COMMUNITY ENERGY
reSOURCE

26 February 2021

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Attention: David Joe, Assistant Rule Development Manager

Supplemental Comment 3 Regarding Regulation 6, Rule 5: Particulate Emissions from Refinery Fluidized Catalytic Cracking (FCC) Units — Catastrophic Explosion Hazard

Mr. Broadbent,

This supplemental comment reasserts my 31 July 2020 comments regarding the need to eliminate a catastrophic explosion/fire hazard, the opportunity to do so in this rule, and the consequences of failure to eliminate this hazard,[1] and recommends further District analysis of these matters.

Using electrostatic precipitators (ESPs) to control FCC emissions creates a catastrophic explosion/fire hazard as an inherent feature of ESP design.[1] Your less protective emission control alternative is expected to result in use of ESPs. Your more protective emission control alternative is expected to result in wet scrubbing instead of ESPs use, which would eliminate this hazard. Despite current safeguards this hazard has caused $6.9 billion in economic damage and severe threats to the health of refinery workers and nearby communities.[1] The January 2021 Workshop Report acknowledges this hazard and lists these current safeguards,[2] but it does not disclose the need to eliminate this hazard, opportunity to do so in this rule, or consequences of failure to eliminate this hazard.

An ESP explosion that cost $6.9 billion would not have happened, had that refinery been required to use the best available retrofit control technology for air quality protection.

The more protective alternative is expected to result in a measure that would eliminate this specific hazard. California refinery process safety management policy defines a measure that eliminates a hazard as a "First Order Inherent Safety Measure."[3] This is the most effective type of measure in the state's Hierarchy of Hazard Control, which ranks "[h]azard prevention

[1] My 31 July 2020 comments and attachments thereto were provided to the District on that date and were entered into the formal record during this comment period at the 4 February 2021 Workshop.

[2] January 2021 Workshop Report for this proposed rule amendment ("Workshop Report") at 11.

[3] California Code of Regulations (CCR) § 5189.1 (c).

and control measures ... from most effective to least effective [as:] First Order Inherent Safety, Second Order Inherent Safety, and passive, active and procedural protection layers.”[3] Where, as here, inherent safety measures have been achieved in practice, state refinery safety policy requires analysis to, as a first priority: “Eliminate hazards to the greatest extent feasible using first order inherent safety measures.”[4] The Workshop Report does not disclose that.

Instead, the Workshop Report lists only safeguards against this hazard that refiners are using now: “Standard industry practices and vendor safety recommendations, including frequent inspection and maintenance, air filter cleaning, use of hydrocarbon sensors, and electronic controls for process automation ... .”[5] All of these currently used measures are ‘procedural’ or ‘active’ safeguards—the least effective types of measures in the hierarchy of hazard control.[6] The Workshop Report does not disclose that either.

Compounding these omissions, the Workshop Report prematurely concludes its incomplete discussion of this hazard with the misplaced assertion that “a number of standard industry and safety practices were not followed, contributing to the” ESP explosion in Torrance CA.[5] In fact, the difficulty and ultimate impossibility of following a standard practice or procedure exactly, every time, in real-world conditions, is the main reason why ‘procedural’ safeguards are the least effective of safety measures. Similarly, the all-too-frequent failures of electronic controls and other ‘active’ safeguards are the main reason why these are the next-least effective of safety measures. It is not wrong to say that failures of such safeguards contribute to an incident, but ending the discussion there elides the root causes of the incident which, if removed, would prevent the incident from recurring.

Here, a root cause is *the decision to continue using less effective safeguards alone instead of coupling them with an inherent safety measure that eliminates the specific hazard.* The Torrance ESP explosion would not have occurred had the refiner replaced its ESP with a wet scrubber. Reporting only contributing causes while omitting that crucial fact in discussing this proposal, which could replace ESPs with wet scrubbers, appears misleading.

The Air District Staff should consider revising its analysis of this hazard to be consistent with the Hierarchy of Hazard Controls Analysis required of refiners by California process safety management policy.[4] For this ESP explosion/fire hazard and inherent safety measure to replace ESPs with wet scrubbers, the staff report could: “Identify, analyze, and document relevant, publicly available information on inherent safety measures and safeguards ... [including] inherent safety measures and safeguards that have been ... achieved in practice ... [and

[4] CCR §§ 5189.1 (*l*) (4) (D) and (E).

[5] Workshop Report at 11.

[6] Procedural safeguards are policies, operating procedures, training, administrative checks, emergency response and other management approaches used to prevent incidents or to minimize the effects of an incident. Examples include hot work procedures and emergency response procedures. Active safeguards are controls, alarms, safety instrumented systems and mitigation systems that are used to detect and respond to deviations from normal process operations; for example, a pump that is shut off by a high-level switch. These rank last in effectiveness; *see* also Hierarchy of Hazard Control. CCR § 5189.1(c).

measures and safeguards that have been required or recommended] ... and develop written recommendations in the following sequence and priority order:

1. Eliminate hazards to the greatest extent feasible using first order inherent safety measures;
2. Reduce any remaining hazards to the greatest extent feasible using second order inherent safety measures;
3. Effectively reduce remaining risks using passive safeguards;
4. Effectively reduce remaining risks using active safeguards; and
5. Effectively reduce remaining risks using procedural safeguards."[7]

District Staff could use information from the work it has done and comment it has received on this rule to accomplish the first and most crucial step in such analysis. Staff also could review reports on recurrent FCC slide valve failures caused by damage mechanisms that remain unpredictable due to monitoring and inspection limitations[8] in assessing the relative ineffectiveness of such 'active' and 'procedural' safeguards.

Future ESP explosions could occur if the best available retrofit control technology is not required for air quality protection now.

Your agency has long recognized its responsibility for industrial safety in its rule-making,[9] and this proposed action will choose between an alternative which would eliminate a safety hazard and an alternative which would not. Moreover, since both alternatives would require emission control technology redesigns and investments, this choice could have long-lasting consequences. As the U.S. Chemical Safety and Hazard Investigation Board reports:

> "It is simpler, less expensive, and more effective to introduce inherently safer features during the design process of a facility rather than after the process is already operating. Process upgrades, rebuilds, and repairs are additional opportunities to implement inherent safety concepts."[10]

The District should view this choice as an opportunity—the alternative that eliminates the hazard better protects air quality and health—and should not duck its responsibility for safe rule-making. Adopting the less protective alternative would trigger redesigns and investments in ESP control technology which could be expected to operate for the life of the rule to meet its less protective emission limit. That would foreclose the opportunity to eliminate an ESP explosion hazard now *and* could further entrench a barrier to action by the District or others attempting to introduce this inherent safety measure in the future. The potential for its action on this rule to result in ESP explosion hazards in this way should be assessed in the District's analysis of the rule.

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[7] CCR §§ 5189.1 (*l*) (4) (D) and (E).

[8] See August 2018 and December 2018 factual investigative reports on the April 26, 2018 Husky Superior Refinery Explosion and Fire. US Chemical Safety and Hazard Investigation Board: Washington, D.C. Attached hereto as Supp. Att. 3-1. The CSB addresses, as well, the Torrance ESP explosion therein.

[9] See BAAQMD regulations, § 12-12-301 (exemption for refinery flaring caused by an emergency).

[10] CSB, 2013. *Interim Investigation Report, Chevron Richmond Refinery Fire;* US Chemical Safety and Hazard Investigation Board: Washington, D.C. See page 40.

Potential hazard impacts of the proposed action should be assessed for public review.

Omitting industrial hazard-related consequences of the District's choice between alternatives threatens to undercut its basis for action on this rule. First, the District identifies potential water supply impacts of the more protective alternative in its environmental analysis while dismissing potential explosion/fire impacts of the less protective alternative without rule-specific analysis. ESP explosion risks include flying shrapnel, fire, acute toxicity, episodic air pollution, serious injury and death. These potential impacts should be evaluated for public review.

Second, the Workshop Report estimates potential costs of the more protective alternative to refiners and (incorrectly) assumes job losses based on those costs, while ignoring far greater cost and job savings that this alternative could provide by avoiding the potential for ESP explosions over the rule's life. Avoiding an ESP explosion could save California's economy $6.9 billion and more than 8,000 jobs, according to analysis commissioned by the state that was provided to the District with my 31 July 2020 comments. Costs of this alternative to refiners are small compared with these potential savings—a fact that remains hidden from the public by omission from the Workshop Report. These potential cost-savings from the more protective alternative can, and should, be evaluated for public review to support District action on this rule.

In sum, a complete analysis of the need to eliminate this hazard, the opportunity to do so, and the consequences of failure to do so, is necessary to ensure that worker and community safety is addressed in your proposed action, and would further strengthen support for the more health-protective emission control action.

In Health,

Greg Karras
Community Energy reSource

Attachments: (1)

Supplemental Attachment 3–1

December 2018 Factual Investigative Update; and August 2018 Factual Investigative Update; April 26, 2018 Husky Superior Refinery Explosion and Fire. U.S. Chemical Safety and Hazard Investigation Board: Washington, D.C.

Suppplemental Comment 3 Regarding Regulation 6, Rule 5: Particulate Emissions from Refinery Fluidized Catalytic Cracking (FCC) Units—Catastophic Explosion Hazard

Community Energy reSource 26 February 2021

20 Years of Driving Chemical Safety Change 1998 2018

CSB

U.S. Chemical Safety and Hazard Investigation Board

Factual Investigative Update

April 26, 2018 Husky Superior Refinery Explosion and Fire

Figure 1. *Surveillance Camera Image of the Husky Superior Refinery Explosion. Credit: WDIO ABC News.*

December 2018

On April 26, 2018, an explosion (**Figure 1**) and subsequent fire (**Figure 2**) occurred at the Superior Refinery Company LLC refinery in Superior, Wisconsin ("Husky Superior Refinery").[1] The incident occurred in the refinery's Fluid Catalytic Cracking Unit (FCCU). As a result of the explosion, thirty-six people sought medical attention, including eleven refinery and contract workers who suffered OSHA recordable injuries. In addition, a portion of Superior,[2] Wisconsin was evacuated. Evidence collected to date suggests similarities with a previous investigation of the February 18, 2015 explosion at a refinery in Torrance, CA.

On Wednesday, February 18, 2015, an explosion occurred in the ExxonMobil Torrance, California refinery's Electrostatic Precipitator (ESP), a pollution control device in the FCCU that removes catalyst particles using charged plates that produce sparks during normal operation. The incident occurred when ExxonMobil was attempting to isolate equipment for unscheduled maintenance while the unit was in an idled mode of operation; preparations for the maintenance activity caused a pressure deviation that allowed hydrocarbons to backflow through the process and ignite in the ESP.[3]

Both the Superior and Torrance explosions resulted from the inadvertent mixing of hydrocarbons with air inside the unit that found an ignition source, resulting in an explosion. In the Torrance explosion, hydrocarbons flowed backward into the air side of the FCCU. In the Superior explosion, air flowed forward into the hydrocarbon side of the FCCU. In both cases, explosion debris impacted equipment in surrounding units and caused subsequent fires and releases to the atmosphere.

Both cases also resulted in an impact on the surrounding community. A portion of the Superior community was evacuated and in Torrance, FCCU catalyst dusted the nearby community.

Prior to both incidents, the process hazard analyses identified scenarios in which hydrocarbons flowed into the air side of the FCCU and vice versa due to a failure of the Spent Catalyst Slide Valve (SCSV), but the safeguards listed to protect against those

1 According to a Calumet filing with the U.S. Securities and Exchange Commission, Husky Superior Refining Holding Corp. acquired the Superior Refinery from Calumet (Calumet Refining, LLC) on November 8, 2017, 170 days before the April 26, 2018 incident. The Superior Refinery Company LLC is a wholly-owned subsidiary of Husky Superior Refining Holding Corp.

2 Superior, Wisconsin covers 45 square miles and has a population over 27,000.

3 In the Superior incident, the ESP had been shut down and was not involved in the explosion.

Figure 2. *Smoke from the Fire at the Husky Superior Refinery. Credit: WDIO ABC News.*

scenarios were ineffective. In Torrance, the ESP was protected from a flammable atmosphere igniting inside the ESP by carbon monoxide monitors that were blind to the hydrocarbons that eventually fueled the explosion. The Superior Refining Company considered a scenario initiated by the SCSV failing open and listed a separate control system as a safeguard. Because the SCSV was closed but had an erosion hole in the orifice port, the separate control system was ineffective at stopping the air migration into the hydrocarbon side of the FCCU which caused the explosion.

Both incidents also occurred while the FCCU was not in normal operation. The Superior incident occurred while the FCCU was being shutdown to enter a turnaround. The Torrance explosion occurred while the FCCU was in a standby mode of operation. One of the Key Lessons from the CSB's Torrance investigation stated: "It is important to consider all modes of operation-including non-routine operations such as unit standby-when performing process hazard analyses. Incident scenarios could be possible during non-routine modes of operations that may not have been considered when analyzing process hazards for normal, continuous operation."

Furthermore, both incidents occurred toward the end of an operating cycle. The Superior FCCU was shutting down for a turnaround after running since 2013, the last unit turnaround. The Torrance FCCU was nearing the end of an operating cycle and equipment had been in operation since either January 2009 or March 2010 when the February 2015 explosion occurred.[4] The CSB's Torrance investigation report noted: "It is essential to schedule and perform maintenance of safety-critical equipment so that the equipment is available to perform its safety-critical function."

Both incidents involved the company relying on a SCSV to maintain a barrier between the hydrocarbon and air sides of the FCCU during non-routine operation. The CSB has determined that the FCCU SCSV used at the Superior refinery was "designed for complete shut-off of flow" and that even though it was subject to erosion from the FCCU catalyst, it was intended to be "provided with erosion protection suitable for the design life at the design conditions." Despite this, the FCCU SCSV was unable to maintain a catalyst level to prevent air from mixing with hydrocarbons in the FCCU during the shut-down (**Figure 3**).

In its investigation of the Torrance incident, the CSB inspected the internal components of the SCSV. The inspection found the valve internals eroded to the point that the valve could not seal (**Figure 4**). An area of approximately 16 square inches eroded away during six years of operation, providing an open path for catalyst to flow through the valve even when in the fully closed position. The

4 The Torrance refinery had a scheduled turnaround for April 2009, but due to timing of other projects taking place in the FCCU, it was split into two turnarounds that took place in January 2009 and March 2010.

Figure 3. *The Husky Superior FCCU SCSV post-incident. The top picture shows the entire valve assembly and the bottom picture shows the eroded orifice port.*

erosion prevented the closed SCSV from developing the necessary catalyst barrier on the day of the incident.

Given the similarities between these two incidents, the CSB will be examining areas of further improvement that need to be taken by industry. It should be noted that as a result of the Torrance investigation, the CSB made a recommendation to American Fuel and Petrochemical Manufacturers (AFPM) to set up forums for its members to discuss the causal factors of this incident to prevent similar incidents. In a letter dated August 3, 2017, AFPM provided the CSB with dates of various forums in which fluid catalytic cracking unit engineers and other relevant personnel from AFPM member companies were invited to discuss the causal factors of the CSB's investigation report and

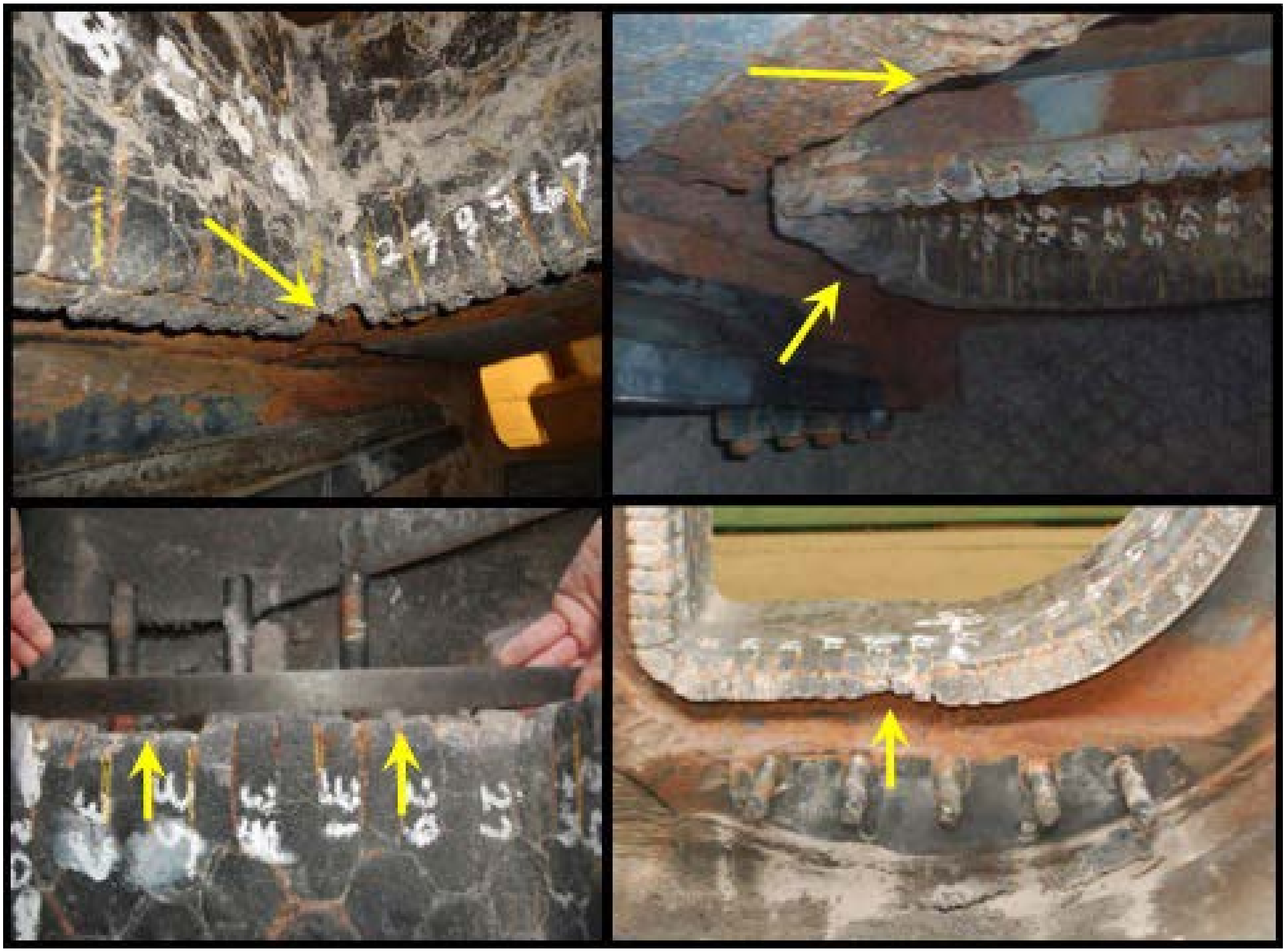

Figure 4. *Torrance Refinery SCSV post-incident. The yellow arrows show the erosion in the valve.*

encouraged to share topics such as design, maintenance, and procedural practices that can prevent a similar incident. As a result of these activities, the CSB voted to change the status of the recommendation to Close-Acceptable Action.

The CSB's Torrance investigation also recommended that the Torrance refinery make changes to the way safety critical equipment, such as the SCSV, was maintained and to ensure that there were operating procedures for each mode of operation. After the incident, the Torrance refinery stated that the refinery conducted a review of the FCCU safety critical devices and implemented the following:

- Identification of all safety critical equipment;
- Consequences of failure for each mode of operation;
- Evaluated and established parameters, limits, and associated equipment to ensure an appropriate steam-induced pressure barrier for FCC Emergency Shutdown and Safe Park procedures;
- Updated Emergency Shutdown and Safe Park procedures to address the loss of catalyst seal, loss of steam barrier, and failure of the ESP to de-energize; and
- Evaluated additional isolation facilities between the main column and the flue gas system.
- The Torrance refinery also formed a cross-functional team of experts and developed an FCCU Safe Park procedure and updated the FCCU Normal Shutdown, Emergency Shutdown, and Start-up procedures for the Torrance Refinery. The Torrance refinery reviewed areas of higher risk or with a higher vulnerability through an independent risk assessment to ensure that adequate layers of protection were in place during stand-by mode and other operation modes.

Factual Investigative Update

April 26, 2018 Husky Superior Refinery Explosion and Fire

Figure 1. *Surveillance Camera Image of the Husky Superior Refinery Explosion. Credit: WDIO ABC News.*

August 2018

On April 26, 2018, an explosion (Figure 1) and subsequent fire (Figure 2) occurred at the Superior Refinery Company LLC refinery in Superior, Wisconsin ("Husky Superior Refinery").[1] The incident occurred in the refinery's Fluid Catalytic Cracking Unit (FCCU). In preparation for the shutdown, the refinery brought in hundreds of contractors and increased operations staffing. The contractors were performing many tasks such as electrical work, preparing for chemical cleaning, building scaffolding, and welding. As a result of the explosion, thirty-six people sought medical attention, including eleven refinery and contract workers who suffered OSHA recordable injuries. In addition, a large portion of Superior,[2] Wisconsin was evacuated.

The explosion occurred around 10:00 am on April 26, 2018, while the refinery was shutting down the FCCU for periodic maintenance and inspection. The explosion occurred during a scheduled break time and many workers who were previously in the unit before the explosion had moved either into blast resistant buildings[3] or away from the process unit before the explosion occurred.

The FCCU uses heat and a small particle-size, solid catalyst to convert high molecular weight hydrocarbons into more valuable, lower molecular weight hydrocarbons.[4] The FCCU has three slide valves, the regenerated catalyst slide valve, spent catalyst slide valve, and a flue gas slide valve to, among other functions, control the flow of catalyst between the reactor (hydrocarbon-side) and the regenerator (air-side) of the FCCU.

The FCCU shutdown began when Husky Superior Refinery workers stopped the hydrocarbon feed to the FCCU at 5:40 am on April 26, 2018. After the feed was stopped, steam was used to clear the FCCU

1 According to a Calumet filing with the U.S. Securities and Exchange Commission, Husky Superior Refining Holding Corp. acquired the Superior Refinery from Calumet (Calumet Refining, LLC) on November 8, 2017, 170 days before the April 26, 2018 incident. The Superior Refinery Company LLC is a wholly-owned subsidiary of Husky Superior Refining Holding Corp.

2 Superior, Wisconsin covers 45 square miles and has a population over 27,000.

3 The CSB's investigation report into the 2005 BP America Refinery Explosion discussed the importance of the use of blast resistant buildings. This report can be found here.

4 The CSB described a FCCU in both its investigation report and its animation of the 2015 explosion at the ExxonMobil refinery in Torrance, California. Among other free online resources, the OSHA Technical Manual provides a description of Petroleum Refining Processes that includes a FCCU discussion in Section IV (F). In addition, some readers may find this API Fluid Catalytic Cracking Unit video to be a helpful overview of a general refinery FCCU process.

Figure 2. *Smoke from the Fire at the Husky Superior Refinery. Credit: WDIO ABC News.*

reactor of hydrocarbons and the regenerated catalyst and spent catalyst slide valves were closed as part of the shutdown procedure.

In all modes of FCCU operation, it is important to prevent air in the regenerator from mixing with hydrocarbons in the reactor and downstream equipment because of the potential for such mixing to create flammable (explosive) hazard conditions within portions of the FCCU. During normal operation this is achieved, in part, by using the slide valves to maintain a catalyst level in both the reactor and regenerator which acts as a barrier.

A differential pressure instrument continually measured the difference in pressure from directly above the spent catalyst slide valve to the regenerator pressure. During the shutdown, a positive differential pressure indicated that the pressure above the spent catalyst slide valve was greater than the regenerator pressure, and that no air was flowing from the regenerator into the reactor.[5] A negative differential pressure, on the other hand, could indicate conditions allowing air to flow from the regenerator through the spent catalyst slide valve and into downstream equipment. This instrumentation, however, would have reported any negative differential pressures as zero because its lower limit was zero, and it was not configured to show negative differential pressures.

The Husky Superior Refinery's FCCU shutdown procedure specified that the unit "may have to have some catalyst in the reactor stripper to hold a seal across the spent [catalyst] slide valve." At times during the shutdown, conditions existed that could have allowed air from the regenerator to flow backwards through the spent catalyst slide valve into the reactor, and into equipment downstream of the reactor which contained flammable hydrocarbons.

Process data indicated that the spent catalyst slide valve was closed about 10 minutes into the shutdown and the reactor catalyst level fell to zero about 30 minutes after operators stopped the feed. Post-incident inspection showed that a catalyst level was not present above the spent catalyst slide valve. Disassembly and evaluation of the spent catalyst slide valve revealed internal wear that could have allowed catalyst flow through the valve even when the valve was in the closed position. The differential pressure across the spent catalyst slide valve was zero for about 10 percent of the time between the beginning of the shutdown at 5:40 am and the incident at about 10:00 am, indicating that air flow from the regenerator into the reactor and downstream equipment was possible.

Iron sulfide deposits can exist inside FCCU equipment. The Husky Superior Refinery's FCCU training manual states that, "The danger of iron sulfide exists in its 'pyrophoric' properties, that is to say,

5 If no catalyst barrier is present above the spent catalyst slide valve, positive differential pressure could indicate conditions allowing hydrocarbon flow into the regenerator and downstream equipment, where air is present.

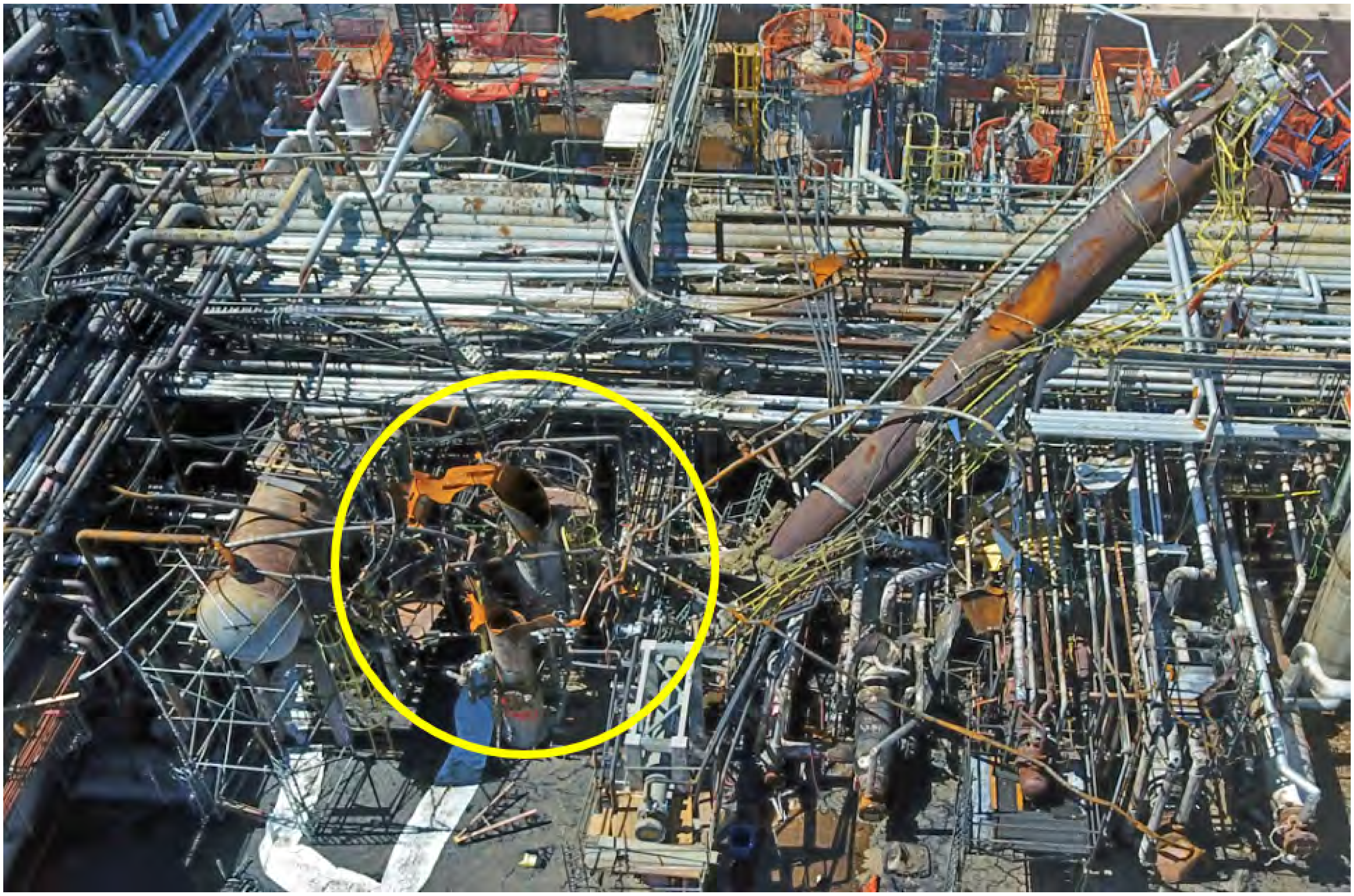

Figure 3. *Two of the Vessels Destroyed in the Explosion at the Husky Superior Refinery (yellow circle). The photo shows that only the bottom portion of the two process vessels remained after the explosion. The remaining portions of the vessels were blown into surrounding units of the refinery. Credit: Husky Superior Refinery.*

it will ignite spontaneously when exposed to air." The Husky Superior Refinery planned to treat its FCCU equipment susceptible to containing iron sulfide with a chemical to mitigate iron sulfide deposits after shutting down the unit. Because these procedures had not been implemented at the time of the explosion, however, iron sulfide deposits were not yet treated and could provide a source of ignition if exposed to air.

Two FCCU vessels,[6] the primary absorber[7] and sponge absorber[8] (Figure 3), were destroyed in the explosion. The primary and sponge absorbers serve to recover heavy hydrocarbons[9] from a gas stream by mixing the gas stream with a liquid stream that absorbs the heavy hydrocarbons.

Debris from the explosion flew about 200 feet, and impacted a large, nearby, aboveground storage tank containing about 50,000 barrels of asphalt, puncturing the side of the steel tank and spilling over 15,000 barrels of hot asphalt into the refinery (Figure 4). This released asphalt ignited about two hours after the explosion, creating a large fire.

A Unified Command was set up to address the situation at the Husky Superior Refinery in accordance with National Incident Management System (NIMS) practice. Operations for the incident command included emergency responders from the Husky Superior Refinery's emer-

6 The two vessels are part of the gas concentration unit, which is a subset of what the Husky Superior Refinery records refer to as the FCCU.

7 The dimensions of the primary absorber were 36 inches (internal diameter) by 69.5 feet tall. The vessel had a maximum allowable working pressure of 250 pounds per square inch at 150 °F. The primary absorber was constructed in 1961 using SA-212-B steel and the vessel was not stress relieved.

8 The dimensions of the sponge absorber were 30 inches (internal diameter) by 48 feet tall. The vessel had a maximum allowable working pressure of 250 pounds per square inch at 150 °F. The sponge absorber was constructed in 1961 using SA-201-A steel and the vessel was not stress relieved.

9 The liquid phase recovers gases heavier than propane from the vapor phase.

Figure 4. *Post-incident photographs of the leaking Asphalt Storage Tank. Debris from the explosion punctured the side wall of the tank creating a large asphalt leak outside of the secondary containment area. Credit: CSB (left) Duluth News Tribune (right).*

gency response team supported by the Superior Fire Department.

Around 12:15 pm the spilled asphalt ignited, creating a large fire spanning multiple units at the refinery. Because this fire risked compromising other process equipment containing hazardous chemicals, the Unified Command issued its first community evacuation notice at 1:00 pm. By 2:41 pm, the evacuation zone consisted of a 3-mile radius around the refinery, and a 10-mile rectangle extending south from the refinery (Figure 5). The evacuation zone size was established to protect the public from the smoke plume and as a precaution in case the refinery's highly toxic hydrofluoric acid equipment was compromised.[10]

Firefighters extinguished the asphalt fire at the refinery by 9:00 pm. The Unified Command then lifted the evacuation zone the next morning at 6:00 am.

The CSB investigation is ongoing. Investigators continue to collect data and evidence from the site. Investigators will develop a root cause analysis of this incident based on 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.

10 The Husky Superior Refinery uses hydrofluoric acid in its alkylation unit. The hydrofluoric acid storage tank is located about 150 feet from the primary and sponge absorbers that exploded. Neither the hydrofluoric acid tank nor the water curtain equipment surrounding the hydrofluoric acid tank, used to provide water suppression in the event of an acid leak, were impacted by explosion debris.

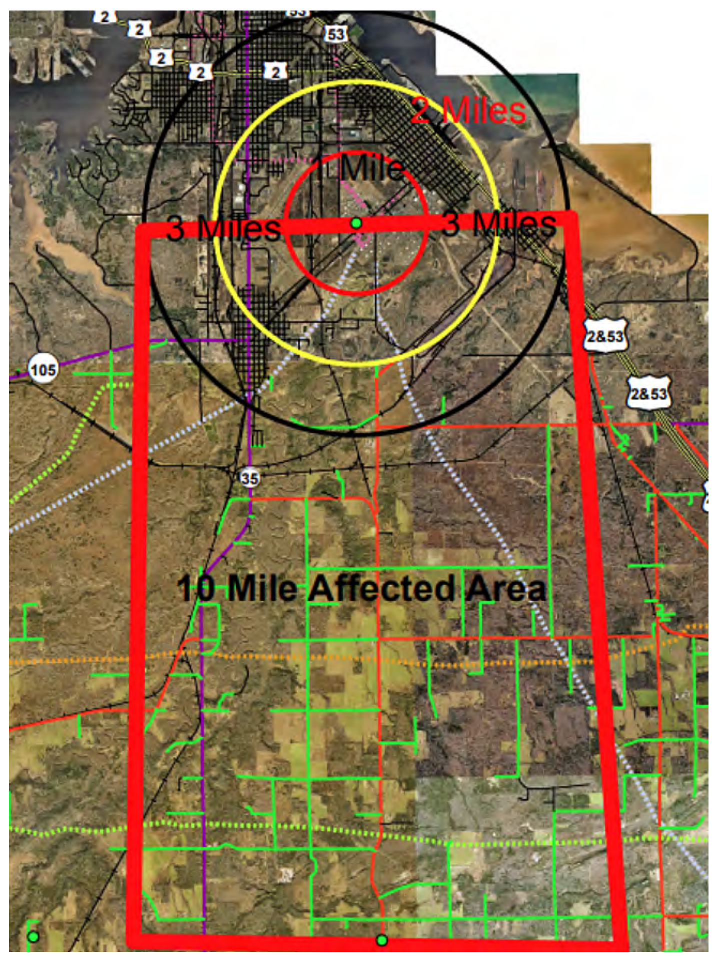

Figure 5. *Evacuation Zone on April 26, 2018. Credit: Douglas County, Wisconsin.*