

# FCC Unit Explosion and Asphalt Fire at Husky Superior Refinery

Melike Yersiz, Chemical Incident Investigator  
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U.S. Chemical Safety and  
Hazard Investigation Board



- April 26, 2018
- Operators were shutting down the fluid catalytic cracking (FCC) unit for a planned turnaround
- Two vessels exploded around 10:00 a.m.
  - Explosion debris struck asphalt storage tank
- Asphalt fire around 12:00 p.m.
  - Evacuation lifted at 6:00 a.m. the next morning
- Consequences:
  - 36 injuries (including 11 OSHA recordable injuries); no fatalities
  - 39,000 pounds of flammable hydrocarbon vapor mixture released
  - \$550 million property damage

**Full report on the CSB website:** <https://www.csb.gov/husky-energy-superior-refinery-explosion-and-fire>

**YouTube video:** <https://www.youtube.com/watch?v=sFhkzK7jkKg>

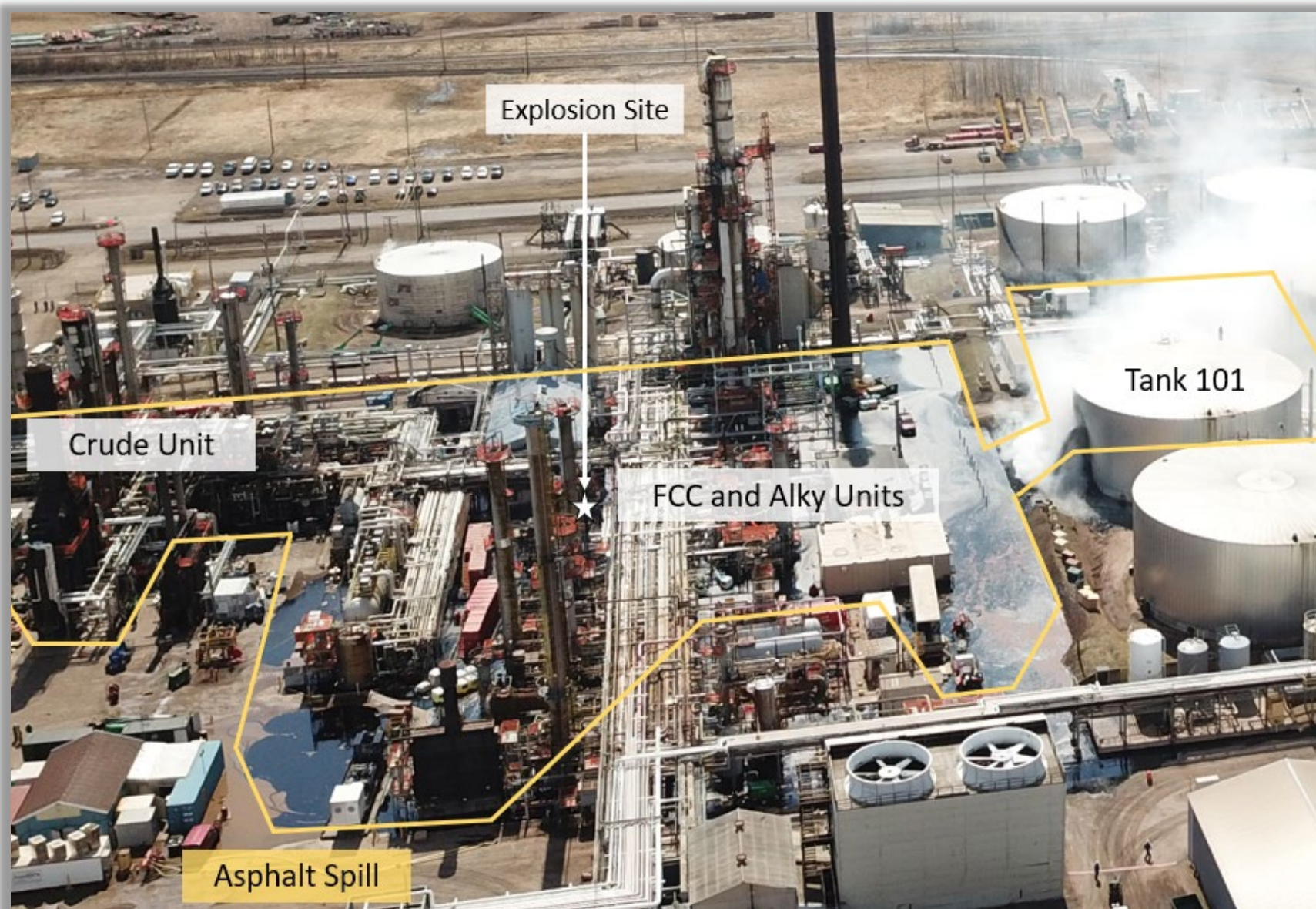




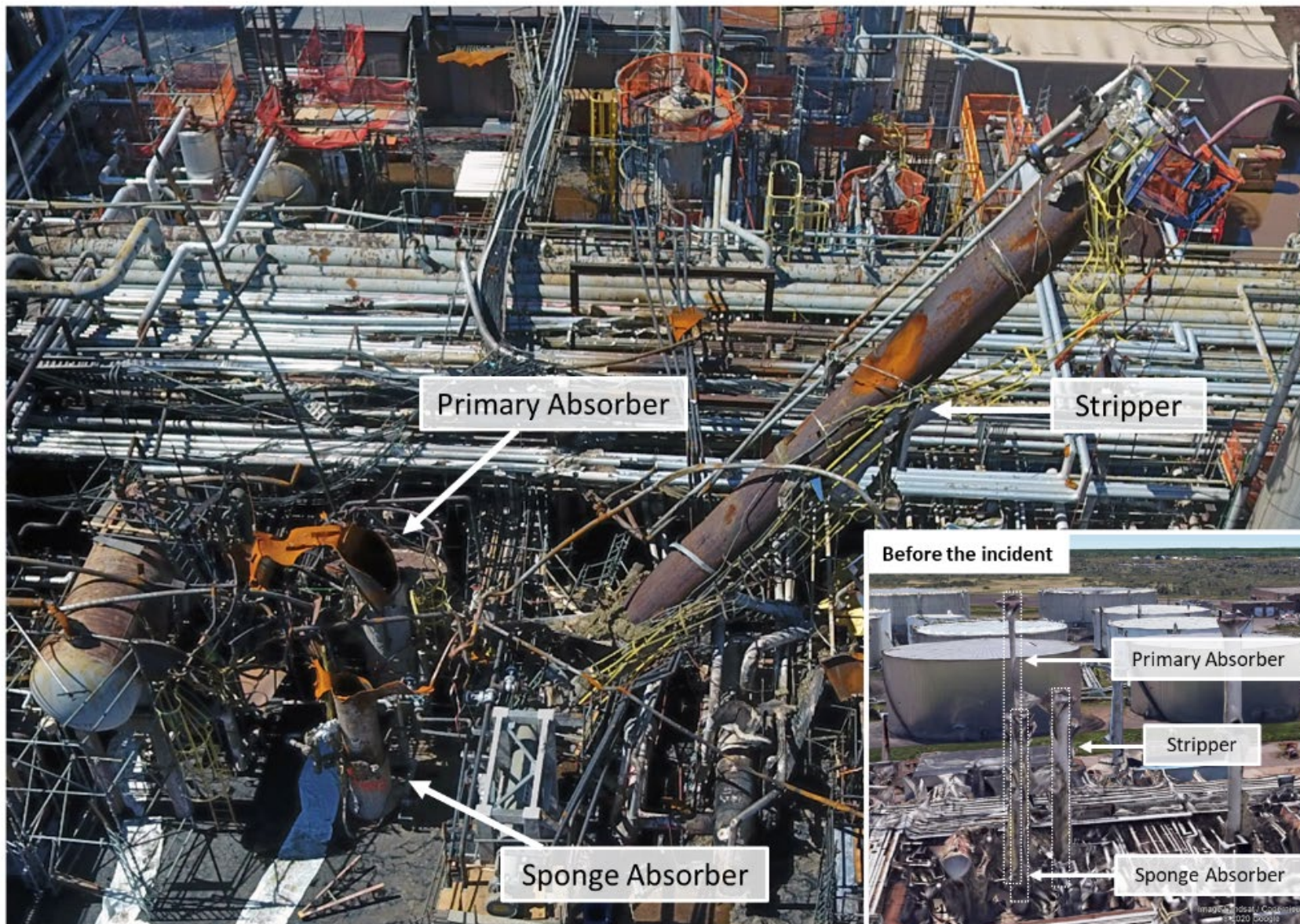


Source: WDIO ABC News









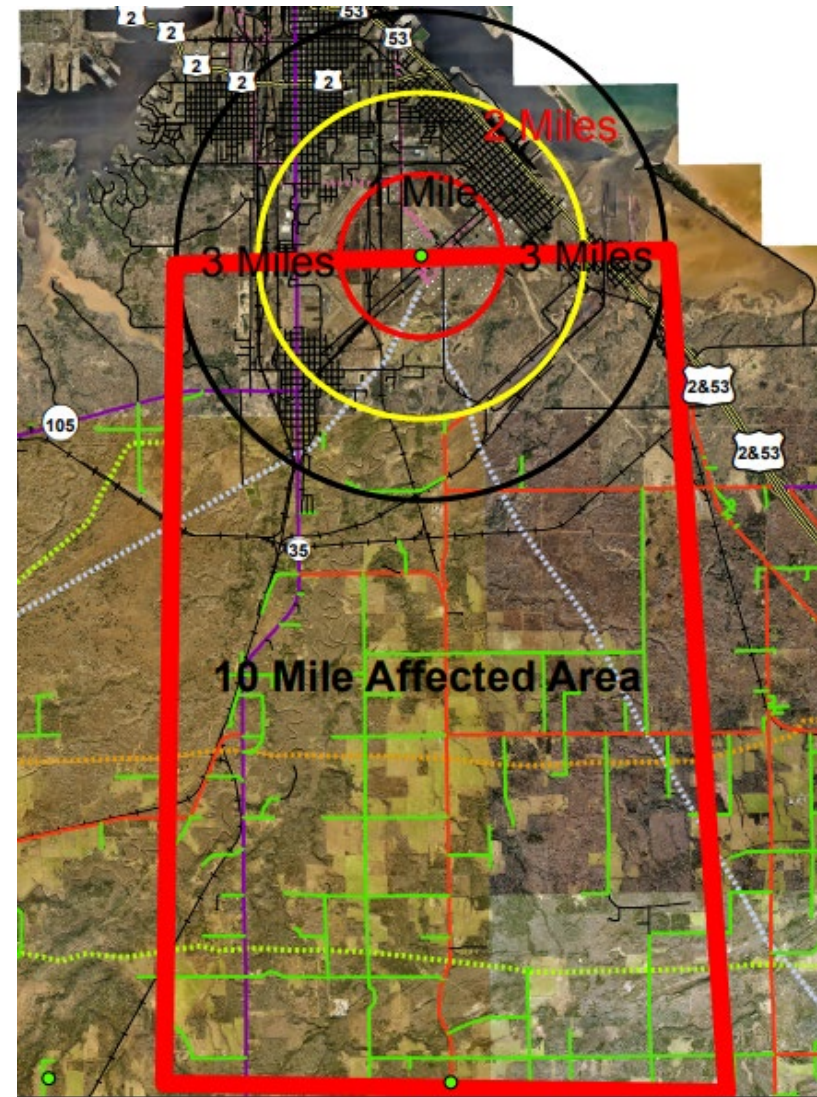




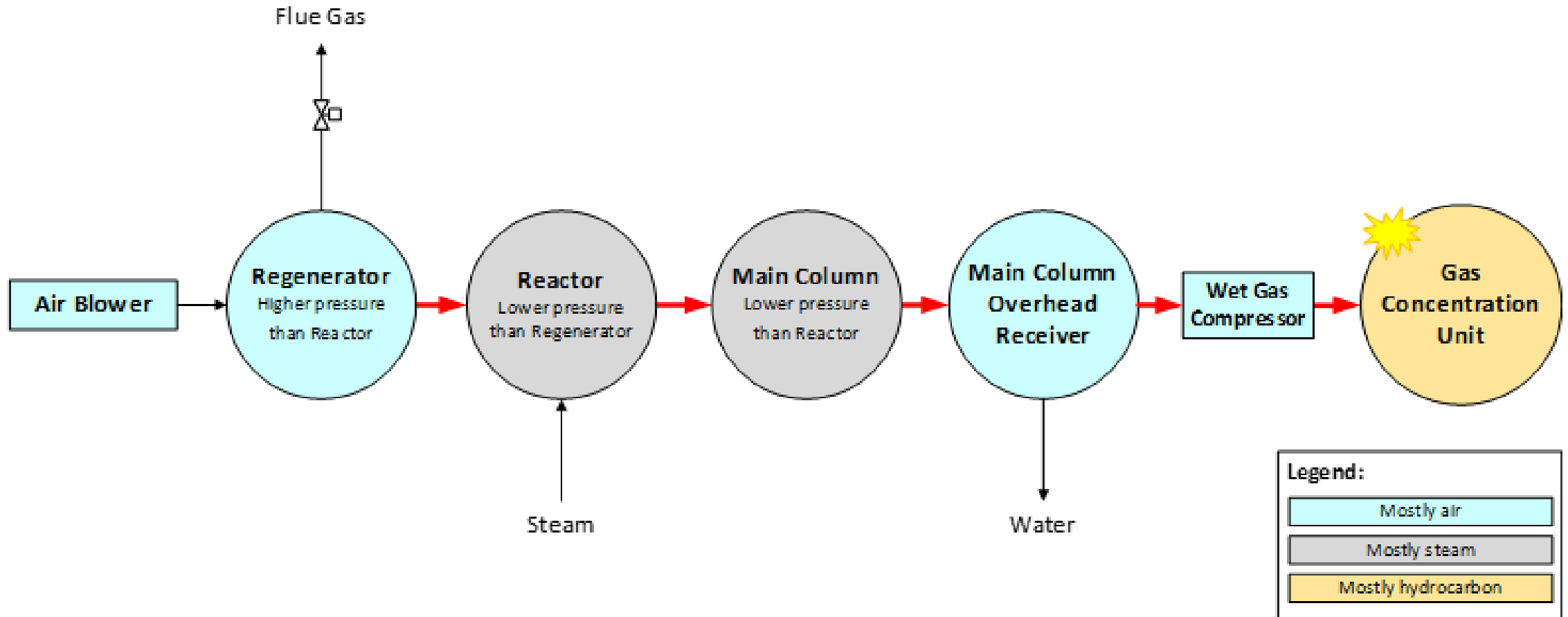




Source: WDIO ABC News









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:**

The operating mode when the process is in transition and is not in its normal operations mode.

## **Examples:**

Startup, shutdown, standby, emergency, procedure-based operations



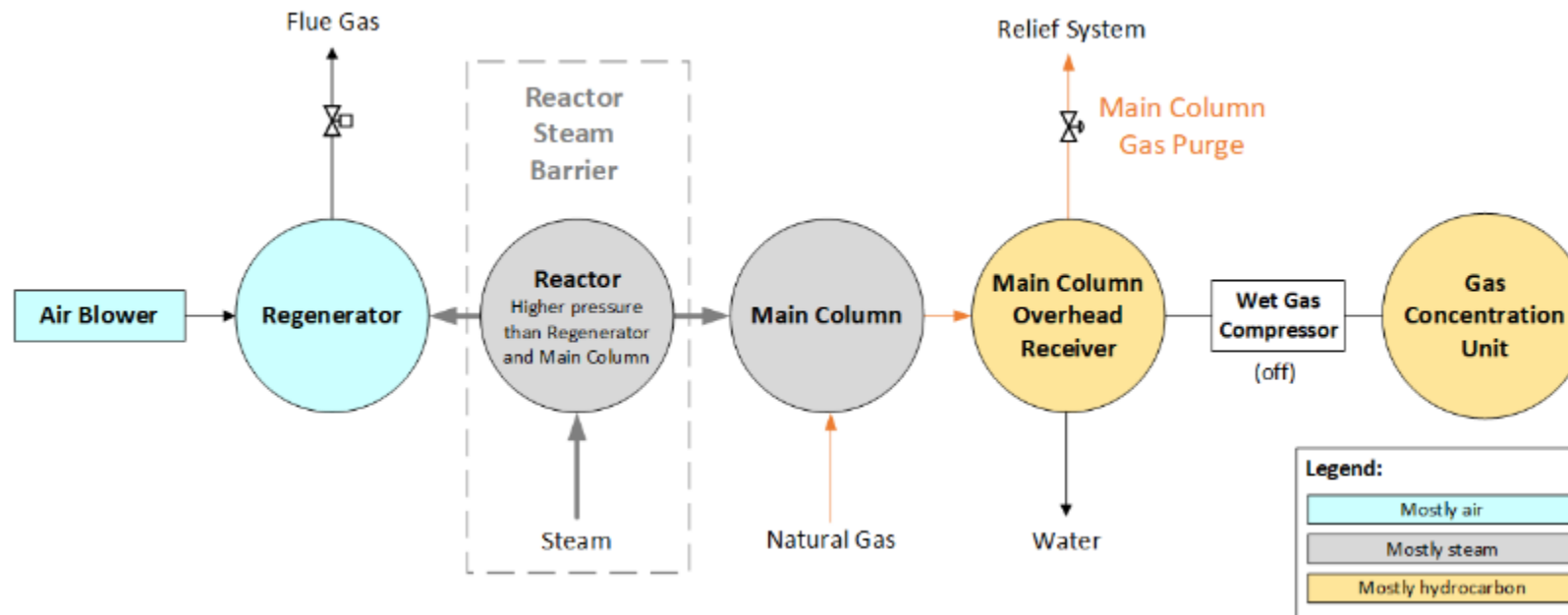
# SAFETY ISSUE #1: TRANSIENT OPERATION SAFEGUARDS



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



Refinery's FCC technology knowledge was not sufficient to safely shut down the FCC unit:

- Refinery's FCC expertise mainly in-house, with minimal engagement with other refineries
- Shutdown procedure had not been technically evaluated for at least 25 years prior to the incident
- Outside expert evaluations were limited to assessing the FCC unit's normal operation
- FCC shutdown procedure contradicted licensor guidance

As a result, refinery workers were not aware of explosion risk

## **CSB recommendations to Cenovus Energy:**

- Develop an FCC PHA guidance document for use at all Cenovus-operated refineries
- Develop and implement a technology-specific knowledge-sharing network program across all Cenovus-operated refineries, which at a minimum includes an FCC technology peer network



# SAFETY ISSUE #3: PROCESS SAFETY MANAGEMENT SYSTEMS

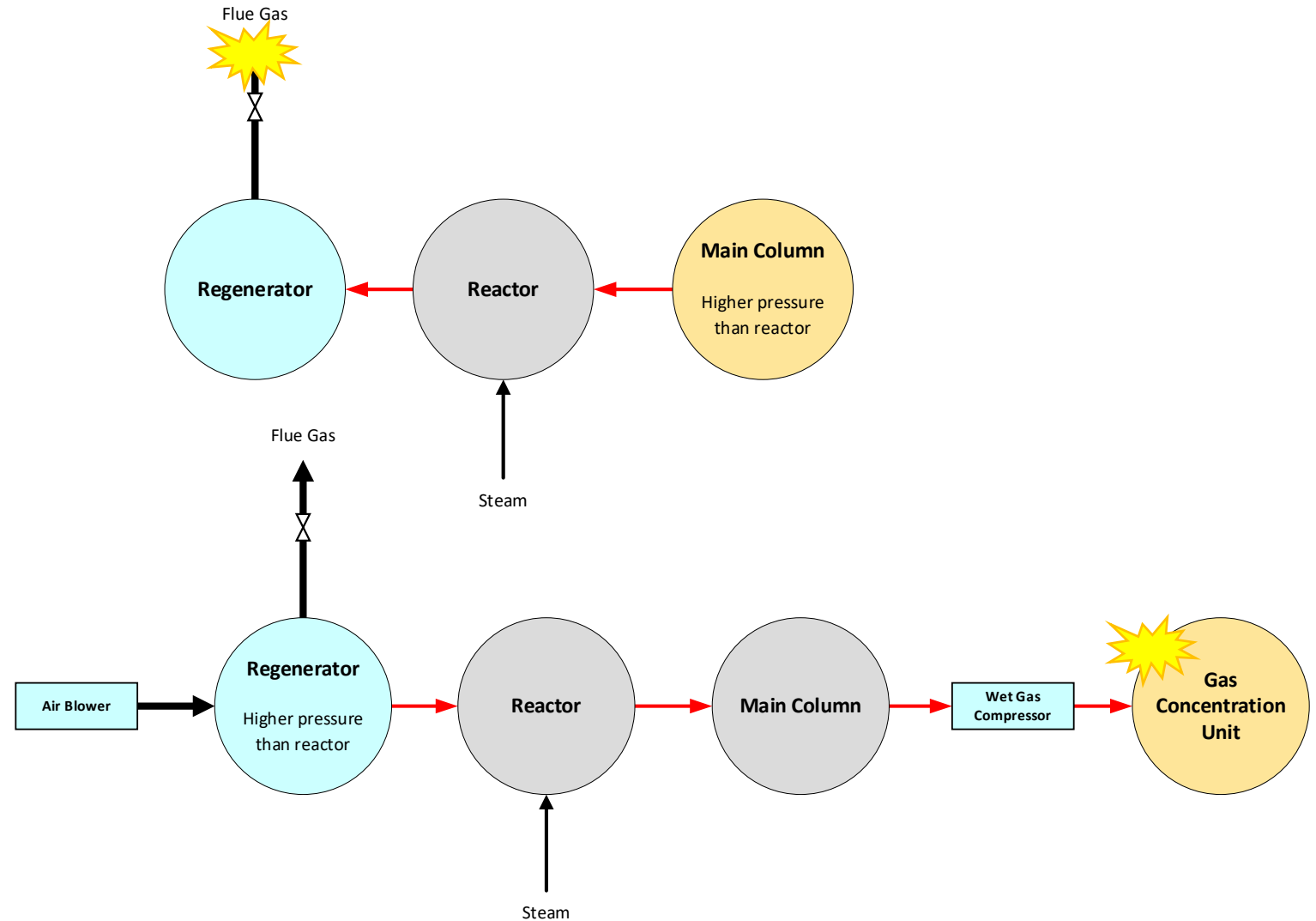
- **Process safety information (PSI)**
  - Licensor's operating manual not incorporated into PSI
- **Operating procedures**
  - Procedures did not have clear instructions, safe operating limits, consequences of deviation
  - Refinery did not identify that venting changes to FCC unit shutdown procedure increased risk of oxygen accumulation inside equipment
- **Process hazard analysis (PHA)**
  - PHA method did not identify some transient operation hazards
- **Operator training**
  - Training program did not prepare operators to safely shut down the FCC unit
  - No hands-on training opportunities (e.g. simulators)

- Torrance (2015)

[Link to CSB report](#)

[Link to CSB video](#)

- Superior (2018)





- Husky Superior Refinery knew about the Torrance incident, but workers did not recognize that inadvertent flow in the reverse direction was also possible
- Similar knowledge gaps may exist at other U.S. refineries
- Many different FCC unit designs exist through multiple technology licensors
- Currently, there is no industry publication that establishes common basic process safety expectations for all FCC units

## **CSB recommendation to American Petroleum Institute (API):**

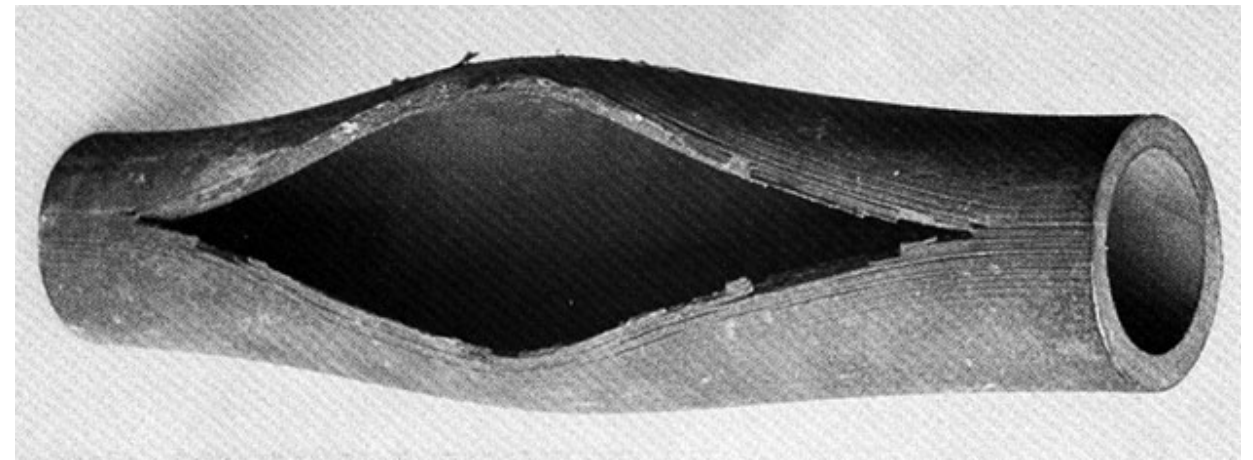
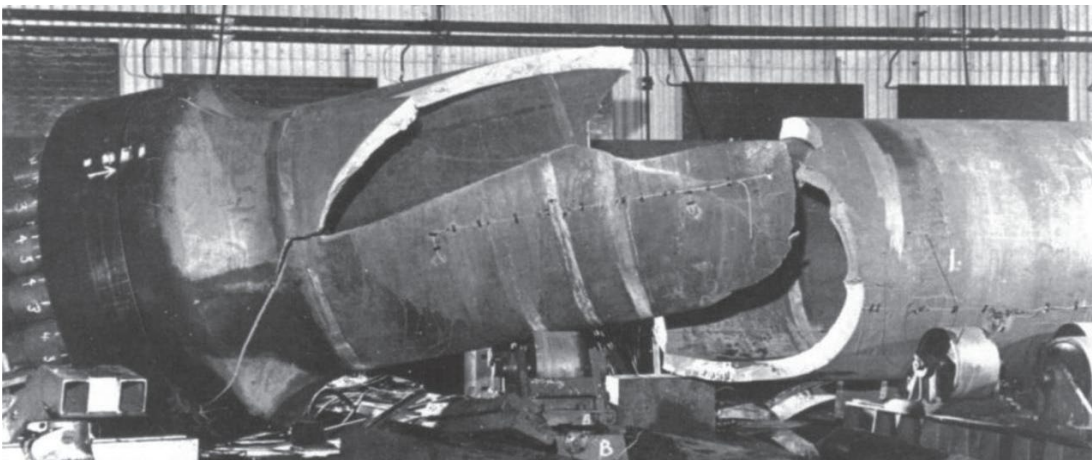
Develop a publicly available technical publication for the safe operation of fluid catalytic cracking (FCC) units. The document should be applicable to both new and existing units.

# SAFETY ISSUE #5: BRITTLE FRACTURE DURING EXTREME EVENTS

- The primary and sponge absorber failed by brittle fracture (like breaking glass)
- Newer grades of steels more likely to fail by ductile fracture (fish mouth)
- A-212 and A-201 grade steels no longer recommended

See [Appendix D](#) for metallurgist's analysis (available on the CSB website)

Examples of brittle fracture (left) and ductile fracture (right) – *Not from this investigation*



Source: The Royal Society Publishing (left), Babcock & Wilcox (right)



# SAFETY ISSUE #6: EMERGENCY PREPAREDNESS

- Asphalt storage tank was punctured on its side (not typically considered during design)
- Hot asphalt was stored above its flash point and ignitable when it spilled
- Likely ignition source: pyrophoric material smoldering inside tank when exposed to oxygen



Source: CSB (left), Duluth News Tribune (right)

- **U.S. Occupational Safety and Health Administration (OSHA):**

Develop guidance for performing process hazard analysis on operating procedures to address transient operation hazards.

- **Environmental Protection Agency (EPA):**

Develop a program that prioritizes and emphasizes inspections of FCC units in refineries that operate HF alkylation units. As part of this program, verify FCC unit safeguards that prevent explosions during transient operation.

- **American Petroleum Institute (API):**

Develop a publicly available technical publication for the safe operation of fluid catalytic cracking (FCC) units. The document should be applicable to both new and existing units.



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# Questions & Discussion

Visit our Website: [www.csb.gov](http://www.csb.gov)

YouTube:

[USCSB](https://www.youtube.com/USCSB)

Twitter:

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# Supplemental Slides

## 2018-02-I-WI-R12

Develop a program that prioritizes and emphasizes inspections of FCC units in refineries that operate HF alkylation units (for example, under EPA's National Compliance Initiative called Reducing Risks of Accidental Releases at Industrial and Chemical Facilities). As part of this program, verify FCC unit safeguards that prevent explosions during transient operation (including startup, shutdown, standby, and emergency procedures). At a minimum the program will verify the following specific safeguards:

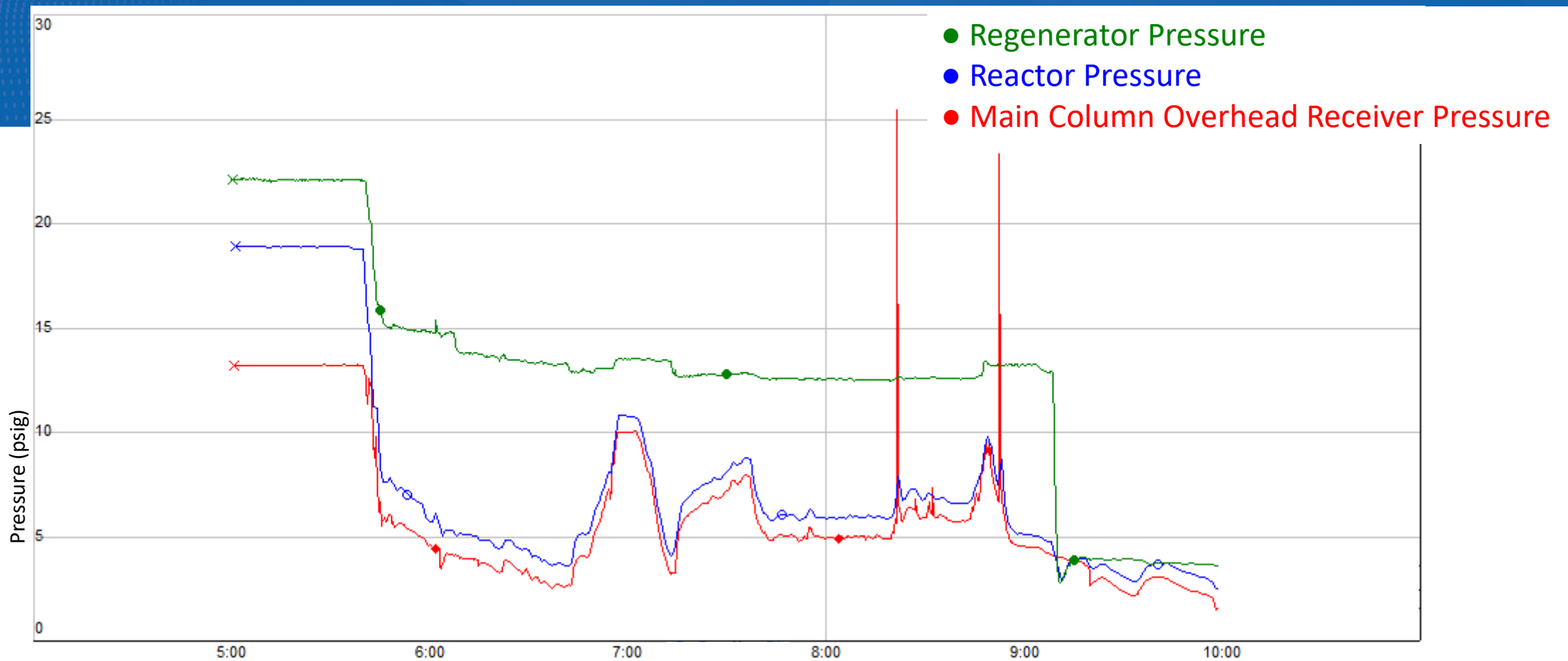
- a) Implementation of the **reactor steam barrier**, or a similar inert gas flow, to maintain an inert barrier at an elevated pressure between the main column (containing hydrocarbon) and the regenerator (containing air);
- b) **Purging the main column** with a non-condensable gas as needed to prevent a dangerous accumulation of oxygen in the main column overhead receiver;
- c) Monitoring to ensure that there is a sufficient non-condensable gas purge of the main column to **prevent a dangerous accumulation of oxygen** in the main column overhead receiver (either through direct measurement of the oxygen concentration and/or through engineering calculation);
- d) **Monitoring** of critical operating parameters for flows, pressures, pressure differences, and catalyst levels;
- e) Documentation of consequences of deviating from the **transient operation safe operating parameters** and of predetermined corrective actions; and
- f) Inclusion of the above items in the appropriate **FCC operator training** curricula

## 2018-02-I-WI-R13

Using API's processes to determine the appropriate safety product, **develop a publicly available technical publication for the safe operation of fluid catalytic cracking (FCC) units**. The document should be applicable to both new and existing units. Include the following topics at a minimum:

- a) Description of typical FCC unit hazards, including air leaks into hydrocarbon systems or hydrocarbon leaks into air systems that could form a flammable mixture during transient operation (startup, shutdown, standby, and the actions required to transition between these modes). If needed, include differences between possible reactor/regenerator configurations;
- b) Recommended practices for safeguards to control FCC unit hazards;
- c) Recommended monitoring for process safety during FCC unit transient operations;
- d) Recommended emergency operating procedures for FCC-specific scenarios;
- e) PHA guidance for key FCC-specific scenarios, including transient operation;
- f) Recommended FCC-specific field and board operator process safety training topics and methods;
- g) Guidelines for process safety assessments of FCC units; and
- h) Incorporate lessons learned from this CSB investigation and the CSB's ExxonMobil Torrance Refinery Electrostatic Precipitator Explosion investigation throughout the document and include references in the document's bibliography.





- 5:40 a.m.: Feed pulled
- Regenerator pressure maintained above reactor pressure almost the entire time
- Wet gas compressor running the entire time
- 10:00 a.m.: Explosion

*More timeline details in report incident description and appendix*

