
Question 3: What process safety (PSM) factors do you consider when contemplating a reformer unit rate increase?

HUTCHINSON (Axens North America)

Any change should be handled through the MOC (management of change) process, according to OSHA 1910.119: Process Safety Management of Highly Hazardous Chemicals. This standard includes requirements for preventing or minimizing the consequences of catastrophic releases that may result in toxic, fire, or explosion hazards. For refiners, the MOC process should include considerations for a number of factors mentioned in this standard, including a rate change. The relief system design and basis must be updated to consider the new unit rate, along with the impact on the flare system. The relief valves will need to be re-rated or replaced based on the appropriate cases including settling out pressure, blocked outlet, and loss of reflux. Note that changes in reboiler duties will impact the relieving cases as well.

A HAZOP (Hazard and Operability) study will need to be performed. The unit PSM (Process Safety Management) information will need to be updated, including material and energy balances. The impact on the unit hydraulics should also be evaluated to determine if vibration issues might result in equipment such as piping, heat exchangers, and heater tubes, especially in cases where you have two-phase flow. The impact on corrosion rates must be reviewed, and the inspection schedule should be updated. Safe upper and lower operating limits for temperature, pressure, flow, or composition should be updated, along with safety systems, such as interlocks and alarms. Additionally, operating procedures must be updated to reflect the new operating limits and any required changes resulting from the increased rate.

RHODES (Marathon Petroleum Company)

For reformers, the reactor heater is typically one of the limits. As the unit increases rates, heater limits –such as duty, tube wall temperature, or fuel gas pressure –will potentially force the unit to operate lower reactor temperatures, resulting in lower octane. The limits for the heater should be identified and monitored. The debutanizer reboiler will also need to have heater duty, firebox, and fuel gas pressure limits established prior to any rate increase.

An increased feed rate will also have an impact on coke make on catalyst. The regenerator coke-burn capacity needs to be reviewed to ensure that carbon can be maintained at a reasonable level. Ability to recycle hydrogen may become limited, which will reduce the hydrogen-to-hydrocarbon ratio. This hydrogen-to-hydrocarbon ratio will impact the amount of coke made, but it will also push the unit toward heater tube ID (inner diameter) carburization; and ultimately, to metal dusting. Sulfur injection is used to mitigate that situation. Heater tubes should be checked for carburization during TAR (turnaround) windows.

While not a PSM concern, catalyst pinning in the lead reactor can also be an issue as rate is increased

in stacked reactor designs. The licenser pinning curves should be reviewed as rates are increased. Pinning can lead to shorter run lengths and unit outages to remove the plug gage from the reactor's center screen. Pinning occurs when the gas flow rate across a radial bed is able to stop catalyst from flowing down the reactor by gravity and press the catalyst against the center screen, which causes the catalyst to get stuck in the center screen. Pinning causes high pressure drop, leading to rates restriction or reactor damage until a unit outage is scheduled to clean the screen.

Chloride guard bed performance will need to be monitored. At higher rates, there will be more hydrogen flow carrying more pounds of chloride for the beds to absorb. For the net gas chloride guard, the upstream separator's ability to prevent liquid carryover will also decrease. Any liquid carryover will impact chloride guard bed performance.

For CCR (continuous catalyst regeneration) units, increasing feed rate does not necessarily mean catalyst circulation will increase beyond the original design of the regenerator. It will mean that the average catalyst circulation rates will potentially increase, and this increased catalyst flow could cause more erosion on the lift lines. Proper lift-gas flow and frequency of inspection monitoring should be reviewed at the time of rate increase.

Establishing PSM rate limits for all of the process units and documenting the procedure for increasing these PSM rates limits are good practices. Prior to any rate increase, the unit should be reviewed to guarantee that all relief valves are adequately sized for the projected rate increase. It is also recommended that the Environmental team review and approve the PSM rate increase to confirm that any emissions from the increase are properly permitted. All affected heater limits should also be identified.

A test run is recommended to ensure that all operational or reliability issues are identified. A robust test run plan assists in determining the new PSM rate and should include the following processes:

Identify existing equipment limits that must be honored during the test.

Review critical alarm settings and instrumentation to address any instruments that may need to be re-ranged.

Identify any control valve that may require bypassing, special samples requirements, and unique equipment monitoring, as well as any product specifications that may need to be waived.

Conduct a Management of Change (MOC) review.

Prior to the test run, gather a baseline including a complete mass balance, survey of vibration data for rotating equipment, and review of the spring-can positions throughout the unit.

Schedule additional Operations staff to assist during the actual test run.

Slowly increase rate within the unit until an equipment limit is reached or the desired PSM rate limit is obtained.

Allow the unit to come to steady-state and conduct a pressure and temperature survey.

Obtain mass balance samples.

Assign Reliability department personnel to check the vibration levels on the rotating equipment and all of the spring-can positions in the unit to ensure that no piping circuits are placed in a strained condition.

Capture or document all control valves outputs, along with a list of any control valves that were bypassed during the test run.

Following the test run, conduct a comprehensive review of the unit to analyze areas that can lead to operating or reliability issues.

Calculate line velocities on the key piping circuits. Establish velocity guidelines for the various piping systems and flow regimes. Any circuits with high velocity must be addressed before the PSM rate is increased.

Check V^2 (Ro-velocity squared) checked for all vessel nozzles. A limit of 10,000 lbs./fps² [pounds per (feet per second) squared] is an absolute limit while any nozzles with V^2 above 4,000 lbs./fps² are selected for routine inspection.

Check vessel capacity for residence time to ensure that it is adequate to provide operator response time.

Check all pumps are to ensure that all of the NPSH (net positive suction head) available meets the pump NPSH requirements at their projected flow rates.

Issue a report that includes all of the information reviewed and a list of recommendations to be completed prior to increasing a unit's PSM rate limit. As those recommendations are completed, the original MOC is completed, and the unit is allowed to operate at the new PSM rate limit.

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