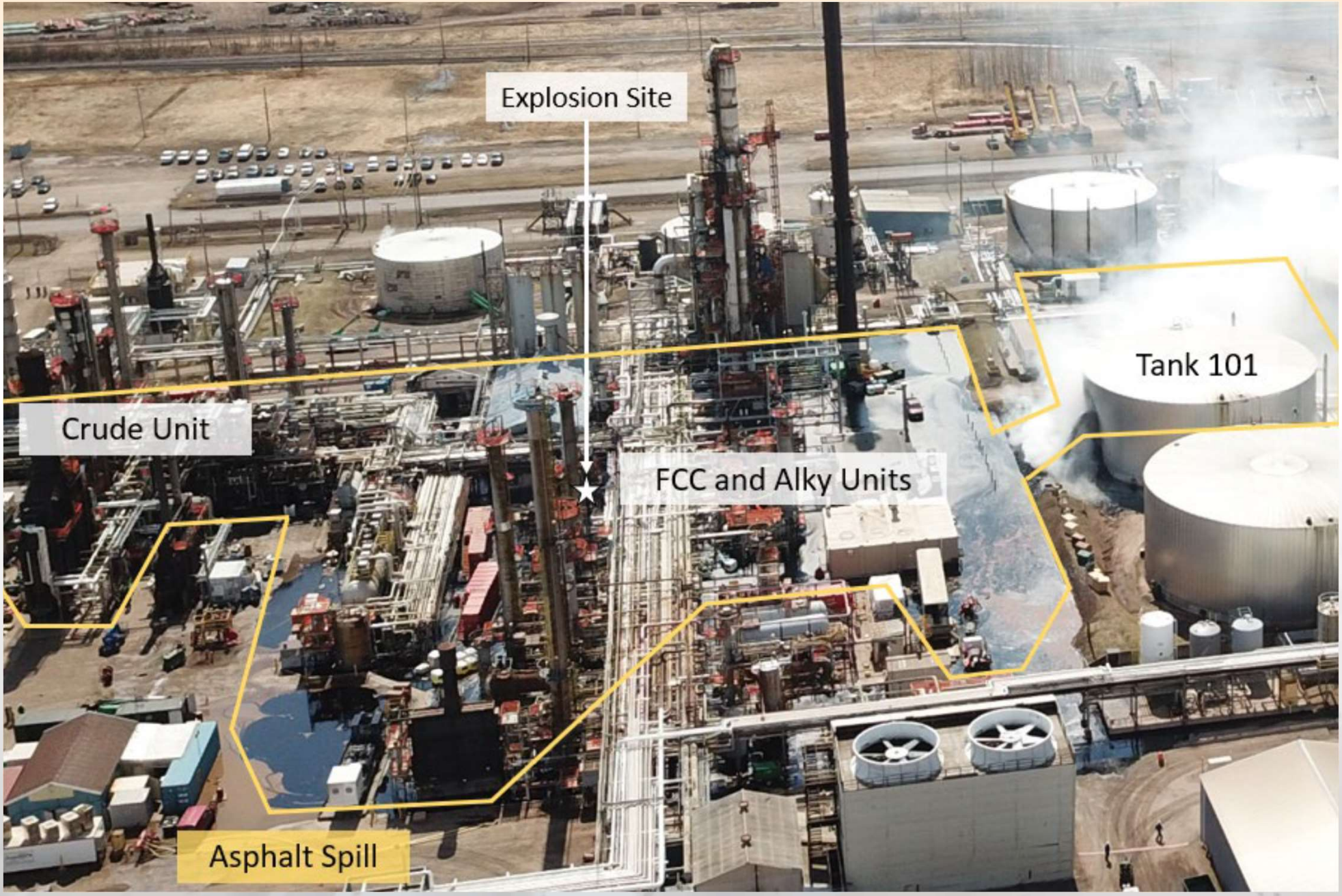
Explosion in the FCC unit occurred at about10:00 a.m.

Incident Summary

Explosion debris struck and punctured an asphalt storage tank.

Debris from the FCC unit did not impact the nearby HF storage tank (near-miss event).

Asphalt fire started at approximately 12:00 p.m.


Explosion Site
Tank 101
Crude Unit
FCC and Alky Units
Asphalt Spill

Safety Issues

1. Transient Operation Safeguards
2. Process Knowledge
3. Process Safety Management Systems
4. Industry Knowledge and Guidance
5. Brittle Fracture During Extreme Events
6. Emergency Preparedness

Transient Operation Safeguards

During the FCC unit shutdown, the refinery's transient operation safeguards were not implemented or effective:

- **Refinery did not implement a reactor steam barrier**
- **Refinery did not implement a main column gas purge**
- **Refinery only relied on slide valves for protection**

Cause

Inadvertent directing of air inside the regenerator through the reactor and main column, and then into the gas concentration unit.

As the air continued flowing into the gas concentration unit, oxygen accumulated and formed a flammable mixture inside the primary and sponge absorbers.

The oxygen also reacted with existing pyrophoric material inside this equipment, creating the ignition source for the explosion.

Recommendations

Cenovus Superior Refinery

- 7 Recommendations

Cenovus Energy

- 3 Recommendations

OSHA

- 1 Recommendation

EPA

- 1 Recommendation

Recommendations

API

- 3 Recommendations

Honeywell UOP

- 1 Recommendation

Intercontinental Terminals Company (ITC) Deer Park, TX

- March 17, 2019
- Storage Tank Fire
- Significant Environmental Damage

Incident Summary

ITC was a bulk liquid storage terminal.

A fire originated in an 80,000-barrel aboveground atmospheric storage tank that held a blend of naphtha and butane product.

Incident Summary

Once the fire erupted, ITC was unable to isolate or stop the release. The fire burned, intensified, and spread to the other 14 tanks in the same containment area.

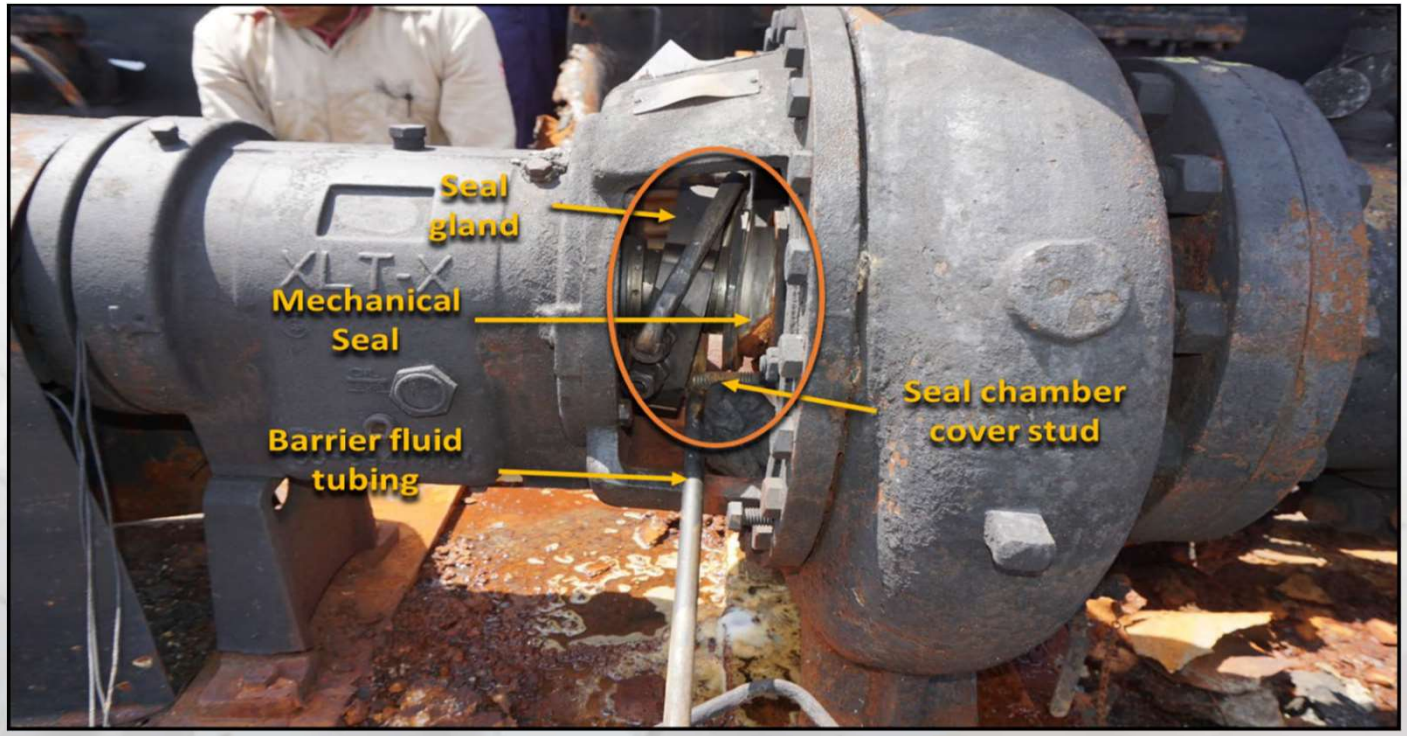
The fire was extinguished three days later.

Safety Issues

- Pump Mechanical Integrity
- Flammable Gas Detection Systems
- Remotely Operated Emergency Isolation Valves
- Tank Farm Design
- OSHA PSM Standard & EPA RMP Rule Applicability

Pump Mechanical Integrity

- The pump failed allowing butane-enriched naphtha product to be released from the pump's mechanical seal while the pump continued to operate.



Pump Mechanical Integrity

- ITC did not have a formal Mechanical Integrity procedure in place that defined requirements for maintaining the mechanical integrity of Tank 80-8 and its associated equipment.
- A formal mechanical integrity program for pumps in highly hazardous chemical service could have prevented this incident by providing ITC with opportunities to identify pump issues prior to the incident.
- The pump was not equipped with condition monitoring equipment capable of detecting excess vibration in the equipment.

Flammable Gas Detection System

- Tank 80-8 was not equipped with a flammable gas detection system.
- In 2014, a hazard review team recommended the addition of flammable gas detection systems near Tank 80-8. ITC did not implement this recommendation.
- The naphtha product continued to release from the failed pump for approximately 30 minutes, completely undetected, before its flammable vapors eventually ignited.

Remotely Operated Emergency Isolation Valves

Tank 80-8 and the other aboveground storage tanks located in the First & Second 80's tank farm were not equipped with ROEIVs.

Remotely Operated Emergency Isolation Valves

- Butane-enriched naphtha product contained in Tank 80-8 could not be remotely or automatically isolated.
- The released continued via the failed pump, fueling the fire that continued to intensify around the tank.
- As the Tank 80-8 fire intensified, flames from the fire spread to adjacent tank piping manifolds in the tank farm and eventually compromised the equipment, causing breaches in piping that allowed additional hydrocarbon and petrochemical products to release into the common containment area.

Cause

The CSB determined that the cause of the incident was:

> the release of flammable butane-enriched naphtha vapor from the failed Tank 80-8 circulation pump.

Cause

Contributing to the severity of the incident were:

- The absence of a flammable gas detection system and the absence of remotely operated emergency isolation valves.
- Tank farm design, including tank spacing, subdivisions, engineering controls for pumps located inside the containment area, and drainage systems that allowed the fire to spread to other tanks within the tank farm.
- The atmospheric storage tank exemption contained in the OSHA PSM standard and the flammability exemption contained in the EPA RMP rule.

Recommendations

The CSB made eight safety recommendations:

- Intercontinental Terminals Company (5)
- American Petroleum Institute (1)
- Occupational Safety & Health Administration (1)
- U.S. Environmental Protection Agency (1)

Where do you go to find what good looks like?

Process Safety Standards and Best Practices

Center for Chemical Process Safety (CCPS)

- *Guidelines for Risk Based Process Safety*
- *Driving Continuous Process Safety Improvement from Investigated Incidents*
- *Guidelines for Auditing Process Safety Management Systems*
- *Inherently Safer Chemical Processes*

Process Safety Standards and Best Practices

American Petroleum Institute (API)

- *API RP 751 – Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*
- *API 570 – Piping Inspection Code*
- *API 510 – Pressure Vessel Inspection Code*
- *API RP 751 – Safe Operation of Hydrofluoric Acid Alkylation Units*

Process Safety Standards and Best Practices

National Fire Protection Association (NFPA

- *NFPA 400 – Hazardous Materials Code*
- *NFPA 30 – Flammable and Combustible Liquids Code*
- *NFPA 51B – Fire Prevention During Welding, Cutting, and Other Hot Work*
- *NFPA 56 – Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*

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