



Leader in Cyclone Design | Specialist in Fluid Bed Applications

Case Study: Erosion on Cyclone System

EMTROL-BUELL
A CECO ENVIRONMENTAL BRAND

PRESENTED BY CECO ENVIRONMENTAL AT THE BARRACUDA VIRTUAL REACTOR USERS' CONFERENCE 2026



Emtrol-Buell a CECO Environmental Brand

Established in 2014 - CECO combined Emtrol & Buell

- Headquartered in Addision
- Buell founded in 1934
 - Pioneer of modern axial cyclones
 - Acquired by CECO in 2008
- Emtrol founded in 1973
 - Acquired by CECO in 2014
- Largest install-base of FCC cyclone systems in the world

CECO Environmental Corp.

- Headquartered in Addision
- Publicly Traded Company on NASDAQ as “CECO”
- Providing solutions to complex environmental issues
 - Focus on air and water quality

CORE TECHNOLOGY

Cyclone Design and Supply, including:

- Cyclone System Process Design
- Mechanical Design
- Specialized, Quality Fabrication
- Engineering Services
- Advisory and Inspection Services

ADDITIONAL OFFERINGS

Ancillary Equipment Detailed Design & Supply

- Vessels & Vessel Heads
- Risers
- Air Grids & Steam Rings

SERVICES

- Cyclone system troubleshooting
- Inspection
- FEA using Ansys Mechanical
 - Stress analysis
 - Thermal expansion
- CFD studies in partnership with CFPD software

Case Study Overview

Cyclone Reliability Improvement Study

As part of a cyclone system replacement project, which included:

- Redesign for cyclone system performance optimization
- Modernized design for best mechanical design and manufacturing processes

Address historic erosion issues

- Erosion on external cyclone surfaces due to catalyst laden gas impact
- Optimize cyclone design features to reduce impact
- Add refractory in strategic regions to mitigate erosion

Approach to the Study

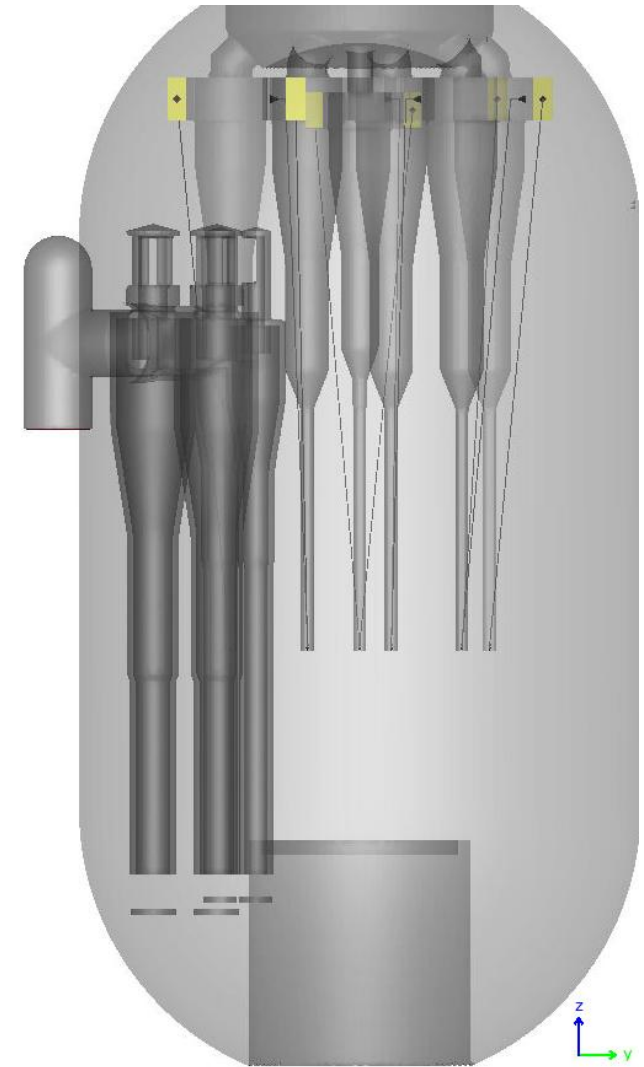
- Compare existing cyclone system with proposed new system
- Use historic erosion data to “calibrate” the existing system

Unit Features

Fluid Catalyst Cracking Unit Reactor

Design Features

- Large diameter reactor
- Dual side risers
- Open-couple internal cyclone system
 - riser, riser cyclones direct coupled to each riser
 - Gas outlet tubes discharge in reactor dilute phase
 - Diplegs discharge in reactor dense phase
 - Upper cyclones
 - Gas outlet tubes discharge into internal plenum
 - Diplegs discharge in reactor dilute phase



Existing Cyclone System

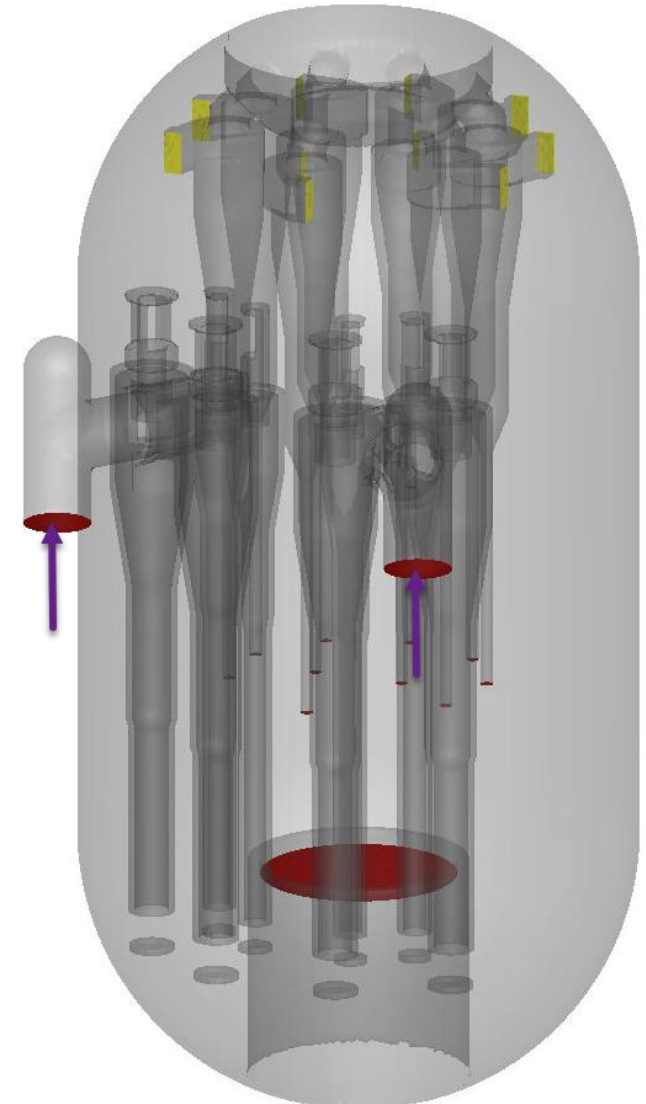
CFD Study Objectives

Investigate overall reactor hydrodynamics and erosion performance of existing reactor cyclone system.

- Validate CFD-predicted erosion patterns against available commercial data and observations.

Investigate the effect of proposed riser and upper cyclone changes on erosion patterns and hydrodynamic behaviors.

- Quantify any differences observed in hydrodynamic flow behavior and erosion in the riser and secondary cyclones.



Existing Cyclone System

Model Setup

General Assumptions:

- Wall thickness in the rough-cut cyclones is increased to 5” in order to achieve a reasonable number of computational cells.
- Flow volume inside the cyclones is maintained as per the drawings, and wall thickness is in the outward direction.
- Upper cyclones are included as voids in the fluid domain. Blocks are added to the inlet horn (shown to the right) to align the inlet boundary along the x, y, and z cartesian axes.
 - Blocks added for modeling feasibility.
 - Cyclone inlet area is maintained at the pressure boundaries
- A portion of the stripper is included in the 3D CAD model with catalyst and entrained vapors flowing outward from the domain.
- Distributor nozzles in the reactor/stripper well are not currently included in the supply steam based on feedback from CECO.
- Only the riser blind Tee is included to capture the effect of the bend on the gas and catalyst flow.

Model Setup

General Assumptions:

- Internal flow patterns of the upper cyclones are not included in the simulation. Upper cyclone inlet ducts are treated as outputs from the domain.
 - A collection efficiency of 100% is assumed for the secondary cyclones.
 - All particles entering secondary cyclones are collected and returned to the domain via the appropriate Dipleg.
 - Any observed distribution of solids, vapor, and individual upper cyclone dust loadings will be exported from the CPFDD model
- The Stripper section is simplified and modeled as an outflow for the catalyst such that the initial bed mass is always constant.
- Distributor nozzles are currently not modeled for fluidization steam. A uniform flow boundary is assumed
- A typical FCC catalyst was used in the simulations.
 - Sauter Mean Diameter: 64 μm
- No heat transfer is considered, and the reactor is maintained isothermal
- Flow through risers is considered to be equal

Erosion Calculations in Barracuda

Based on particle-wall collisions

Function of particle mass, speed, and impact angle

Calculates total particle impacts on selected area

Erosion is mainly driven by particle mass and velocity

Angular dependence: Highly dependent on the property of the wall material and region of interest for estimating erosion

Barracuda Impact calculations:

$$I = \frac{\sum_p C_\alpha m_p^{1.5} v_p^{3.5}}{AT}$$

I = Erosion Index

C_α = Angle Weighting Factor

m_p = Mass of particle

v_p = Particle velocity

A = Area

T = time

Design Features

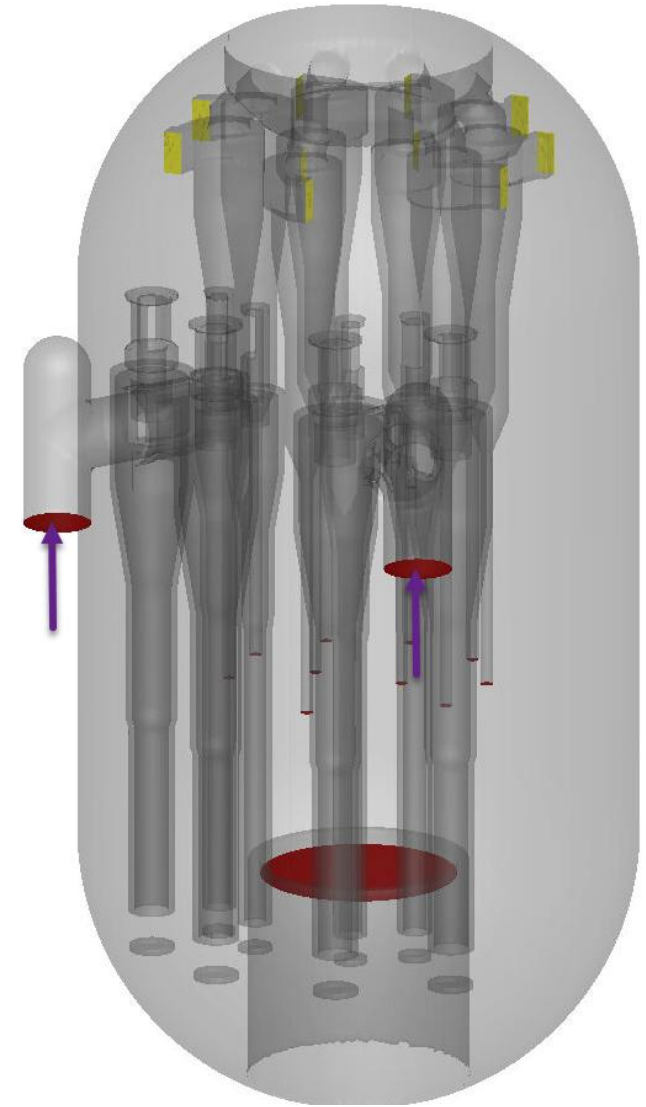
Areas of focus during the study include:

Riser cyclone gas outlet tube deflectors

- Design validation for optimized flow into the reactor

External surfaces of riser & upper cyclones

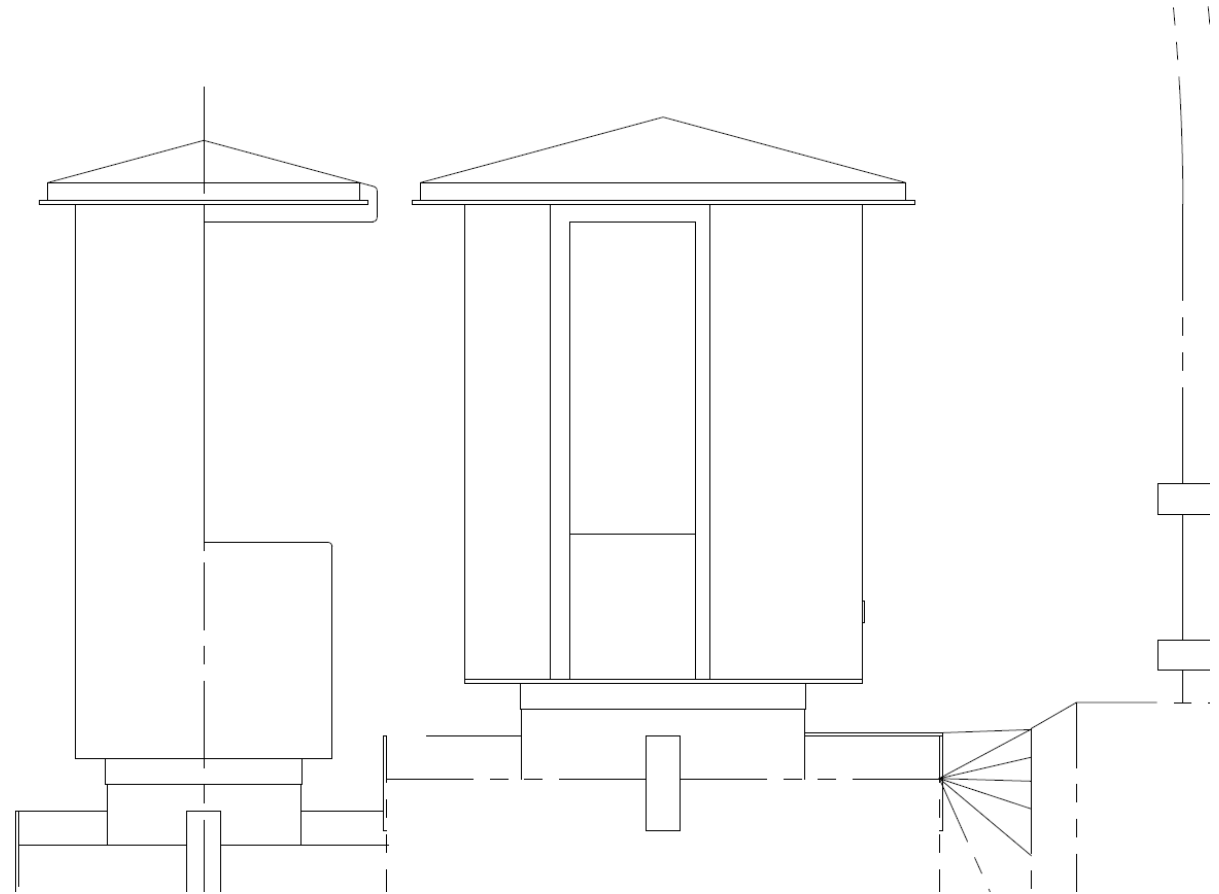
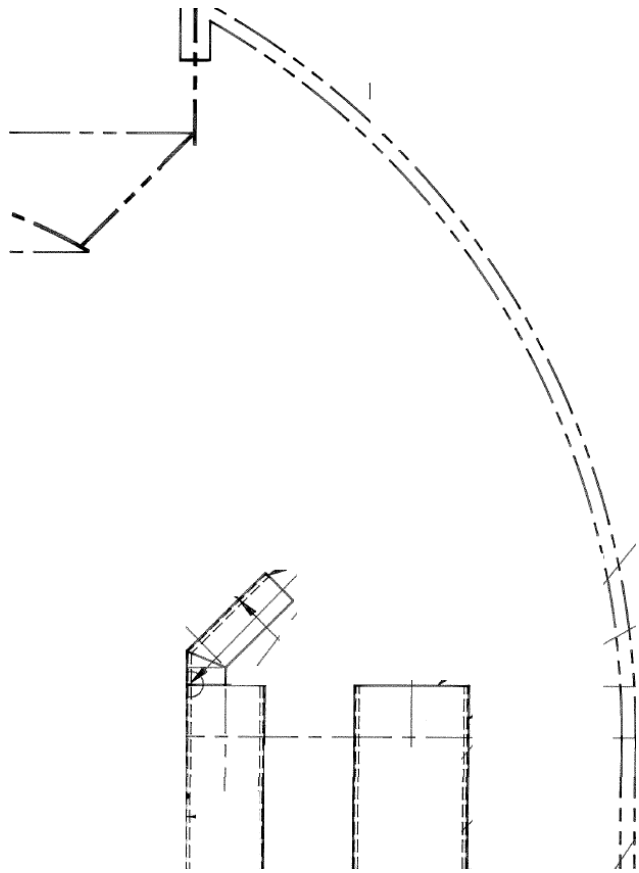
- Determine where refractory installation is required to mitigate erosion



Existing Cyclone System

Existing System

Multiple design revisions to mitigate significant erosion

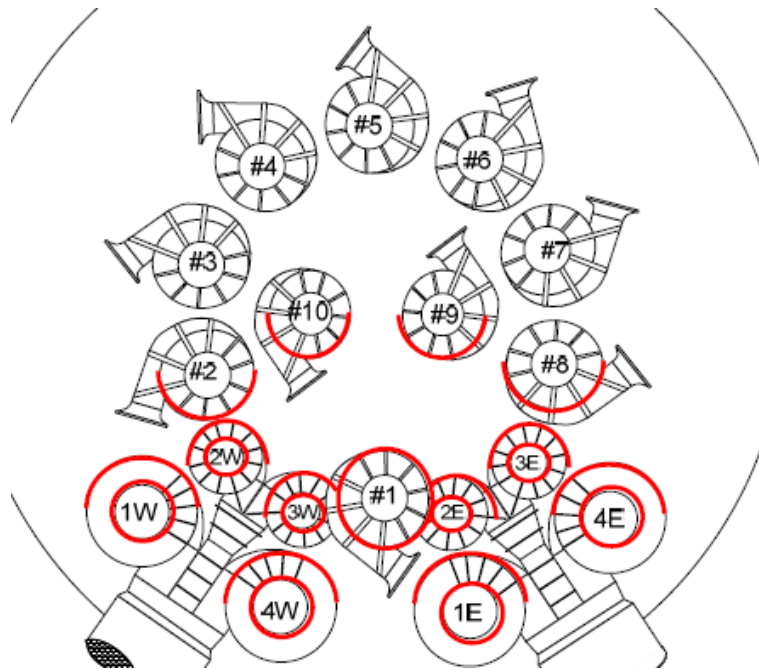


Existing System

Erosion on external surfaces of cyclones

Significant effect on riser cyclones and

50% of upper cyclones



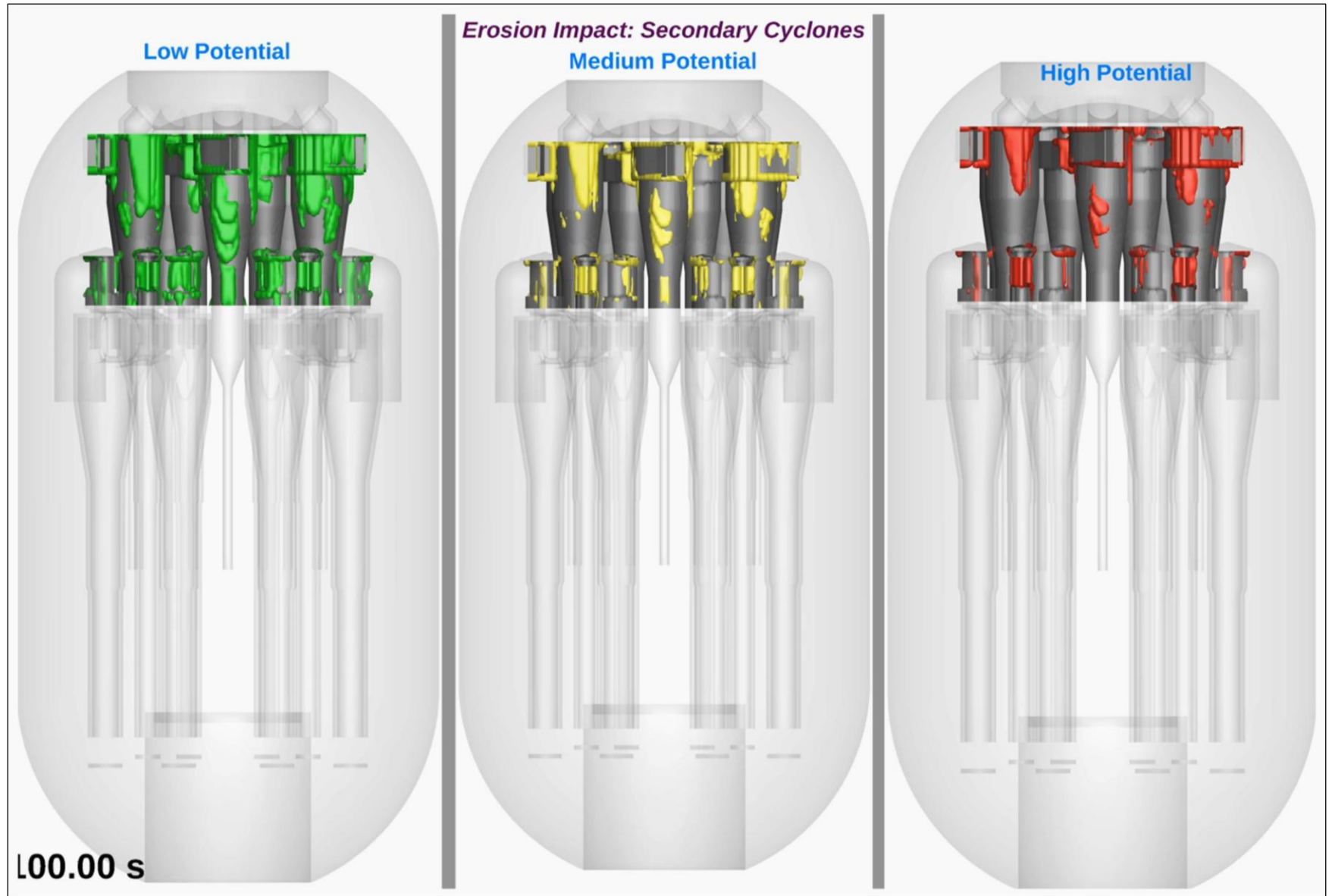
Reported by Operator

Findings:

- Higher erosion potential in the riser cyclone deflectors due to the high velocity of the catalyst and vapor exiting through the outlet of the cyclones.
 - Flow visualization shown in the subsequent slides shows the flow path.
- The erosion potential on the secondary cyclones (1, 2, 8) is closest to the risers.
- Outlet flow exits the risers like a jet and impinges on the secondary cyclones closest to the outlets.
- Erosion potential is observed on the outer secondary cyclones (5), likely caused by the higher velocity distribution across the reactor wall.

Existing System

Secondary Cyclone External Erosion

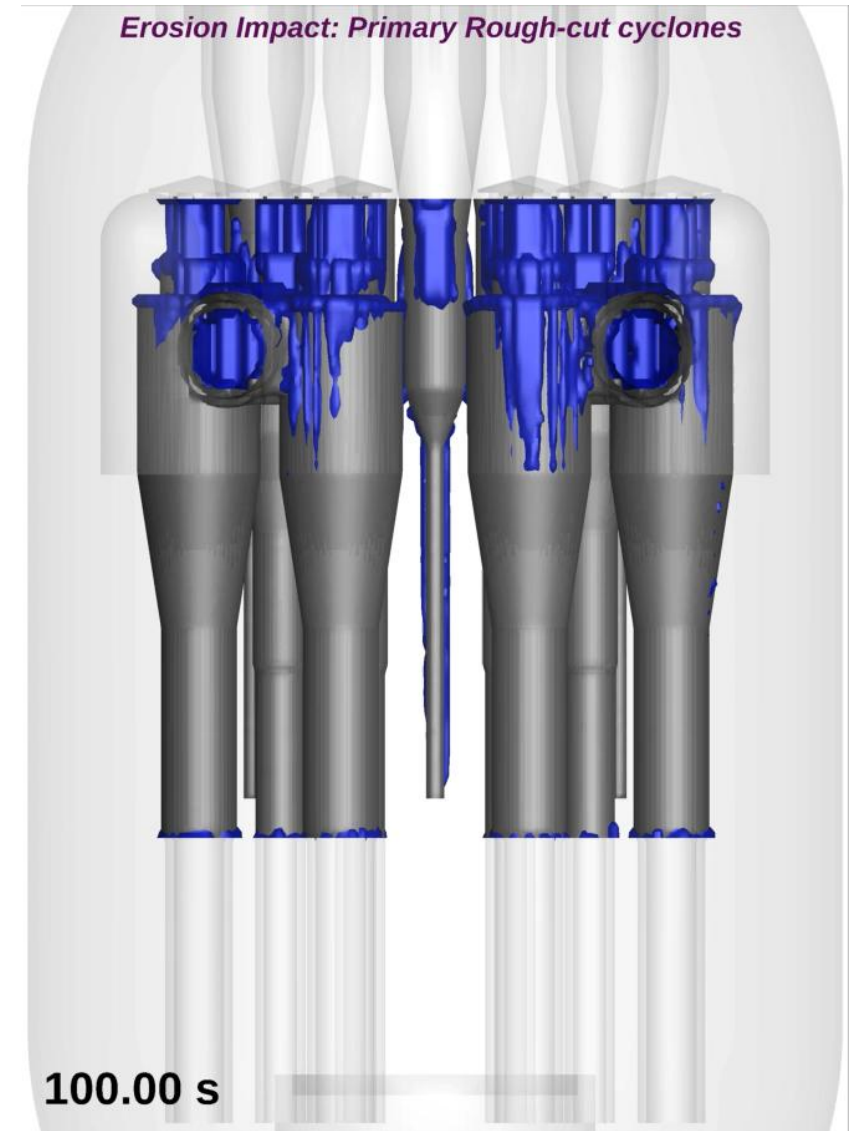


Existing System

Riser Cyclone External Erosion

Observations:

- Higher erosion potential regions are highlighted in the animation.
- The simulation does not show a high variance for erosion potential on the primary rough cuts. Hence, a single erosion potential level is shown in the animation.
- The turbulent nature of vapor and catalyst flow inside the reactor primarily drives the catalyst impact on the wall.
- The source of turbulence appears to be the high velocity of vapor and catalyst flowing from the riser outlets.
- Erosion appears to be caused by a combination of recirculation of catalyst and vapor in the freeboard and recirculation from the Dipleg.

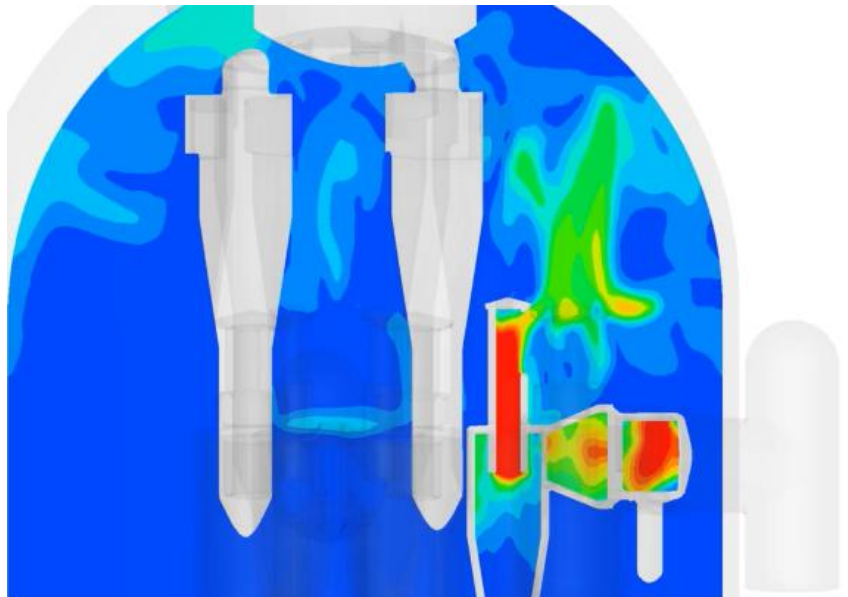


Existing System – Flow

Observations:

- Higher vapor and catalyst velocities (~150 fps) through the outlets impinge on the deflector and are redirected toward the reactor wall and the nearest secondary cyclones.
- Vapor and catalyst flow around the reactor circumference and impinge on the secondary cyclones with relatively higher velocities.
- Higher velocity distribution in the freeboard at elevations above the riser outlets indicates that most of the outlet flow is circulating in this region and impinging on the secondary cyclones.

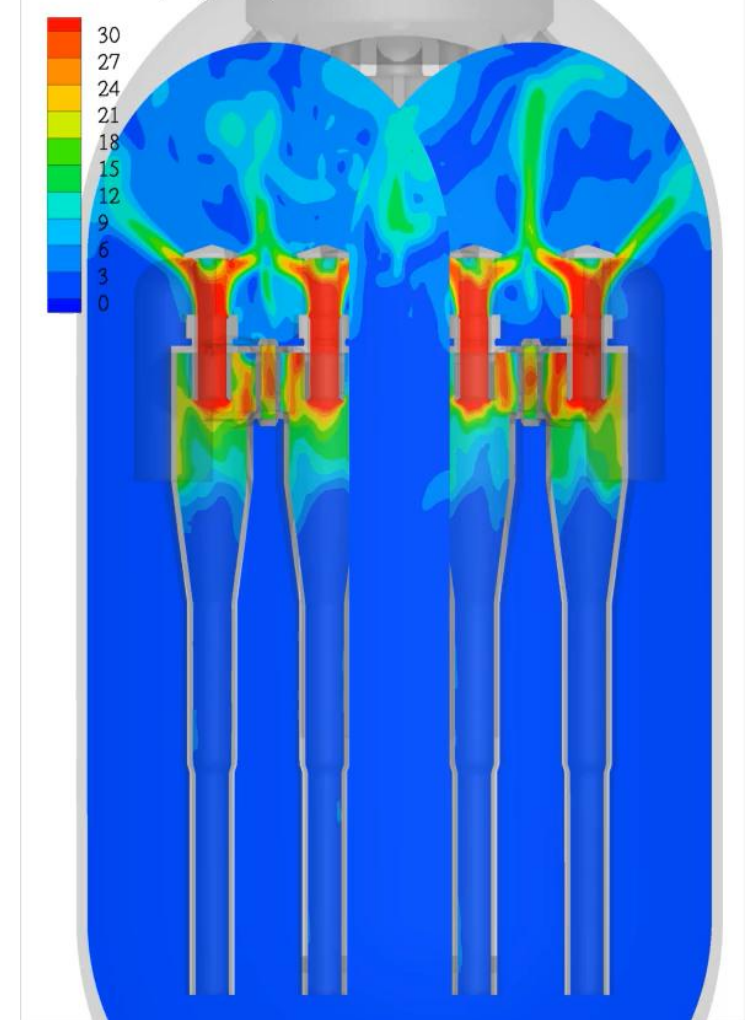
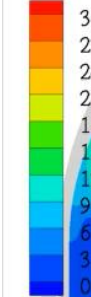
Vapor
velocity
magnitude



Center plane: Rough-cut cyclones (1W, 4W, 1E, 4E)

Existing system

Fluid velocity magnitude, m/s

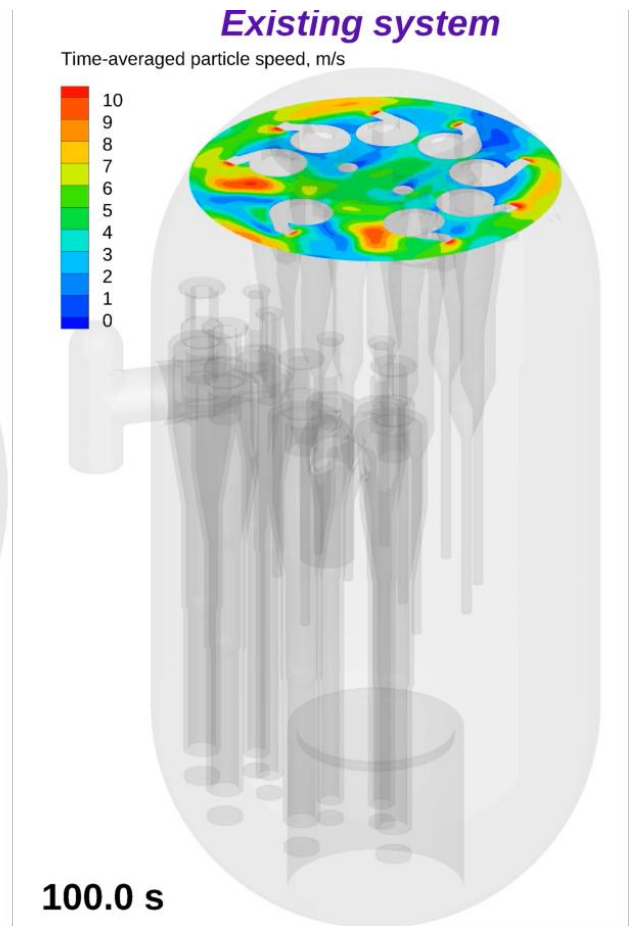
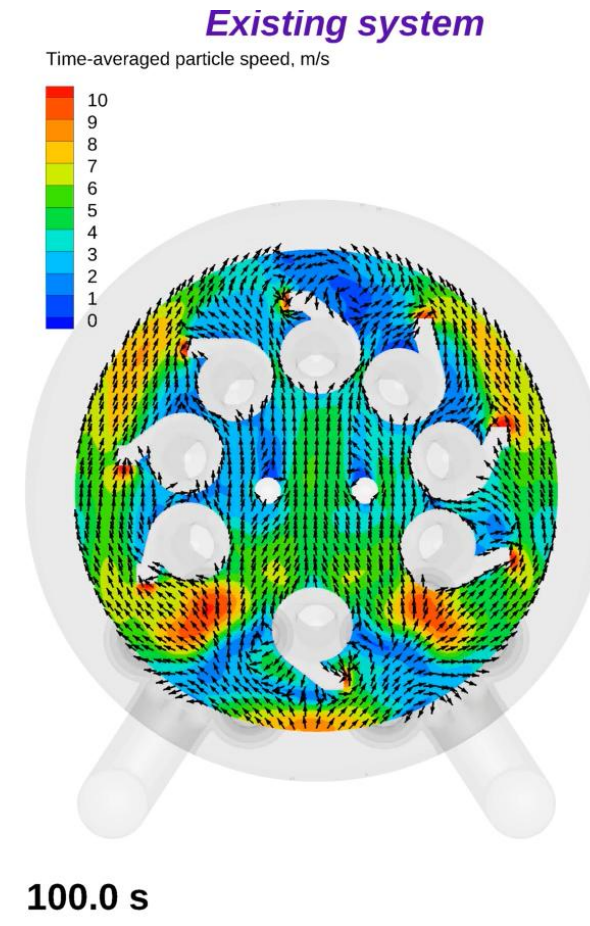


Vapor velocity

Existing System – Particle Distribution

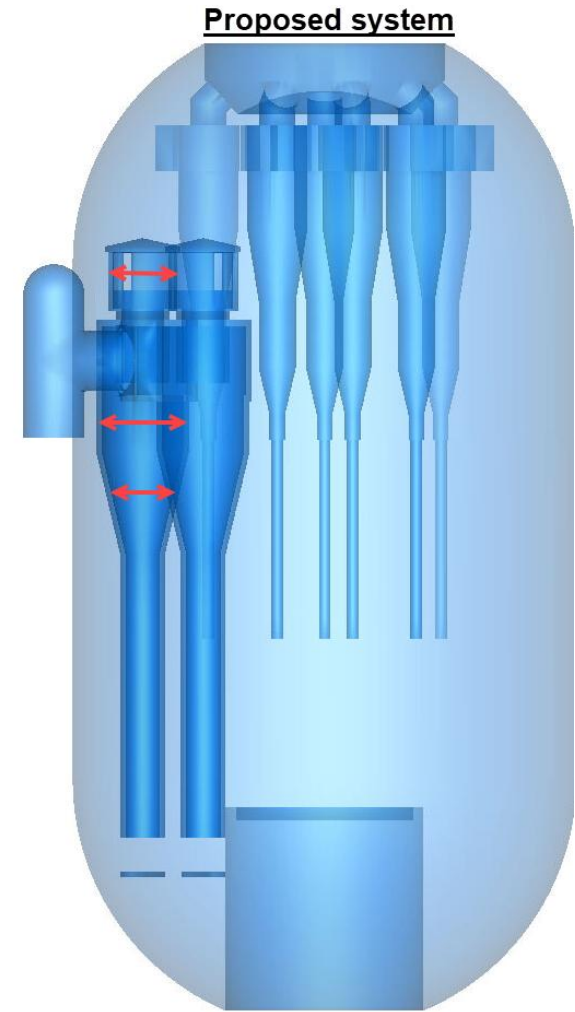
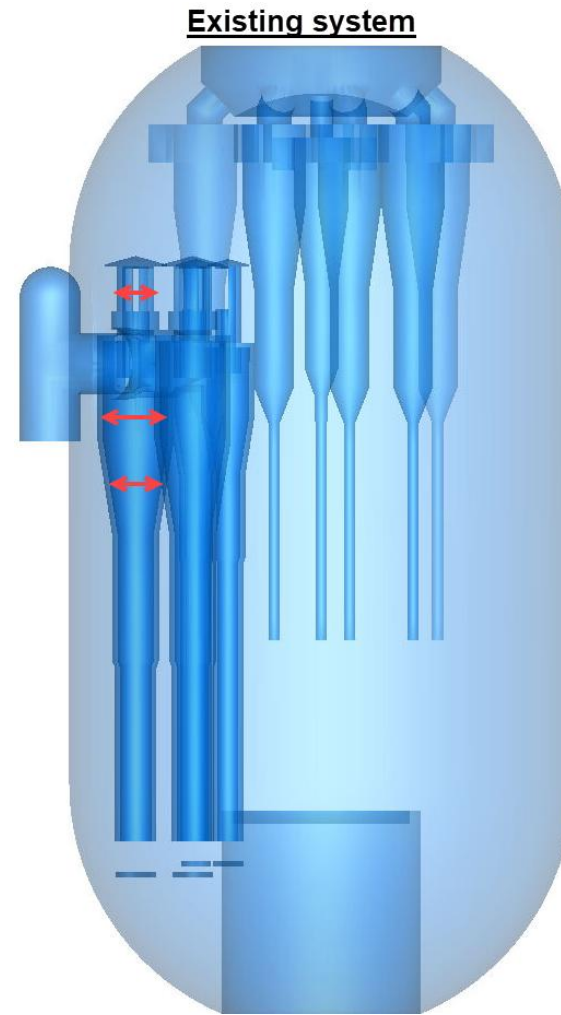
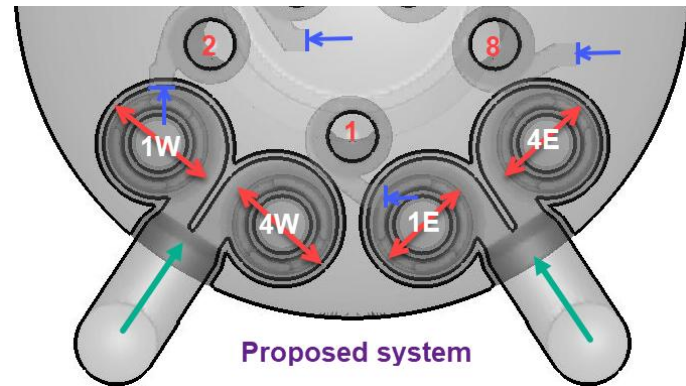
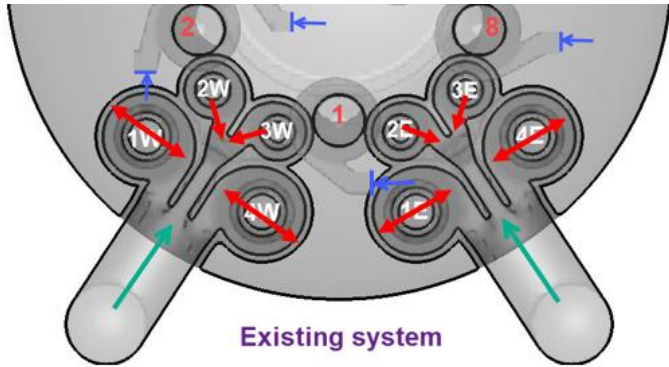
Observations:

- Vapor and catalyst from the primary riser outlets are driven to the reactor wall by the high outlet velocity and the direction of the outlet flow.
- Higher particle velocities near the reactor wall, as seen by the velocity contour and vectors, indicate that the outlet flow is concentrated near the reactor wall.
- A portion of the outlet flow from the primary riser cyclones coalesces with each other, causing flow recirculation near the cyclone barrels.
 - Flow circulation causes impingement of catalyst on the primary risers, increasing the erosion potential on the cyclone barrels.



Vapor velocity

System Comparison

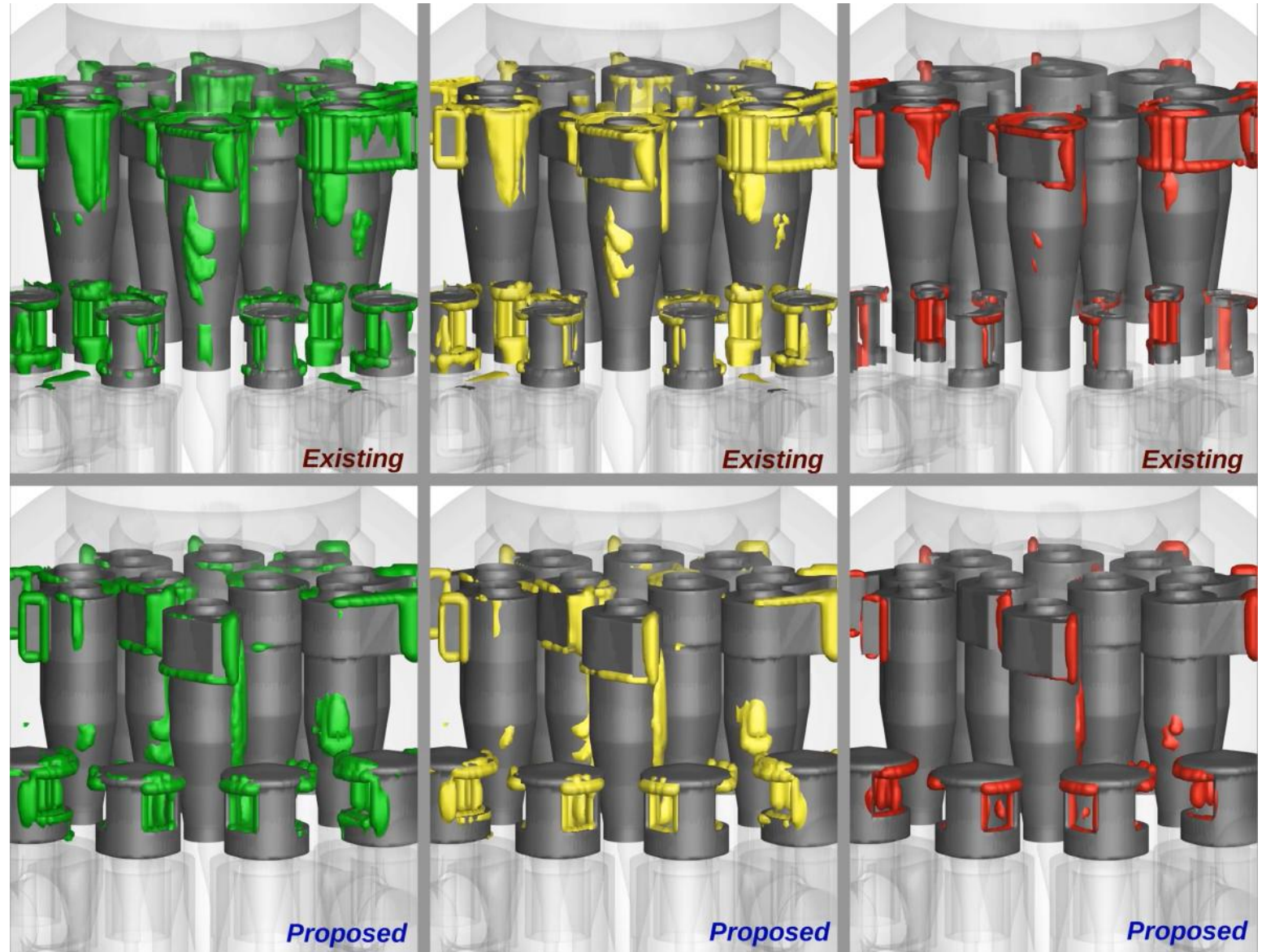


Vapor velocity

System Comparison – Secondary Erosion

Observations:

- Erosion potential regions are more pronounced in the existing system due to concentrations of regions with higher velocity.
- Volute regions in the existing system (medium potential) show a higher potential for erosion (**Cyclones 1, 2, 8**).
- Erosion potential is observed on secondary cyclones roof in the existing system.
- Overall, erosion potential in the proposed system is likely lower due to a more uniform velocity distribution in the reactor.



Vapor velocity

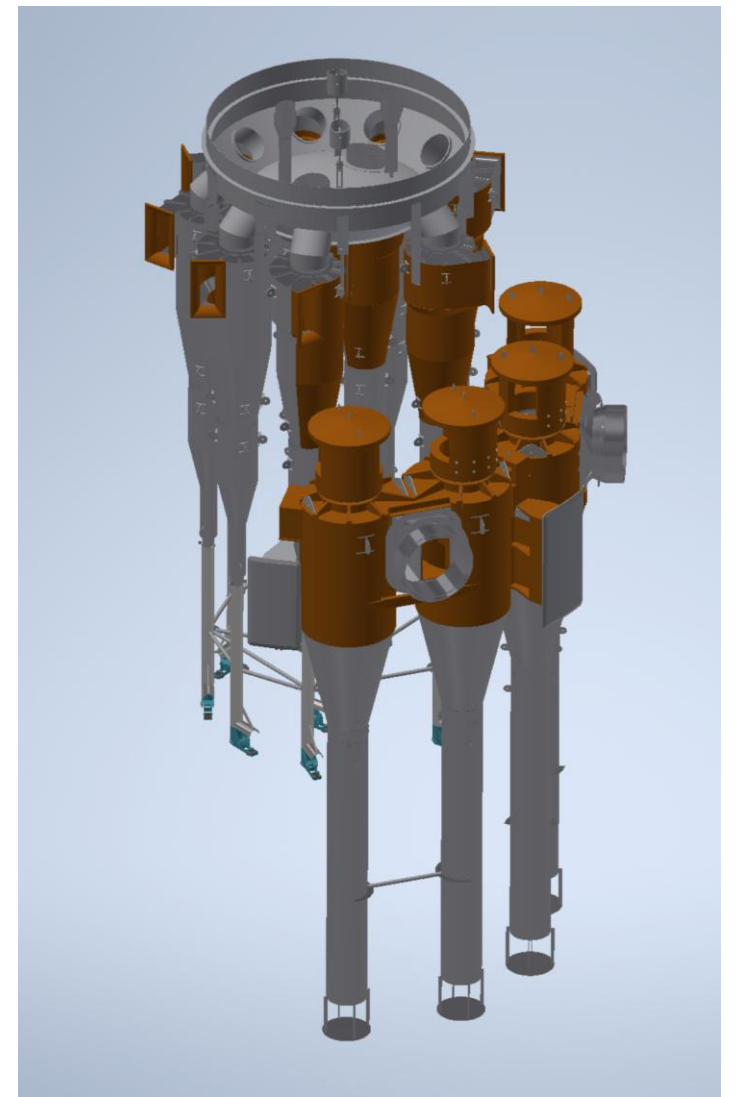
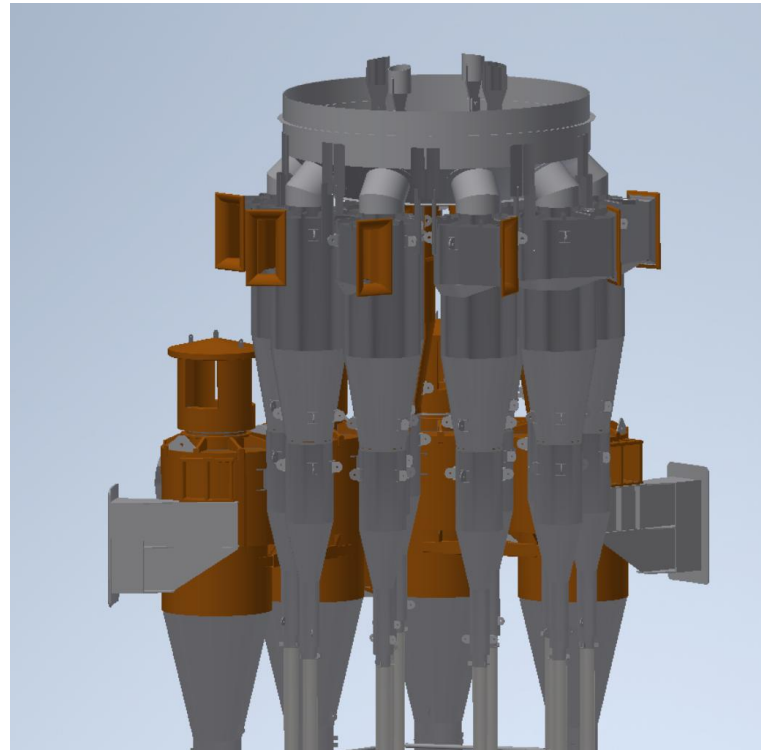
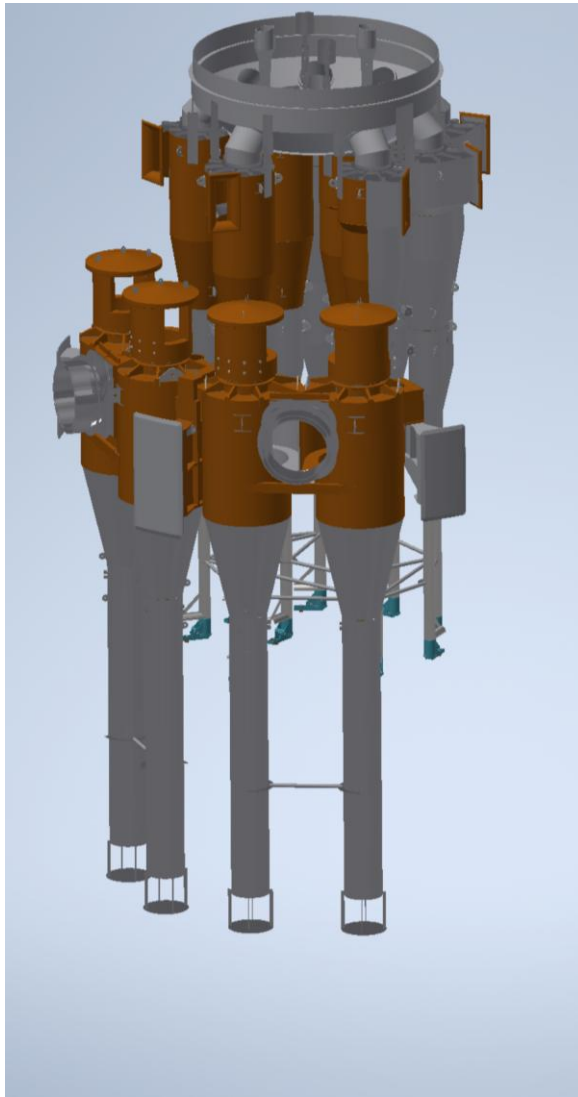
Design Decisions

Based on CFD findings:

- Minor changes to riser cyclone deflector for improved flow patterns
- Strategic application of refractory lining on external surfaces of cyclones
 - Extent of lining minimized to limit added weight in the reactor



Refractory Lining on External Surfaces



Questions?

Thank you for your attention!

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