PRACTICE SHARING

FCC PHA Scenario Reference List

Purpose and Use:

The purpose of this document is to share the practice of using a scenario reference list to prompt Process Hazards Analysis (PHA) teams to examine incident scenarios applicable to Fluidized Catalytic Cracking (FCC) units. This List, while not taking the place of any PHA documents can be used as a reference to help ensure all potential issues applicable to an FCC unit are addressed. The scenario reference list shared in this practice may be used during the PHA in any way that the team finds to be convenient. Adjustments may be needed based on the PHA methodology used, as well as the company risk philosophy.

The intended audience for this practice share is anyone leading or participating in a PHA of an FCC unit, including Process Safety, Operations, Process Design, Environmental, and Engineering representatives.

Disclaimer:

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.

Scope:

This Practice Share document applies to FCC units of any configuration. It may be used during the formal PHA typically conducted on a 5-year interval but may also be useful when evaluating Management of Change packages of significance. The checklist provided in this practice sharing document covers scenarios unique to FCC technology as well as others of a more general nature that are also applicable to FCC units. The checklist is segmented by General, Feed System, Reactor/Regenerator, Flue Gas System, Standpipes and Expansion Joints, Standpipe Slide Valves, Main Fractionator, Gas Recovery Unit (GRU), and Wet Gas Compressor/Main Air Blower/Power Recovery Turbine sections.

Description and Implementation:

This document shares a checklist useful to prompt PHA teams to examine potential LOC incident scenarios applicable to FCC units. The checklist does not replace the PHA methodology in use by the team. The checklist shared in this practice may be used during the PHA in any way that the team finds to be convenient. The checklist is segmented by unit system for ease of use by the PHA team. The PHA team may find it convenient to use the reference list immediately after the normal PHA methodology for the applicable section of the unit to prompt consideration/reconsideration of the preventive and/or mitigative measures in place. Users of the reference list may find it useful to populate the list of scenarios with dates when related incidents have occurred. This is particularly useful if details, such as the absence and/or failure of preventive/mitigative measures, of those scenarios are available to prompt further discussion.

The list of potential scenarios or scenario initiators is provided below. Once the PHA team determines that the scenario or scenario initiator is valid it would go on to determine the potential consequences.

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General

- Water cooler tube leak (downstream of Wet Gas Compressor)
- Backflow of hydrocarbon into utility systems
- Inadvertent trip of the Emergency or Safety Shutdown System
- Failure of the Safety Shutdown system to function as designed during startup or at other times – shutdown valves fail to close
- Loss of utilities, e.g., power, instrument air, steam, and nitrogen
- Loss of DCS control or view
- Failure to reset all the permissives for an SIS (Safety Instrumented System) reset

Feed System

- Excessive corrosive contaminants in feed
- Loss of feed
- Excessive water in feed
- Light hydrocarbon in feed
- Feed control valve fails open
- Feed Furnace Tube Failure
- Furnace Explosion
- Concarbon (CCR) of the feed stream outside acceptable range

Reactor/Regenerator

- Excessive coke or accumulation of hydrocarbons in the regenerator
- Liquid hydrocarbon to airline heater
- Airline heater flameout
- Opening reactor or regenerator with combustible material present
- Wet catalyst to hot regenerator
- Water in emergency steam lines due to malfunctioning steam traps
- Excessive regenerator catalyst carryover to flue gas system or fractionator
- Air entering the reactor and / or fractionator (flow reversal)
- Hydrocarbon entering regenerator (flow reversal)
- Reaction mix line, Reactor, or Fractionation vessel leak due to refractory failure. Manway leaks in Reactor, Regenerator or Fractionation systems
- Reactor overhead line plugging
- Excessive coking in riser leading to a loss of circulation and slide valve differential pressures
- Overheating of reactor exceeding design temp
- Overheating of regenerator exceeding design temp
- Over pressure of reactor exceeding design pressure
- Over pressure of regenerator exceeding design pressure
- Excessive catalyst carryover from reactor to the main fractionator
- Torch oil does not ignite upon introduction. This could be due to insufficient temperature, composition outside flammable limits, faulty ignitor, etc.
- Reintroducing air to the regenerator (upon a trip) when the regenerator contains flammable hydrocarbon
- Feed leaking to the riser during standby operation, significant temp excursion when circulation is initiated leads to exceedance of equipment design temps, significant internal damage
- Torch oil leaking by to the regenerator during standby or introduced with insufficient air/temperature/catalyst level.
- Instrument taps plugged causing bad level readings
- Reverse flow upon failure of Main Air Blower (MAB) check valve to close in case of MAB failure
- Use of torch oil for regen heat-up during startup or during low coke operation, with some torch oil nozzles blocked, results in maldistribution of torch oil injection leading to areas of excess oxygen and areas of oxygen deficiency, resulting in significant afterburn and equipment damage. The blockages could be due to either the closure of manual valves, if provided, or to coking of the nozzles
- Airline heater in operation, blower trips, and fuel injection continues, possibly due to an unrevealed failure of the cut-out valve
- Insulation over cold wall vessel (with internal refractory) leads to significant design temp exceedance, bulge formation and potential leak

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- Transfer line gets plugged, try to unplug with steam, results in overpressure, significant catalyst leak, and exposure of personnel in area
- High catalyst losses from reactor to main fractionator (carryover, high attrition, etc.) leads to erosion of bottoms circuit, loss of containment, potential fire
- Loss of purge gas to instrumentation taps (Pressure, Temperature)

Flue Gas System

- Failure of Butterfly valves
- Failure of internal or external insulation
- Blockage in wet gas scrubber venturi chamber backs water to CO boiler, back-pressuring system and potentially causing a leak of high CO gas from the boiler
- Expander failure (blade failure, coupling failure leading to overspeed, turbine inlet control system failure, etc.)
- High CO to ESP and risk of ignition (i.e., loss of forced draft air fans, carbon build incident overwhelms boiler)
- Leak in aqueous or anhydrous ammonia system for the SCR or thermal deNOx facilities
- Excessive catalyst carryover to the flue gas scrubber

Flue Gas & Catalyst Cooler

- Flue Gas Cooler Tube Failure
- Catalyst cooler tube failure
- Overfill flue gas boiler, catalyst cooler or fractionator steam generators
- Loss of water spray for flue gas line off Regenerator

ESP, SCR, and CO Boiler

- Flammable mixture present in CO Boiler and SCR when soot blowers actuate on auto-cycle
- ESP detonation or accumulation of an explosive mixture of hydrocarbon or CO and air while the ESP is energized
- Loss of boiler feedwater to cat cooler or CO boiler
- Bogging in CO boiler
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Standpipes and Expansion Joints

- Regen Catalyst Standpipe Expansion joint failure
- Spent Catalyst Standpipe Expansion joint failure
- Cat cooler standpipe expansion joint failure
- Air blower discharge expansion joint failure
- Flue gas expansion joint failure

Standpipe Slide Valve

- Regenerated Catalyst Slide Valve (RCSV) malfunctions – fail to open, close, actuate
- Spent Catalyst Slide Valve (SCSV) malfunctions – fail to open, close, actuate
- Slide valve disc or orifice erosion leading to passing

Main Fractionator (MF)

- Excessive catalyst carryover to fractionator
- Fire in packed fractionators
- Heat exchanger flash fire
- Refluxing water in fractionator
- Water left in fractionator pump-arounds and bottoms system and dead legs
- Bottoms circuit exchanger tube failure and steam generator tube leak
- Fractionator plugging due to salt deposits or rapid corrosion under salt deposits
- Excessive Fractionator bottoms systems coking / fouling
- High rundown product temperatures
- Loss of liquid levels, blow through of vapor to tankage
- High liquid levels in Main Fractionator bottoms
- Overfill of MF overhead accumulator
- Release of hydrocarbon, risk to personnel from steam/vapors/flash fire during changeout of reaction mix blind

- Cladding failure in MF results in corrosion
- High temperature in the MF bottom from loss of slurry pumps/slurry pump arounds
- Oxygen from the MF overhead to the flare header via Pressure Controller during hot standby
- Corrosion on the low points/dead legs on the MF overhead piping system
- During testing of pilot operated Safety Valves (SV) relieving to the atmosphere on the MF, operator or tech inadvertently closes the N_2 purge to sensing line, resulting in SV lifting. This creates the potential light-off of the release due to static electricity resulting in exposure of operator to high thermal radiation levels if not sufficiently remote from the relief point
- Loss of pumparound flow on MF leads to dry-out and significant safety valve load, and/or significant design temp exceedance and damage to fractionator
- Main frac overhead accumulator water overfilling during S/U causing reactor pressure excursion
- High ash in bottoms circuit resulting in erosion/corrosion, loss of containment
- Materials specification or quality control for piping and/or pipe welds in bottoms circuit inappropriate for conditions (temperature, sulfur, etc.), resulting in excessive corrosion and loss of containment
- High temperature sulfidation corrosion in MF bottoms circuit leads to loss of containment / pool fire
- Ammonium chloride salts and under-deposit corrosion on MF overhead exchangers leads to leak of high H2S gas
- Reduction in feed sulfur to nitrogen ratio (i.e., gofiner catalyst change) leads to high pH in overhead sour water, resulting in carbonate stress corrosion cracking of non-post weld heat treated welds, leading to significant leak
- MF overhead condensers fouling

Gas Recovery Unit (GRU)

- High liquid level in distillation columns, vessels, and relief drums
- Liquid Petroleum Gas (LPG), light hydrocarbon release
- LPG blow through to gasoline tank
- Miscellaneous GRU issues including corrosion and cracking issues

Wet Gas Compressor / Main Air Blower / Power Recovery Turbine

- Liquid carryover into Wet Gas Compressor (WGC) suction
- Wet Gas Compressor discharge check valve or non-return valve fails
- Malfunction of WGC spill back controllers
- Steam driven turbine failure or damage
- Failure of Main Air Blower (MAB) discharge check valve
- Power Recovery Turbine (PRT) Expander Blade Failure
- PRT Expander Coupling Failure
- High Oxygen (O_2) level in WGC suction leading to fire/explosion in WGC
- “Surge stress” immediately upon an air diversion to the regenerator (air blower in total blow off)
- Main air blower anti-surge valve fails open
- WGC anti-surge valve fails open
- Enriched O_2 supply to regenerator fails open
- WGC trip leads to MF safety valves lifting. If to atmosphere, leads to rainout of flammable material and ignition
- Inadequate quality and quantity of water wash to remove salts in WGC train leads to accelerated corrosion, leak of high H2S gas
- Air blower surface condenser loses vacuum

Each of the scenarios in the reference list is known to have occurred at an FCC facility, while some have occurred multiple times.

References:
None

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AFPM American Fuel & Petrochemical Manufacturers

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Revision	Date	Summary of Changes
Initial Draft	April 2022	Initial Version
Revision	May 2022	HIPS Review
Revision	August 2022	PSW Review
Legal Review	August 2022	AFPM Legal Review
Final	August 2022	Published

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