FCC **Common Threads**

While all FCC units are unique, they do have a lot of things in common.

AFPM **Antitrust**

AFPM takes its antitrust compliance obligations seriously and our antitrust policy goes beyond the minimum requirements.

To ensure compliance with the antitrust laws and avoid any appearance of anticompetitive activity, every participant in AFPM meetings and AFPM activities must adhere to the AFPM antitrust guidelines.

As a general matter, the antitrust laws prohibit competitors from agreeing on the prices they will charge, the products they will offer, the customers they will serve, or the markets in which they will compete. Therefore, there should be no discussion or disclosure of information with respect to:

(a) expected profits, premiums, prices, surcharges, or discounts;

(b) specific customers or classes of customers, or whether you will or will not do business with them;

(c) proposed product offerings;

(d) allocation of geographic or product markets;

(e) any refusal to deal with a customer or supplier;

(f) how to deal with the market behavior of a competitor; or

(g) any other topic involving a potentially anticompetitive practice.

Practice Sharing Documents are meant to share information on process safety practices in order to help improve process safety performance and awareness throughout industry. The goal is to capture and share knowledge that could be used by other companies or sites when developing new process safety practices or improving existing ones. The Practice being shared has been used by an industry member, but this does not mean it should be used or that it will produce similar results at any other site. Rather, it is an option to consider when implementing or adjusting programs and practices at a site.

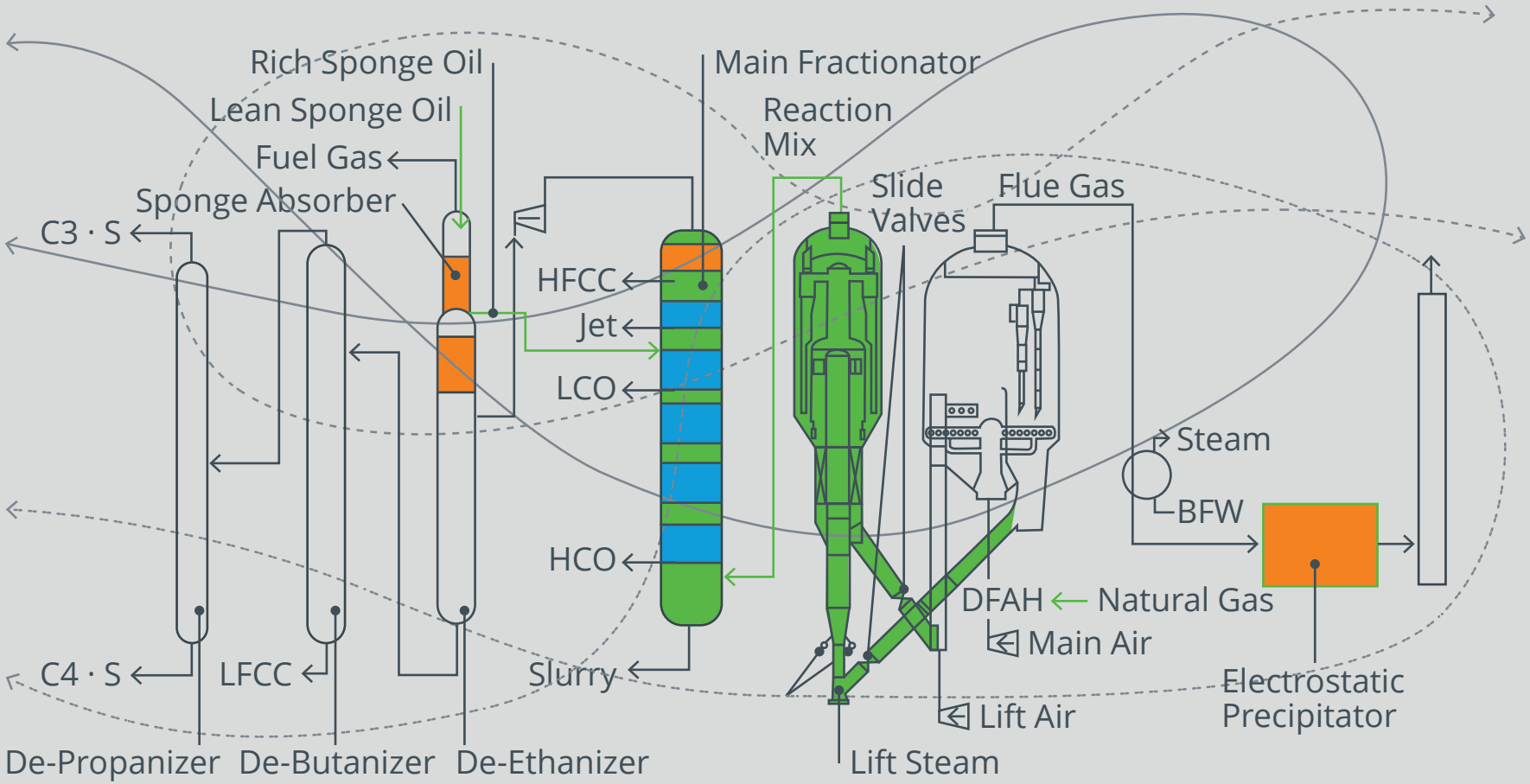
BY THEMSELVES, THE PRACTICE SHARING DOCUMENTS ARE NOT STANDARDS OR RECOMMENDED PRACTICES. THEY ARE NOT INTENDED TO REPLACE SOUND ENGINEERING JUDGMENT. THEY DO NOT PRECLUDE THE USE OF ALTERNATIVE METHODS THAT COMPLY WITH LEGAL REQUIREMENTS. A SUBJECT MATTER EXPERT SHOULD BE CONSULTED PRIOR TO DETERMINING WHETHER A PRACTICE SHARING DOCUMENT CAN BE USED IN ANY SPECIFIC SITUATION.

BY THEMSELVES, THESE DOCUMENTS ARE NOT STANDARDS OR RECOMMENDED PRACTICES. THEY ARE NOT INTENDED TO REPLACE SOUND ENGINEERING JUDGMENT. THEY DO NOT PRECLUDE THE USE OF ALTERNATIVE METHODS THAT COMPLY WITH LEGAL REQUIREMENTS. A SUBJECT MATTER EXPERT SHOULD BE CONSULTED PRIOR TO DETERMINING WHETHER A PRACTICE CAN BE USED IN ANY SPECIFIC SITUATION.

FCC
Common Threads

While no two FCCs are exactly the same, there are **common threads between all units.**

These threads can be traced back to the root causes of multiple events in the industry.



Air Sources	Hydrocarbon Sources	Ignition Sources
MAB	Feed, Torch Oil	ESP
Penthouse Purge	Frac/GRL/Relief	Airline Heater
Regen Air Purges	Rx Nat Gas Purges	Igniter
	DALH Nat Gas	Pyrophorics

Do not allow the hydrocarbon side to mix with the air side!

Exercise
What Do **All FCC Units Have in Common?**

Hydrocarbon and air are being continuously introduced into the process.

Air is introduced into the regenerator and hydrocarbon is fed into the reactor.

The two vessels are separated by maintaining a positive pressure differential across the slide valves.

Fluidized catalyst is continuously moving between the reactor and the regenerator.

Hydrocarbon leaving the reactor is above its autoignition temperature. The regenerator is a controlled burn.

During start-up, shutdown and any feed outage when catalyst is not circulating there is little or no fluidized catalyst "head" to build standpipe pressure.

If the unit trips, the reactor MUST be maintained as the high-pressure "inert" boundary between the hydrocarbon in the fractionator and the air in the regenerator.

Slide valves are not gas tight (cats are not seals).

Question:

Do you have other items that all FCCs have in common?

All Units Experience **Start-Up, Shutdown, and Standby** (aka Safe Park)

It is never an **emergency** to put or keep feed in the unit. Take the feed out and make sure the unit is **safe then proceed with a safe restart.**

FCC start-up and shutdown are a time of critical concern, when the risk of an incident is at its highest.

Torch oil and/or the DFAH will bring hydrocarbons into the “air side.”

While catalyst is not circulating, it is critical to keep sufficient steam in the riser and reactor to keep your reactor as the high-pressure barrier.

Maintain positive slide valve differential pressures during dry (steam) circulation to keep the reactor and regenerator separate

Air will be entrained with the circulating catalyst to the reactor. To ensure oxygen does not accumulate in the main fractionator overhead, the main fractionator purge allows oxygen to vent.

Standby Operation

High risk – multiple events have occurred when feed was out of the unit

Often referred to as "Safe Park" but there is nothing "safe" about it.

Standby Operation or "non-routine" operation are better terms to denote the separate Operating Mode.

Risks of Standby Operation

Unit is outside of normal operating envelope.

SIS is bypassed or already in the "trip" mode.

Alarm overload for board operators.

Control room distractions.

Occurs infrequently – site experience in these scenarios may be limited.

Primary Conditions Needed to be in Standby Operation

Feed bypassed from Riser

Main Fractionator is not isolated

Potential Variations

Catalyst Circulation · active/inactive

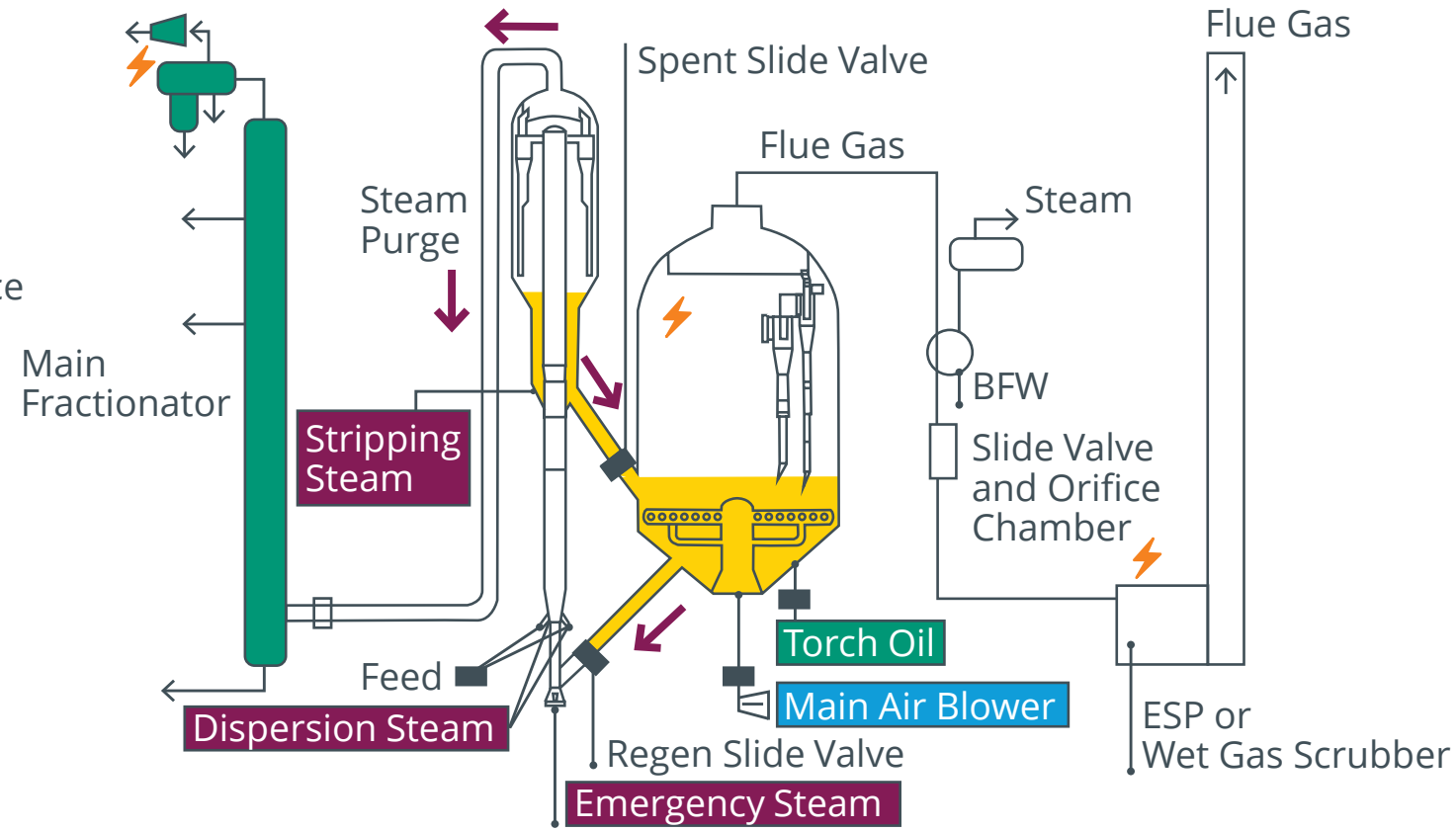
Wet Gas Compressor · running/idle

Torch oil/Air Heater · firing/idle

Main Air Blower · running/idle

Standby Operation Modes - Fully Slumped

No Combustion Air
Feed isolated
Main Fractionator not isolated from Reactor
Slide Valves closed
Main Air Blower down
Catalyst Inventory is in Regenerator or Hoppers



Main Hazards

Reverse Flow
Air Ingress
Oil Soaked Catalyst
Coke Steam Gasification

Standby Operation Modes - Partially Slumped

No Catalyst Circulation

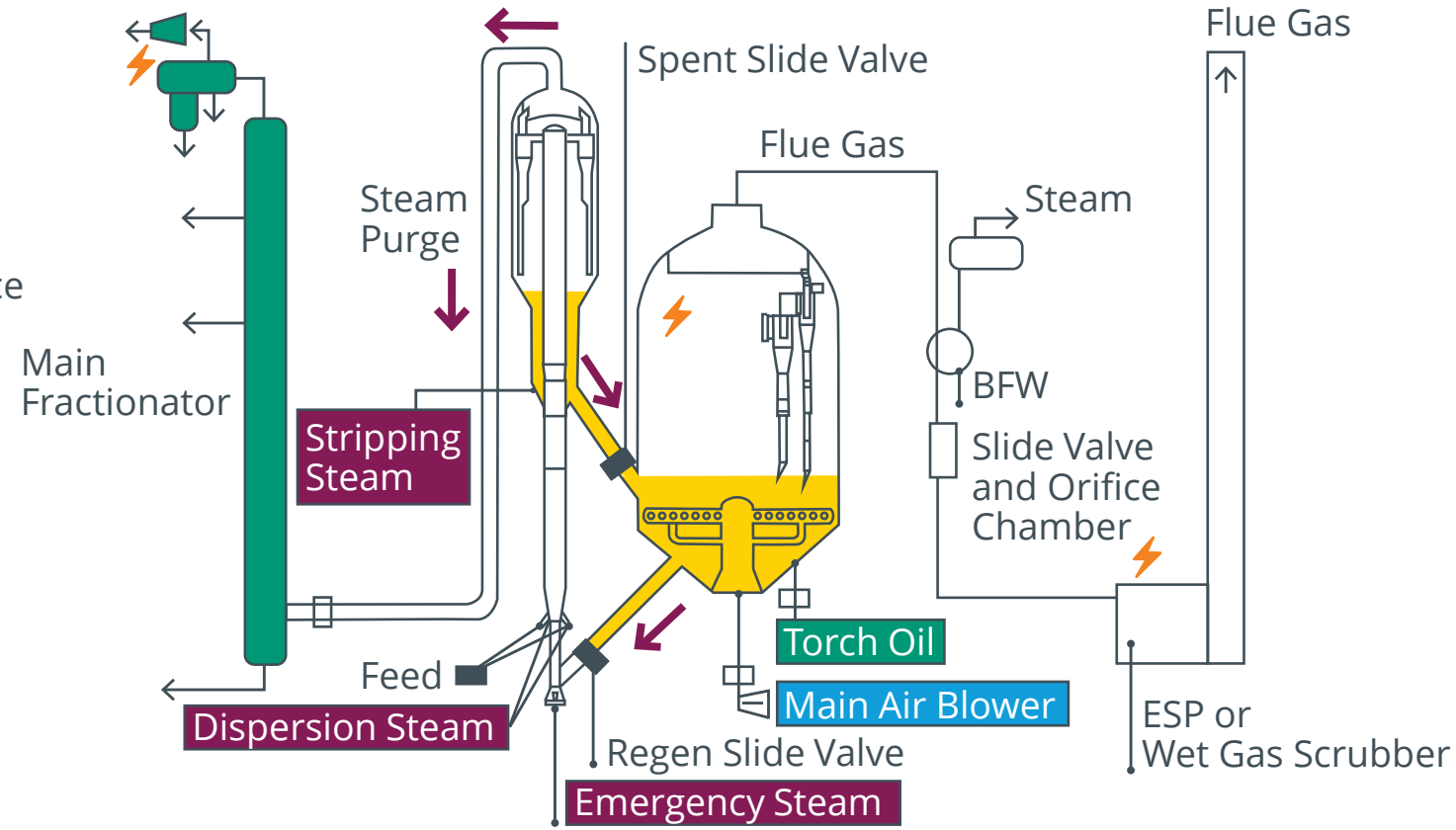
Feed isolated

Main Fractionator not isolated from Reactor

Slide Valves closed

Main Air Blower running

Air Heater and/or Torch Oil in use for regenerator temp control



Main Hazards

Reverse Flow

Air Ingress

Oil-Soaked Catalyst

Standby Operation Modes – Steam Circulation

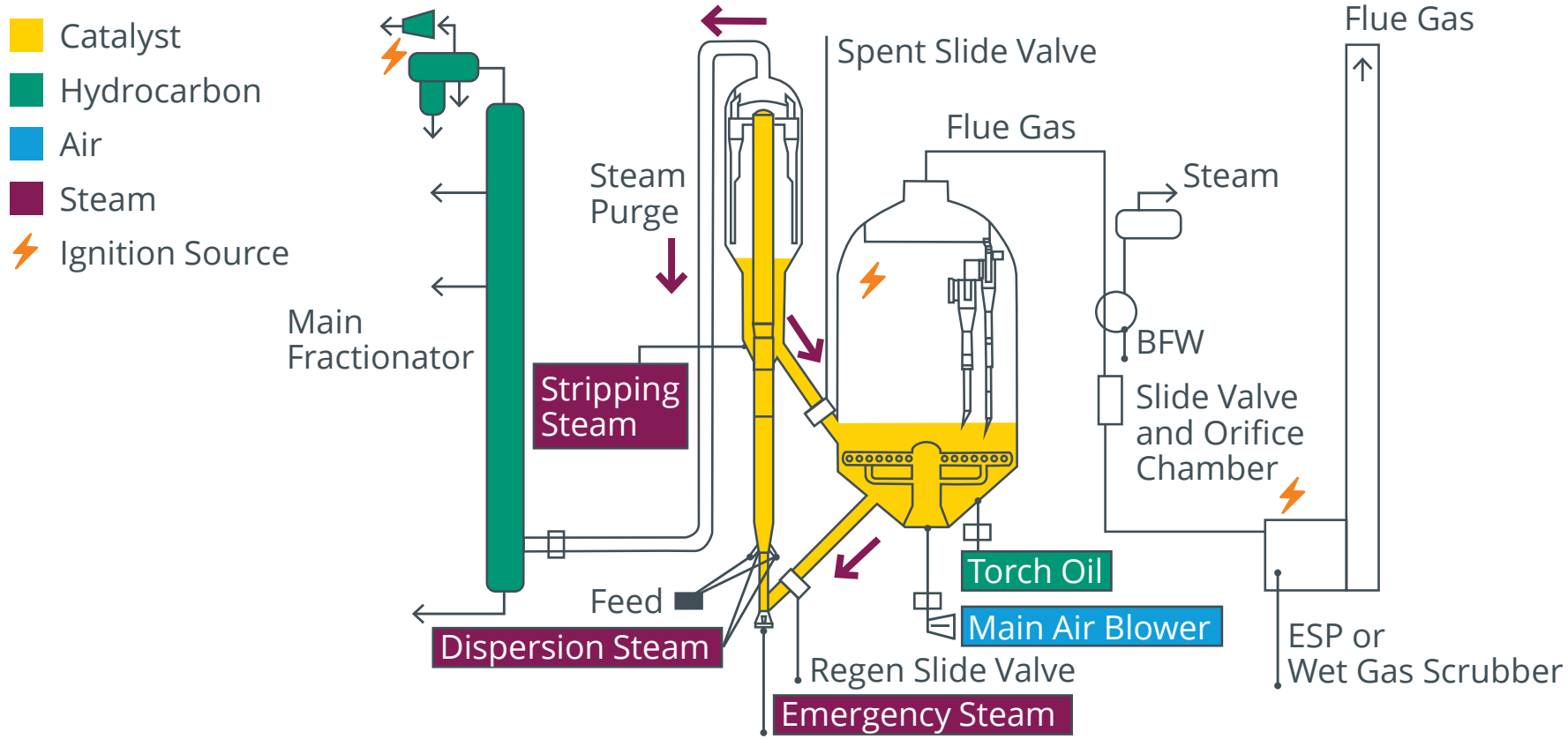
Feed isolated

Main Fractionator not isolated from Reactor

Slide Valves open

Main Air Blower running

Catalyst circulating slowly to maintain Reactor temp



Main Hazards

Reverse Flow

Oil Soaked Catalyst

Coke Steam Gasification

Key Takeaway

Remember the FCC Fire Triangle – **Keep things separated.**

Air

- MAB
- CAB
- Penthouse Purge
- Regen Air Purges
- Ambient Air

Ignition

- ESP
- Lit Torch
- Lit ALH
- Hot Catalyst
- Pyrophorics

Safeguards

- Catalyst Circulation
- Rx Pressure Barrier
- Steam and or N2 Purge
- Rx/ Regen Cat Level
- Slide Valve Maintenance
- Slide Valve dP and Position
- Slide Valve Leak-by Evaluation
- Fuel Gas Purge to Main Frac
- Main Frac Ovhd Oxygen Purge
- RMV-RMV Purge
- S/D WGC, MAB, or CAB
- Leak Response Protocol
- SIS, Alarms, Procedures
- Oxygen Testing
- CO Monitoring
- Training, PPE
- LEL Testing

Fuel

- CO
- Torch Oil
- ALH Nat Gas
- Rx Nat Gas Purges
- Feed
- Frac/GRU/Relief
- Fuel Gas to LCO Stripper/Main Frac
- Light Ends to Tankage
- Hydrogen from WGSR

FCC **Incidents**

GRU (De-Ethanizer and Sponge Absorber) **Explosion**

Unit is shutting down for a planned TA.

Wet gas compressor is running.

The regenerator is the high pressure point of the system and the MAB is running.

Air is carried into the main fractionator and is pumped into the sponge absorber.

Four hours after pulling feed, pyrophoric material ignites and an explosion occurs in the sponge absorber.

Debris from the absorber ruptures a nearby resid tank.

The leak occurs above the tank berm and the heavy oil is released into the refinery and catches fire.

Images taken from a CSB video.

GRU (De-ethanizer and Sponge Absorber) **Explosion**

Lessons Learned

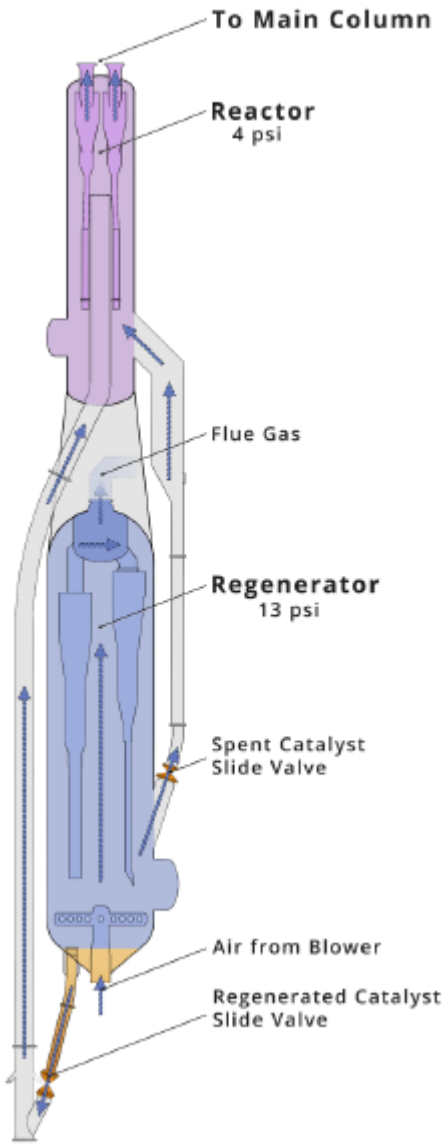
Maintaining the reactor as the high pressure point in the system.

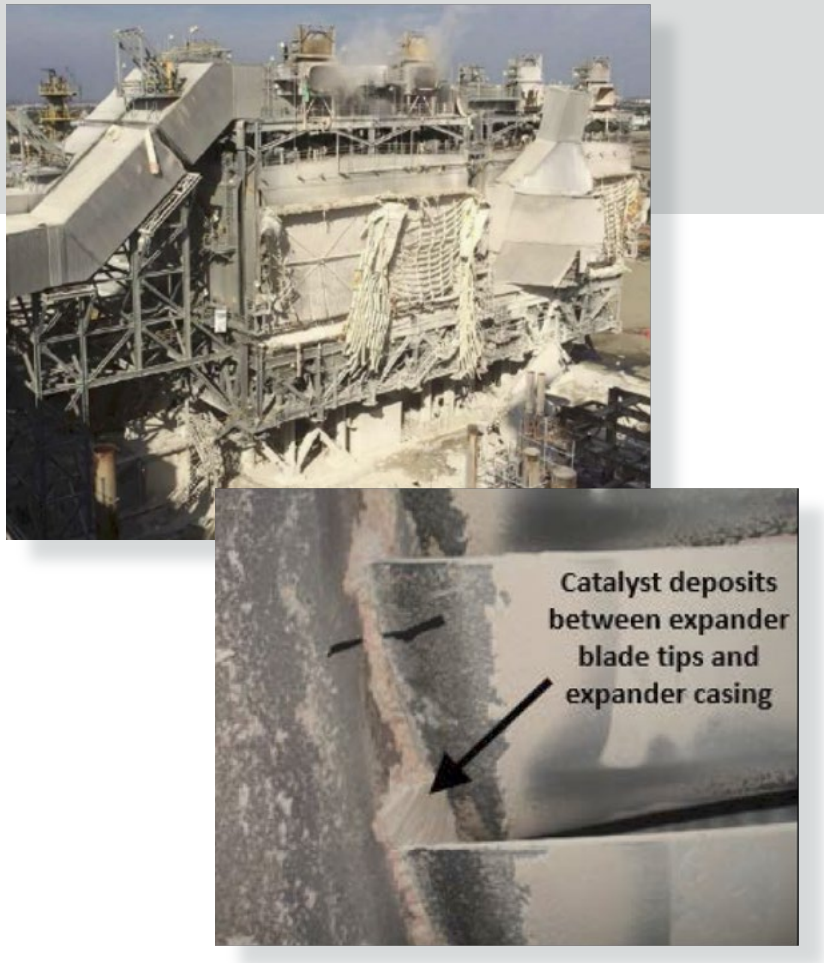
Reactor isolation valves can prevent this from occurring.

(comments?)

Full report at the CSB website

https://www.csb.gov/husky-energy-superior-refinery-explosion-and-fire





ESP Events

FCC Unit trips due to loss of main air. PRT turbine is suspected to be jammed.

Both slide valves are closed and Reactor is maintained under a steam atmosphere.

ESP is energized.

Reactor steam and pressure is reduced to allow the installation of a blind at the PRT.

ESP detonates.

Key Learnings

Deenergize the ESP unless the unit is running and stable. Note: there may be regulatory requirements associated with this – consult your legal.

ESP should be tripped on loss of air.

Maintain reactor under an inert atmosphere and as the high pressure point in the system.

CSB Torrance Link

ESP Events

Unit shut shutdown for tube leak on waste heat boiler.

MAB reduced to minimum speed due to lower regenerator pressure. There was concern of allowing air to get into the Reactor and Main Fractionator. ESP is online.

Hydrocarbon vapor travels from Main Fractionator to flue gas train. (MF is high pressure point in the system.)

ESP detonates when hydrocarbon vapors reach the ESP.

Key Learnings

Deenergize the ESP unless the unit is running and stable. Note: there may be regulatory requirements associated with this – consult your legal.

Maintain reactor under an inert atmosphere and as the high pressure point in the system.

ESP Events

Refinery-wide power spikes result in reduction of high-pressure steam.

MAB rate falls below the SIS trip and the unit is tripped to Safe Park 2. ESP does not have SIS trip.

Torch oil interlock works as intended and torch oil control valves are closed.

Torch oil is fed to the unit via the torch oil control valve bypass.

ESP detonates.

Key Learnings

Deenergize the ESP unless the unit is running and stable. Note: there may be regulatory requirements associated with this – consult your legal.

ESP should be tripped on loss of air.

SIS bypass valves should not be used to supply torch oil.

Main Fractionator Bottoms Fire · **Six Fatalities**

Unit is restarting following a planned TA.

During start up water can condense in the Main Fractionator and the bottoms system is flushed through the bottoms drum. Normally the water is drained through a valve on the bottom of the drum. The drum bottoms can be fed to the reactor and/or sent to product storage.

The block valve on the bottom of the drum is left in the closed position and it is assumed the drum contains a mixture of oil and water.

When the unit was coming up on rate and temperature, the valve to the drum was opened and hot oil contacted the water in the drum and the water flashed explosively and ruptured the drum. The oil ignited following failure of the drum and corresponding loss of containment.

Key Learnings

Drain all water from the system prior to heat up.

All low points must be verified as "dry."

GRU Explosion · **Seven Fatalities and 28 Injuries**

Rupture of 8-inch elbow located on the De-Propanizer Column Overhead piping system.

~20,000 lbs of LPG was released and the vapor cloud ignited.

Explosion demolished the nearby control room and toppled the Main Fractionator.

Failed elbow was located vertically downstream of an ammoniated water injection point; poorly dispersed water spray contacted the elbow in a cone shape; the spray interface became sufficiently acidic to promote localized corrosion along the outer edge of the cone contacting the elbow; localized grooving/ thinning took place, resulting in a large coupon blowout and the LPG release.

Key Learnings

Routine point UT measurements can miss localized corrosion. UT scanning, mapping and radiography provide a better assessment of the corrosion taking place and raises the assurance of identifying localized corrosion. Injection and mix point inspection practices and guidelines were updated accordingly.

The inspection data management system was modified to highlight monitoring points that diverged from the circuit-average corrosion rate.

New engineering standards were developed for the design of injection and corrosive mix points.

Catalyst Reversal Event

Key Events

Power “blip” resulted in total loss of power.

No SIS on loss of feed. Slide valves closed but were still in auto.

When pumps were restarted, feed and slurry recycle were fed to the reactor with no catalyst circulation.

No SIS on low reactor temperature.

Unclear if there was a reversal or un-vaporized feed was carried under.

Autoignition of hydrocarbons in stack.

Oil-Soaked Catalyst Events

Key Events

Feed introduced to the riser too quickly, causing the reactor overhead temperature to drop well below 900°F

Oil carry-under to the regenerator

Catalyst carryover to the Main Fractionator, causing an extended shutdown

Main Fractionator Bottoms

Main column bottoms pump fails on restart. The pump is isolated by closing the upstream and downstream gate valves.

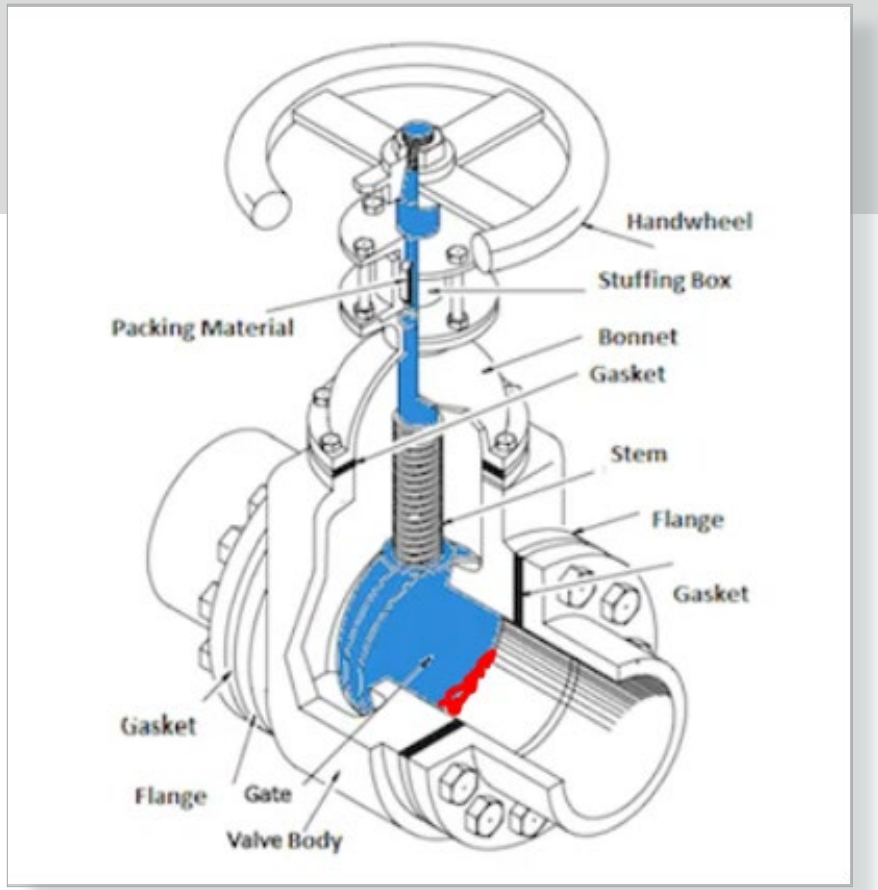
It was believed the pump was spinning backwards when it was restarted and the check valve downstream of the pump was suspected to be broken.

The cover of the check valve is removed and a slug of oil and catalyst is released followed by a large quantity of slurry oil, which then ignites.

Key Learnings

Gate valve stems should clearly indicate if the valve is properly closed.

Double block and bleed should be used to ensure there is no leak-by of the valves.



Exercise
FCCs in Jeopardy

Let’s start with a fun exercise to see how many FCC experts are present.

Take a Break...

- 7:30-8:00am **Arrival & Breakfast**
- 8:00-8:30am **Welcome & Intro**
- 8:30-9:00am **A Different Approach to an Old Problem**
- 9:00-10:00am **Common Threads**
- break
- 10:15-11:30am **Startup, Shutdown, Emergency Procedures · Exercise**
- lunch
- 12:30-1:30pm **Monitoring Transient Operations · Exercise**
- 1:30-2:30pm **Safety and Supporting Information · Exercise**
- break
- 2:45-3:45pm **Air & Hydro-carbon · Exercise**
- 3:45-4:30pm **Wrap Up & Path Forward · Exercise**