Reliability vs Recovery for Delayed Coking Fractionators

A Tower Internals Discussion

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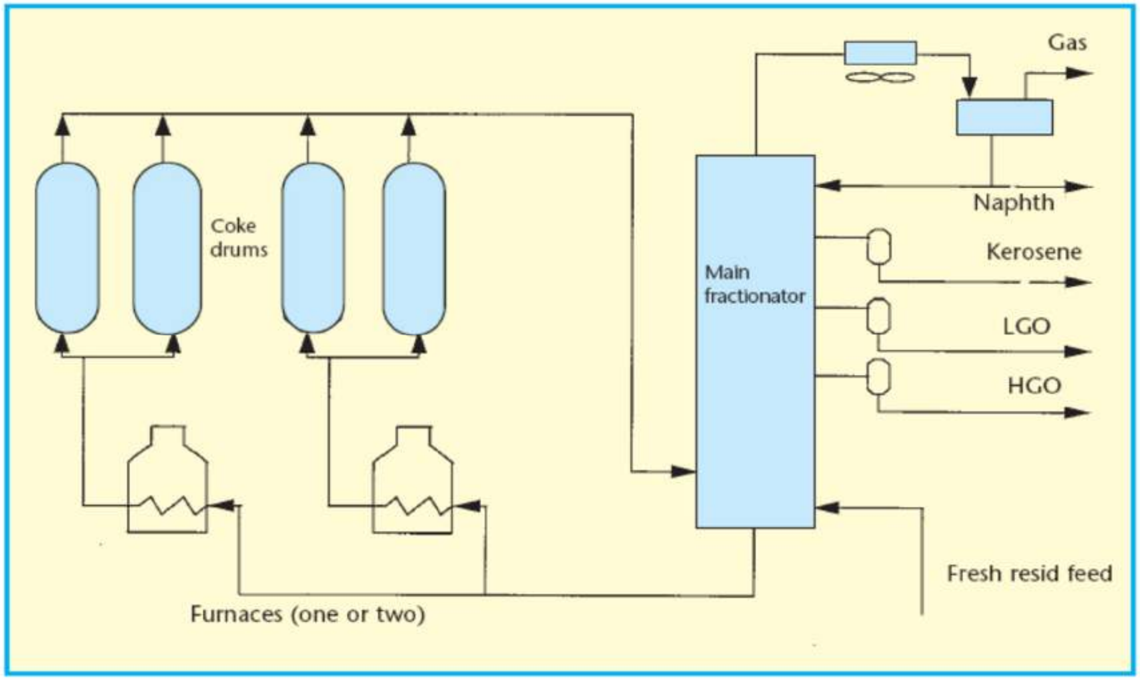
Agenda

- Reliability Issues – Fouling
- Technology Options – Wash Zone
- Fouling Resistant Considerations

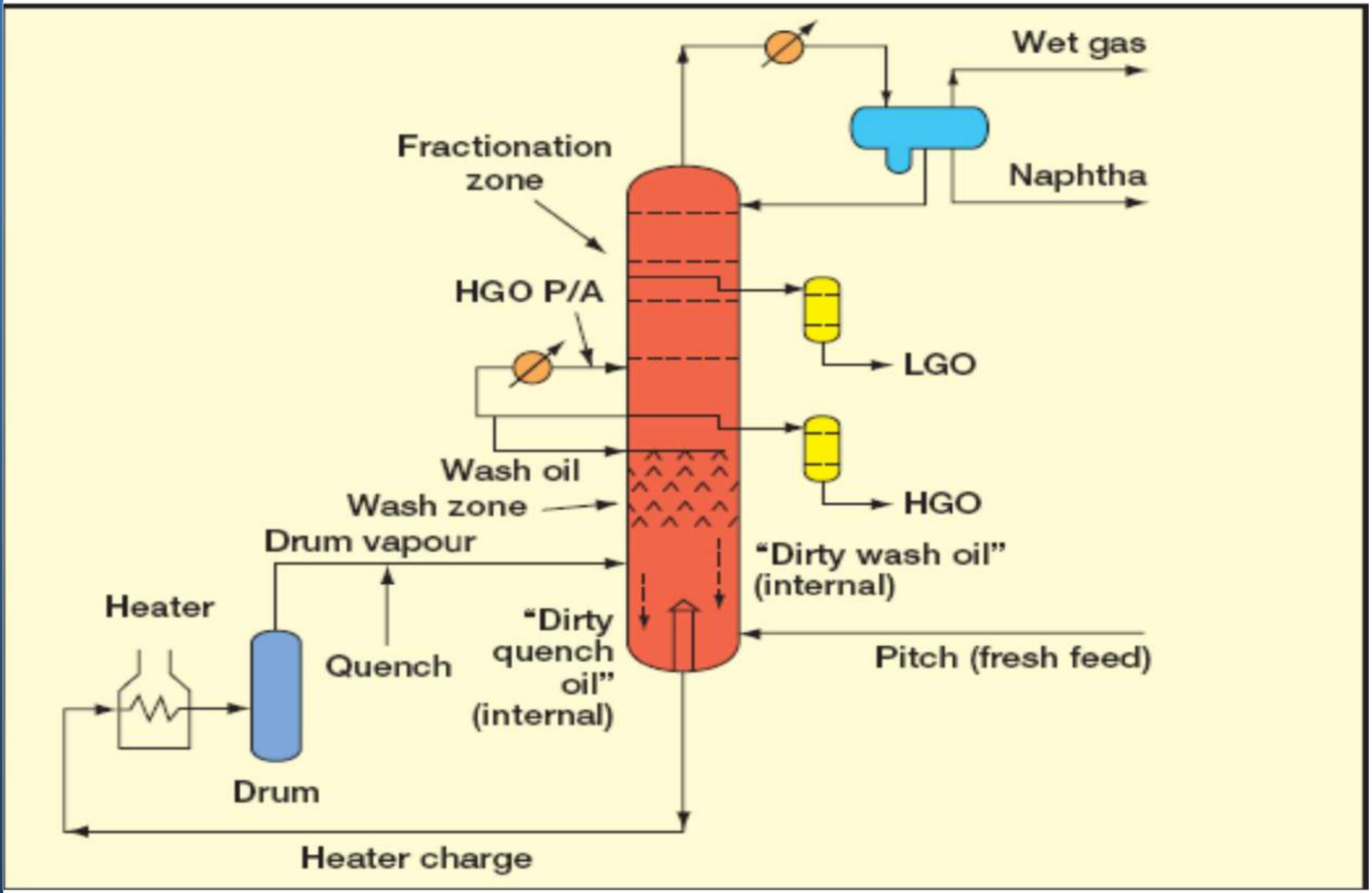
Coking Common Knowledge

- **Effective units to decarbonize and demetallize heavy petroleum residues**
- **Typically, objective is to maximize liquids and minimize coke generation**
- **Deals with the "nasty" components of the processed crude**



PTQ Q3, 2003 - "Debottlenecking Coker fractionators" Herman et al

Simple BFD of Coker Fractionator



PTQ Q3, 2003 - "Debottlenecking Coker fractionators" Herman et al

Biggest Separation Issue
Fouling

- **Fouling largest contributor to malfunction**
  - Coking, scale account for 15% of problems
- **# of Occurrences increasing each decade**
  - Processing more heavier crudes
  - Operating units pushed
  - Standard design guidelines not updated
- **Basis - 900[1] column malfunction examples**

1 Kister, IChemE 2003

Biggest Separation Issue
Fouling-Phenomena

- **Contributors**
  - Process conditions - T, ΔT, P, flow rates
    - Coking of hydrocarbon
    - Salt Formation
  - Particulates in feed
  - Flow Mal-distribution

Fouled Tray Deck

Fouled Collector Tray

Biggest Separation Issue
Fouling - Implications

- **Loss of throughput (reduced production).**
  - During operation (increased pressure)
  - Additional Turnaround time
- **Replacement of equipment.**
- **Increases safety hazards (fires)**
- **Cleaning and disposing of toxic wastes.**

Fouling is a symptom – Ideal situation is to address problem at source
- but source is the heart of the process
- Address some symptoms in coker fractionator

Mitigate Fouling
Tools

- **Process**
  - **Technology choices**
  - Design Guidelines
  - CFD (computational fluid dynamics) Analysis
  - In/Out Design Approach
- **Equipment**
  - Trays
  - Internals/Grid

General Design Guidelines

Process-Mitigate Fouling

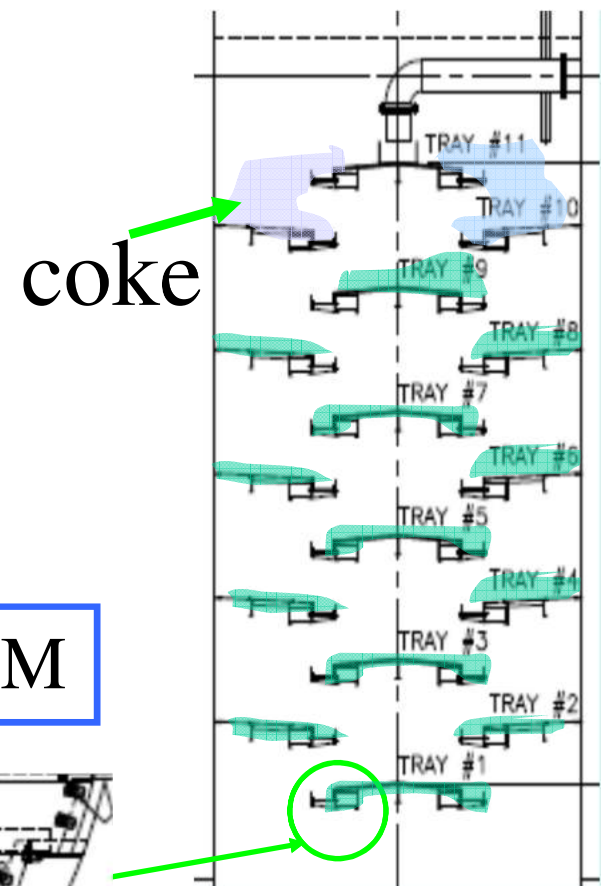
- **Provide adequate space in vessel**
  - Design fouling accumulation into design
  - Include fouling resistance locations
    - Maximum openings in packing/trays
- **Minimize Liquid Residence time**
  - Minimize low liquid flow locations
- **Design for optimal flow distribution**

- **Use Past Experience and other's Experience to set Design**

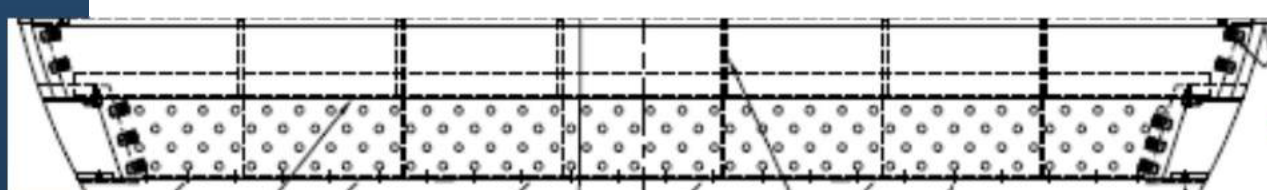
Design Guidelines

Process-Mitigate Fouling

- **Fractionators/Strippers Example**
  - Coker, FCC, Heavy Oil
  - <<30" tray spacing
  - Troughs perforated
  - Notched weirs
  - No rudimentary vapour distribution
  - "Low" quench rate



Severe Production shortages- $MM



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Design Guidelines

Equipment-Mitigate Fouling

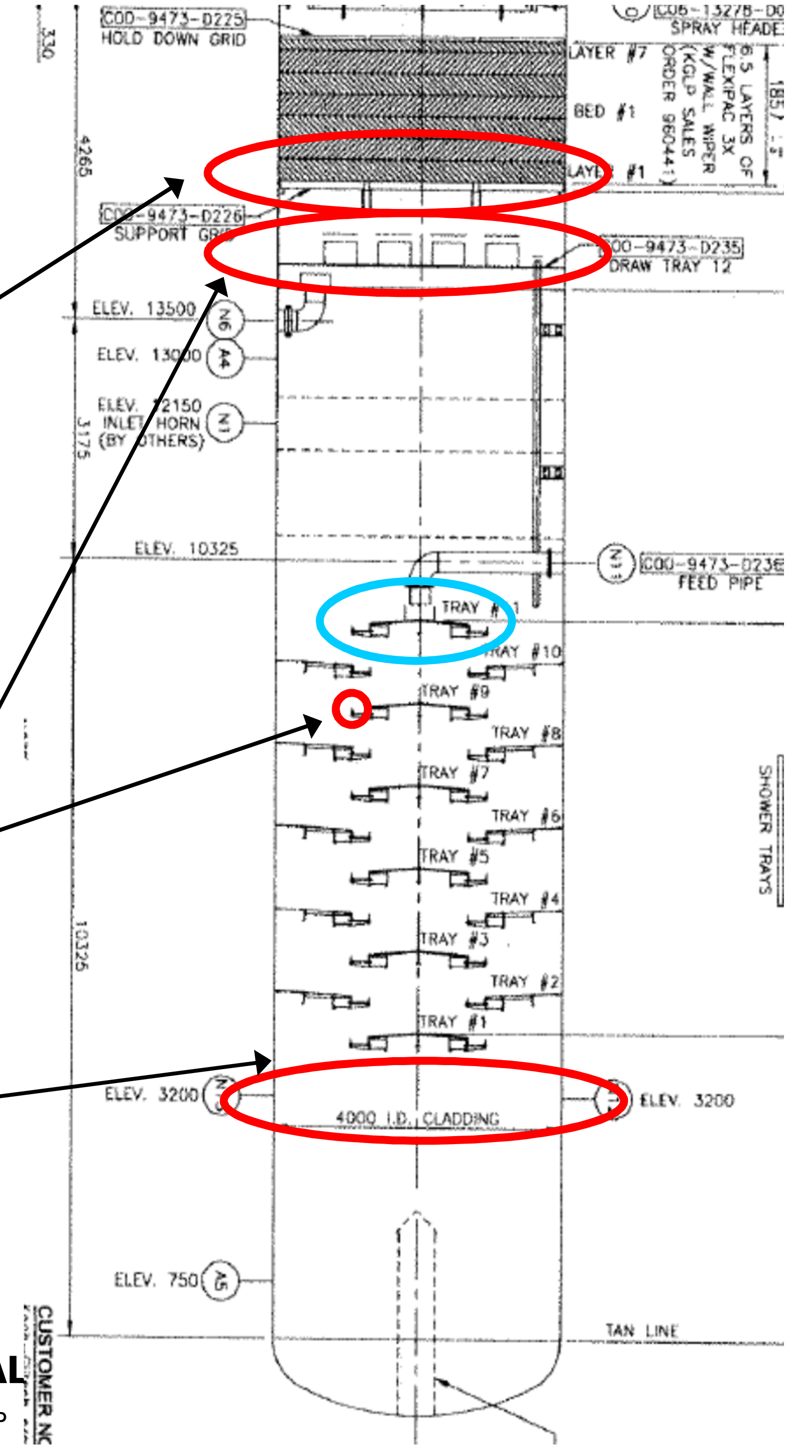
1. Packing vs Grid (bottom Bed)

2. Draw-off - sloped or hulled

3. Remove Notched Weir

   - shed design

4. Feed Distributor?



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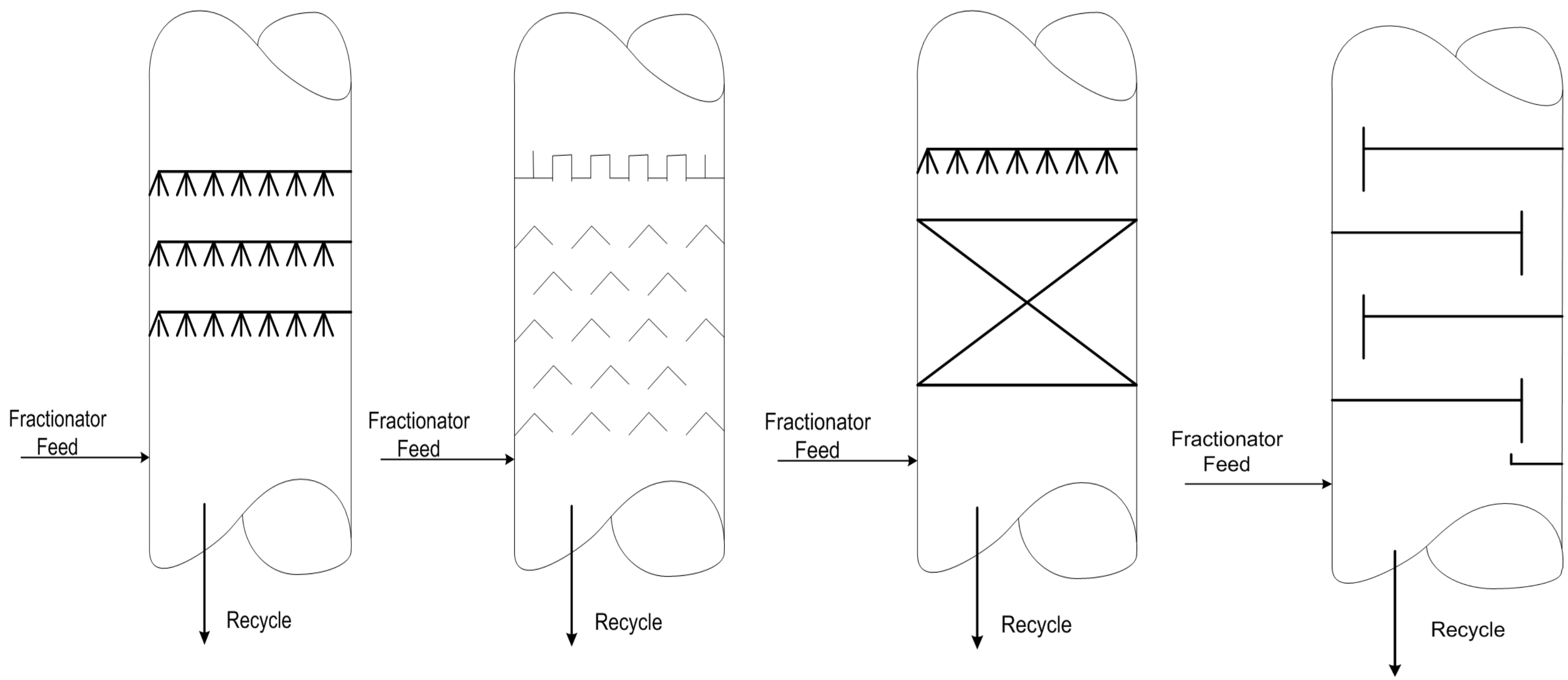
MORE PRODUCTION - LESS RISK!

Wash Zone Purpose

The wash zone has three objectives:

- **To control the heavy "tail" of the HGO distillation**
- **Minimise entrained coke fines in the main fractionator products (mainly HGO)**
- **Optimize product yield by setting recycle cut point**

Typical Wash Zone Configurations
Internals Choices



Spray Chamber Shed Decks Grid Trays

Qualitative Selection Criteria
Industry Experience

Wash zone internals: selection criteria

	Valve or sleeve tray	Grid packing	Grid tray	Baffle tray	Spray zone
Fouling resistance	1	2	3	4	4
Required wetting rate	1	2	2	4	4
Efficiency	4	3	2	2	1
Ease of inspection	4	1	4	4	3
Cost	3	1	3	3	4
Capacity	1	4	2	3	3

1 = Worst, 4 = Best (based on authors' experience with cokers and other heavy oil processes)

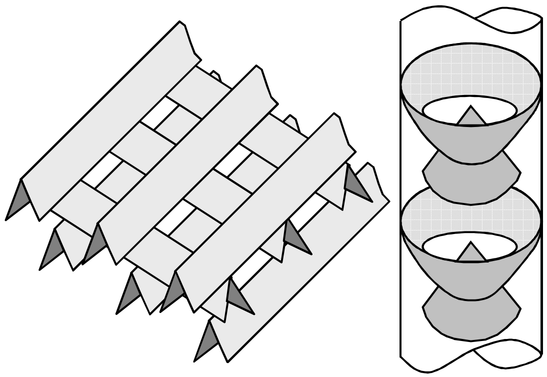
Table 1

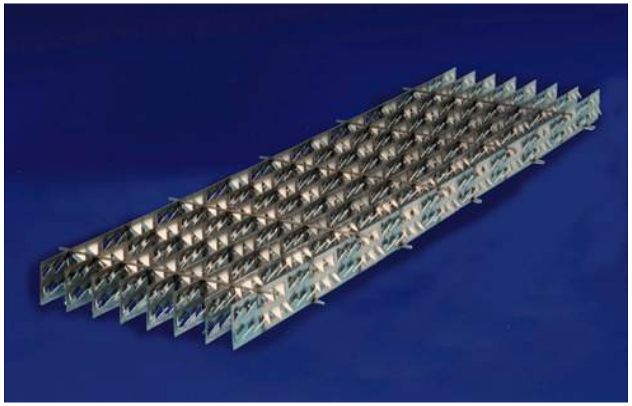
PTQ Q3, 2003 - "Debottlenecking Coker fractionators" Herman et al

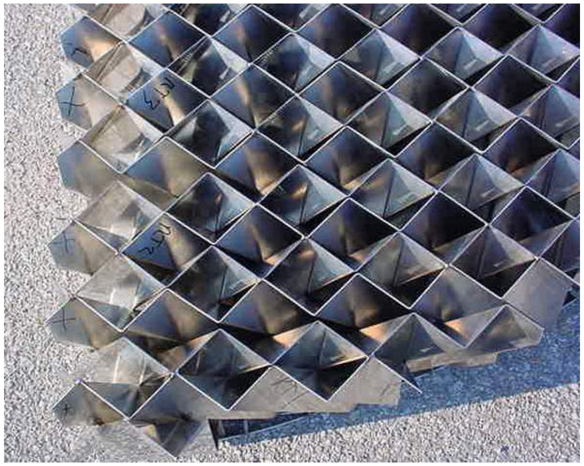
Equipment

Mitigate Fouling

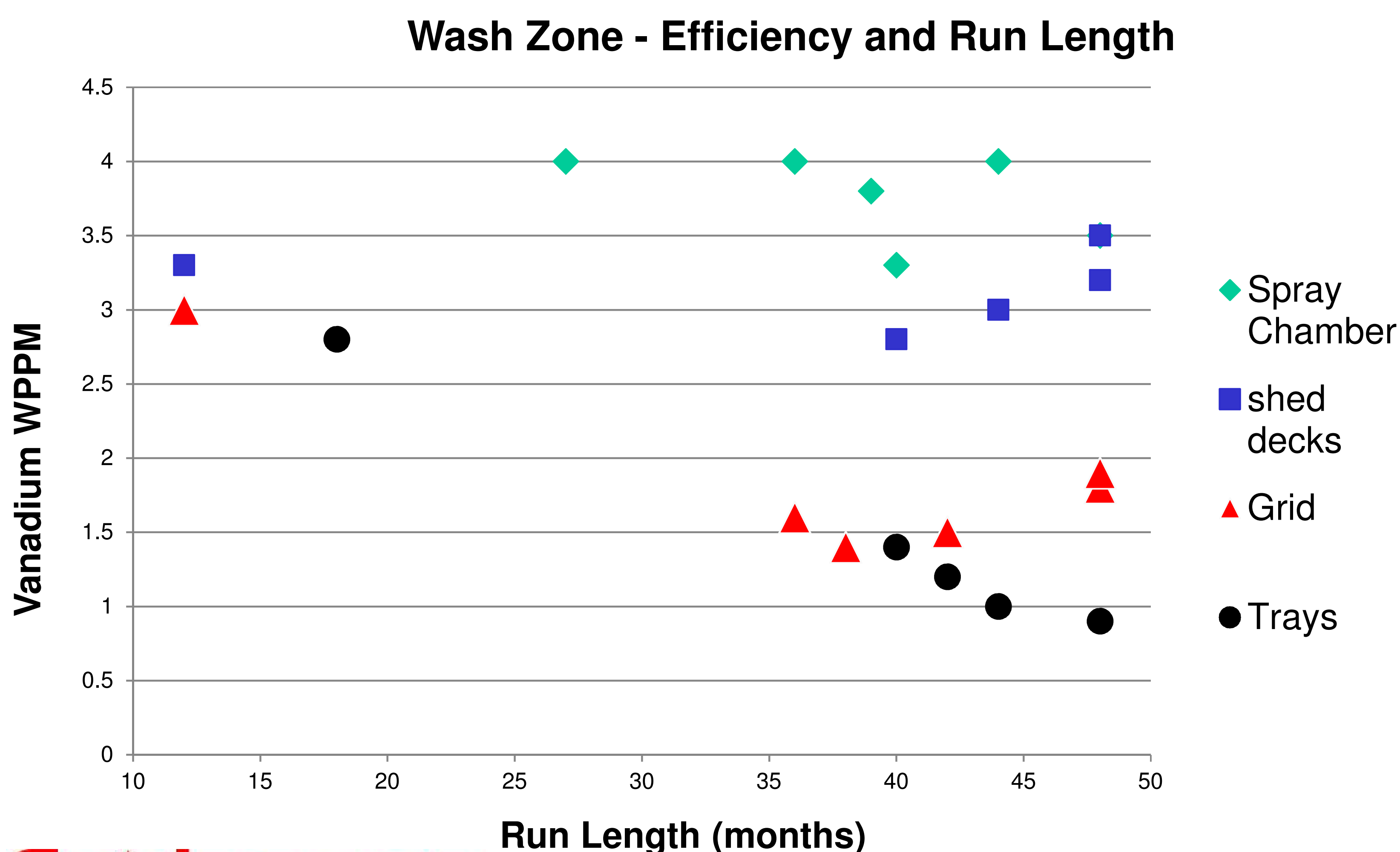
- **Fouling Resistance**
  - Sheds > Grid > ProValve® trays > Smooth Packing







Wash Zone Performance
Efficiency vs Reliability



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Wash Zone Configuration Performance Comments

- **All wash zone designs can provide desired run length with the appropriate matching of internals to crude type and severity of operation**

- **Opportunity exists to evaluate improving performance without sacrificing reliability**
  - Eg. Adding Severe service grid

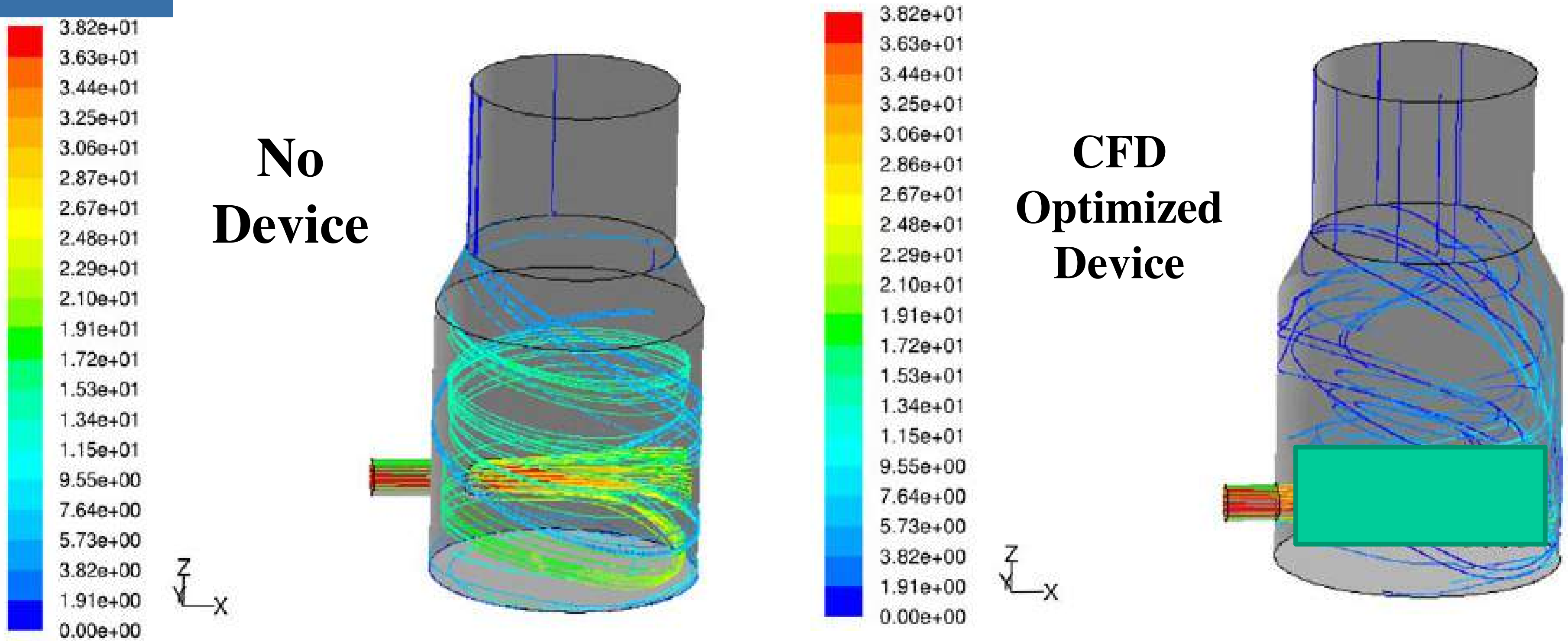
Improved Fractionator Performance Flow Distribution Optimization

Proper Vapor Distribution key to improved performance while maintaining reliability.

Possible options for reducing the inlet feed velocity to deal with the highly fouling and erosive nature of the vapour flow is to:

- Increase the feed nozzle size by removing some of the refractory or installing new nozzle
- Swaging up immediately upstream of the nozzle
- Install a vapour feed inlet device.

Flow Distribution Optimization
CFD Analysis



- **Severe Service Vapour Inlet Feed Device**
  - Handles high velocity, erosive nature of feed from coke drums (improves vapor distribution)

Improved Fractionator Performance

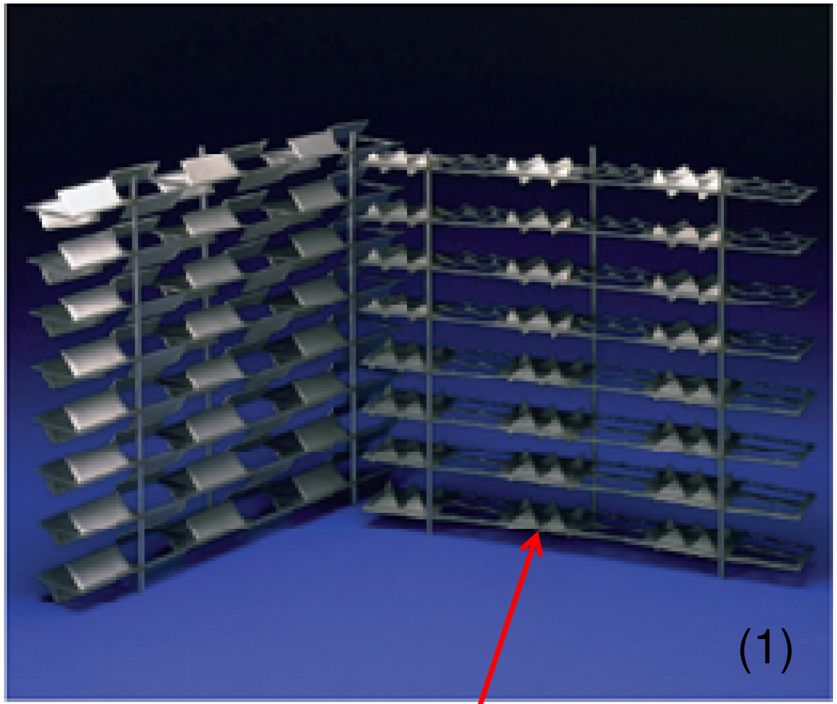
Severe Service Grid- Wash Zone

Grid Characteristic	FLEXIGRID®2	FLEXIGRID® 3 or Snap Grid®	Mellagrid® FLEXIPAC® YS or Equivalent
Minimum Thickness (2)	16 ga or 1.58mm	16 ga or 1.58mm	Up to 0.5mm
Packing factor fp (1/ft) (1)	4	9-10	6
Pressure drop (inwc/ft) (2)	0.054	.176	.2105 (Flexipac® YS) .200 (Mellagrid)

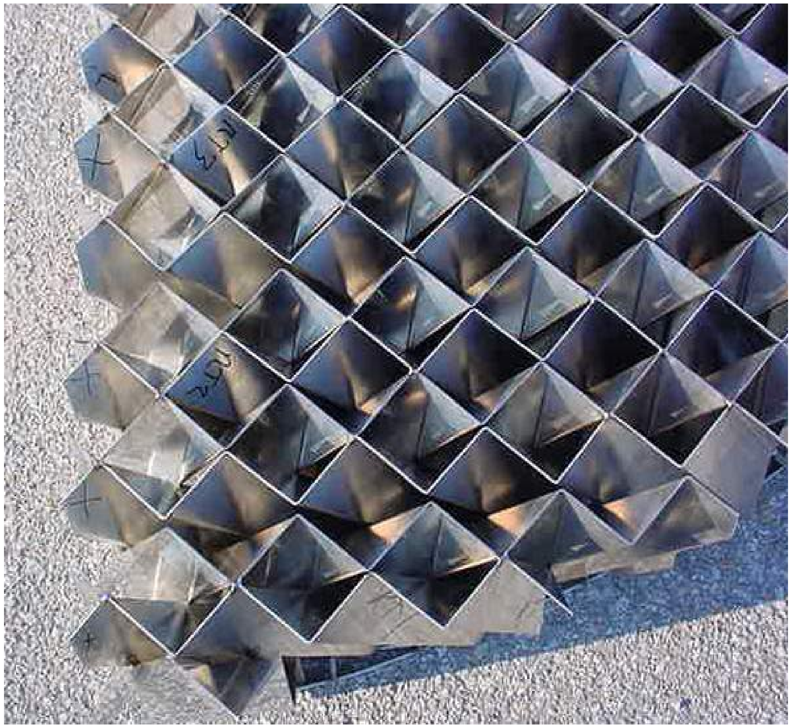
(1) Kister, H., Distillation Design, McGraw-Hill, 1992

(2) KGTower®, Sulpak® Rating Programs

Improved Fractionator Performance
Severe Service Grid - Wash Zone



FLEXIGRID® Style 3 High Efficiency Packing (Left) and
FLEXIGRID® Style 2 High Capacity Packing (Right)



FLEXIPAC® S packing

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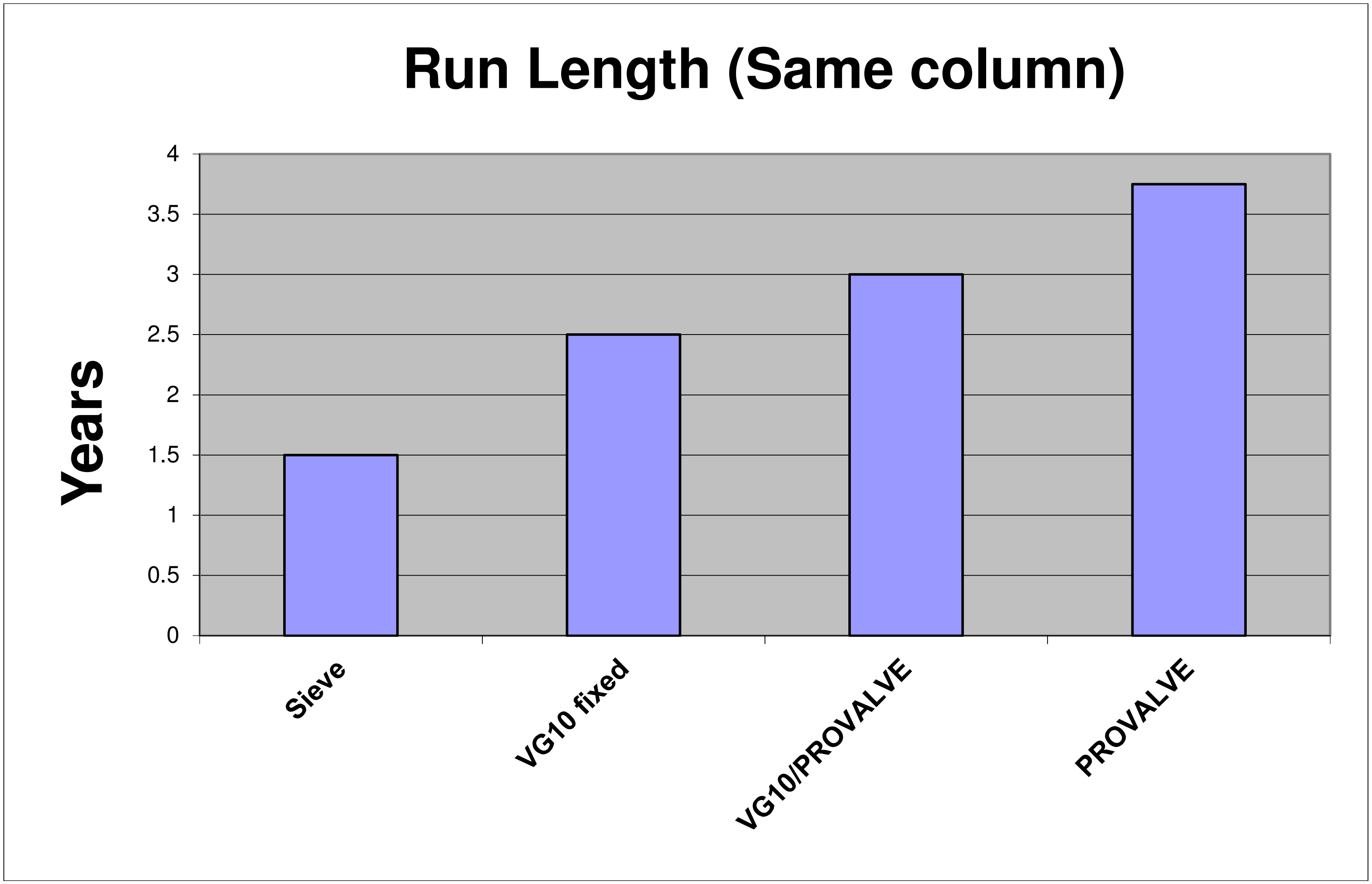
Improved Fractionator Performance
Severe Service Trays - PA, Fractionating Zones



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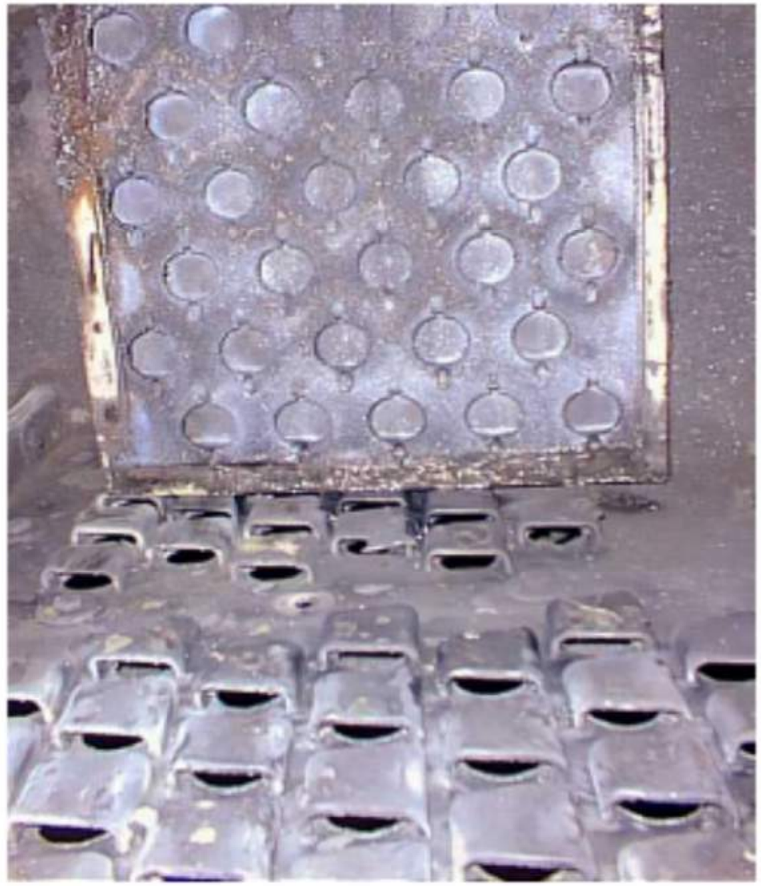
Improved Fractionator Performance
Severe Service Trays - PA, Fractionating Zones

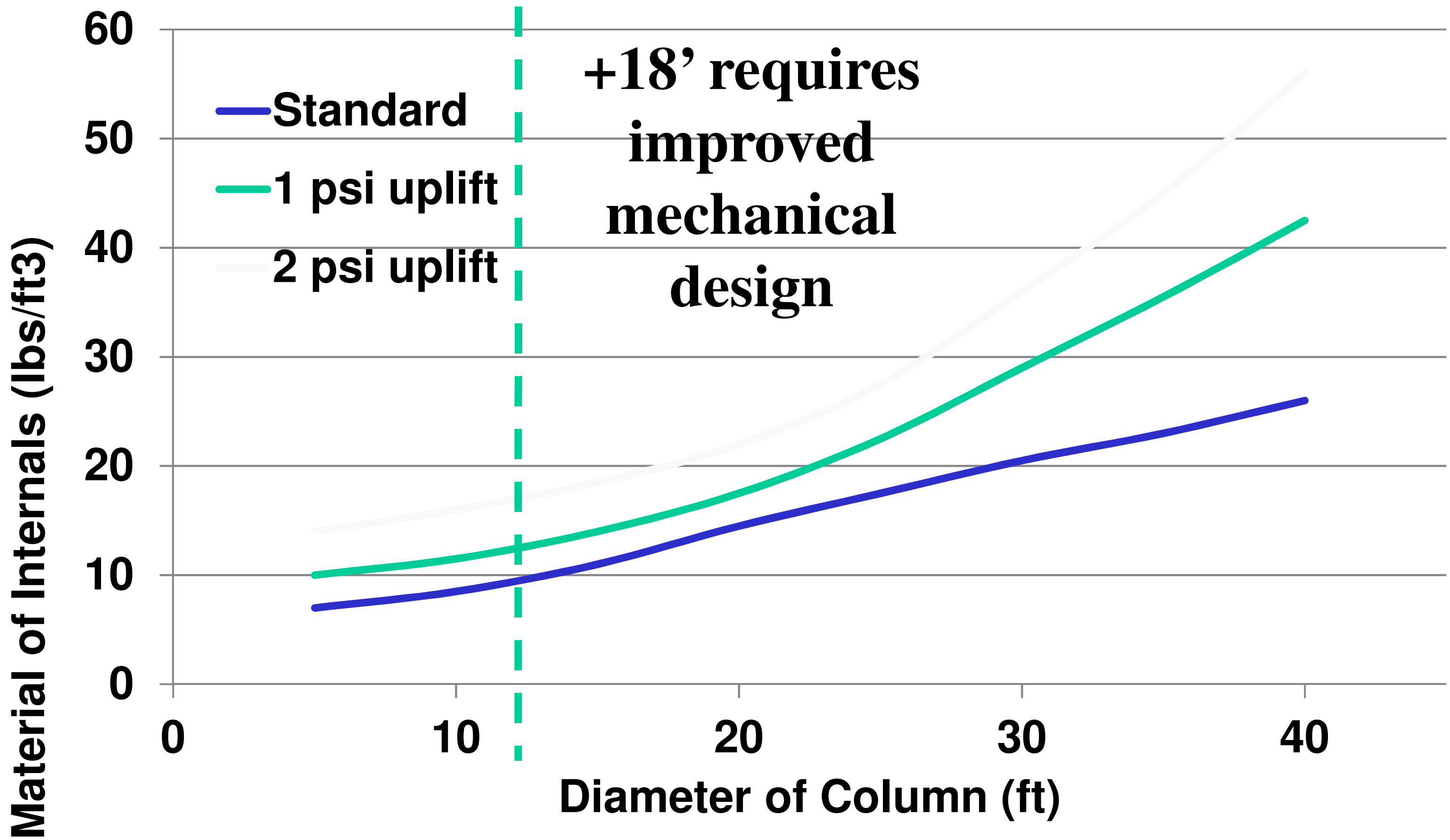
Sieve

PROVALVE® Fixed Valve



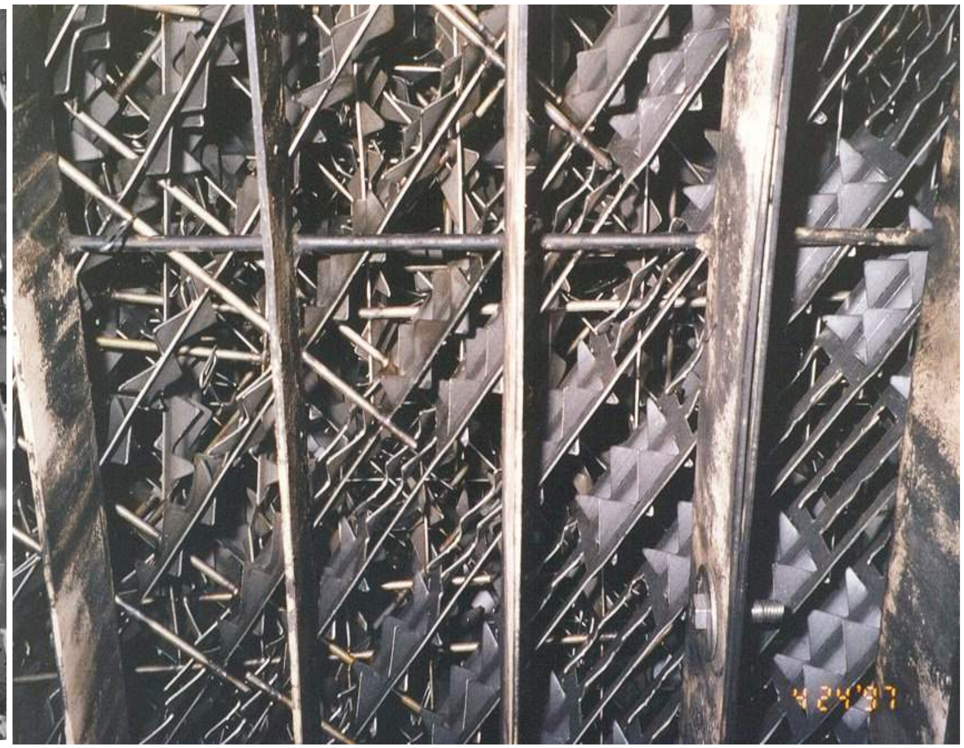
Tray Design for Reliability

More uplift protection = more metal



Increased Uplift protection – improved beams, more bolting, thicker material

Reliability
Mechanical Strength



Standard design is to use through rods from packing hold-down grid to support grid.

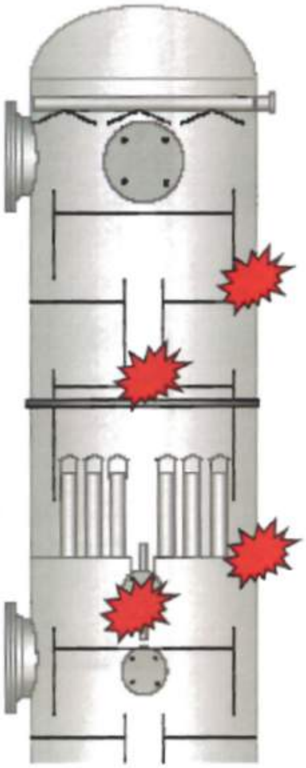
Internals Design for Reliability
Other Considerations

- **Sloped Collector Trays**
  - reduce residence time of liquid in column
- **Downcomers**
  - "funnel" designs to prevent particle accumulation
- **Tray Active Areas - "push" valves**
  - to limit accumulation of solid material on tray
  - to limit stagnant zones; better contact
- **Reinforced Grid**
  - double welded layers (successful in Oil Sands)
- **Spray distributors**
  - combat Salting fouling at top of fractionation zone
- **Additional Nozzles in downcomers**
  - provide for water wash to deal with salting issues

Heavy Naphtha Section
- Central DC Salt Accumulation

Salt Deposition Learnings

- **Ideal**
  - Limit chlorides in crude (<15ppm)
  - Limit short duration spikes in chloride (<25 ppm)
- **Reality**
  - Develop a water wash plan
  - Provide spray distributor to top tray
  - Provide sparger(s) in downcomer
  - Provide downcomer and tray design to maximize liquid turbulence



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Recap
Internals choices for Reliability, Recovery

- **Coking units continue to be built and revamped**
  - Various coker fractionator designs available
  - Recovery can be increased without compromising reliability (crude, and operating severity dependant)
- **Severe service internals using advanced design techniques available for consideration**
  (at both grassroots and revamp stages):
  - Inlet Feed Devices
  - Grid (double layered)
  - PROVALVE® trays
  - Robust Internals

Thank YOU!!

- **Contact Information**
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- **Comments? Questions?**
  - Involved in Revamps/Troubleshooting
  - Specific Severe Service Designs