2020 AFPM SUMMIT

Excellence in Plant Performance

AFPM WEBINAR SERIES:

SAFEGUARDING THE FCCU DURING TRANSIENT OPERATIONS

FEBRUARY 27, 2020

WHAT IS AFPM WEBINAR SERIES?

- AFPM has been doing various webinars for years, mostly on the safety related

- As we embark in developing The Summit, Excellence in Plant Performance, there will be more opportunity for member engagement

- There will be one webinar a month until the August Summit :

  March 31, 2020; 2:00pm Eastern

  Shutdown Best Practices for Hydrotreater Reactor Systems
  James Esteban, Refined Technologies, Inc.

  April - Crude/Coking

  May - Learning Teams, Reliability & Maintenance

  June - Gasoline Processing

  July - Operational Planning, Control & Automation Technologies

PRESENTERS

Ziad Jawad, Phillips 66

FCC Subject Matter Expert
BSChE Virginia Tech
25 years experience
Operations, Licensing, Equipment

CJ Farley, G.W. Aru LLC

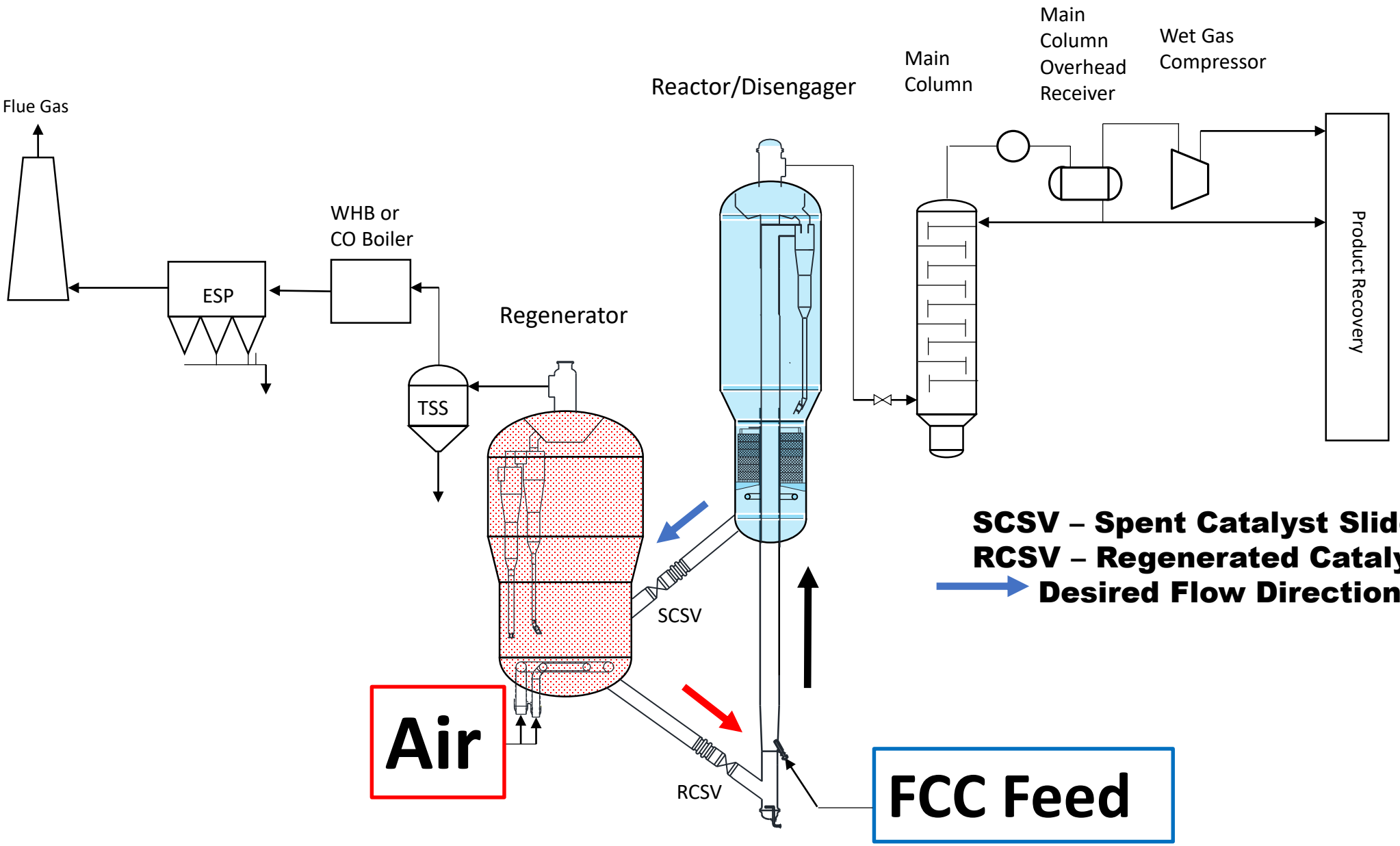
FCC specialist, BSChE from Purdue, 29 years FCC work at operating, design, and catalyst/additive companies

G. W. Aru, LLC
Integrity · Innovation · Value

OUTLINE

- Team acknowledgement for AFPM FCC Townhall Committee
- General Fluidized Catalytic Cracking Unit (FCCU) geometry
- Rapid summary of 2 incidents in industry last 5 years
- Pressure balance or ‘catalyst seal’?
- FCC Fluidization
- Steps to prevent and mitigate unintended flow
- Audience questions and comments

GENERAL FCCU GEOMETRY



SCSV – Spent Catalyst Slide Valve
RCSV – Regenerated Catalyst Slide Valve
Desired Flow Direction

RECENT FCCU INCIDENTS

- 2015 Electrostatic Precipitator explosion (photo from csb.gov)
  - Explosive mixture of vapor reached an energized ESP during expander maintenance activities, a few days after unit was shutdown
  - Hydrocarbon from main column flowed to reactor, then to the regenerator through the spent standpipe
  - No injuries reported
- 2018 Gas Plant explosion and tank fire (photo from csb.gov)
  - Unit shutdown for planned turnaround about 6 AM
  - 10 AM, explosion in gas plant due to air/oxygen from regenerator migrating through main column and gas plant
  - 11 OSHA recordable injuries, 36 people received medical treatment
- Both incidents involved a spent slide valve that closed but had erosion damage – stripper catalyst level was lost
  - No. 2015-02-I-CA
  - https://www.youtube.com/watch?v=3RFDKpwdbEA#action=share
  - https://www.csb.gov/assets/1/6/husky_factual_update_-_2.pdf

FURTHER COMMENTS BY THE CHEMICAL SAFETY BOARD (CSB)

"Prior to both incidents, the process hazard analyses identified scenarios in which hydrocarbons flowed into the air side of the FCCU and vice versa due to a failure of the spent catalyst slide valve (SCSV), but the safeguards listed to protect against those scenarios were ineffective," the board said.

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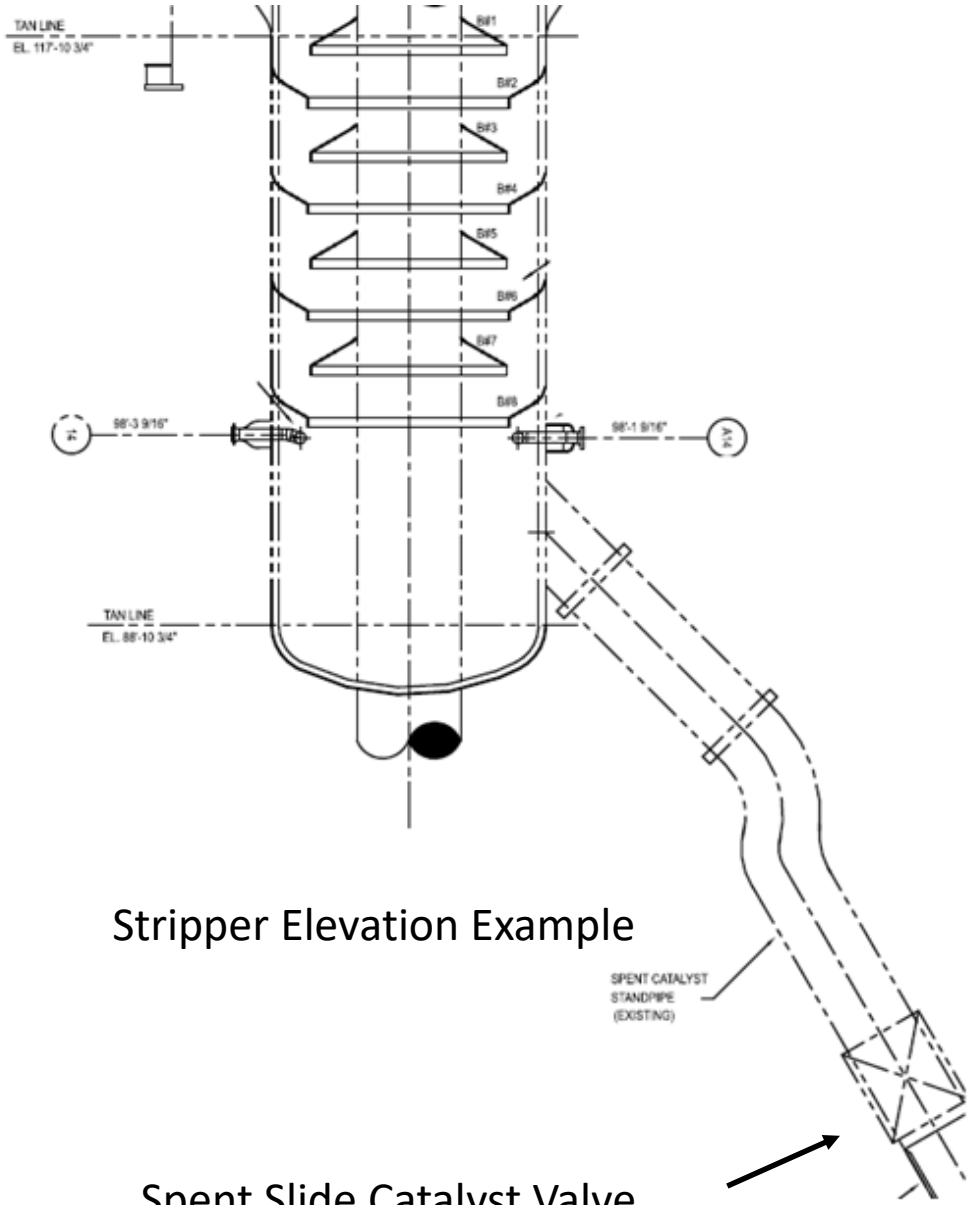
UNIT ELEVATIONS

- Catalyst bed levels are typically ~ 12’ or more above the air grid in the regenerator vessel
- The reactor/stripper usually has a bed depth of 20’ or more above bottom stripping steam distributor
- Elevation to the slide valves, add another 15 – 25’
- Pressure taps near the bottom of the vessels measure pressure build relative to the dilute phase of the vessels to determine level



Stripper Elevation Example

Spent Slide Catalyst Valve

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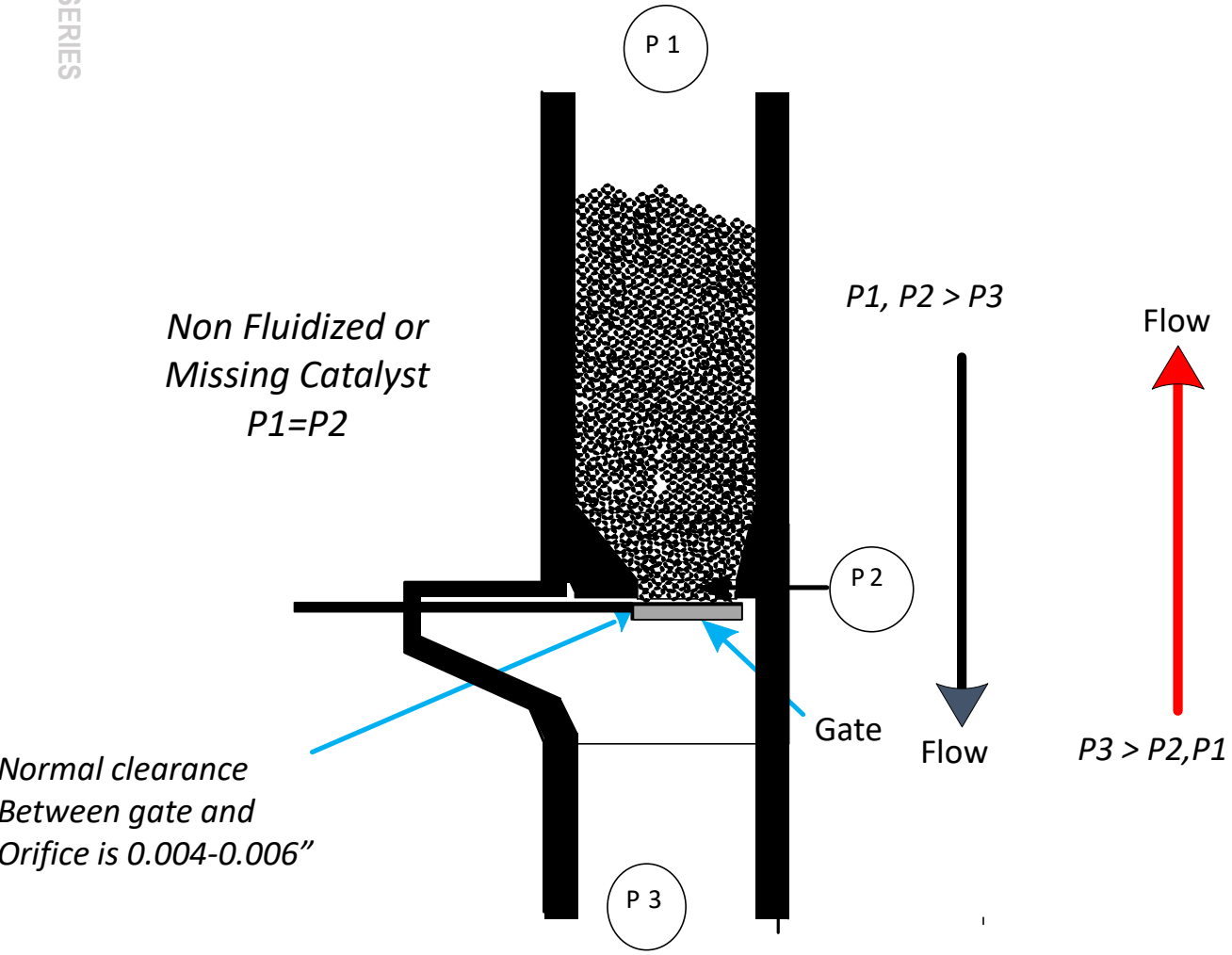
FLUIDIZATION IN THE FCC

- Fluidized catalyst moves easily and at high rates
  - Typically discussed in terms of catalyst flux, lbs/ft2-sec in standpipes
  - Typical values are 150+ lbs/ft2-sec, but can be 200+
- Catalyst in vessels can be fluidized or packed
- Fluidized, moves easily
- Packed, does not move well, but gas can pass through bed readily

https://www.youtube.com/watch?v=3BqVFGCUviY

Video from Professor Martin Rhodes, Monash University, Melborne Australia

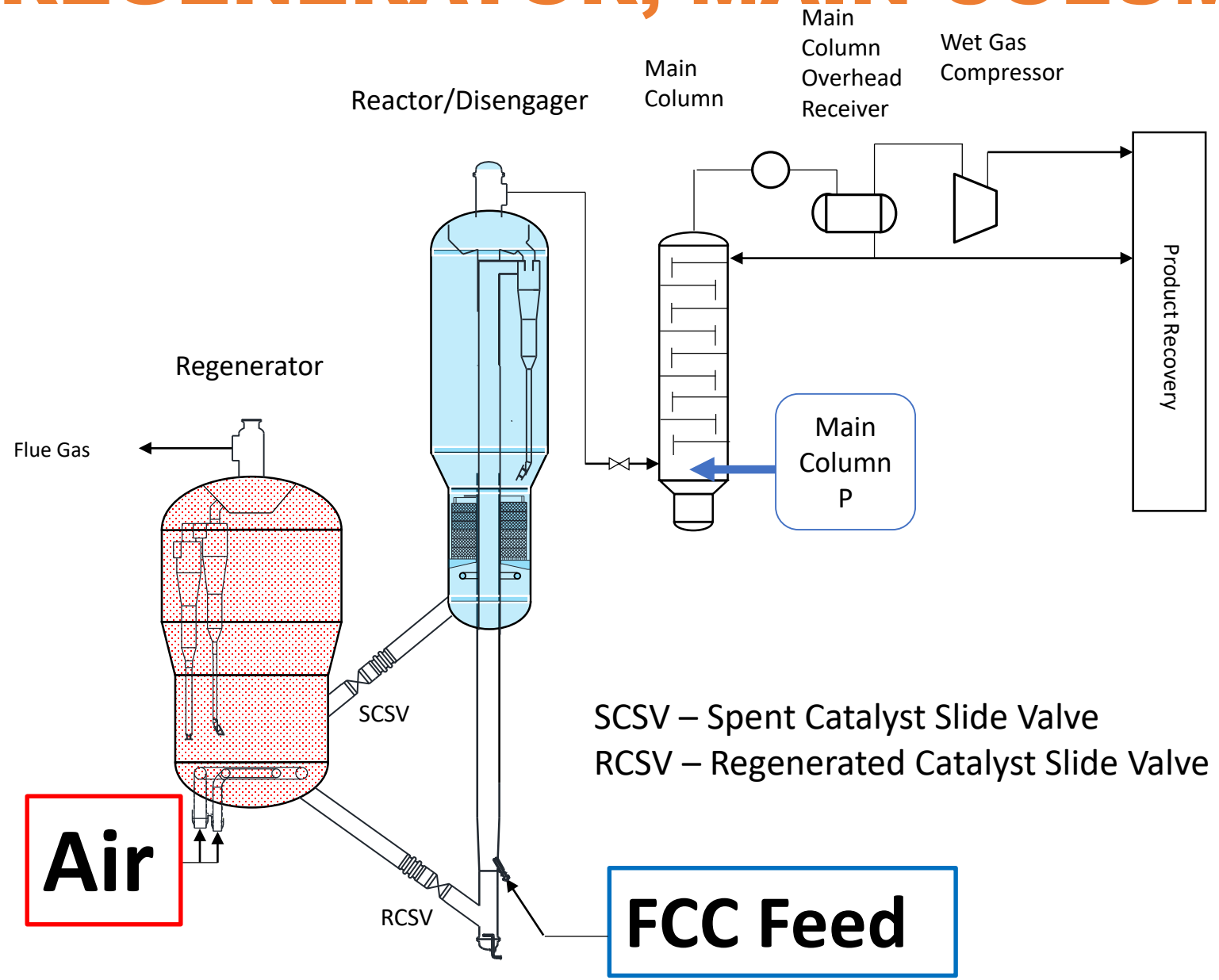
PRESSURE BALANCE OR CATALYST SEAL?



Gas flows from higher pressure to low

- CSB references loss of catalyst seal repeatedly
- IF the catalyst is defluidized, it will still pass vapor through it – it will not provide an active barrier for unintended flow
- IF the catalyst is fluidized, it will flow through the gap/tolerances in the slide valve, and will be in the environment of the fluidizing vapor
- To prevent gas flow from the region of P3 in the sketch, P2 MUST be higher pressure than P3. If no catalyst level is present, or if the catalyst is defluidized, P1 MUST also be higher than P3

RELATIVE PRESSURES – REACTOR, REGENERATOR, MAIN COLUMN



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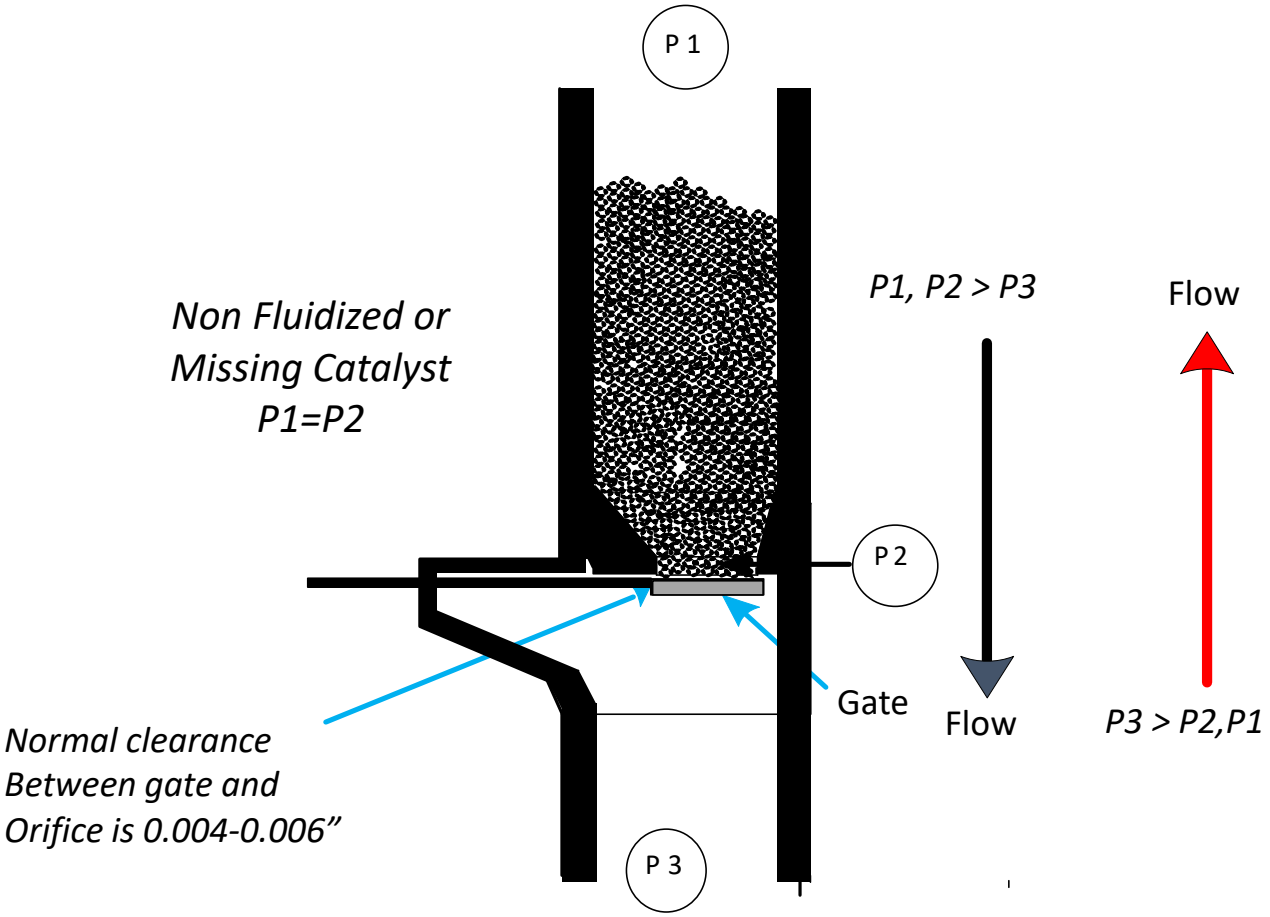
	Regenerator Pressure	Reactor Pressure	Main Column Pressure
Typical Operation	Highest (ex 30 psig)	Middle (ex 28.5 psig)	Lowest (ex 26.5 psig)
Transient without catalyst circulation	Slightly lower	**Highest**	Slightly lower

- Typical terminology is to 'invert the reactor/regenerator delta P' when circulation stops
- Do not believe there is a standard time for when this occurs as it depends upon the reason for loss of circulation
- Shifting to reactor being slightly highest pressure greatly reduces risk of oxygen coming to reactor and eliminates risk of hydrocarbon from main column coming to regenerator

FURTHER COMMENTS ON CATALYST LEVELS



Gas flows from higher pressure to low

- The clearance gap on the slide valve cannot be ignored
- If catalyst is fluidized, catalyst will flow through the tolerance gap
- Supposing 24 linear inches of gate area around perimeter, what is a reasonable rate of catalyst leakage?
  - About 2.5 tons/hour…
  - How many hours will the reactor level be maintained if the valve shuts and works perfectly?

RECOMMENDED STEPS TO PREVENT UNINTENDED FLOW

- Closely monitor catalyst levels in regenerator and reactor vessels (Note: fluidized catalyst required!)
- Upon loss of circulation (either inadvertent or by design), VERY rapidly:
  - Shift pressures to have reactor slightly higher than regenerator and main column
    - Change set point on reactor/regenerator differential pressure controller
    - Requires steam flow to the riser and stripper be at high enough quantity to get required pressure
  - Monitor pressure differences between reactor and regenerator AND reactor and main column
    - Not main column overhead receiver, should be bottom of main column
    - Want ‘low’ delta P values with reactor as highest pressure
    - Instrumentation needs to be of sufficient quality to show in the -1 to +1 psi range, with delta P of ~ 0.25 psi maintained (site specific)
  - Routinely measure for oxygen in main column overhead receiver and take steps to control if anything other than trace amounts found
    - Should have non-condensable gas blanket in place rapidly on main column when catalyst circulation stops, typically nitrogen or fuel gas as steam will condense in overhead coolers
- Other failures exist that will require inversion of the typical pressure profile
  - These should be investigated during Process Hazards Analysis studies and include items such as slide valve actuator failure or stuck slide valve

QUESTIONS AND COMMENTS FROM ATTENDEES

WRAP UP

- General Fluidized Catalytic Cracking Unit (FCCU) geometry
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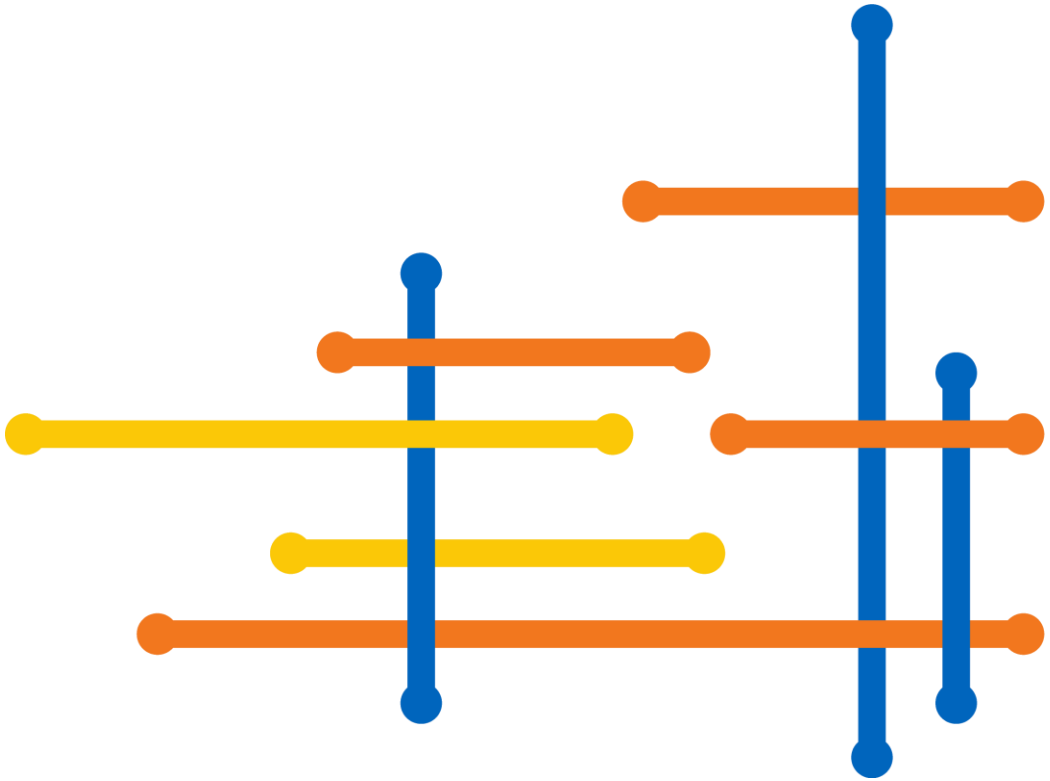

2020 AFPM SUMMIT

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August 25-27, 2020

Grand Hyatt San Antonio

www.afpm.org/2020Summit

Collaboration &
Knowledge Share

Timely Topics &
Tangible Takeaways

Networking &
Peer Engagement

More & New
Technology

SUMMIT TOPICS

August 25 – Day 1

Leverage Emerging Technology for Improved Plant Performance and Efficiency

- Wireless Handheld Devices
- Public Policy Driving Technology
- Leveraging Technology for Knowledge Management
- Return on Investment with Refining and Petrochemical Data

Topics with Industry Wide Implications

- Fostering Profitability - Panel Discussion
- Turnaround Planning and Execution - Roundtable
- Utilizing Refinery Data – Solutions via Case Studies
- Emerging Leaders
- Future of Refining
- New Ideas for Turnaround Safety - Roundtable
- Human Organizational Performance (HOP)
- Contractor Onboarding for Turnarounds
- Workforce Development and Retention

August 26 and 27 – Day 2 and 3

Crude, Coking

- Town Hall featuring HSFO processing, Crude Compatibility, T/A and Reliability
- Monitoring and Improving Equipment Operations
- Coking and Crude Troubleshooting and Lessons Learned
- Unit Optimization
- FAQs – dive into hold-over topics from prior days

Gasoline Processing

- Lessons Learned PES Incident
- HF Alkylation Risk Management
- Town Hall featuring:
  - Corrosion in Alky Units (Poll)
  - Light Naphtha Balance Issues
  - Issues with Higher Utilization of Reformers (with higher octane demand)
  - Current Challenges with Gasoline Blending
  - Chloride Management Issues around Reformer/Isom
  - Unique challenges around Preparation for TA of Gasoline Units with recent regulation updates
- Benzene in Gasoline
- Reformer Reliability Issues
- Molecular Management around Gasoline Units
- Increased Octane Demand – Investment Strategy for the Future
- FAQs – dive into hold-over topics from prior days

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SUMMIT TOPICS CONT.

Hydroprocessing

- Emptying Your Reactor – A Primer
- Effective Catalyst Selection Strategies
- Regulatory Compliance: Perception vs Reality
- Turnaround Scope Development for Dummies
- The How and Why of Hydroprocessing Safety Systems
- Driving Hydrocracker Profitability without Capital Investment
- FAQs – dive into hold-over topics from prior days

FCC

- Key Equipment Fundamentals and Maintenance
- Spent Catalyst Unloading Equipment Reliability
- Optimization at Reduced Rates
- Pressure Balance Fundamentals
- Refinery of the Future – Case study with Gulf Coast Economics
- Refractory Reliability
  Failure Mechanisms, New Technology and Best Practices

Technical Breakouts

- Integrating Operating Windows and Corrosions Control Documents Roundtable and Case Study on Integrity
- Flange Assemble Breakout
- Drones for Inspection Strategies
- Corrosion Control Case Studies, Inspection and Technology
- Risk Based Inspection
- Reliability Roundtable
- How to get the most Tool Time
- Asset Strategy Optimization
- Turnaround Scope
- Rope Access Repairs Roundtable
- Tank Maintenance and Cleaning

QUESTIONS?