FCCU Spent Catalyst Standpipe Troubleshooting Case Study

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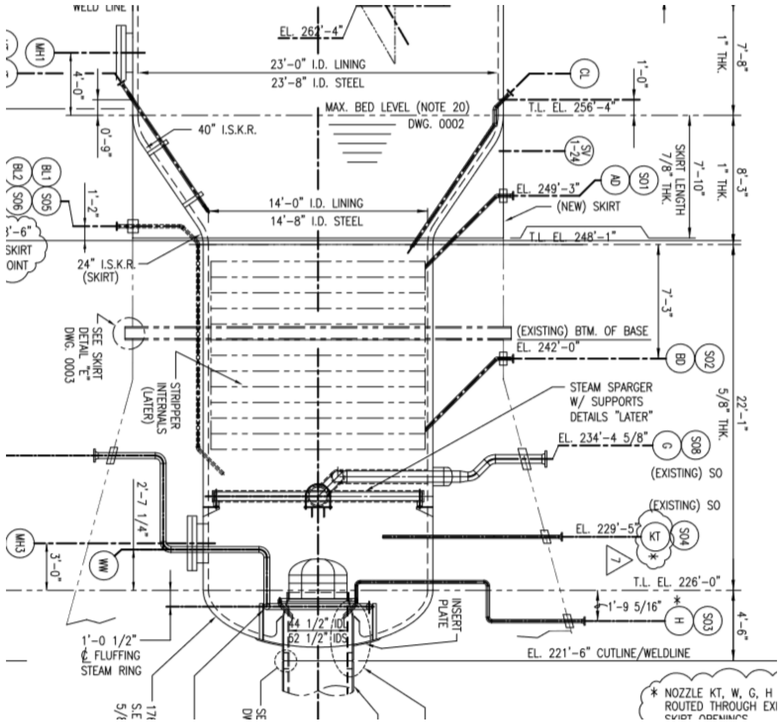
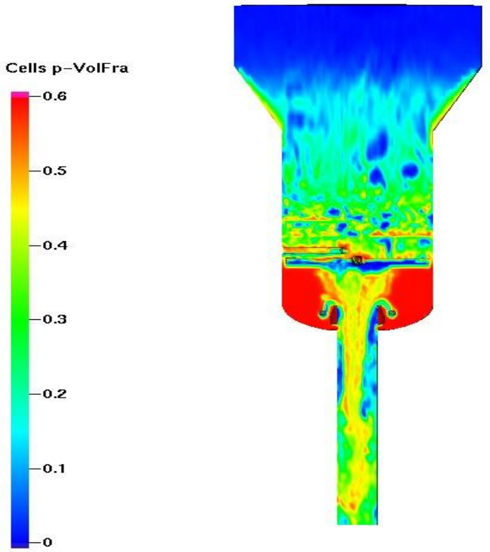
Stripper and Standpipe Performance

- Ecat PSD has significant impact on FCCU/CFB operation
  - Coarse/low fines content Ecat may lead to unstable circulation
  - Operational interruption

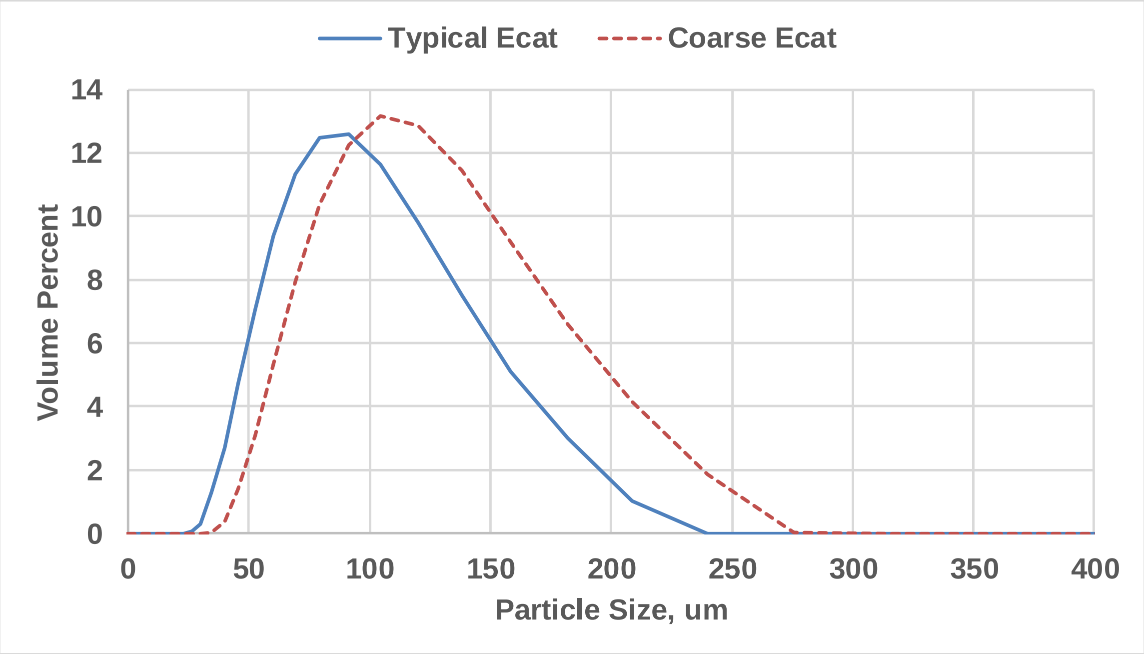
- Circulation constraints associated with a course Ecat can manifest itself in the following ways:
  - Rapid de-fluidization below stripping steam ring
  - Stagnant zones near base of stripper and standpipe entry
  - Slumping catalyst flow into the standpipe
  - Narrow window of stable expansion: sensitivity to aeration
  - Larger and faster rising bubbles
  - Low standpipe and slide valve DP
  - Unstable circulation





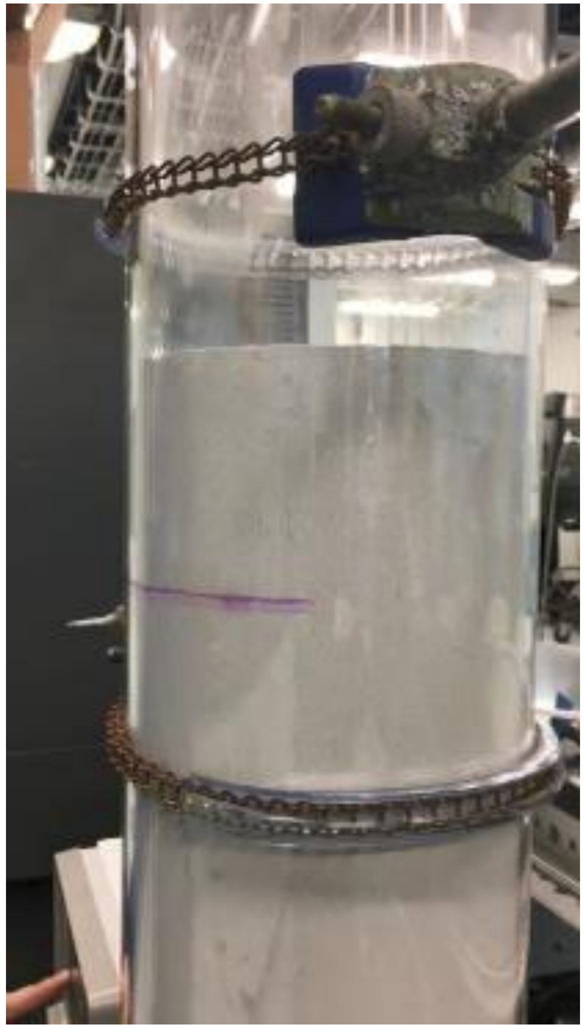
Sensitivity of Stripper and Standpipe Performance

- CFD has been used to simulate stripper and standpipe flow
  - *CFD modeling of Standpipe Flow With and Without Aeration*, Ray Cocco and Ted Knowlton, 2017
- Limited attempts in capturing the effects of PSD changes typically experienced by a refiner
  - Loss of fines due to poor cyclone performance
  - Course grade catalyst and additives
  - Highly attrition resistant catalysts
- Capturing fluidization properties are critical for dense phase applications
  - Window of stable expansion/de-fluidization times
  - Accurate representation of particle phase stress
  - Parameters are extracted through simple experiments

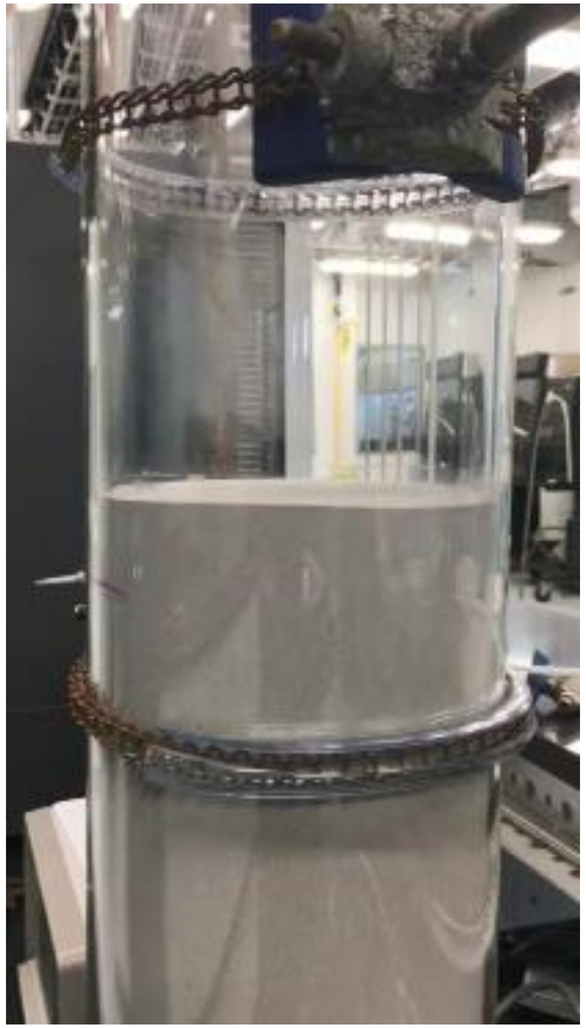


Catalyst Fluidization Characteristics

Typical Ecat



Coarse Ecat

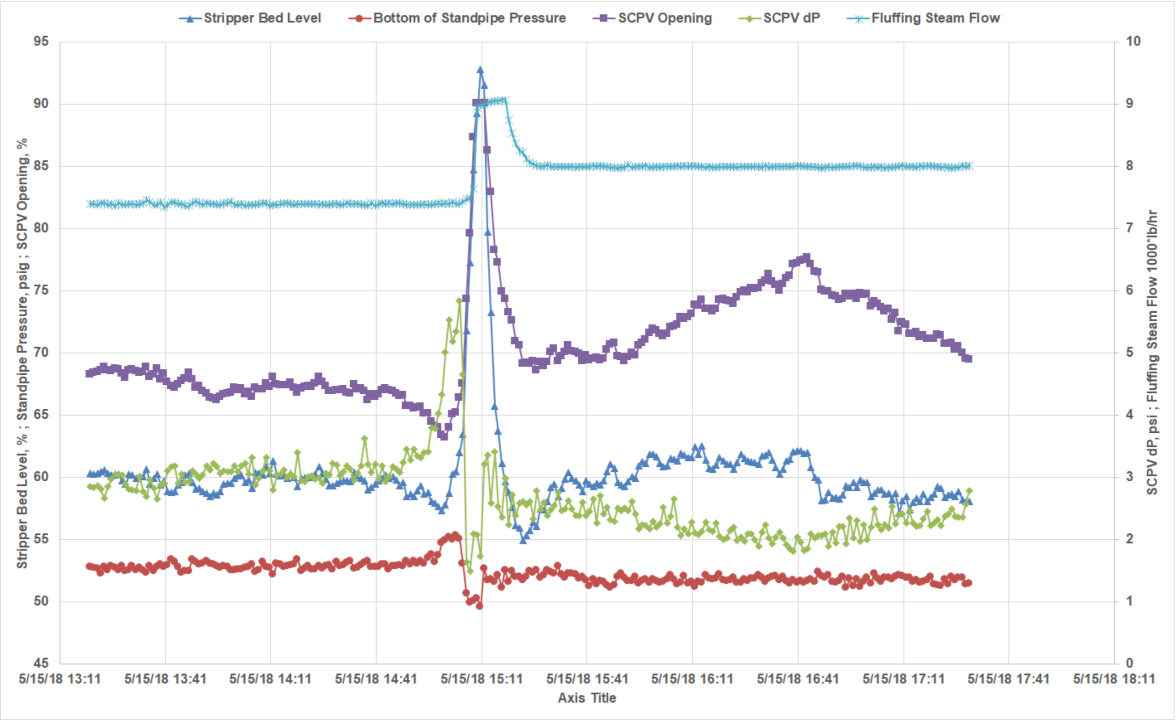


FCCU Catalyst Circulation Constraints

- Gulf coast refiner experiencing erratic circulation in their stripper and standpipe post revamp
  - Although revamp was generally successful, circulation performance fell short of expectations
  - Stable operation was only achieved by overaerating SCSP resulting in low DP across the standpipe and spent catalyst plug valve

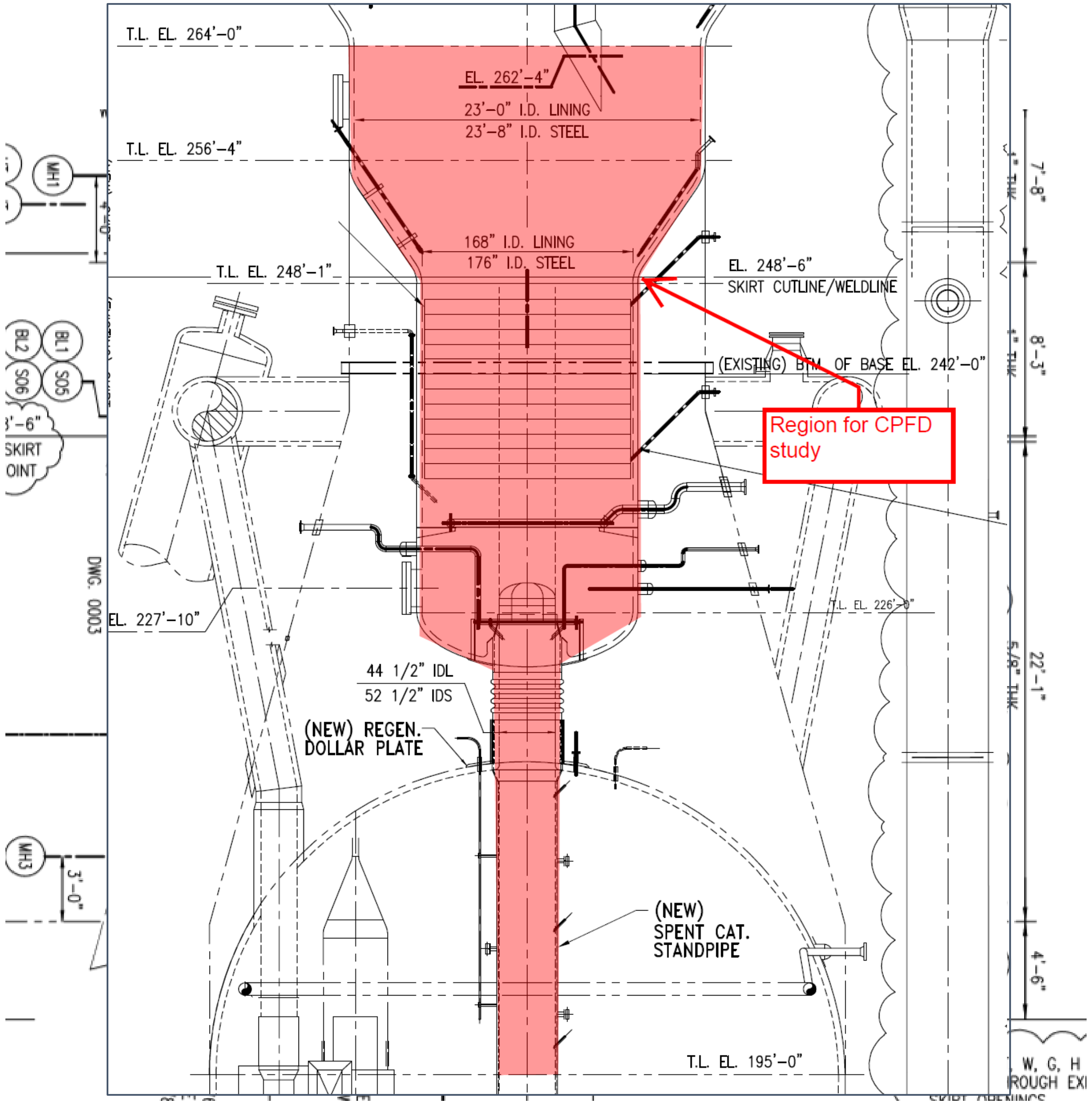
- CPFD approached to identify root cause
  - Stripper/standpipe redesign and fluffing steam/standpipe aeration rates
  - Coarse Ecat resulting from excessive losses through regen cyclones

- Critical to quantitatively predict changes in fluidization properties as a function of fines/PSD



Stripper and Standpipe Case Study

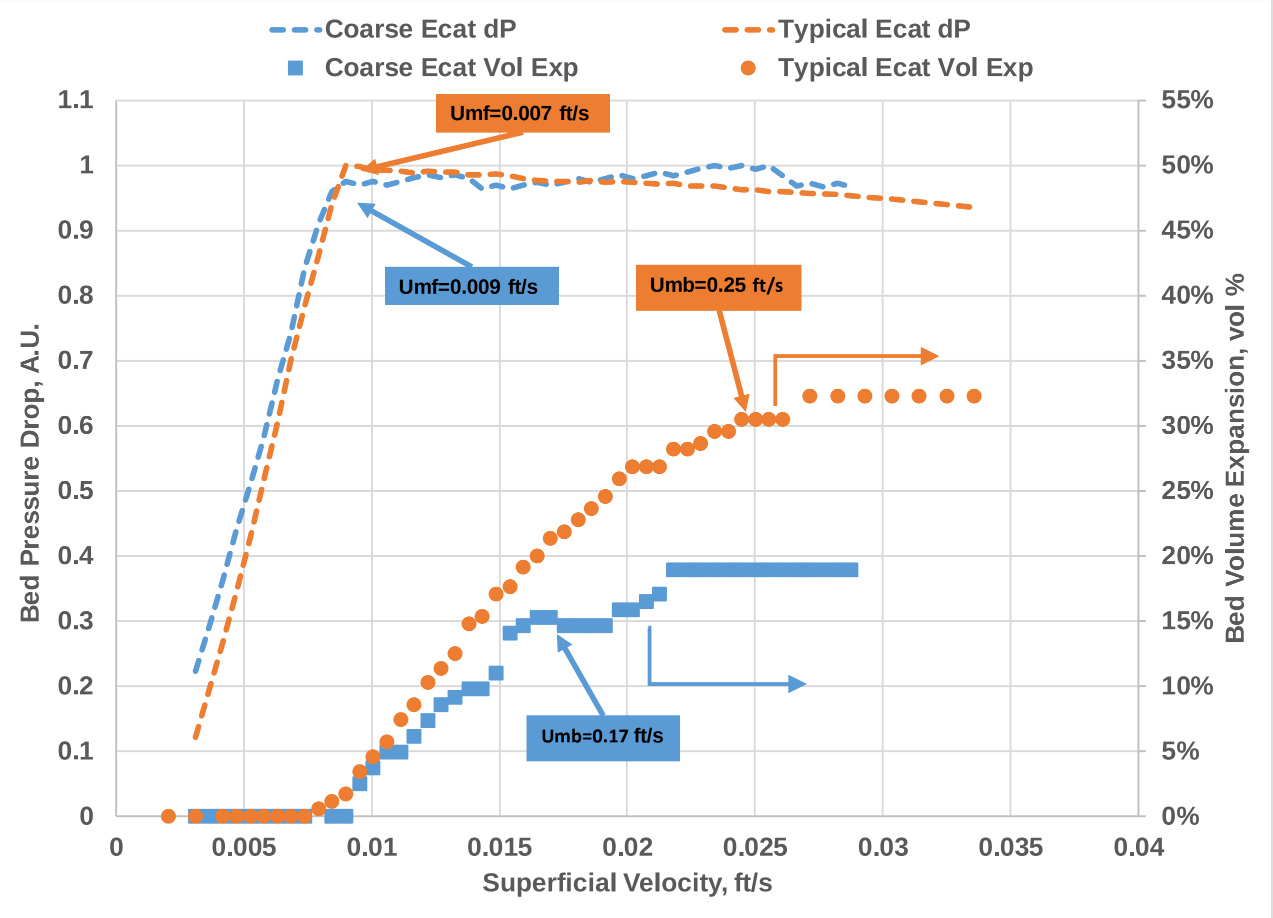
- Simulations performed to gain insight into the particle/vapor hydrodynamics from the bottom of the stripper internals to the inlet of the standpipe
- Base case simulations
  - Case 1 – Typical Ecat PSD
  - Case 2 – Coarse Ecat PSD
- Identify root cause of poor circulation performance



Catalyst Fluidization Characteristics

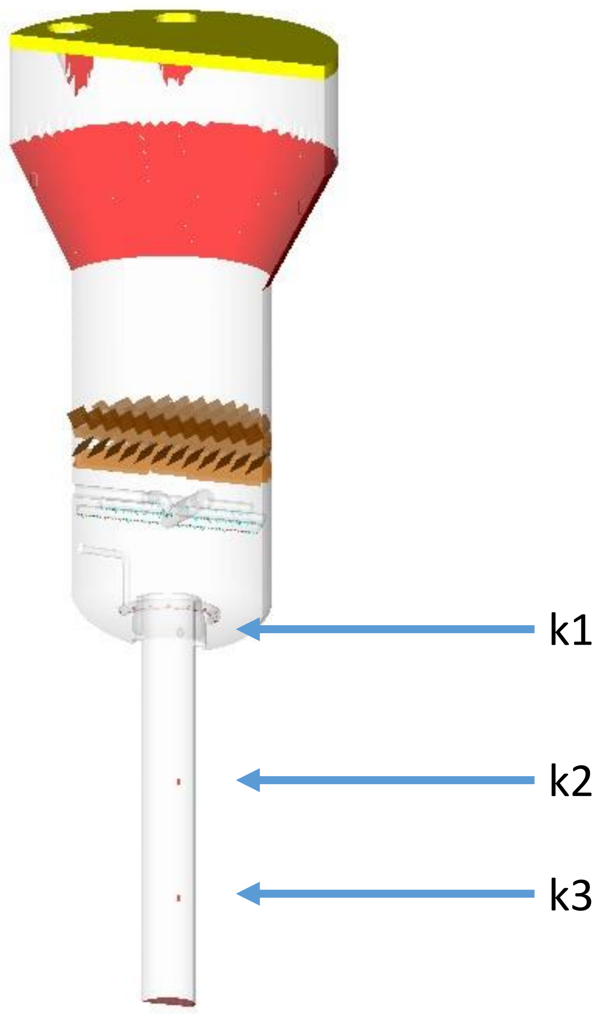
- Typical u_{mf}, u_{mb} and de-aeration testing was performed on the two catalysts
- Client coarse catalyst is a low/no fines Group A powder which has a low amount of bed expansion prior to the onset of bubbling
- Fluidization Properties were compared against a "typical" FCC catalyst with 4% nominal fines content

Catalyst		Typical Ecat	Coarse Ecat
Fluidization Media		Air	Air
APS	um	80	99
ABD	g/cc	0.8	0.86
0-20 um		0	0
0-40 um		4.0%	0.5%
0-80 um		39%	31%
Fluidization Properties			
Umb/Umf		3.57	1.89
MSER	vol/vol	1.31	1.15
Umf	ft/s	0.007	0.009
Umb	ft/s	0.025	0.017



Simulation Setup

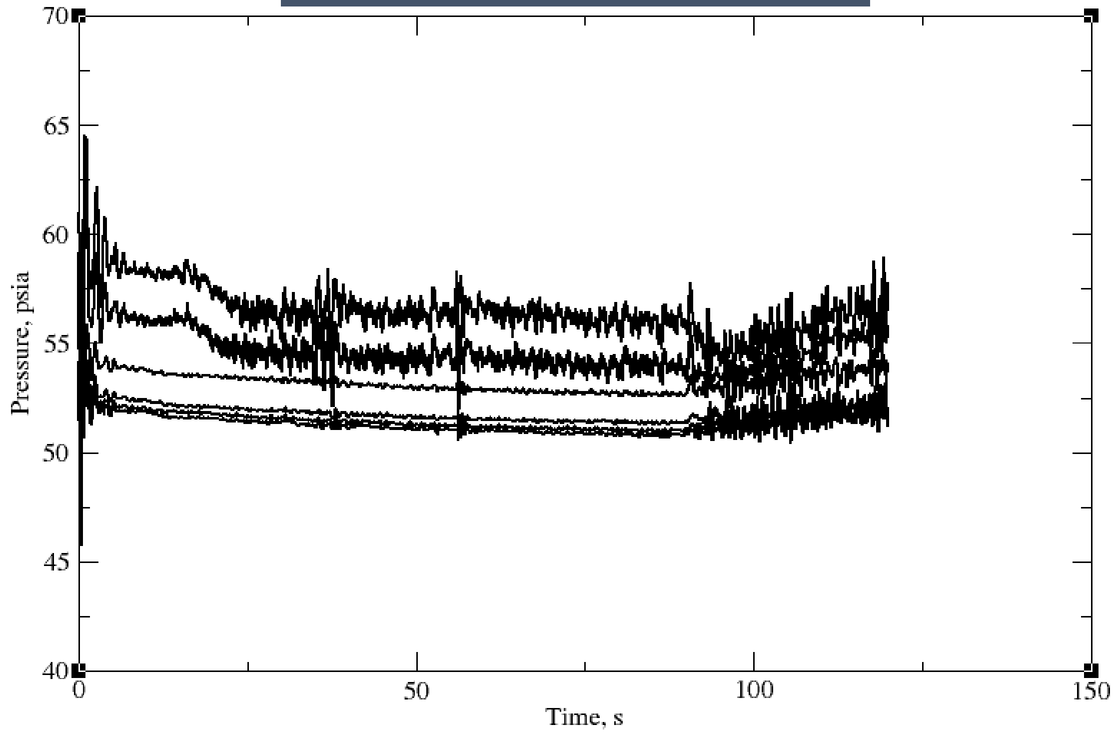
- Freeboard of disengager is modeled as pressure boundary
- Cyclone diplegs are modeled as flow boundaries
- Bottom standpipe boundary is modeled as flow boundary with target outlet flow of solids
- Upper SCSP aeration is included
- Main stripping steam set at design conditions
- Fluffing steam varied based on simulation
- Small interior features are omitted and structured packing was simplified



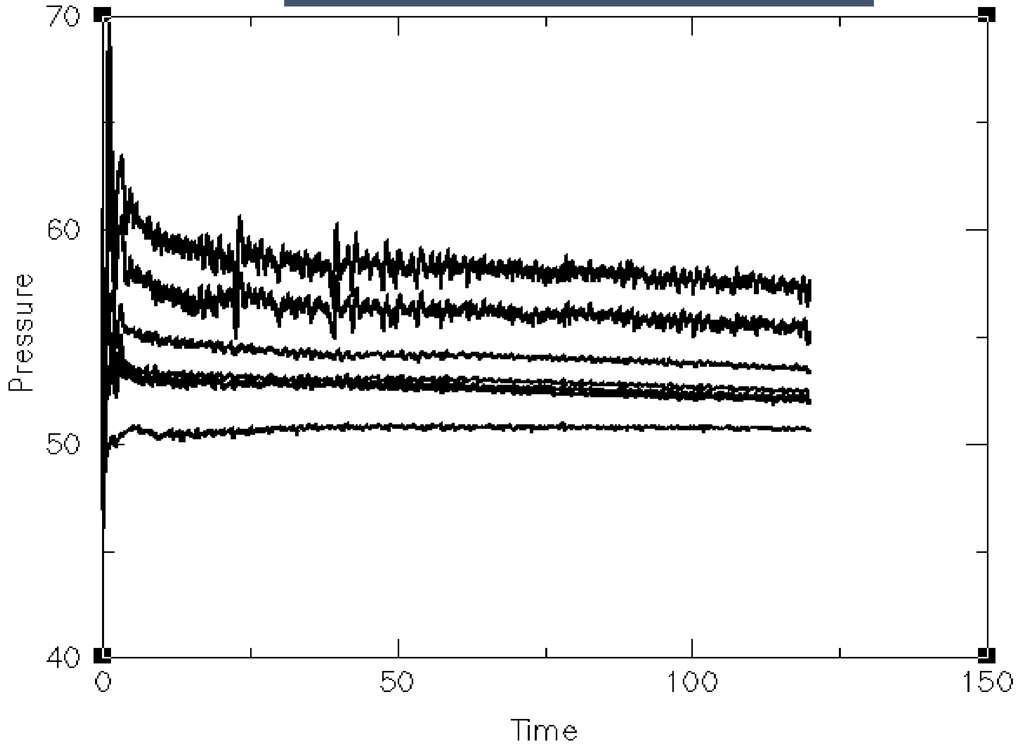
Simulation Results

- Coarse Ecat simulations have difficulty achieving steady circulation at desired aeration rates, increased fluffing steam flow to compensate
- Typical Ecat exhibits a smooth pressure profile over the domain with slightly greater pressure build versus the Coarse Ecat simulation due to lower fluffing steam flow

Coarse Ecat



Typical Ecat



Simulation Results

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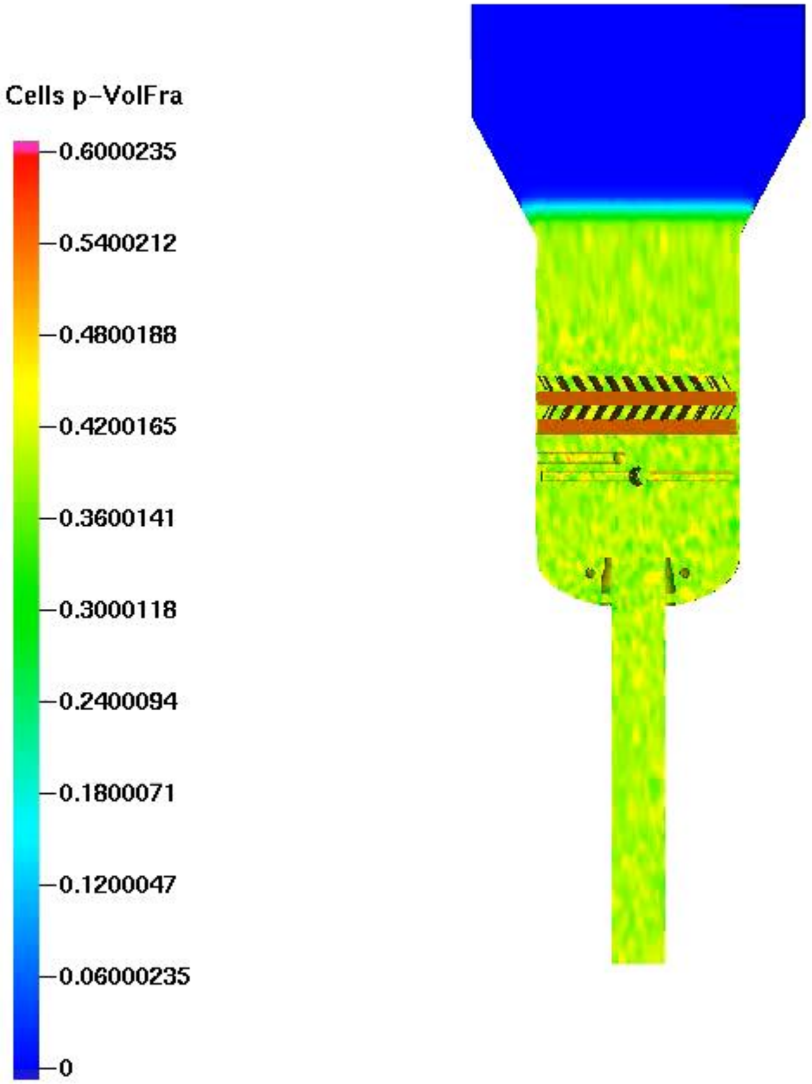

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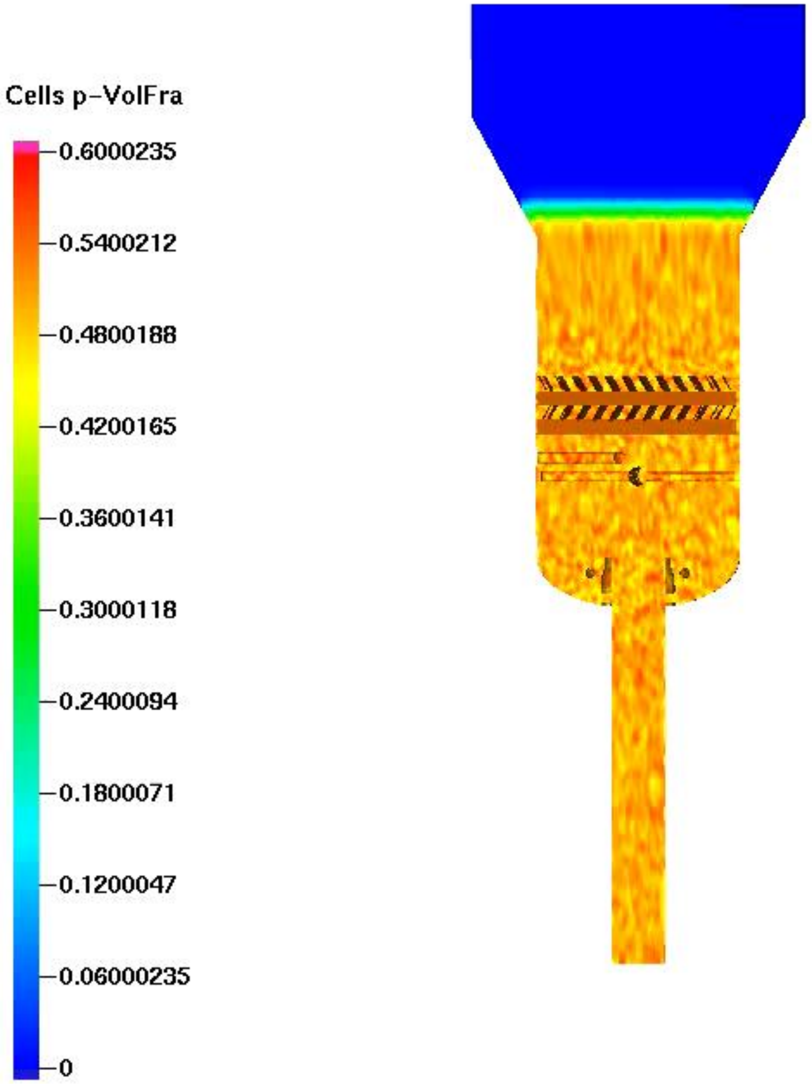

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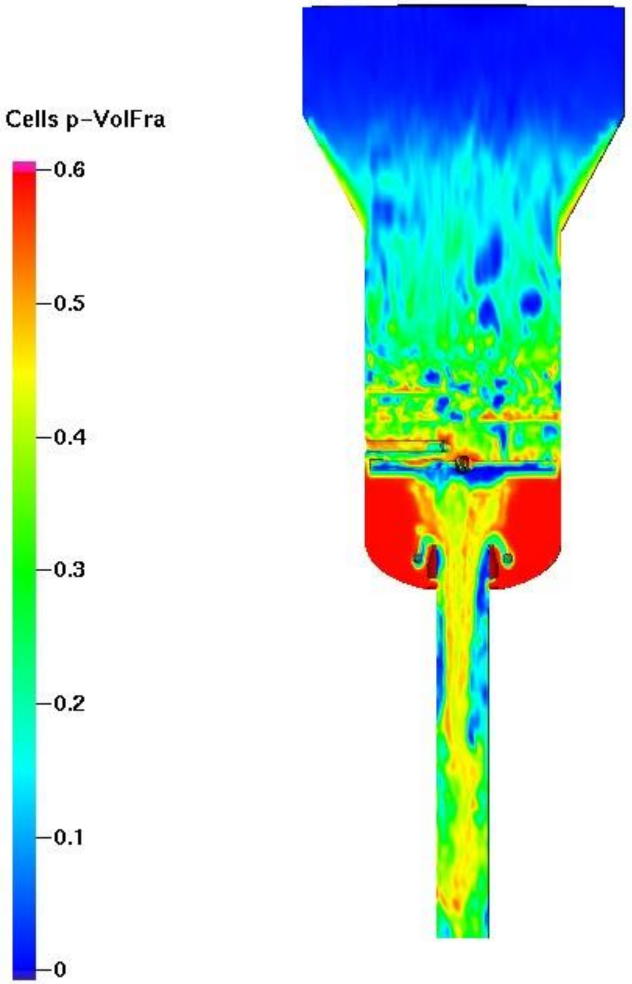

- Large de-fluidized catalyst zone apparent in elliptical head extending to the main stripping steam ring
- Fluffing steam ring has poor penetration into the de-fluidized zone
- Longer de-aeration time of typical Ecat simulation allows for smoother transition and well fluidized catalyst at the inlet of the SCSP

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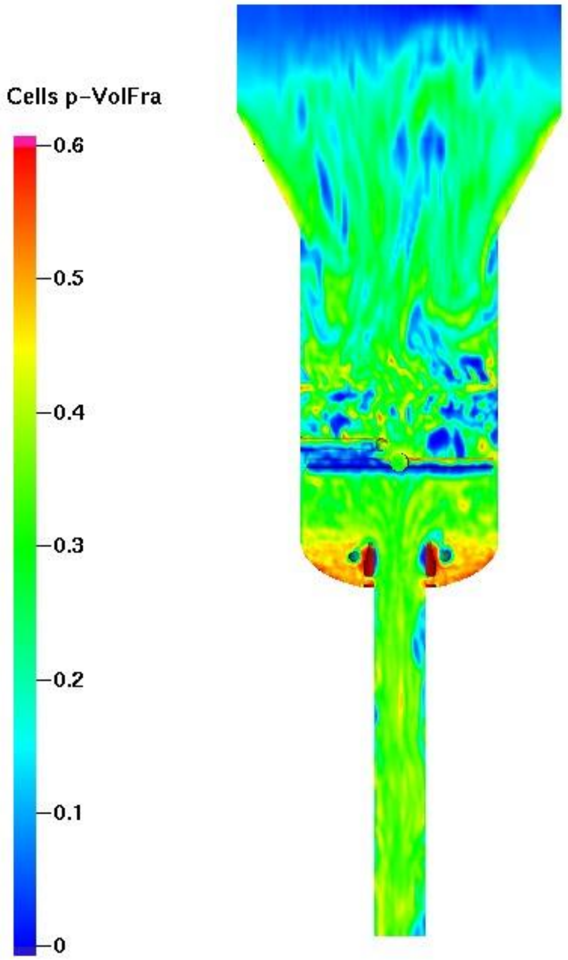
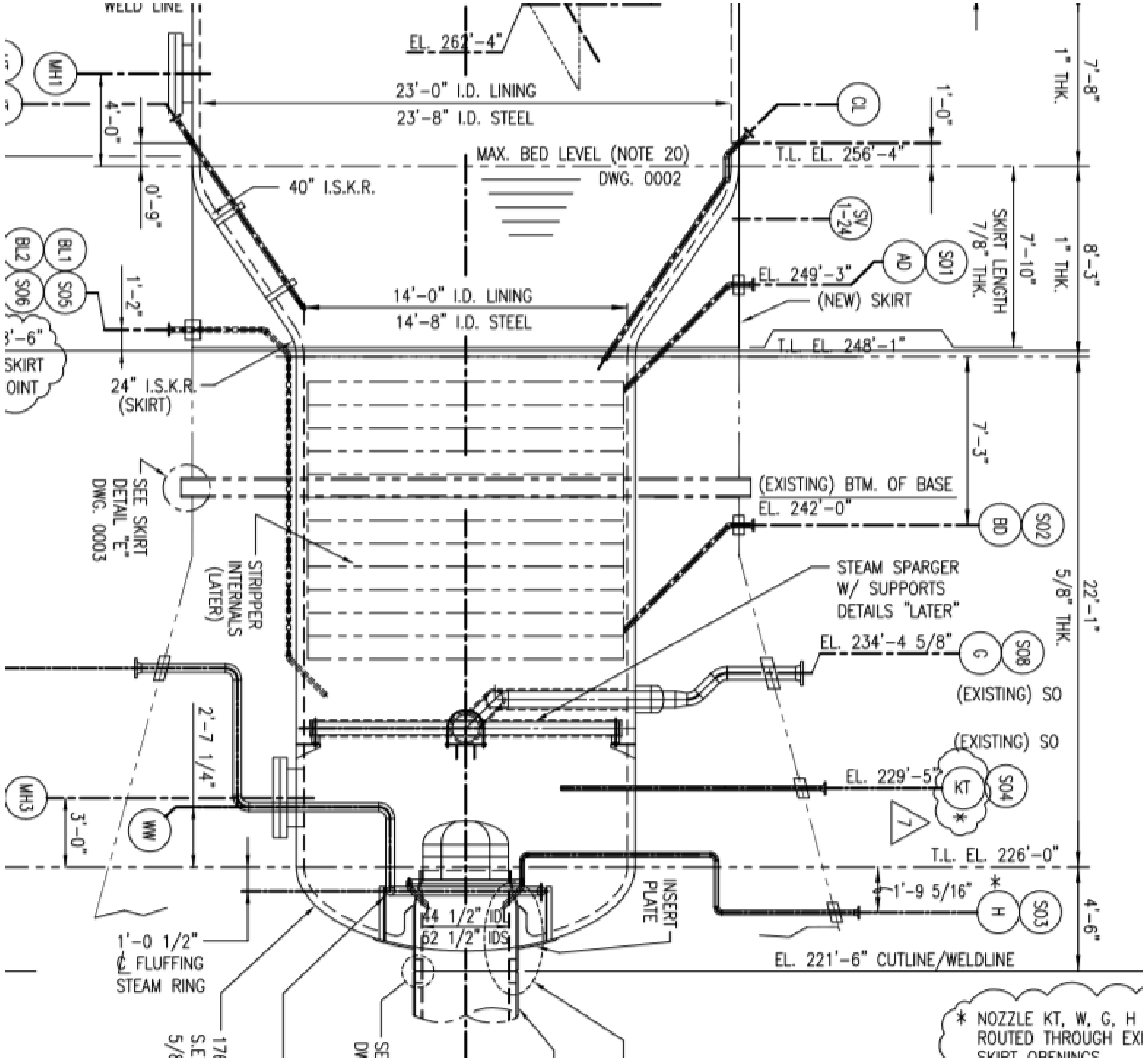


Conclusions And Path Forward

- Simulation results provide key insight into fluidization characteristics of catalyst in the stripper transition to the SCSP
- Refiner is conducting additional simulation efforts with CPFD to assist in identifying scope of next TAR
  - Secondary fluffing ring
  - Increase standpipe penetration into stripper vessel
  - Larger diameter single fluffing ring
  - Lower height main stripping steam distributor
  - Revamp regenerator cyclones to maintain fines inventory in the Ecat



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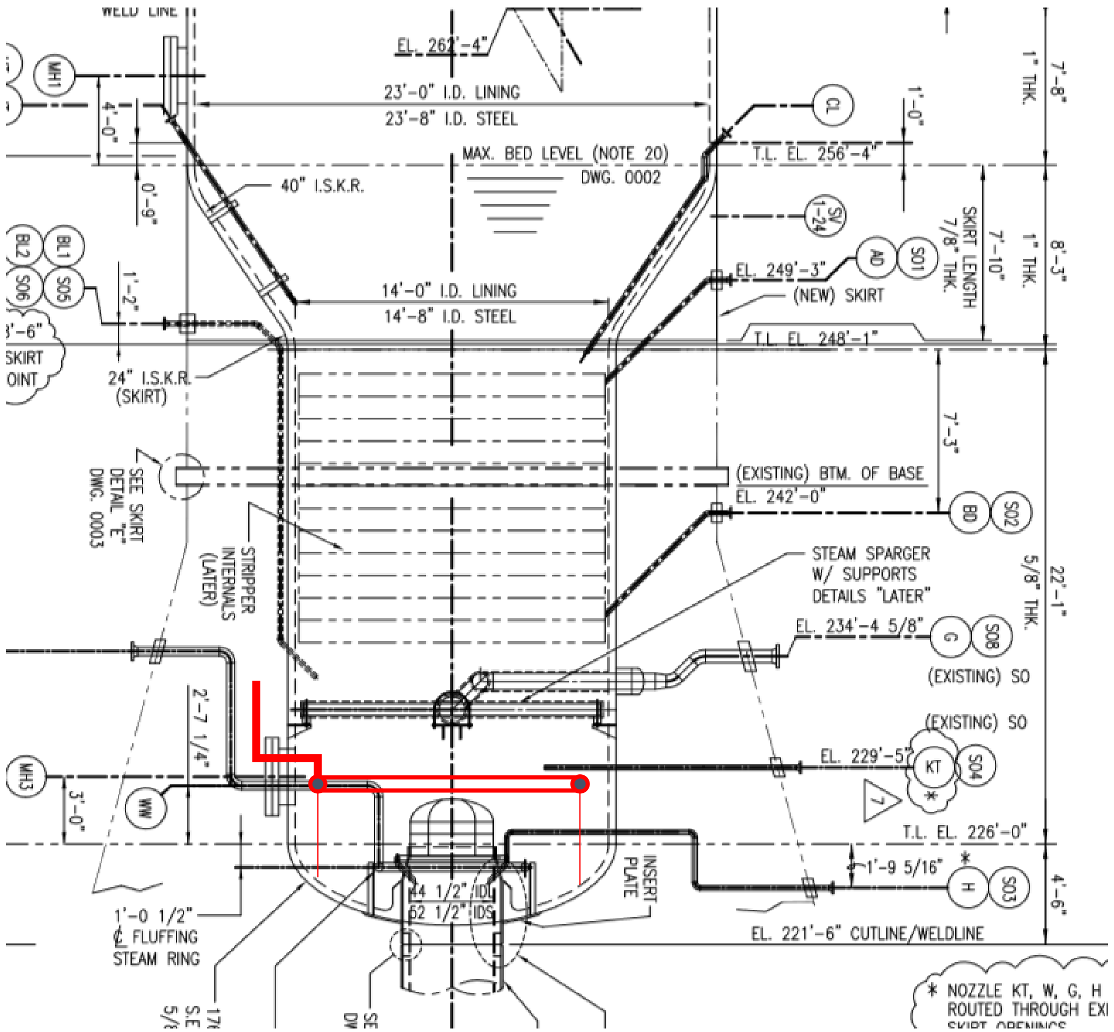

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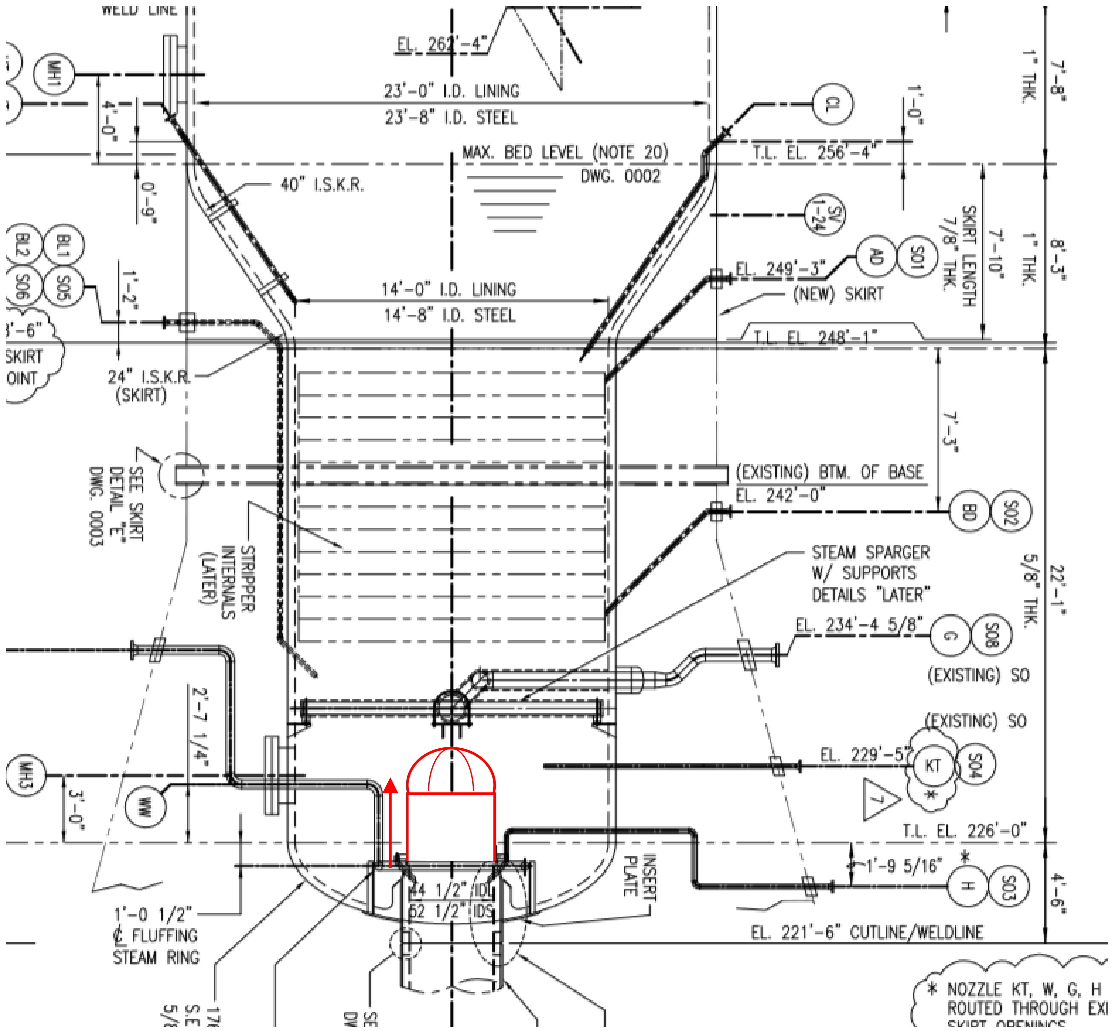

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