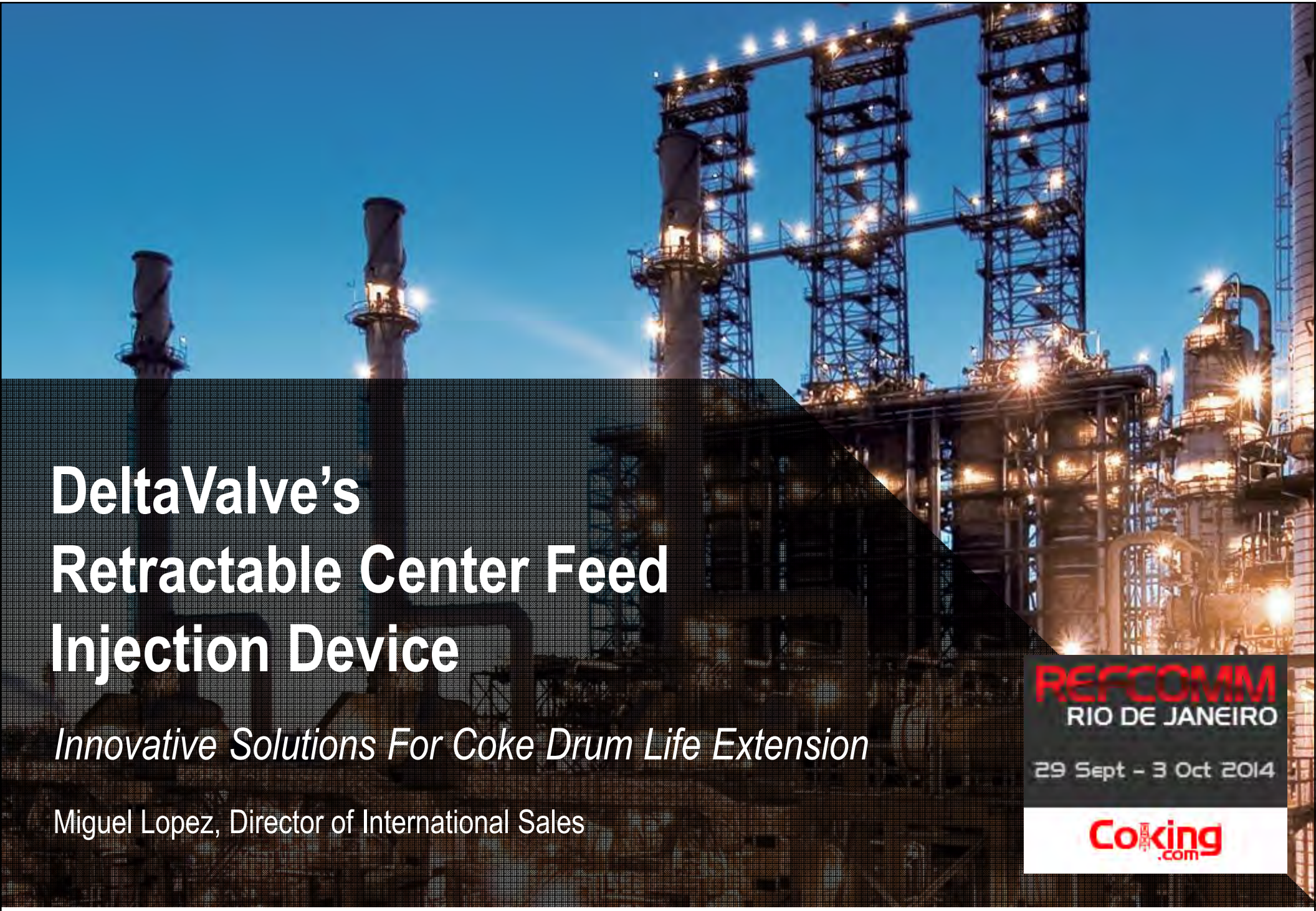

DeltaValve's Retractable Center Feed Injection Device

Innovative Solutions For Coke Drum Life Extension

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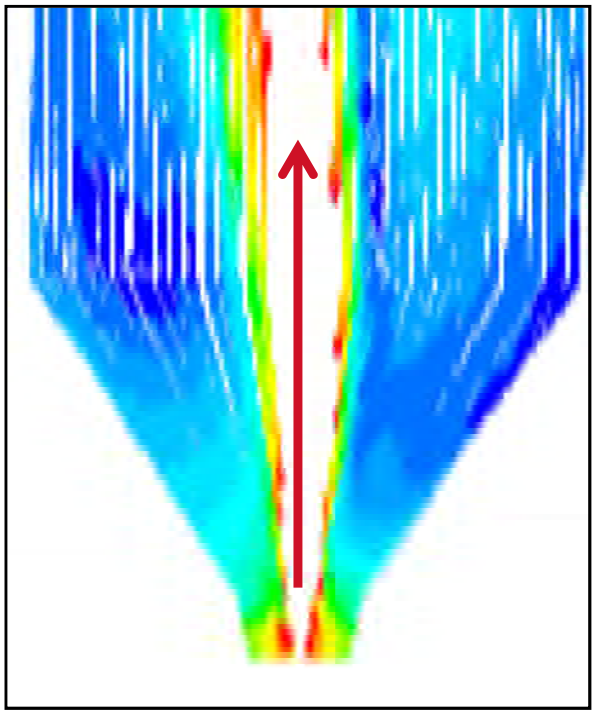
REFCOMM
RIO DE JANEIRO
29 Sept - 3 Oct 2014
Coking.com

CURTISS-WRIGHT

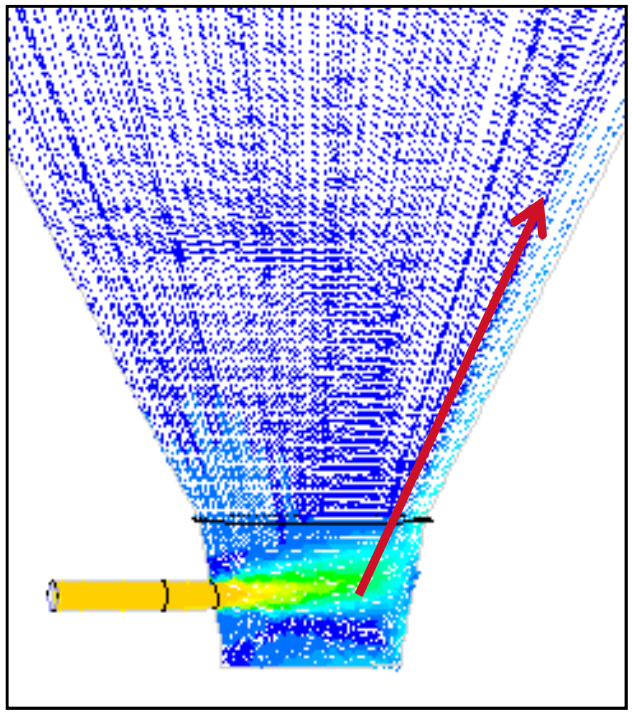
Initial Theories Driving Retractable Center Feed Development

- **Side-feed entry by design, encourages;**
  - Localized hot spots
  - Higher rates of temperature change with a negative impact on fatigue life of affected drum sections
    - Lower transition cone
    - Drum wall
    - Coke drum support skirt
  - Perimeter channeling against the drum wall causing
    - Unsteady coke drum during feed
    - Drum tilting, (banana effect)
    - Top head steam geysers, blowouts
    - Inefficient quenching due to channeling along drum wall, resulting in quenching coke bed from the outside in

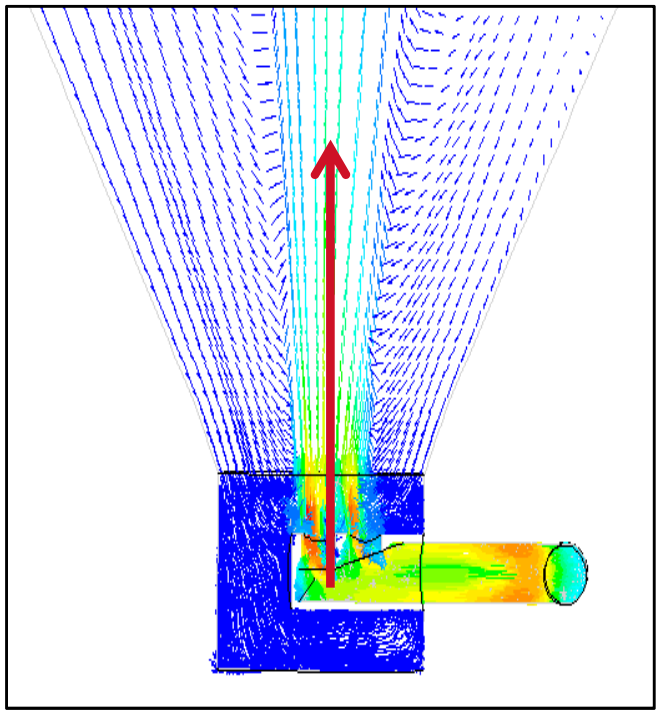
Flow Pattern Comparisons



Traditional Bottom Feed

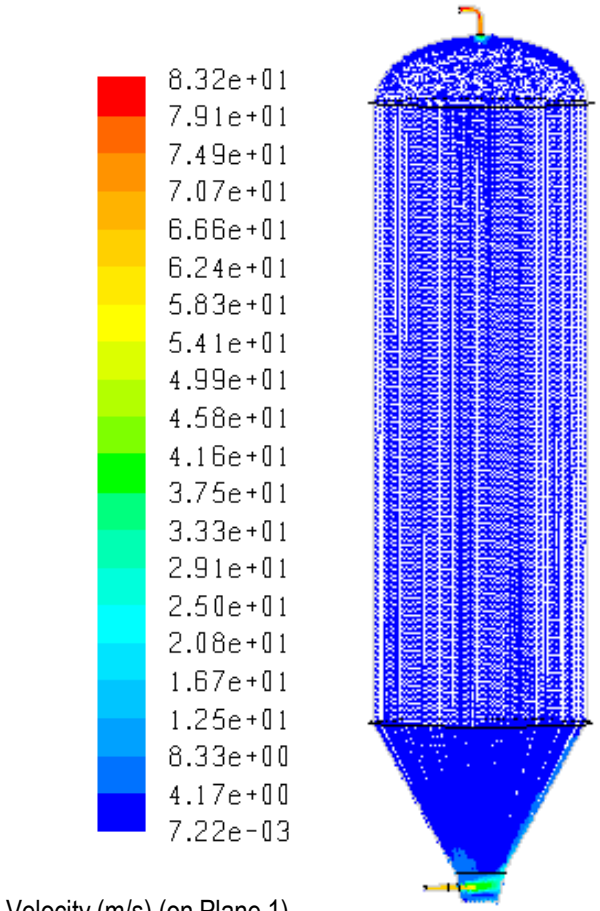


Current Side Feed

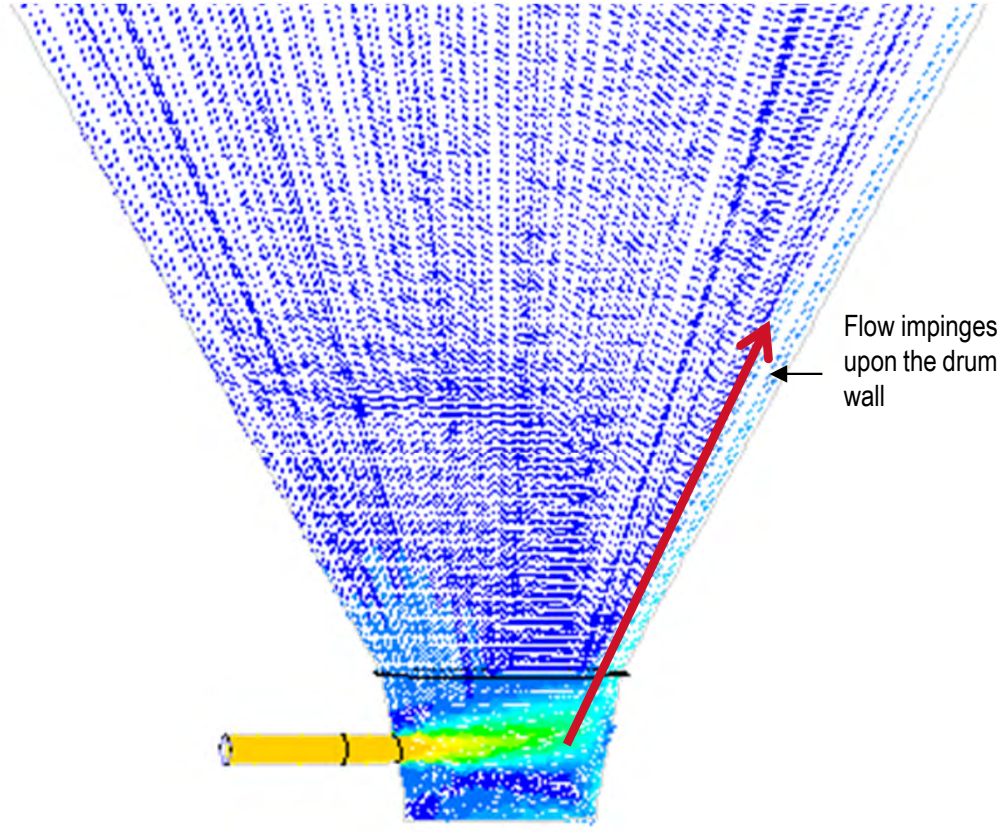


Center Feed Injection

Side Feed Flow Pattern Analysis



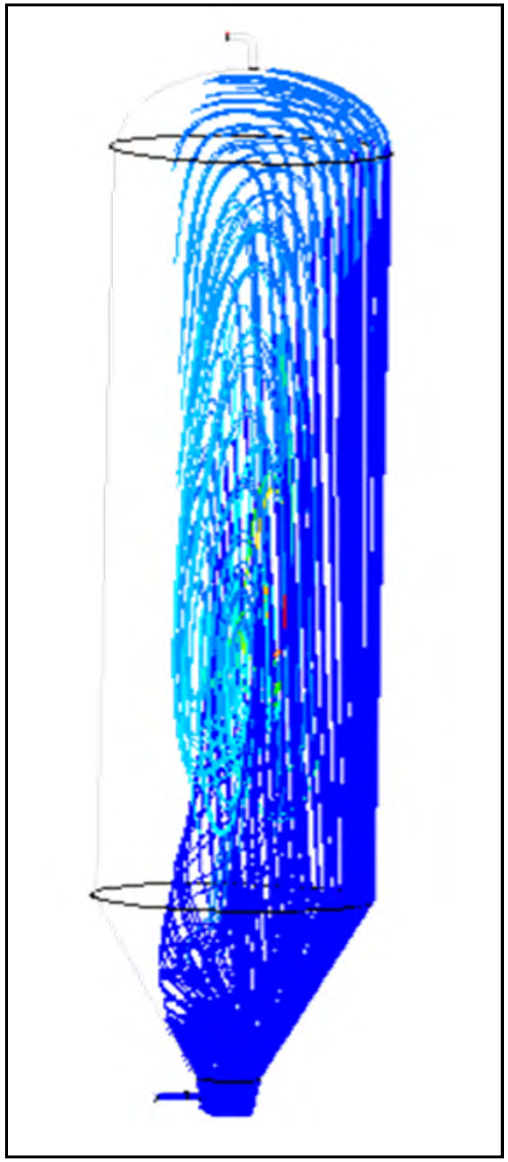
Velocity (m/s) (on Plane 1)



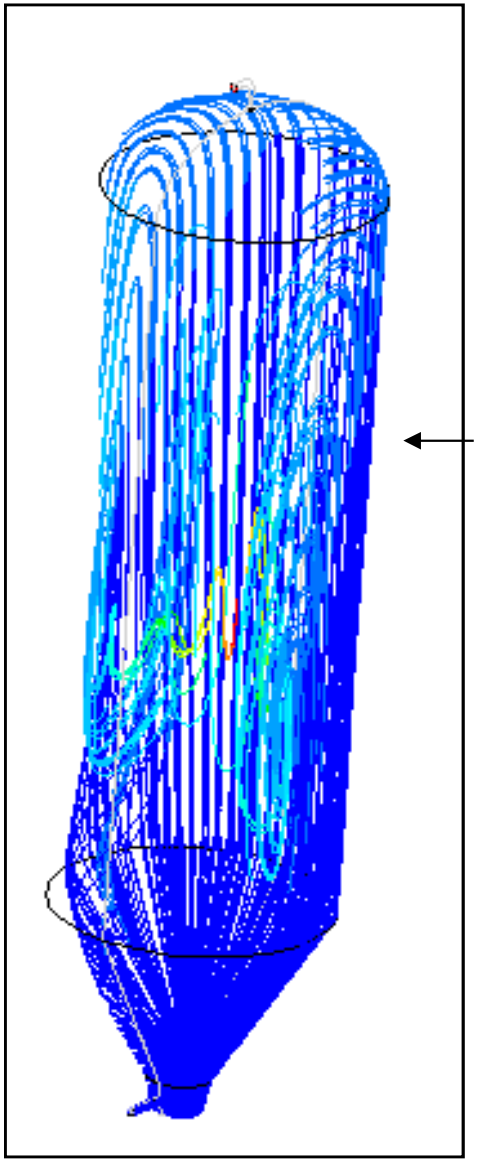
The simulations represent the beginning of the coking process when vacuum reduced vapor is injected into an empty drum

Side Feed Flow Pattern Analysis

- The path lines show the flow impinges upon the drum wall
- The impingement causes the flow to disperse partially around the circumference of the drum
- The flow rises vertically upwards along the walls of the drum, strongly favoring one side of the drum



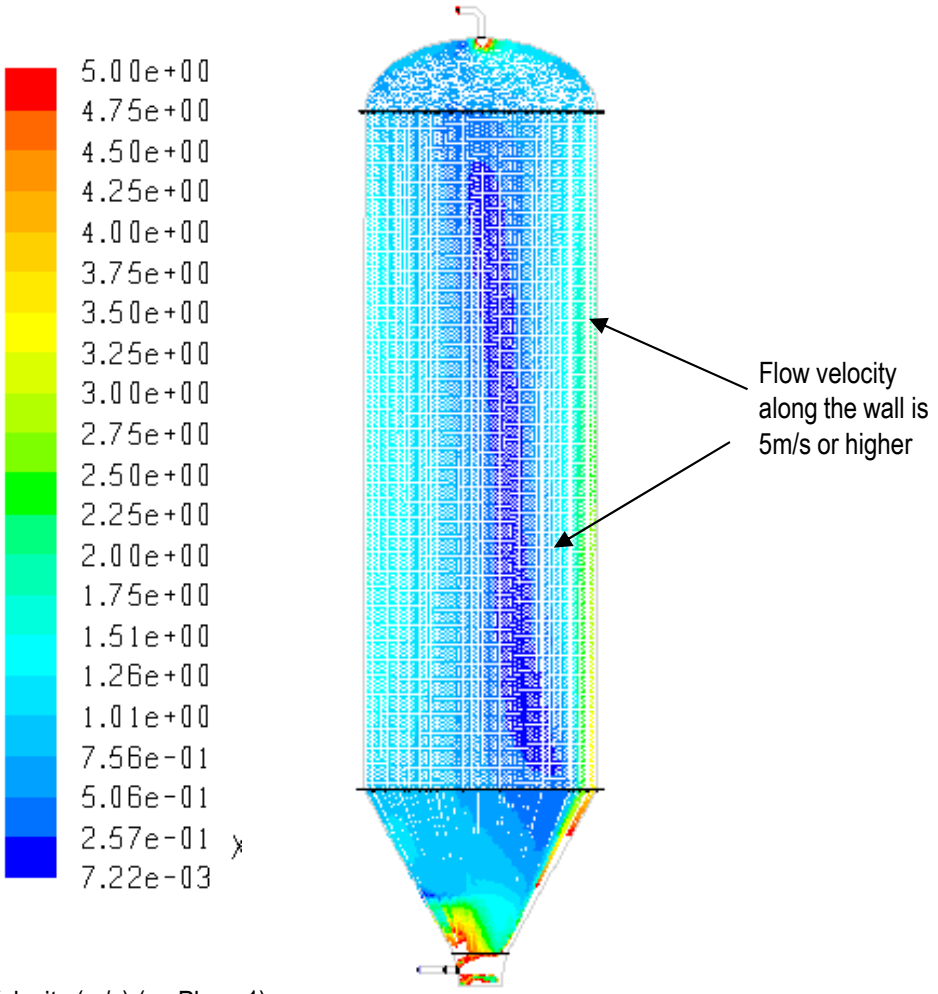
Path lines of flow originating at the inlet



Alternate view

Side Feed Flow Pattern Analysis

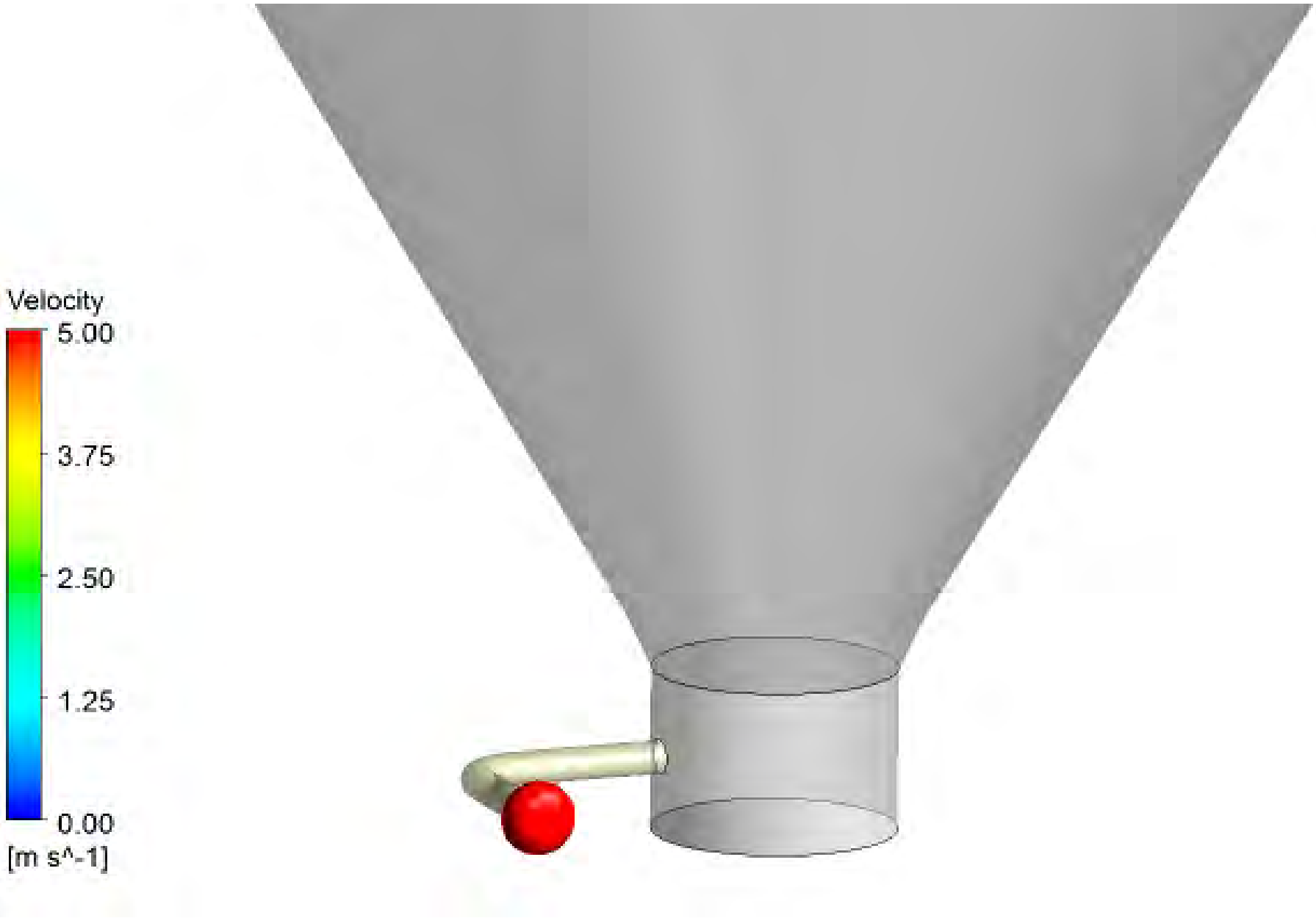
- Slight unsteadiness is observed in the flow in the upper portion of the drum
- This aspect is not explored in detail as the overall flow pattern inside the drum is almost unchanged



Velocity (m/s) (on Plane 1)

Red color denotes velocity of **5 m/s** .
The white region next to red denotes velocity higher than **5 m/s**

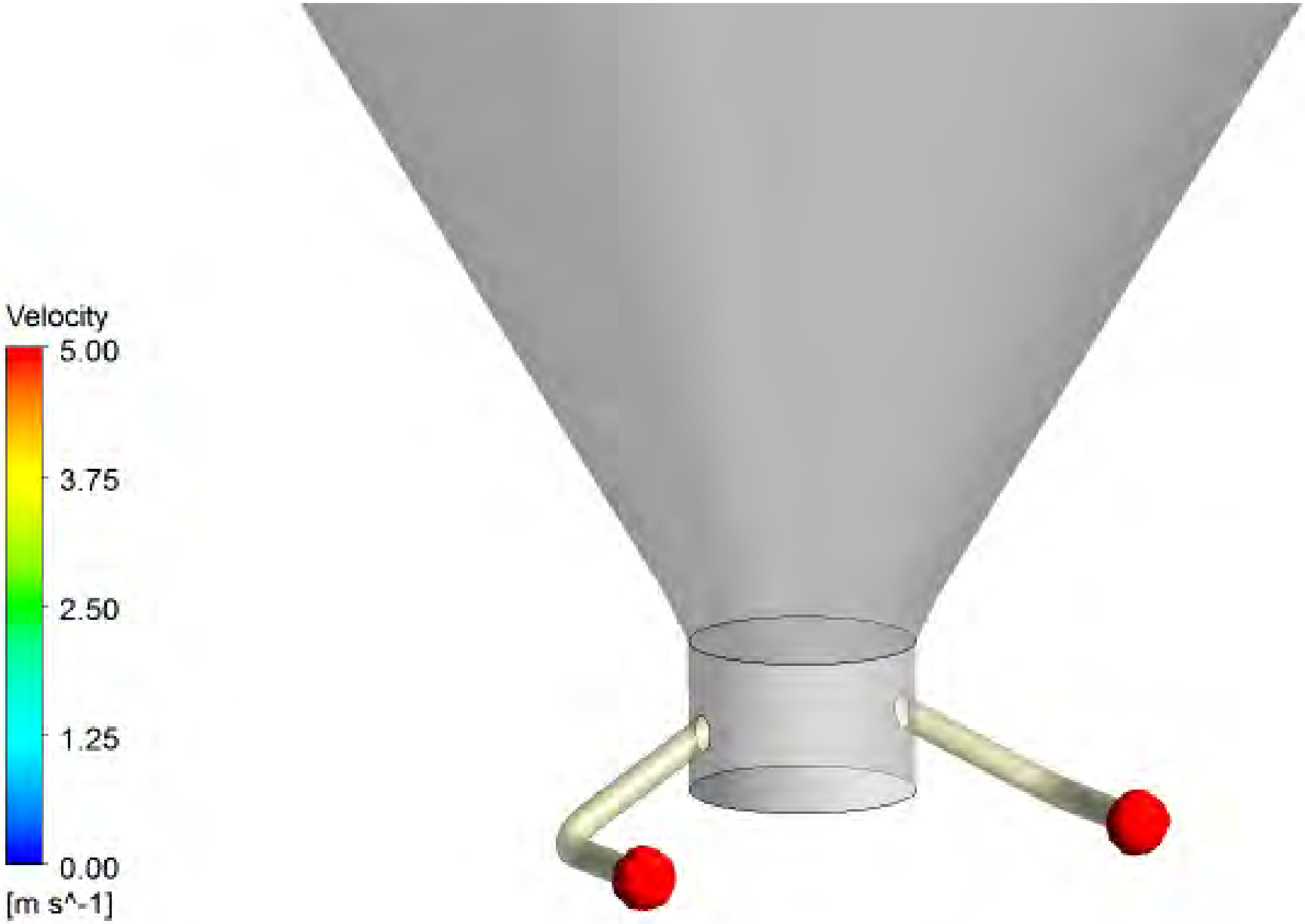
Side Feed Entry Simulation



Side Feed Flow Pattern Conclusions

- Flow channeling tends to travel out to the coke drum wall, then proceed vertically up the wall at a high velocity
- Residual coke bed temperatures suggest that quench water may be following the resid flow channels, thus predominantly quenching from outside to inside of the coke bed
- Preferential thermal distribution during feed and quench from a side feed entry system will cause a reduction in the fatigue life cycle of the drum

Dual Side Feed Simulation



Dual Side Feed Flow Pattern Conclusions

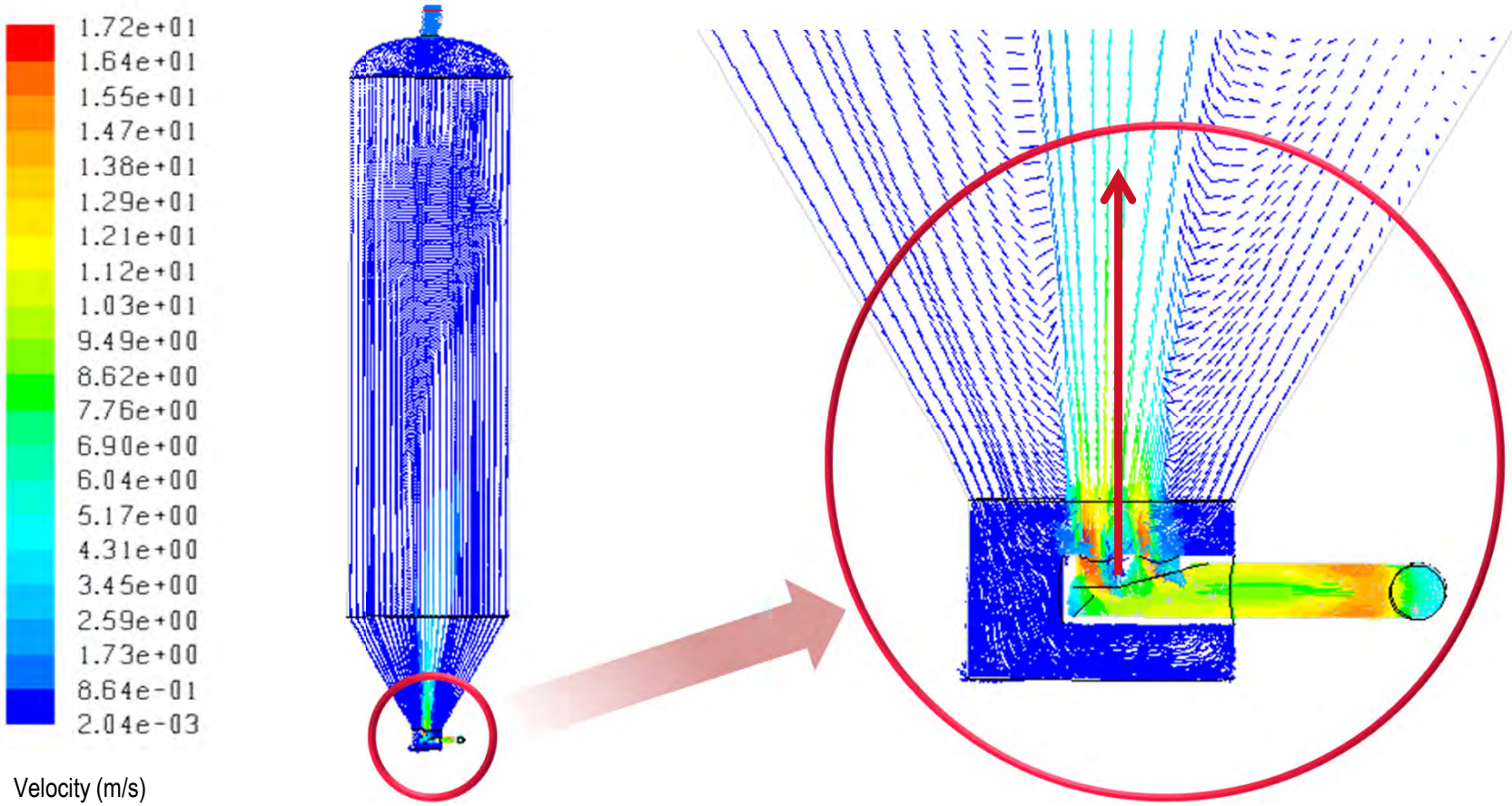
- Despite “perfect” geometry of the model, dual side feed shows that one side of the flow dominates the other. This is even more prominent in actuality because of the known irregularities in pipe length, surface finish, etc.
- The two unequal flows come together and serve to cancel one another apart, reducing upward energy required for flow channels in the coke bed above the transition spool
- Models clearly show that the flow, just like single side feed, naturally wants to flow along the drum wall

Initial Design Objectives of Center Feed Injection Device

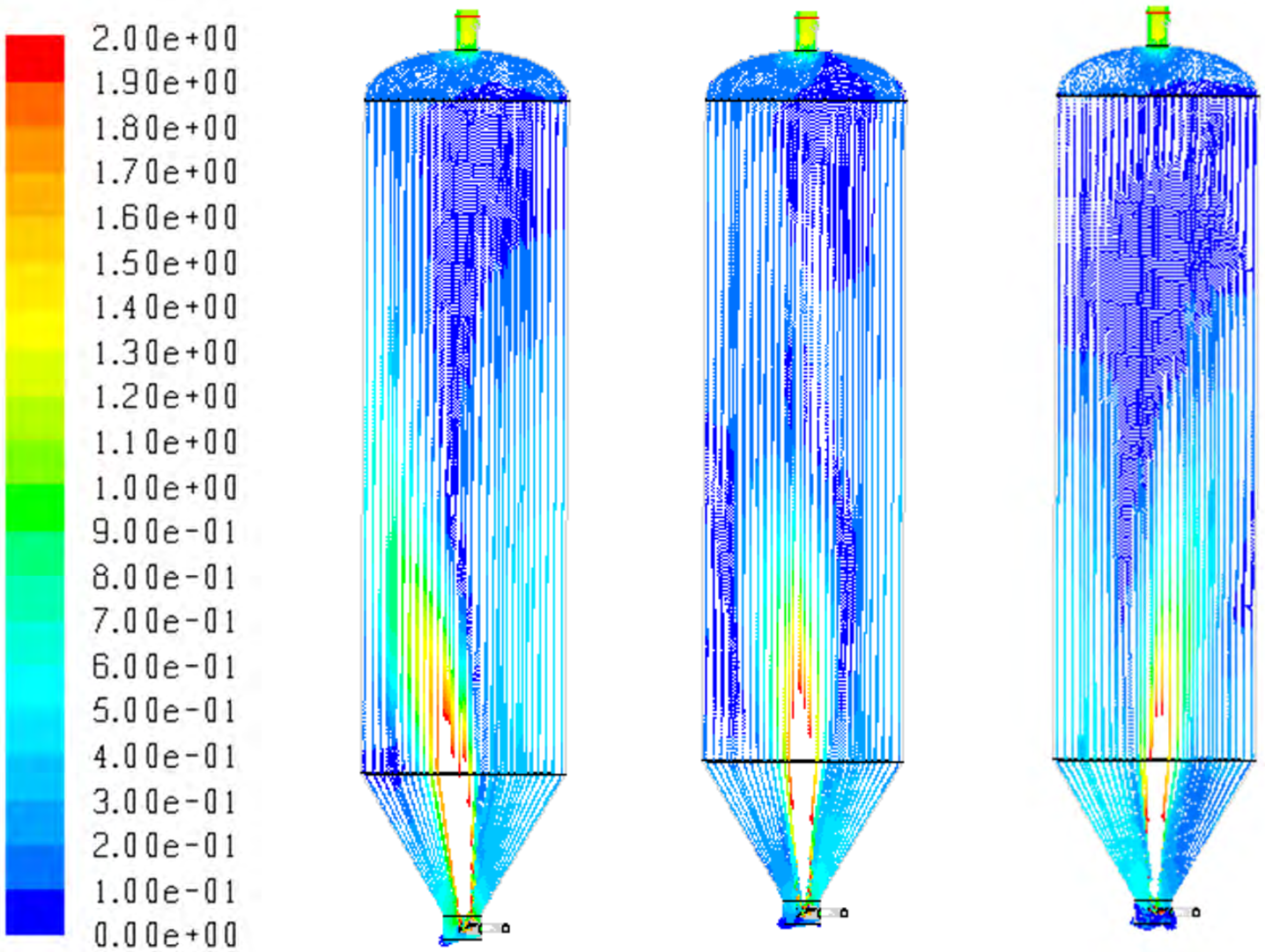
- **To provide**
  - Same flow properties and benefits as bottom feed
    - Centralized flow channeling and reduced flow channeling along drum wall
    - Elimination of hot spots directly opposite the feed line
    - Lower drum wall temperatures and reduced rate of local temperature change
    - Improved coke drum fatigue life
    - Improved top head safety through better behaved top heads
    - Improved quenching efficiencies, improved time
  - High reliability and simplicity in design
  - Simple cost effective installation
  - Easy removal for maintenance during turnarounds
  - Low cost of operation and maintenance
  - Total isolation of feed line from solids during drum cutting, preventing the possibility of feed line plugs from product thus removing need for flush water

Center Feed Injection Flow Pattern Analysis

- The simulations represent the beginning of the coking process when VRC is injected into an empty drum
- Unsteadiness in the plume/jet is observed this is investigated using unsteady CFD simulations



Center Feed Injection Flow Pattern Analysis

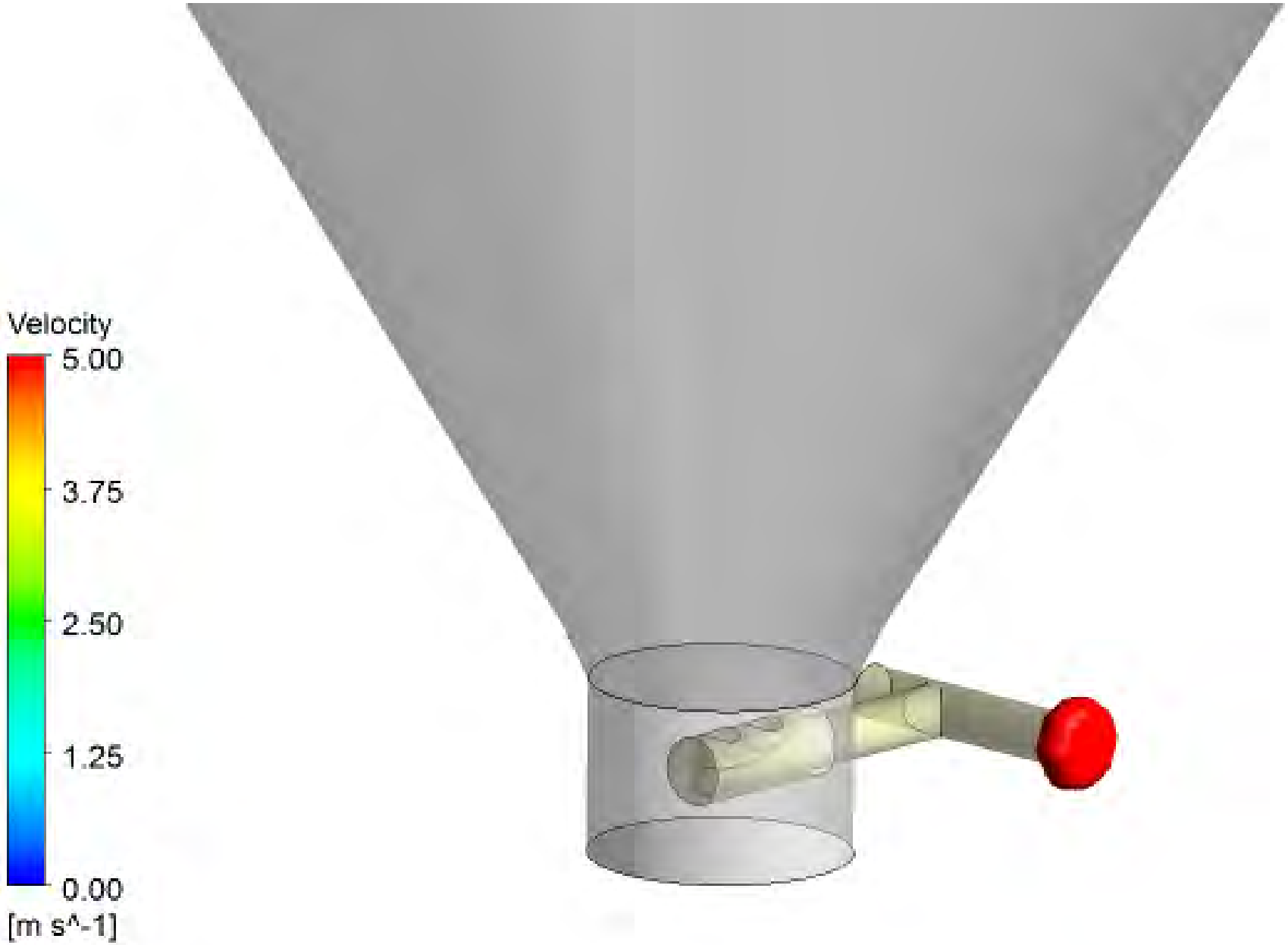


Velocity (m/s)

Velocity distribution at different time instants (indicating oscillation of plume)

Red color denotes velocity of 2 m/s and the white areas next to red denotes regions of velocity higher than 2 m/s

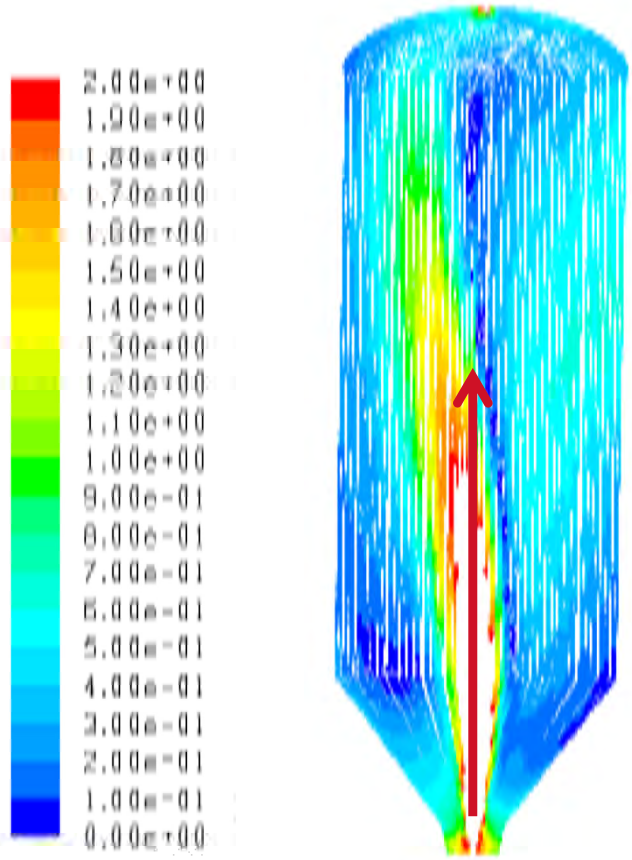
Center Feed Simulation



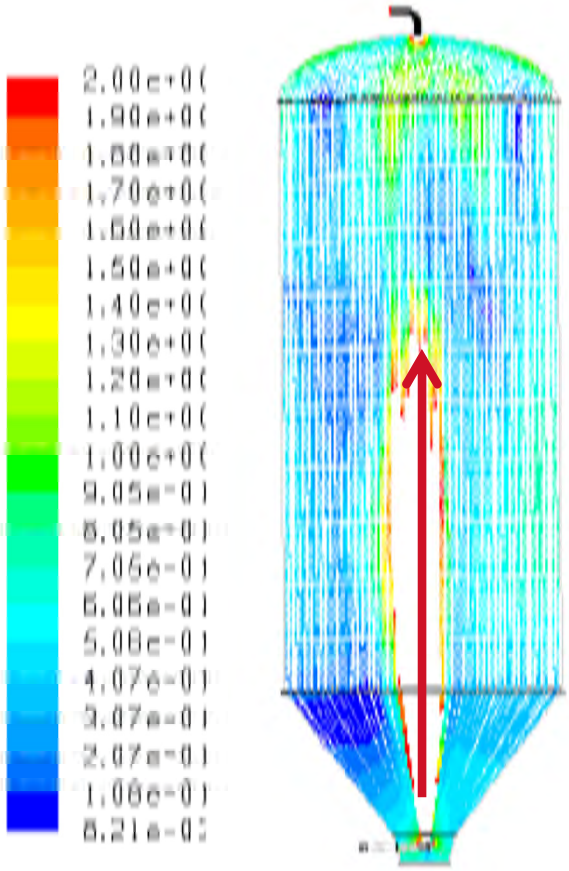
Center Feed Injection Flow Pattern Conclusions

- **The new nozzle design results in a well centered feed stream**
- **Flow does not favor paths along the drum wall as is the case with any side feed (dual or single) configured drum**
- **Feeding and quenching from the center of the drum will**
  - improve thermal distribution at the lower cone area during feed
  - decrease the rate of temperature drop at the drum skin during quench
  - enhance fatigue cycle life of the drum

Bottom Feed vs. Center Feed Injection



Bottom Feed Inlet Line



Center Feed Injection

Bottom Feed vs. Center Feed Injection Device Conclusions

- **The new nozzle design results in a well centered feed stream which mimics the same centered pattern as bottom feed**
- **Feeding and quenching from the center of the drum will**
  - improve thermal distribution at the lower cone area during feed
  - decrease the rate of temperature drop at the drum skin during quench
  - enhance fatigue cycle life of the drum

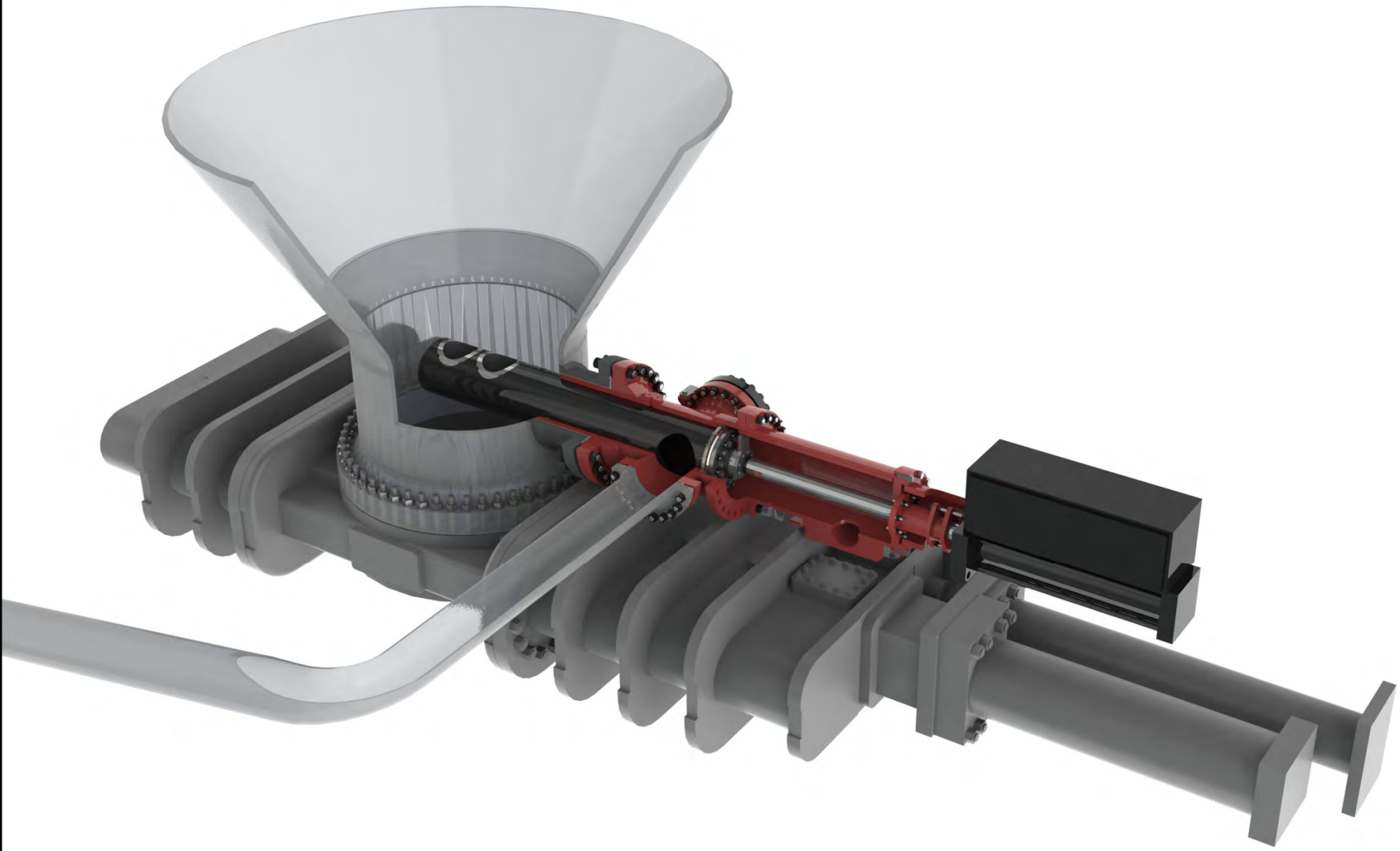
Dual Side Feed vs. Center Feed Injection Conclusions

- **Dual feed entry was intended to centralize the resid flow stream by balancing the fluid energy input from opposing sides. In practice, the fluid streams can not be balanced.**
  - Due to irregularities in the volume, flow rates, vapor phase, etc. of the dual opposing streams, the plume is forced to one side of the coke drum and can shift around the circumference sporadically.
  - Dual feed streams cause rapid heating of the lower portion of both the coke drum cone and spool, followed by a rapid cooling of the same sections during quench. This can cause premature fatigue failure of the lower cone and spool walls.
    - Rapid thermal changes to the lower cone and spool walls can cause lower drum flange roll (toe down/up), distortion, and failure of the drum to flange connection.

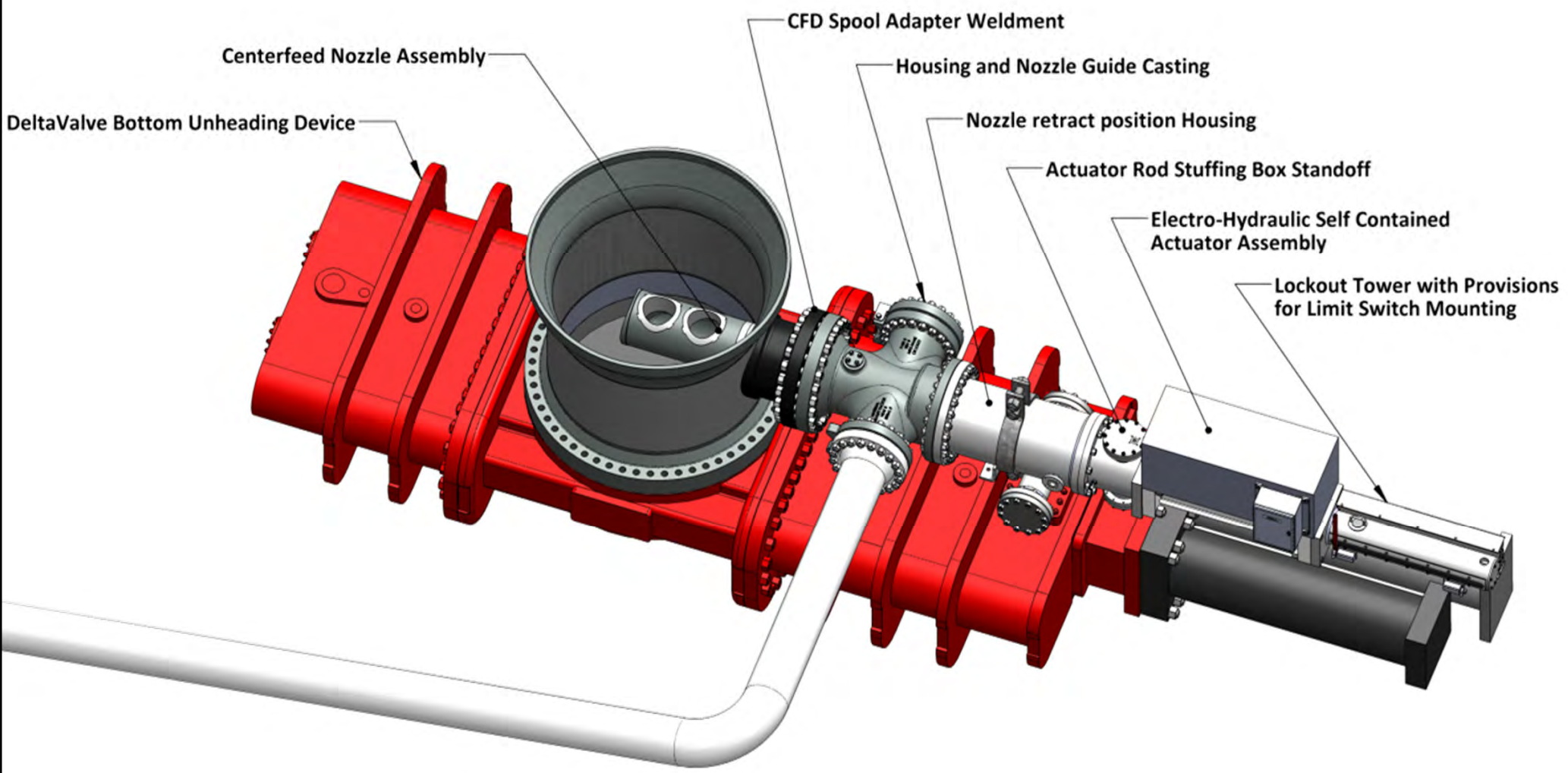
Dual Side Feed vs. Center Feed Injection Conclusions

- **Center-feed results in a well centered feed stream which mimics or improves upon the centered pattern from bottom feed resulting in:**
  - Even drum skin temperatures and reduction of hot spots
  - Formation of an insulating layer of coke resulting in lower temperatures at the drum wall at time of quench dramatically reducing drum fatigue damage
  - An insulating layer of coke across the exposed component of the unheading valve facilitating a state of thermal equilibrium thus improving long-term sealing, reliability and fatigue life of the pressure retaining boundaries

DeltaValve's Retractable Center Feed Injection Device



DeltaValve's Retractable Center Feed Injection Device



DeltaValve's Retractable Center Feed Injection Device

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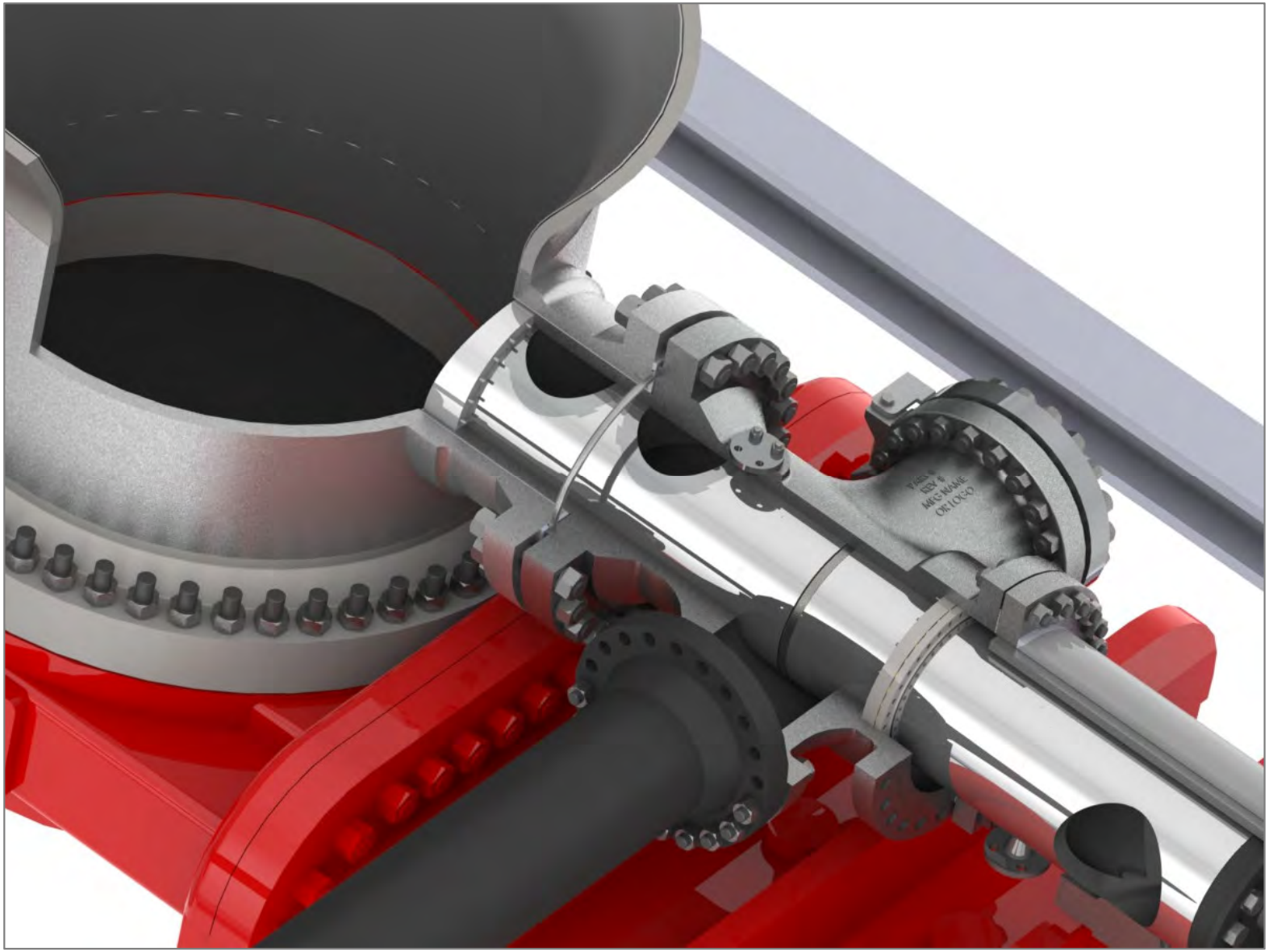
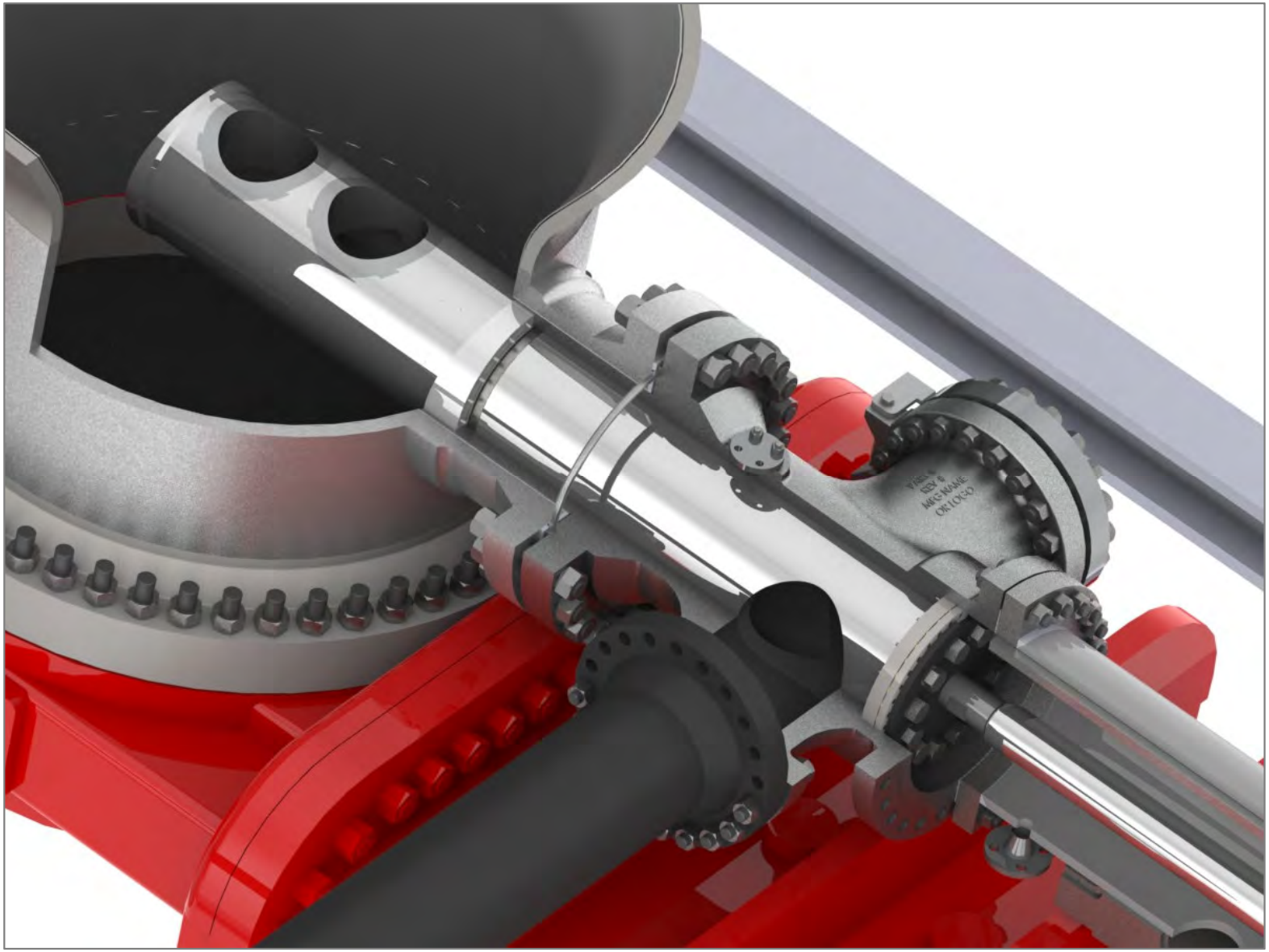
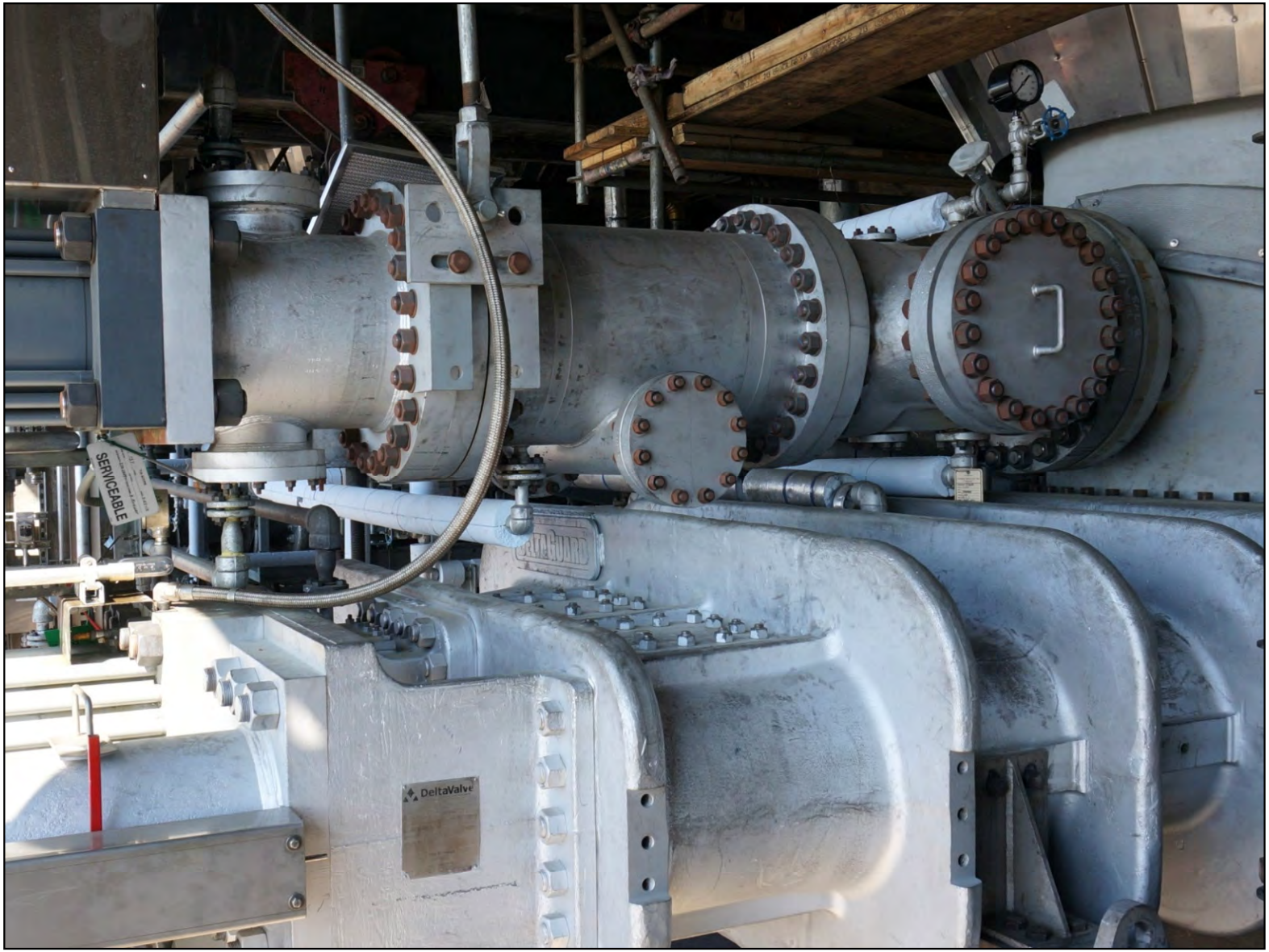


DeltaValve's Retractable Center Feed Injection Device

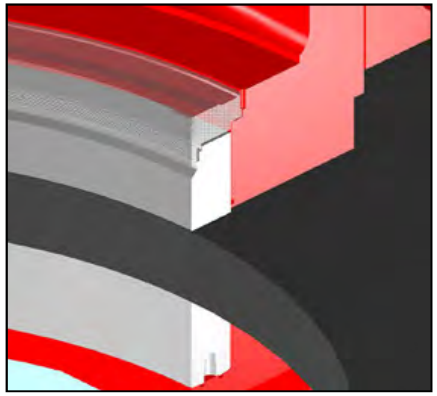


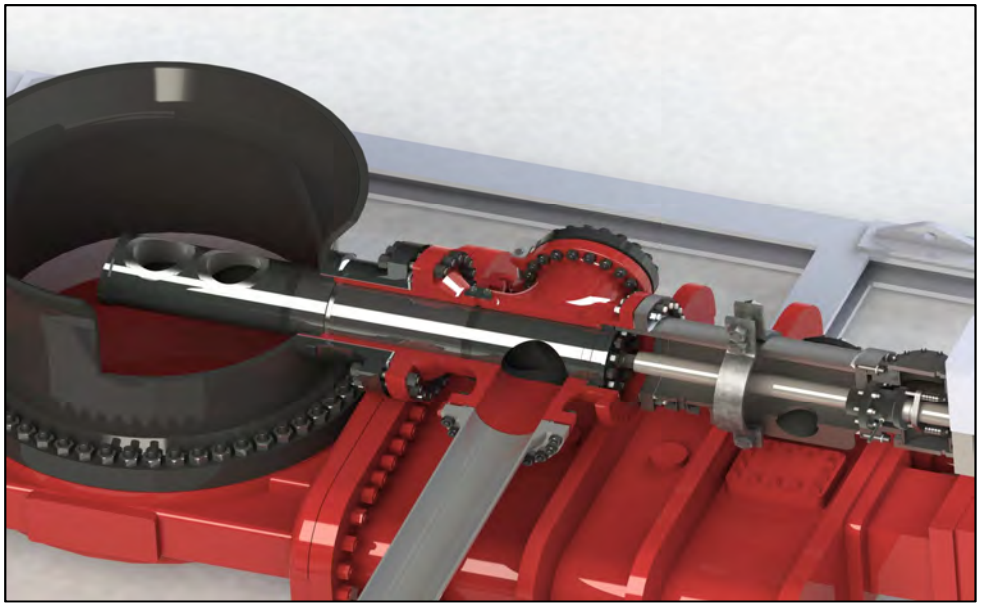
DeltaValve's Retractable Center Feed Injection Device

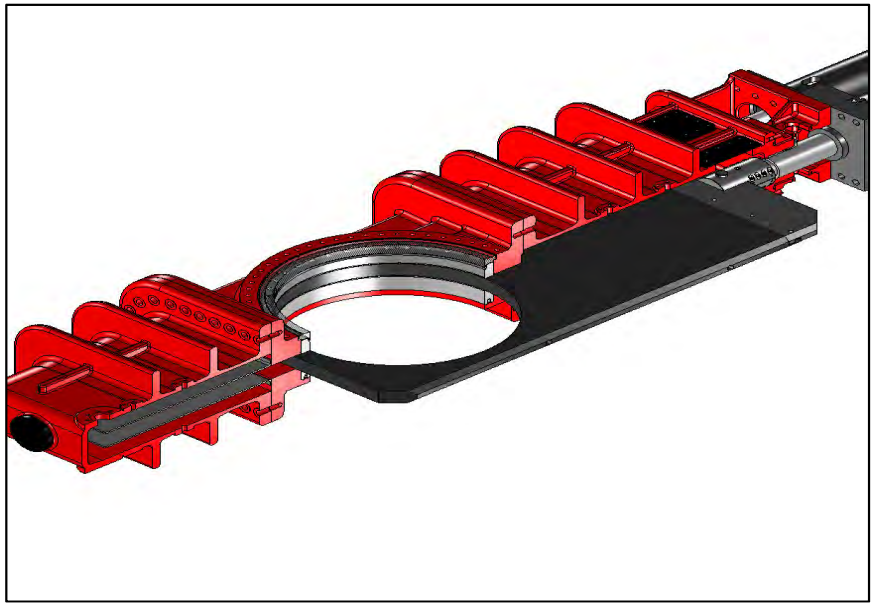


DeltaValve's Retractable Center Feed Injection Device

- **Sealing technology similar to bottom unheading valve**
  - All metal sealing, using similar design principals as unheading valves
  - Nozzle extension and retraction similar to gate in bottom unheading valves
  - Bonnet isolation is achieved by utilizing a dynamic live loaded seat design







DeltaValve's Retractable Center Feed Injection Device

- **Nozzle design results in a well centered feed stream**
- **Better thermal distribution during feed results in**
  - Maximized coke-drum life, minimized down-time and repairs, by creating lower overall drum wall temperatures
  - Minimizing sever thermal rates of change during coke drum quenching
  - Eliminates feed line plugging during decoking by reducing local hot spots
  - Improving top head safety by minimizing blowouts and geysers

DeltaValve's Retractable Center Feed Injection Device

- **Initial installation**
  - May 2011 prototype installed
  - "Blocking steam" in the device was connected and functioning, but the purge steam in the nozzle was not connected
  - As a result of no nozzle purge steam, the injection nozzle became bound within its housing as the device was retracted back out of the drum
  - Subsequently the device was removed from service

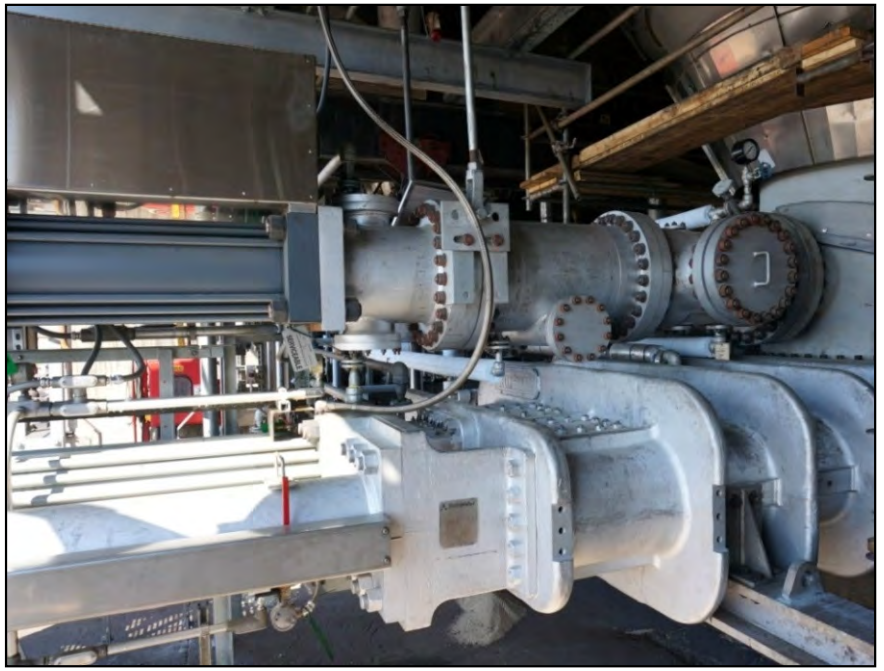
DeltaValve's Retractable Center Feed Injection Device

- **Removal**
  - June 2011
    The center-feed nozzle was removed, cleaned then reassembled without modification, and delivered back to LyondellBasell in Houston for re-installation.

  - Steam purge piping was installed to the center-feed

DeltaValve's Retractable Center Feed Injection Device

- Four units in successful operation, no issues
- Five more units to be in service by year end



DeltaValve's Retractable Center Feed Injection Device

Questions?

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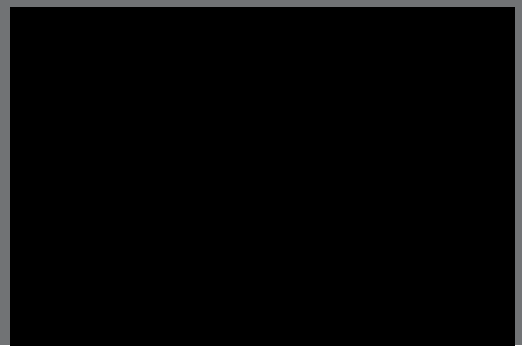

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