Monitoring, Mitigating and Troubleshooting FCC Catalyst Losses

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Presentation Outline

- Loss Precursors & Warning Signs
- Catalyst Monitoring
- Equipment Contributions
- Troubleshooting Loss Causes
- Mitigation & Pre-Entry Activities

Catalyst Loss
Precursors and Warning Signs

Regenerator & Flue Gas System

- Slow regenerator bed level build with typical catalyst additions
- Growing differences in dense bed or cyclone temperatures
- Higher stack opacity baseline
- Higher superficial velocity than typical
- Higher cyclone velocities than typical
- More frequent Electrostatic Precipitator roll-off bin removal
- Higher or lower than expected bed level due to error in level and density instrumentation
- Higher slide/plug valve %open to achieve catalyst circulation rate
- More frequent soot blowing boilers, economizers, and/or Selective Catalytic Reduction (SCR) reactors
- Faster gain in SCR reactor ΔP over time
- Higher Wet Gas Scrubber purge rate to manage Total Suspended Solids

Catalyst Loss
Precursors and Warning Signs

Reactor Side

- Higher slurry BS&W or Ash (product blending issues)
- Holing through of slurry pump casings
- Loss of slurry pumping capacity (impeller wear)
- Thinning of slurry circuit piping
- Higher cyclone velocities than typical
- Growing differences in 2nd stage outlet temperatures of connected cyclone systems
- Higher or lower than expected stripper bed level due to error in level and density instrumentation
- Higher slide/plug valve %open to control stripper level at a given catalyst circulation rate

Catalyst Monitoring

Conduct a Catalyst Balance Monthly
for Early Recognition of Loss Issues

Measure the loss rate from each vessel
in TPD and % of catalyst additions

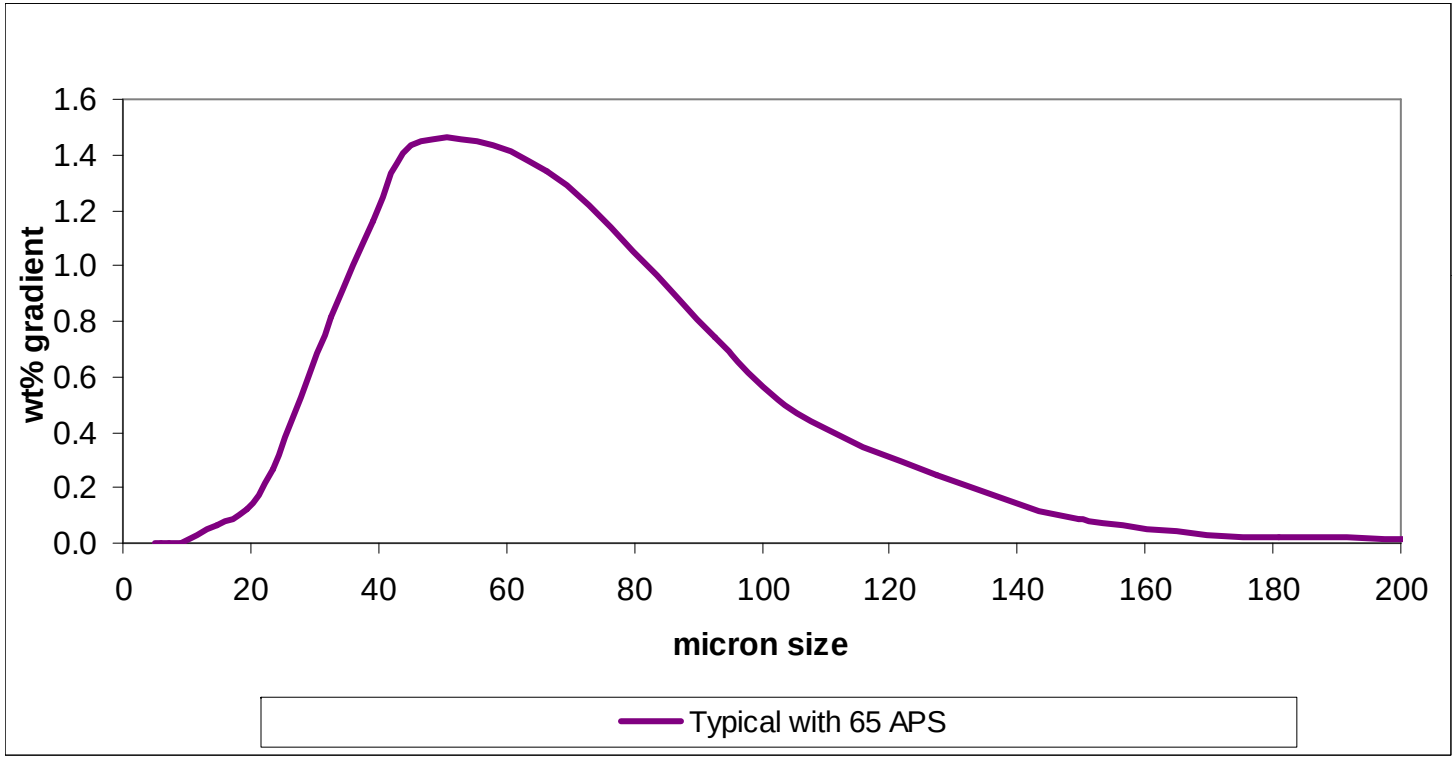
+ Catalyst additions from weigh cell, hopper and/or shipping data
- Reactor losses from slurry ash content
- Withdrawals of spent equilibrium catalyst
- Regenerator fines losses from
  - 3rd Stage Separator (TSS),
  - 4th Stage Separator (FSS),
  - Electrostatic Precipitator (ESP), or
  - Wet Gas Scrubber (WGS)

Catalyst Monitoring

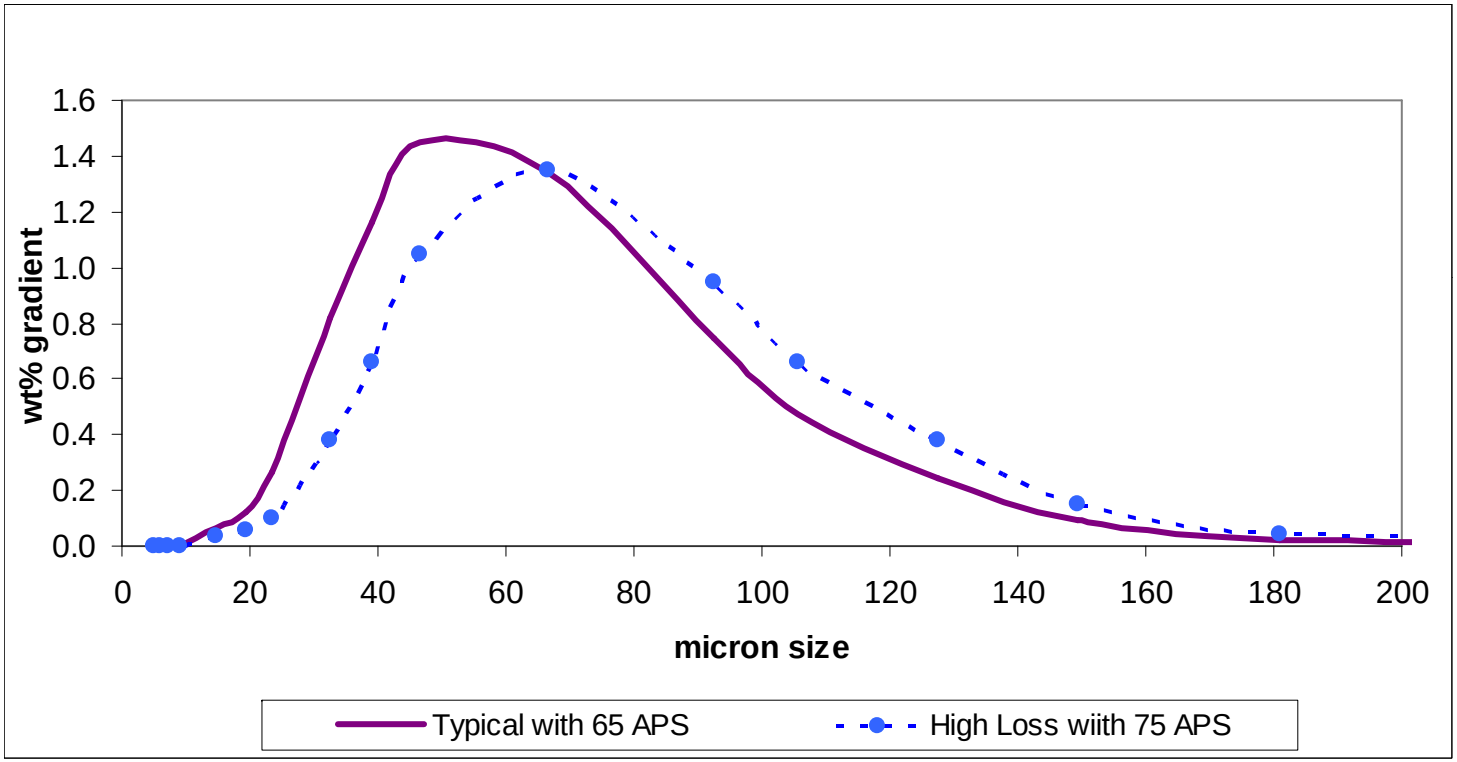
Evaluate Catalyst Properties Frequently for Possible Cause or Confirmation of Losses

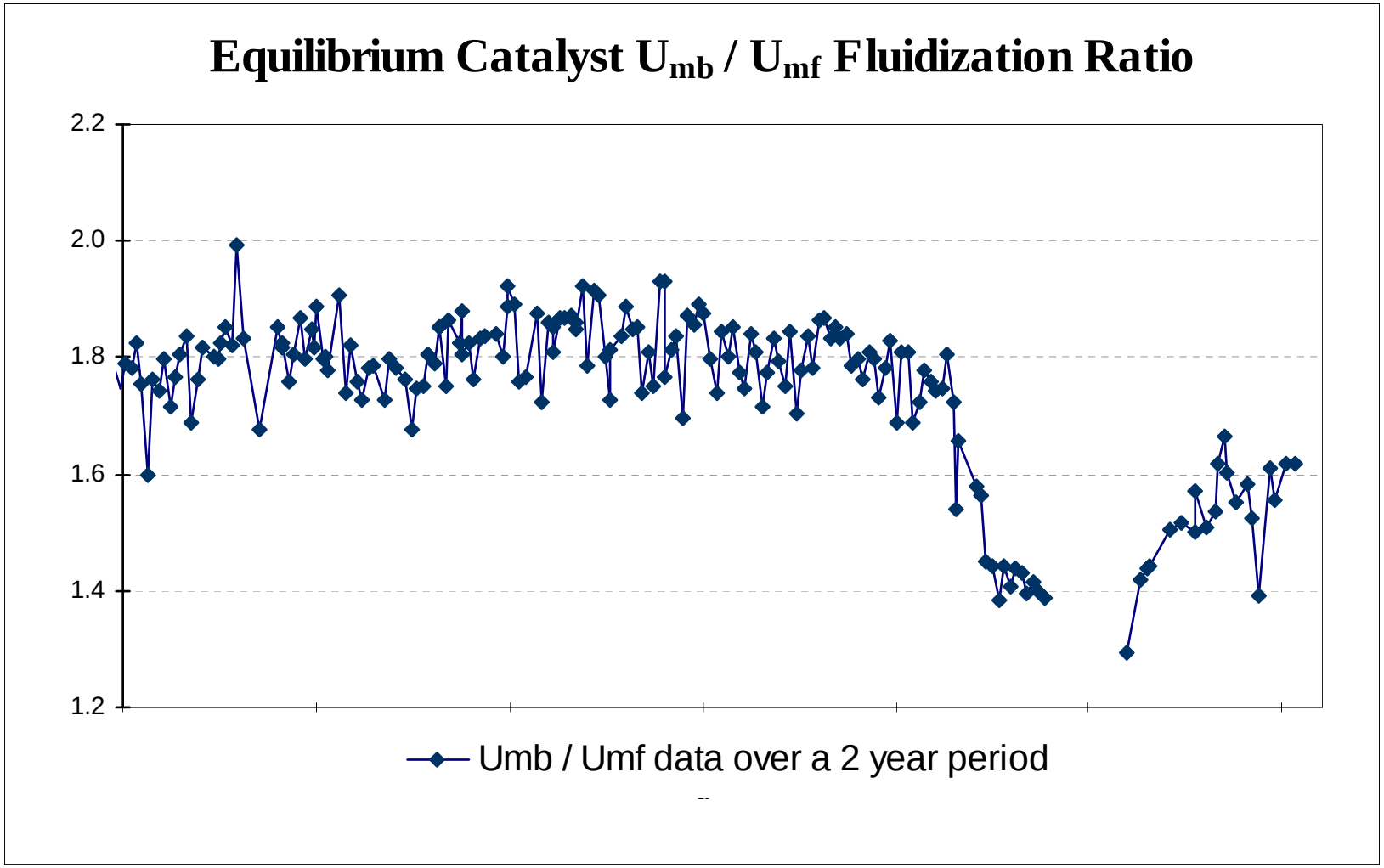
- Fresh catalyst (each delivery)
  - Attrition Resistance and Particle Size Distribution
- Equilibrium catalyst (at least weekly)
  - Detailed Particle Size Distribution
  - U_{mb}/U_{mf}, F-Prop
- TSS, FSS, ESP, WGS fines/solids (at least monthly)
  - Detailed Particle Size Distribution

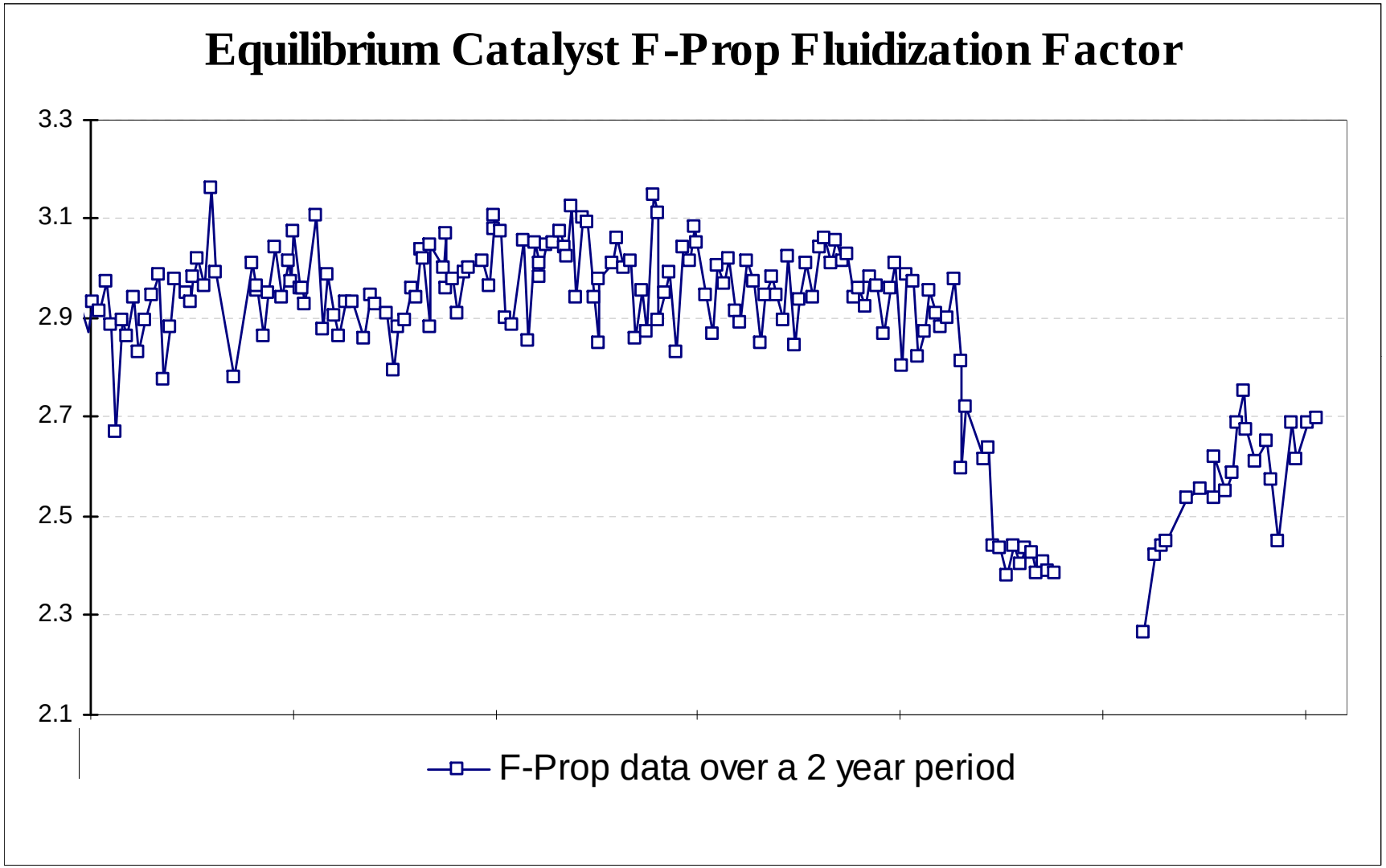
Typical Equilibrium Catalyst



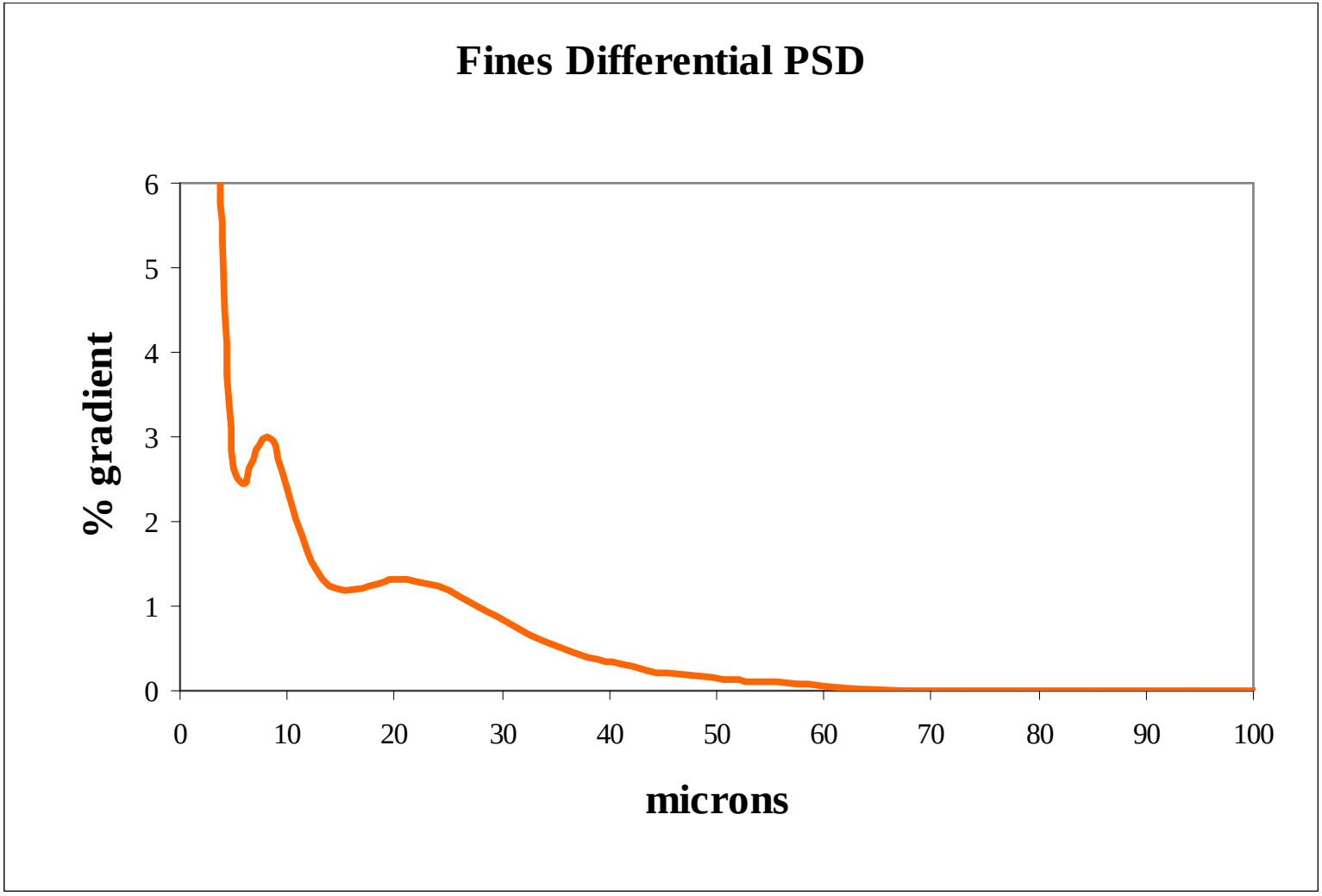
Impact of High Loss on Equilibrium Catalyst Size Distribution



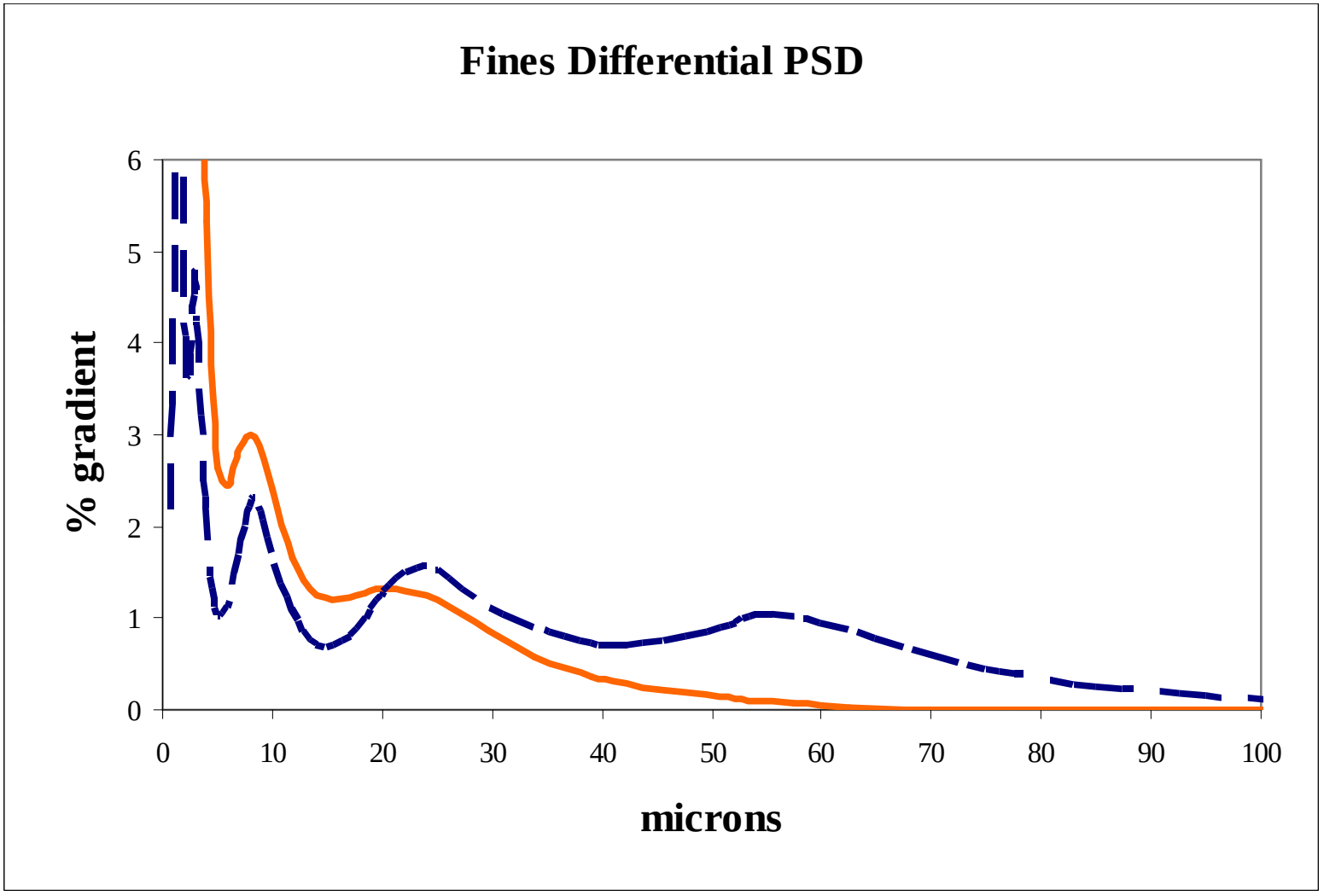

Equilibrium Catalyst U_{mb} / U_{mf} Fluidization Ratio
2.2
2.0
1.8
1.6
1.4
1.2
Umb / Umf data over a 2 year period


Equilibrium Catalyst F-Prop Fluidization Factor
3.3
3.1
2.9
2.7
2.5
2.3
2.1
F-Prop data over a 2 year period

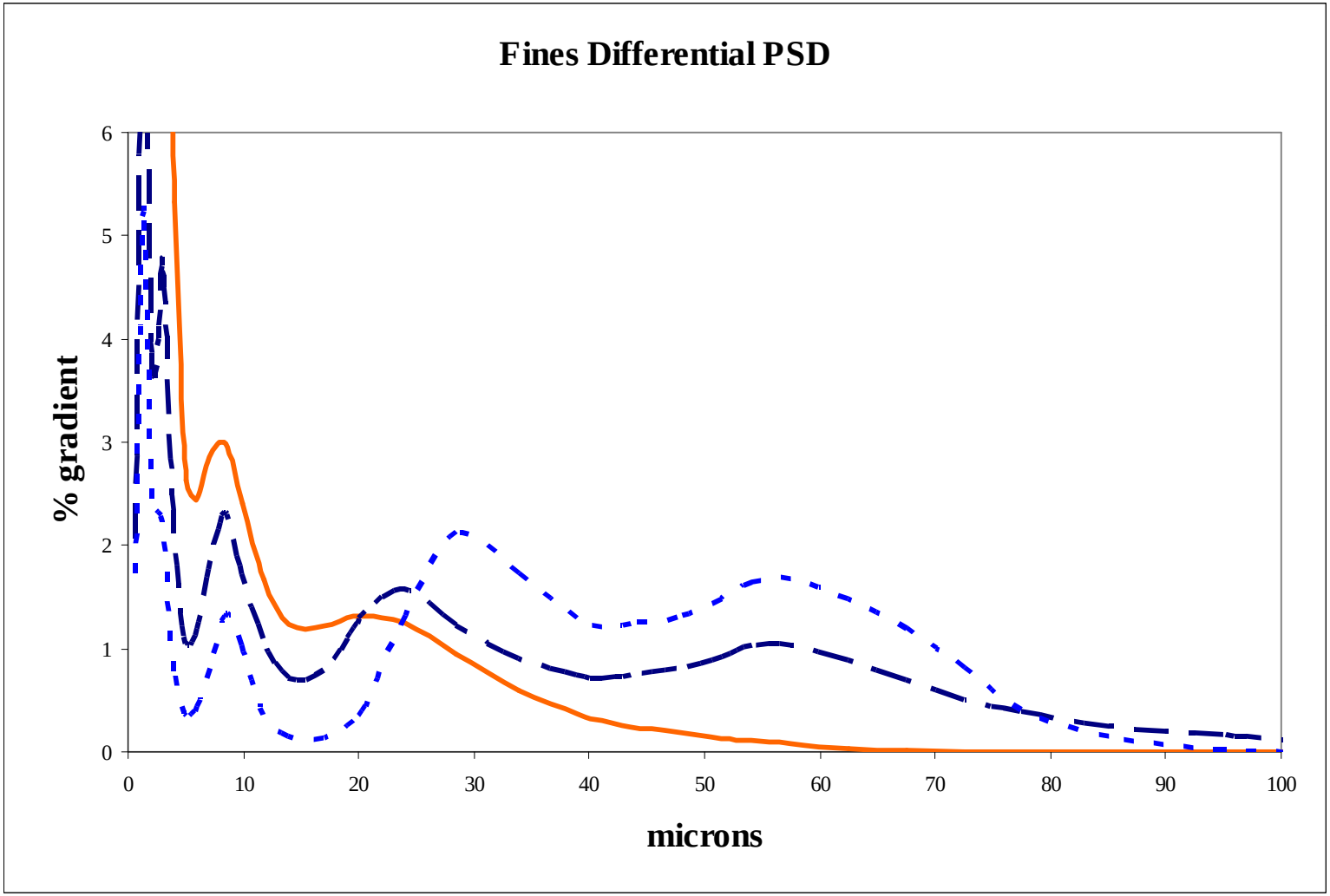
Typical Fines Size Distribution



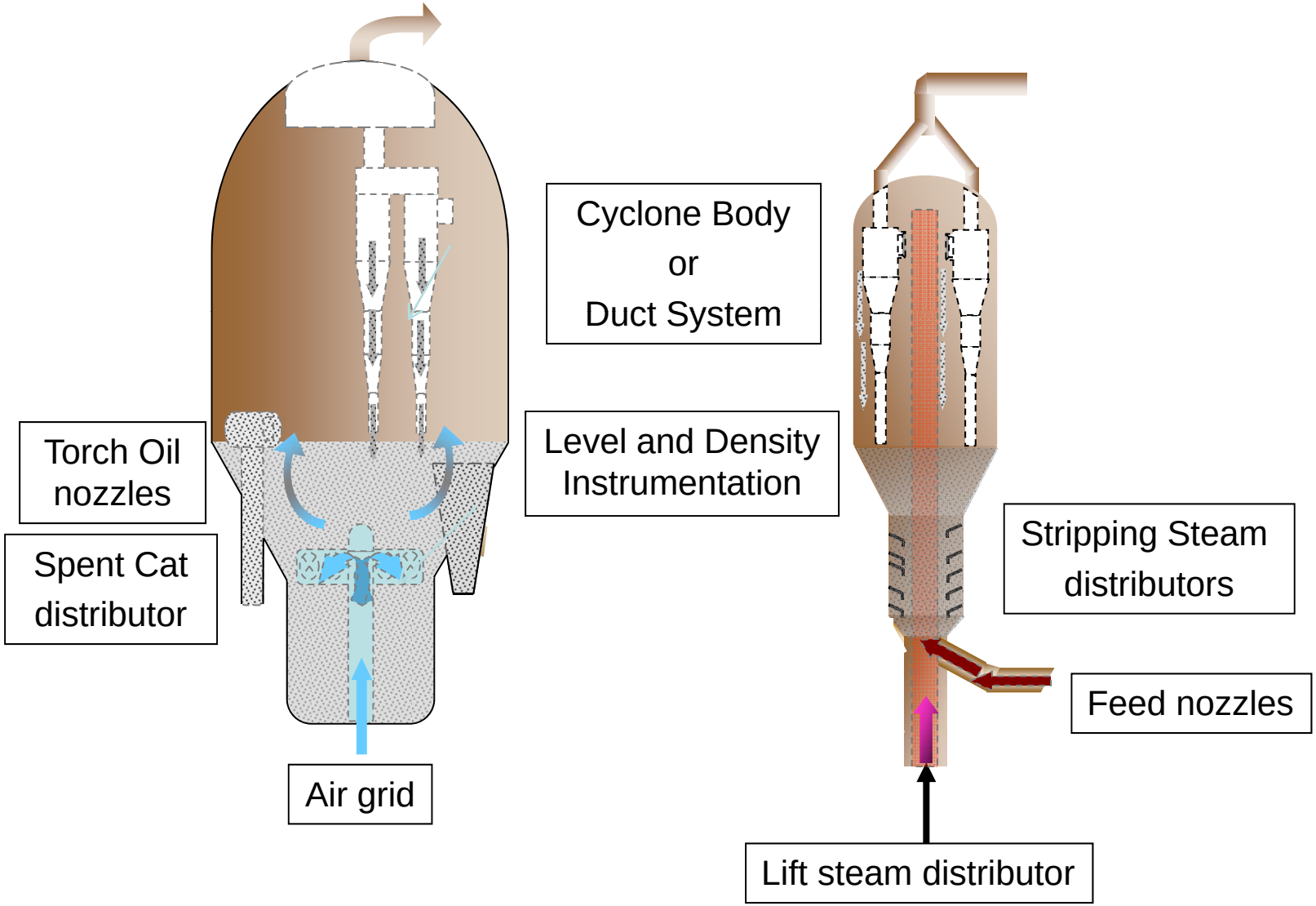
Coarse Fines Showing Up



Cyclone Separation Worsening



Possible Equipment Contributing to Excessive Catalyst Losses



Equipment Investigations

Has the loss been gradual or sudden?

What excursions, shutdowns, startups, or unusual operations have occurred?

Troubleshooting Loss Causes

For “Low” losses:

- Fresh catalyst property shifts
- High catalyst addition periods
- Damaged stripping steam distributor
- Operating with excess steam to the torch oil nozzles
- Partially plugged air distributor
- Damaged dome steam distributor
- Damaged feed nozzles / riser coke build-up
- Damaged or plugged riser lift vapor distributor
- Excessive emergency/lift steam rates
- Introducing wet steam
- Open blast nozzles
- Damaged spent catalyst distributor interfering with dipleg valves

Troubleshooting Loss Causes

For “Low” losses (continued):

- Cyclones
  - High gas backflow up the cyclone diplegs
  - Refractory liner erosion at high gas rates
  - Dipleg holes, weld cracks
  - Dipleg valve loss, partial movement
  - Low cyclone efficiency from turndown operations
  - Operating with high bed level (for splash plate/trickle valve cyclone designs)

Troubleshooting Loss Causes

For “High” losses:

- Obstructions interfering with cyclone cone or dipleg flow
- Dipleg valve mostly closed
- Operating with high bed level (for counterweighted valve cyclone designs)
- Damaged air distributor leading to
  - high, mal-distributed catalyst to the cyclones,
  - dense bed density differences restricting cyclone diplegs, and
  - severe attrition
- Damaged spent catalyst distributor leading to high, mal-distributed catalyst to the cyclones
- Very high superficial velocities (especially small diameter vessels)
- Excessive holing in cyclone ductwork and internals

Catalyst Loss Causes

Stripping Steam Distributor nozzle damage

Catalyst Loss Causes

Air Distributor nozzle damage

Catalyst Loss Cause

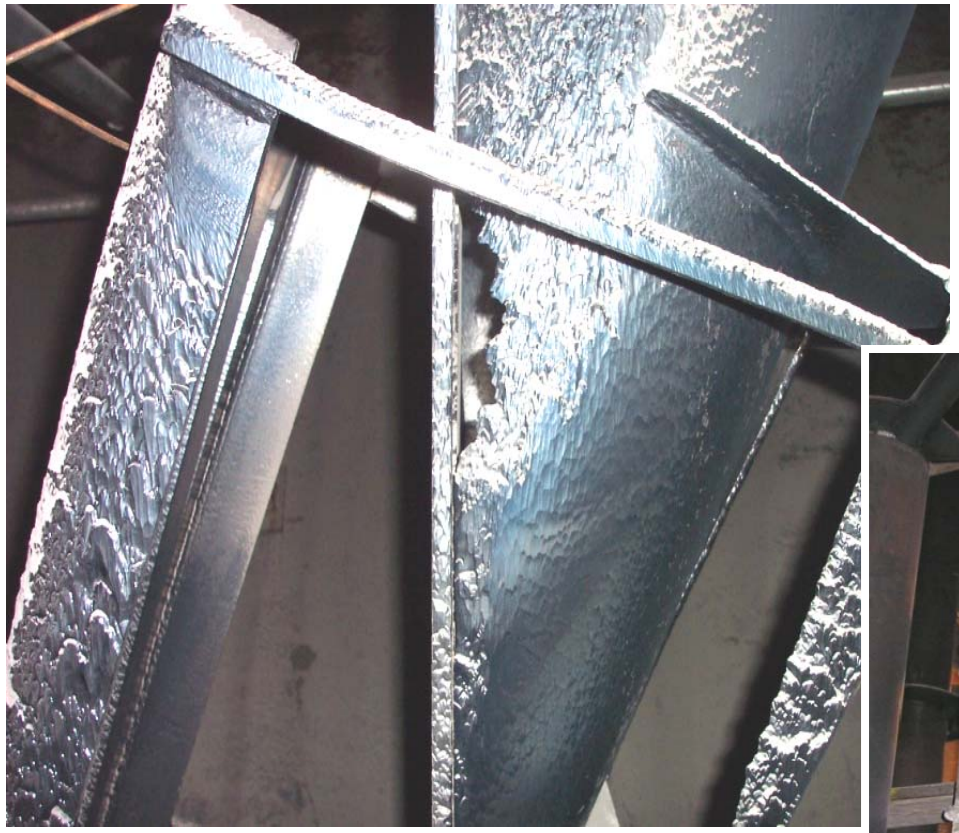
Spent catalyst distributor failure

Catalyst Loss Causes

Cyclone Outlet Tube & Duct failures

Catalyst Loss Causes

Cyclone Dipleg & Termination failures



Mitigation & Pre-Entry Actions

- ✓ Pressure bump to possibly dislodge or aerate an obstruction
- ✓ Reformulate the fresh catalyst
  - Increase attrition resistance
  - Adjust fines content
- ✓ Make up with equilibrium versus fresh catalyst
- ✓ Reduce air/steam rates
- ✓ Modify air/steam distribution if multiple distributors are available
- ✓ Lower/raise bed levels
- ✓ Lower/raise operating temperature/pressure to lower/raise velocities
- ✓ Evaluate cyclone performance with in-house model or work along with cyclone manufacturer
- ✓ Improve feed quality to reduce temperature and catalyst additions
- ✓ Conduct pressure drop & flow surveys of distributors
- ✓ Consider tracer studies and gamma scans to check distributor integrity, bed levels and short-circuits (e.g. cracks)

Summary

It is important to track the catalyst loss rate from each vessel
as well as measure the properties of the lost catalyst

The information enables the refiner to assess
the operating condition of key equipment
and physical integrity of the inventory catalyst

Changes in inventory catalyst properties can
negatively impact catalyst fluidization
and limit the capacity or upgrading capability of the unit

Early recognition of these changes will enable the refiner
to troubleshoot and develop quicker corrective action plans
for staying on-line and keeping operating costs down

Questions?

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