# Reliability vs Recovery
# for
# Delayed Coking Fractionators

## A Tower Internals Discussion

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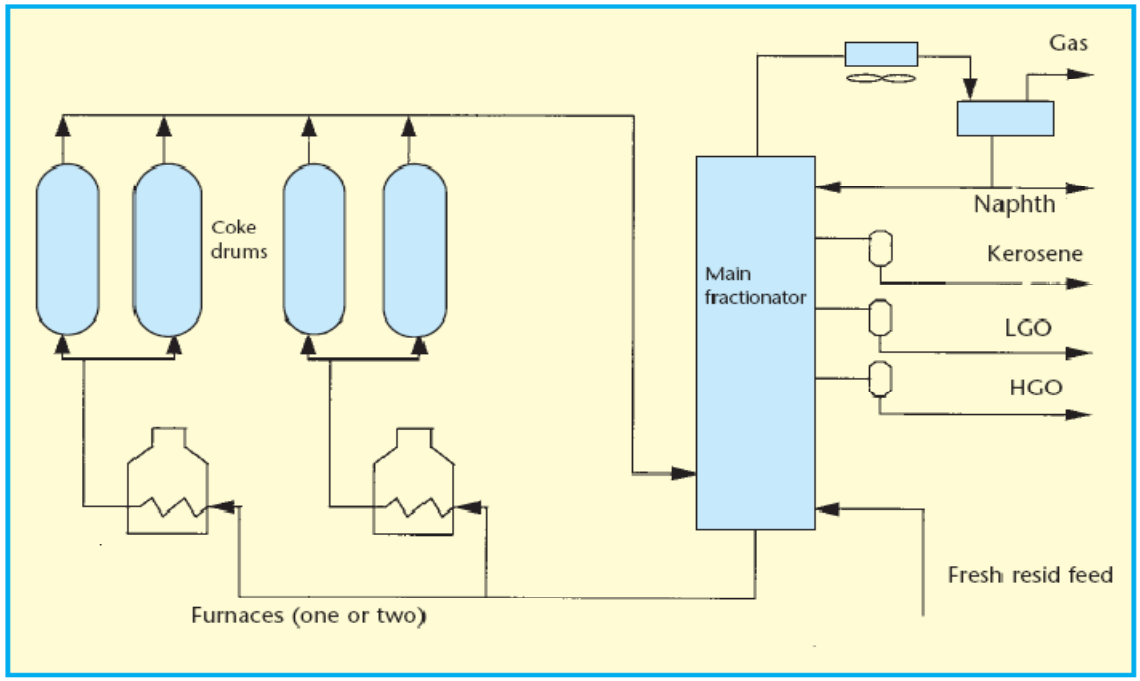
# Agenda

- **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



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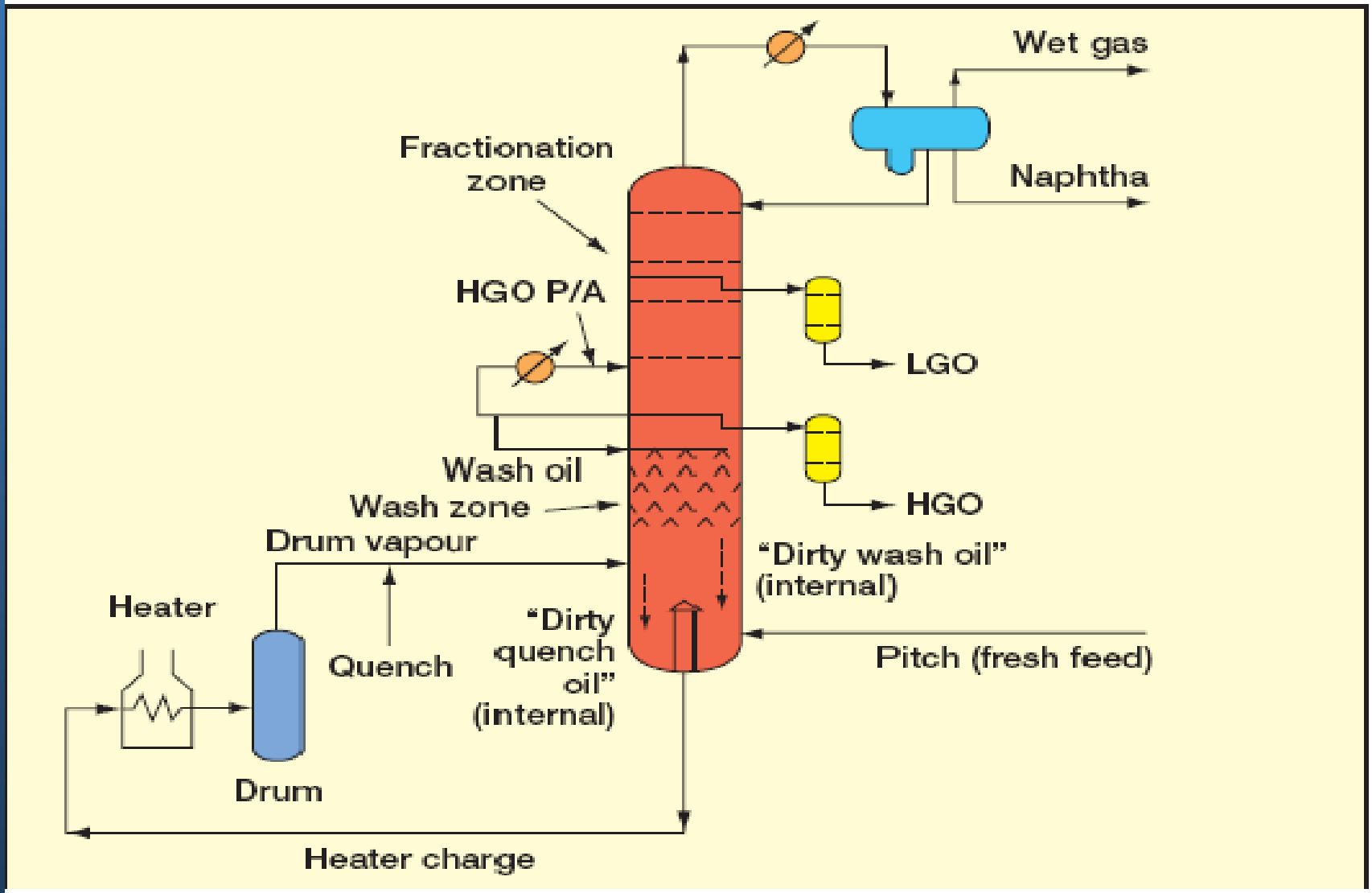
# Simple BFD of Coker Fractionator



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# 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**

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1 Kister, IChemE 2003





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# 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

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# 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



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# 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**

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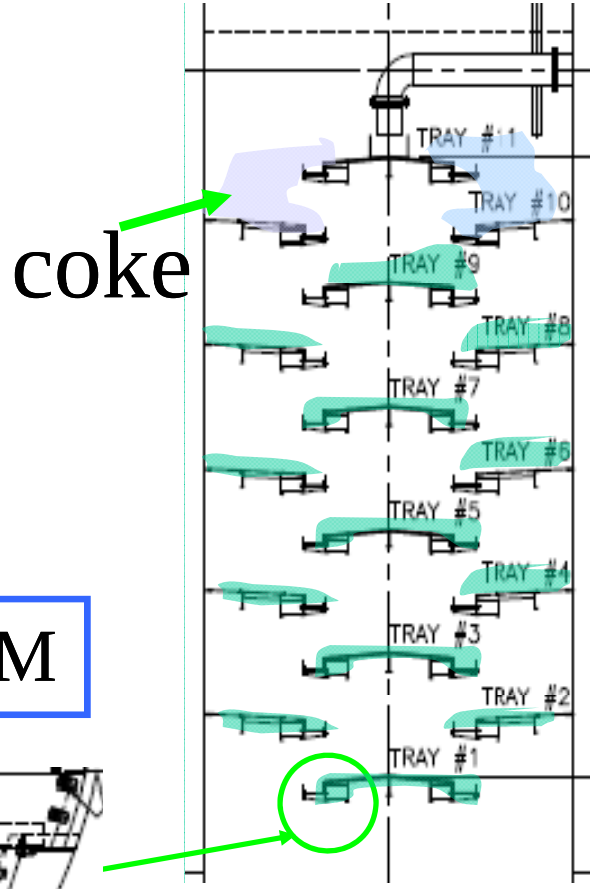
- **Use Past Experience and other's Experience to set Design**

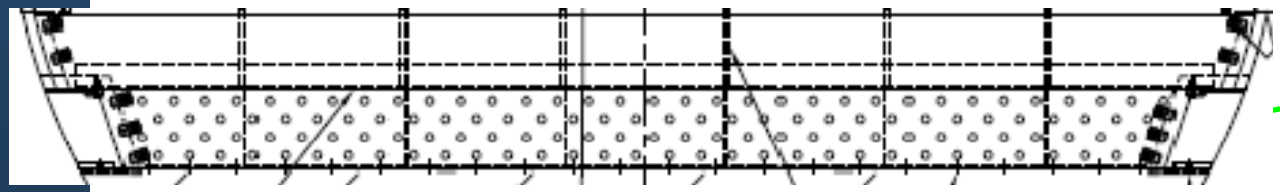
# Design Guidelines

## *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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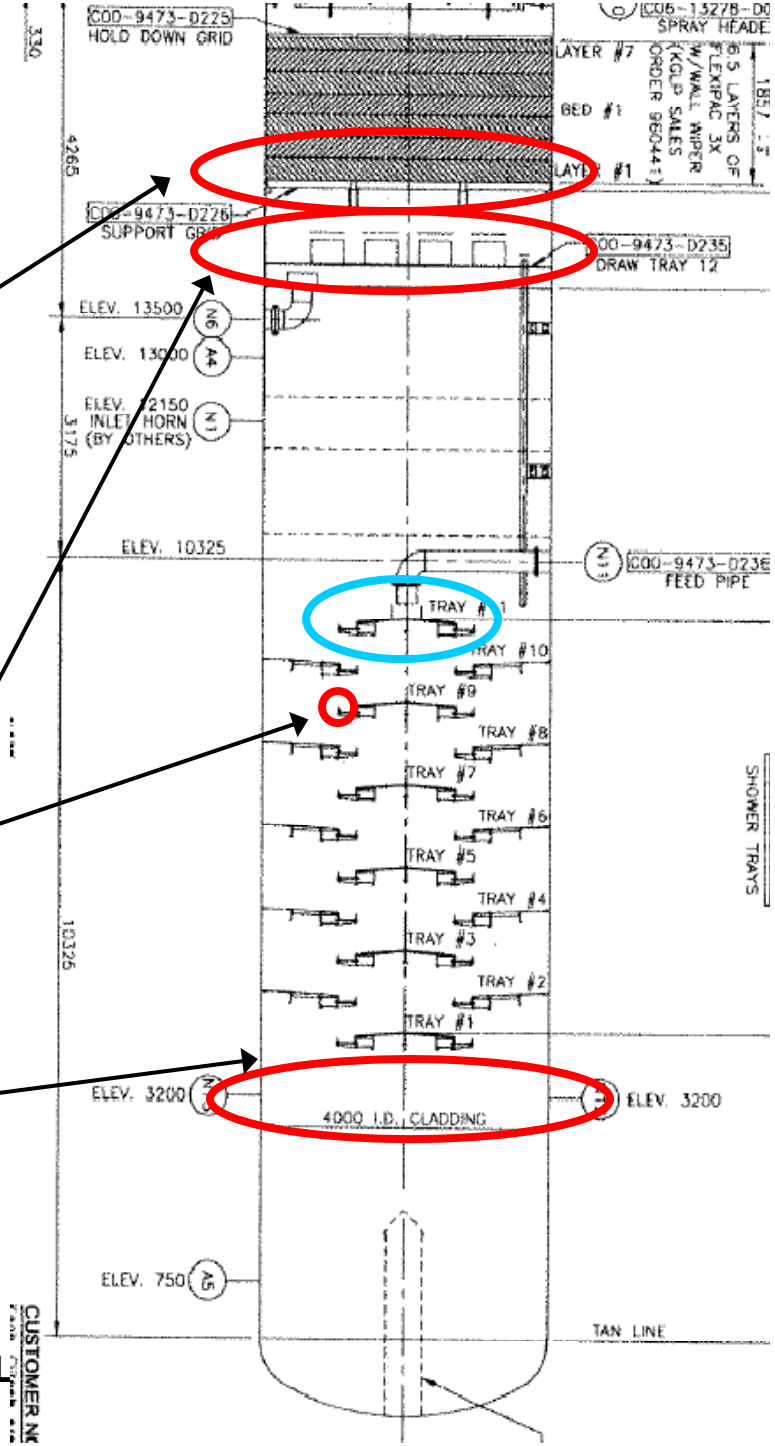
# Design Guidelines

## *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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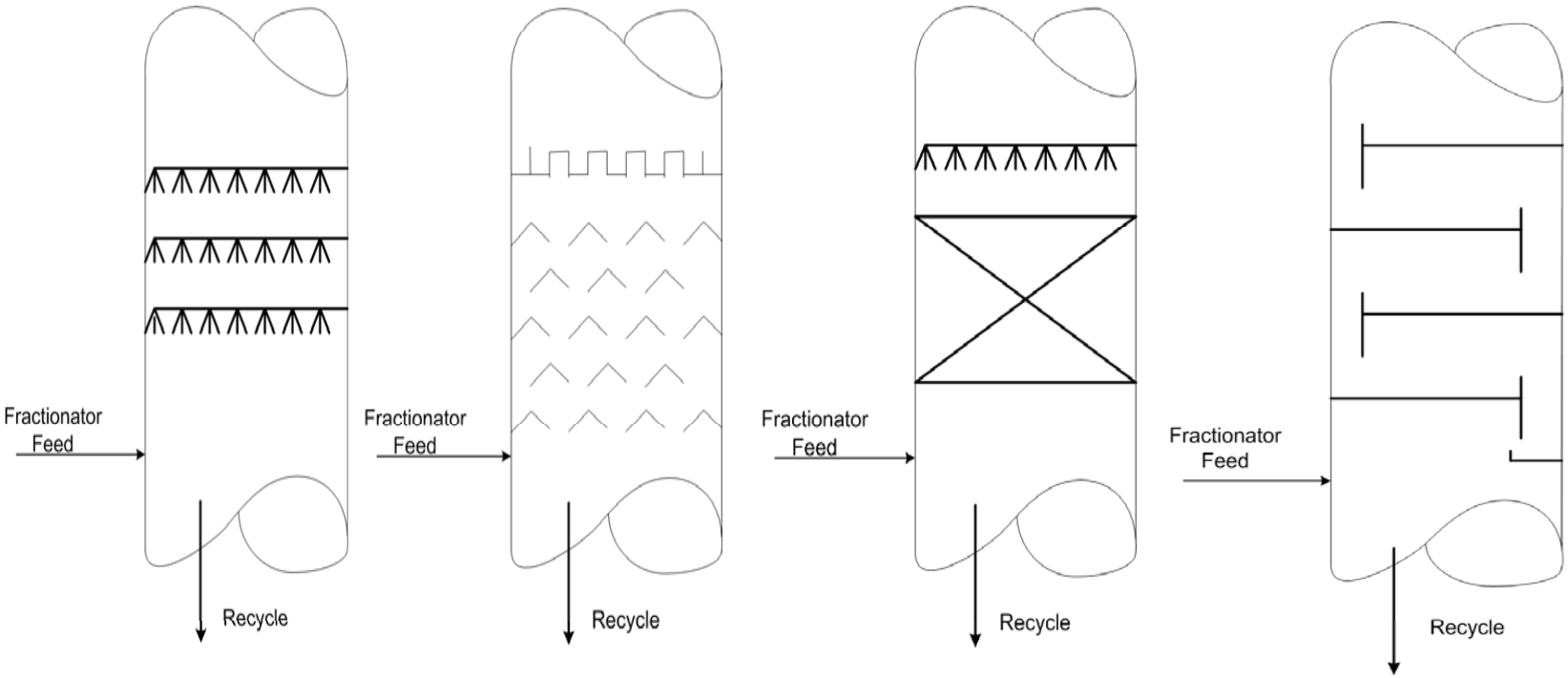
# Wash Zone Purpose

**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)

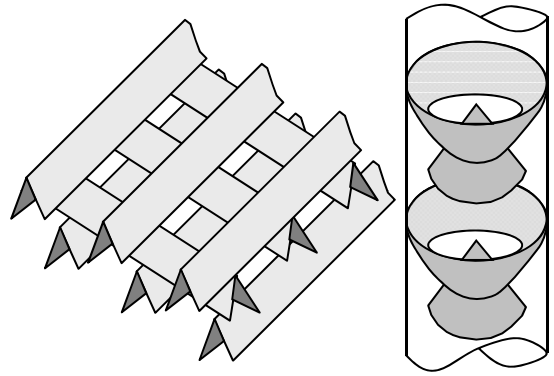
*Table 1*

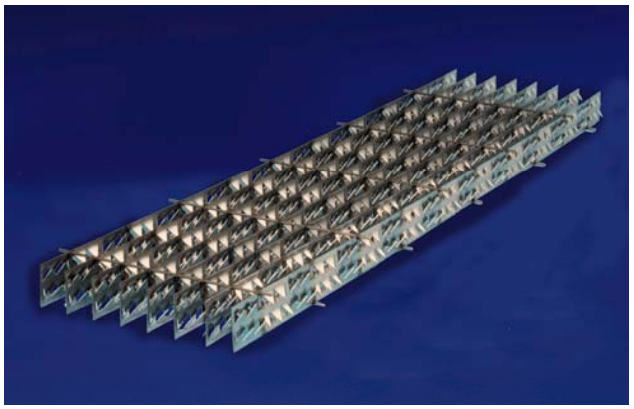
PTQ Q3, 2003 - "Debottlenecking Coker fractionators" Herman et al

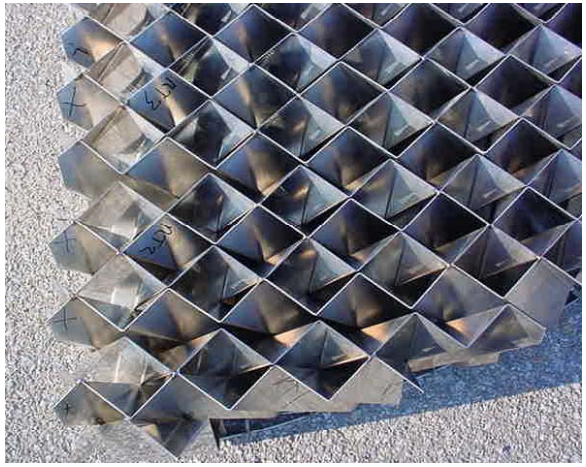
# Equipment

## *Mitigate Fouling*

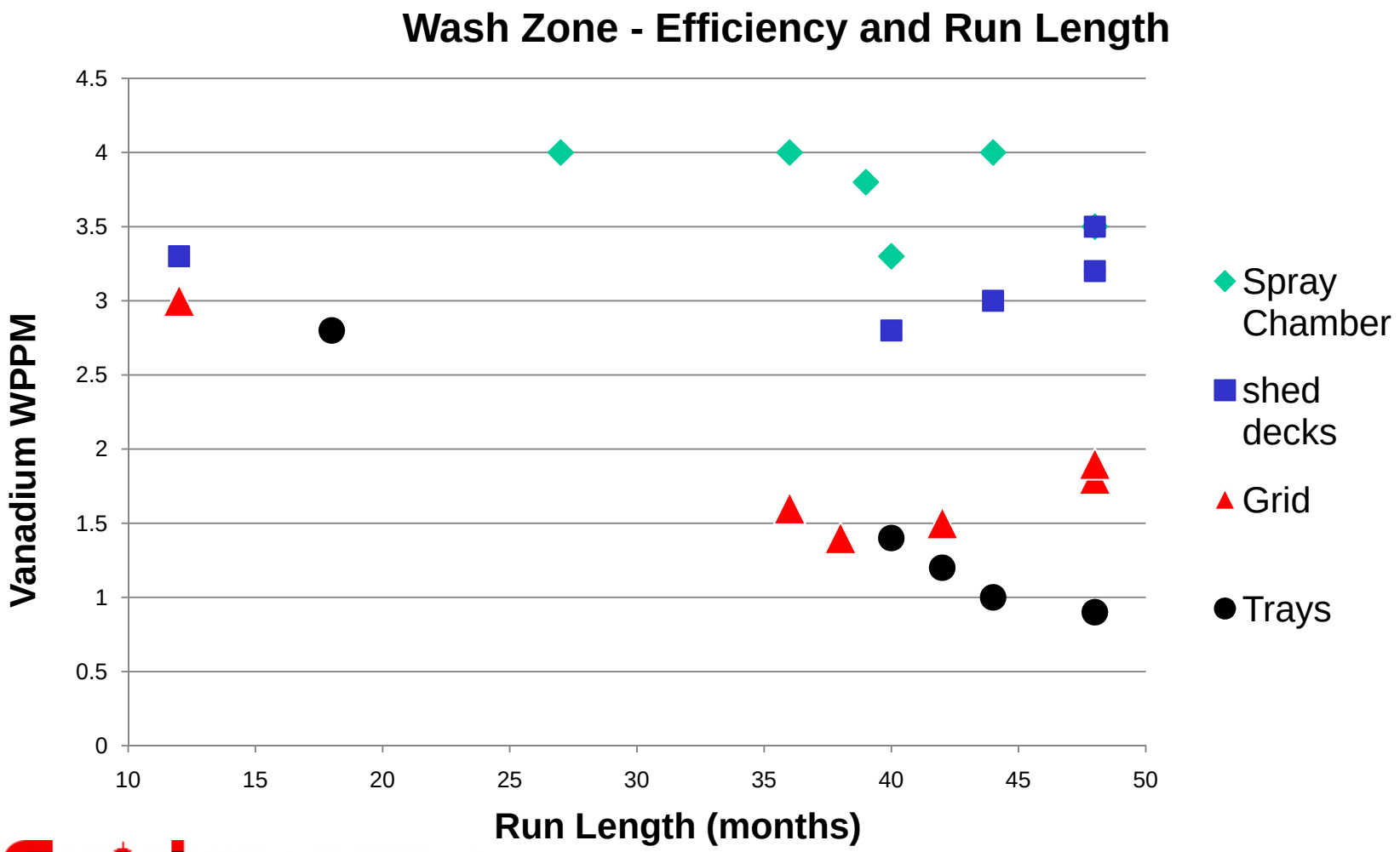
- **Fouling Resistance**
  - Sheds > Grid > ProValve® trays > Smooth Packing







# 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

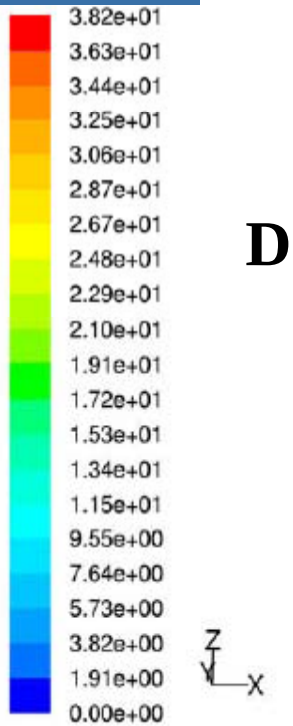
# Improved Fractionator Performance Flow Distribution Optimization

**Proper Vapor Distribution key to improved performance while maintaining reliability.**

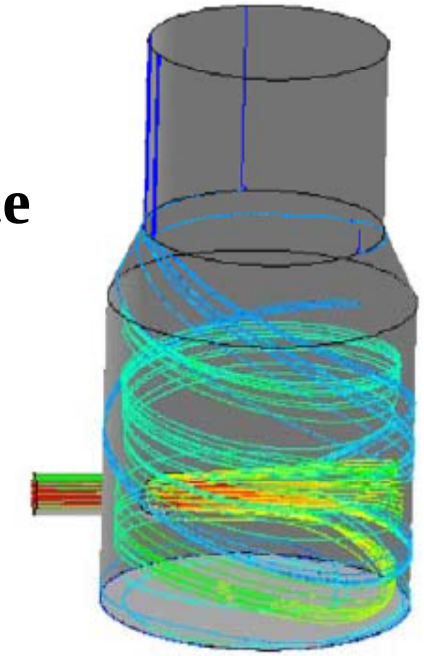
**Possible options for reducing the inlet feed velocity to deal with the highly fouling and erosive nature of the vapour flow is to:**

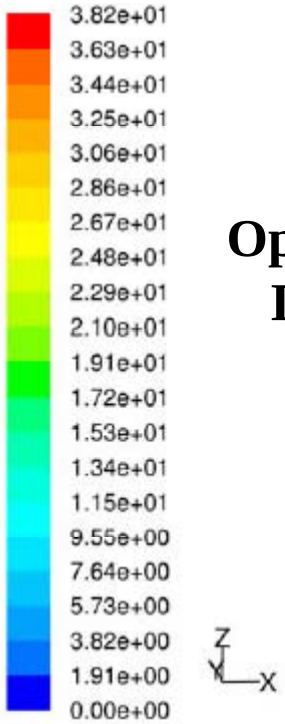
- **Increase the feed nozzle size by removing some of the refractory or installing new nozzle**
- **Swaging up immediately upstream of the nozzle**
- **Install a vapour feed inlet device.**

# Flow Distribution Optimization
# CFD Analysis

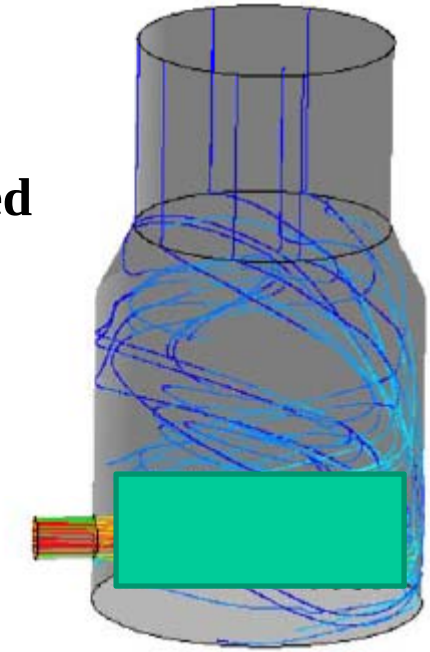



**No Device**






**CFD Optimized Device**



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



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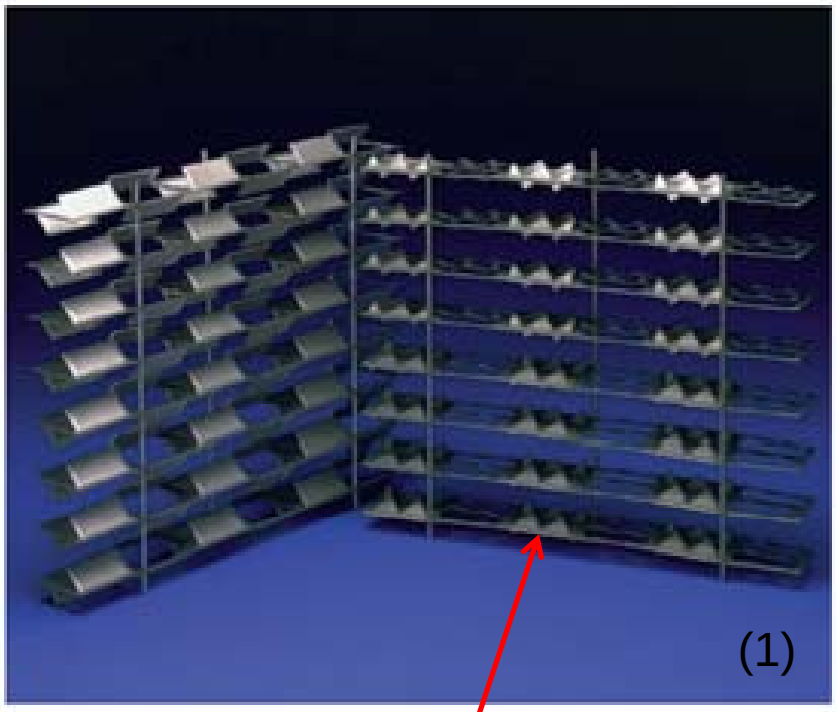
# Improved Fractionator Performance
# Severe Service Grid- Wash Zone

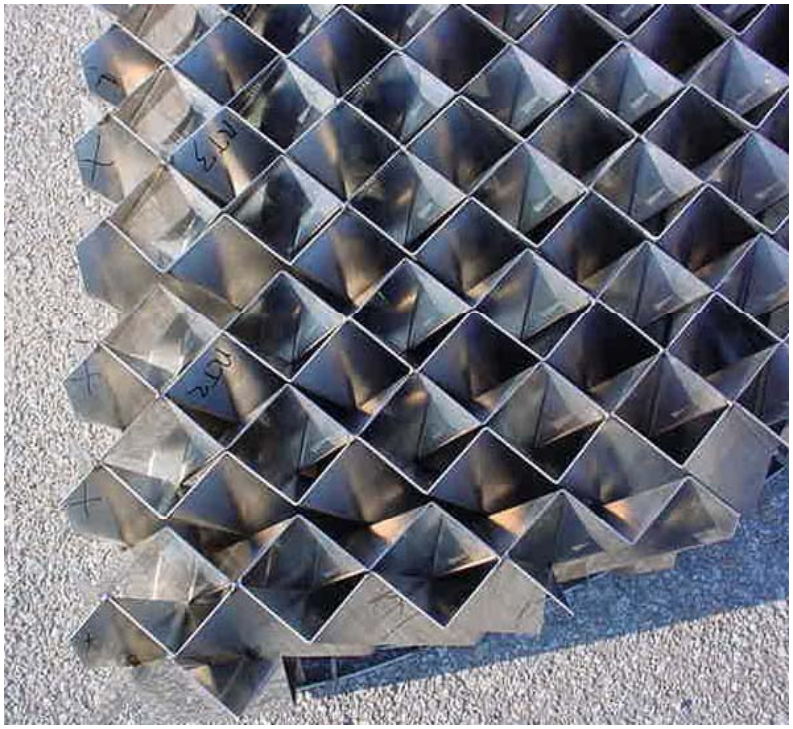
| Grid Characteristic | FLEXIGRID®2 | FLEXIGRID® 3 or Snap Grid® | Mellagrid® FLEXIPAC® YS or Equivalent |
|---|---|---|---|
| Minimum Thickness (2) | 16 ga or 1.58mm | 16 ga or 1.58mm | Up to 0.5mm |
| Packing factor fp (1/ft) (1) | 4 | 9-10 | 6 |
| Pressure drop (inwc/ft) (2) | 0.054 | .176 | .2105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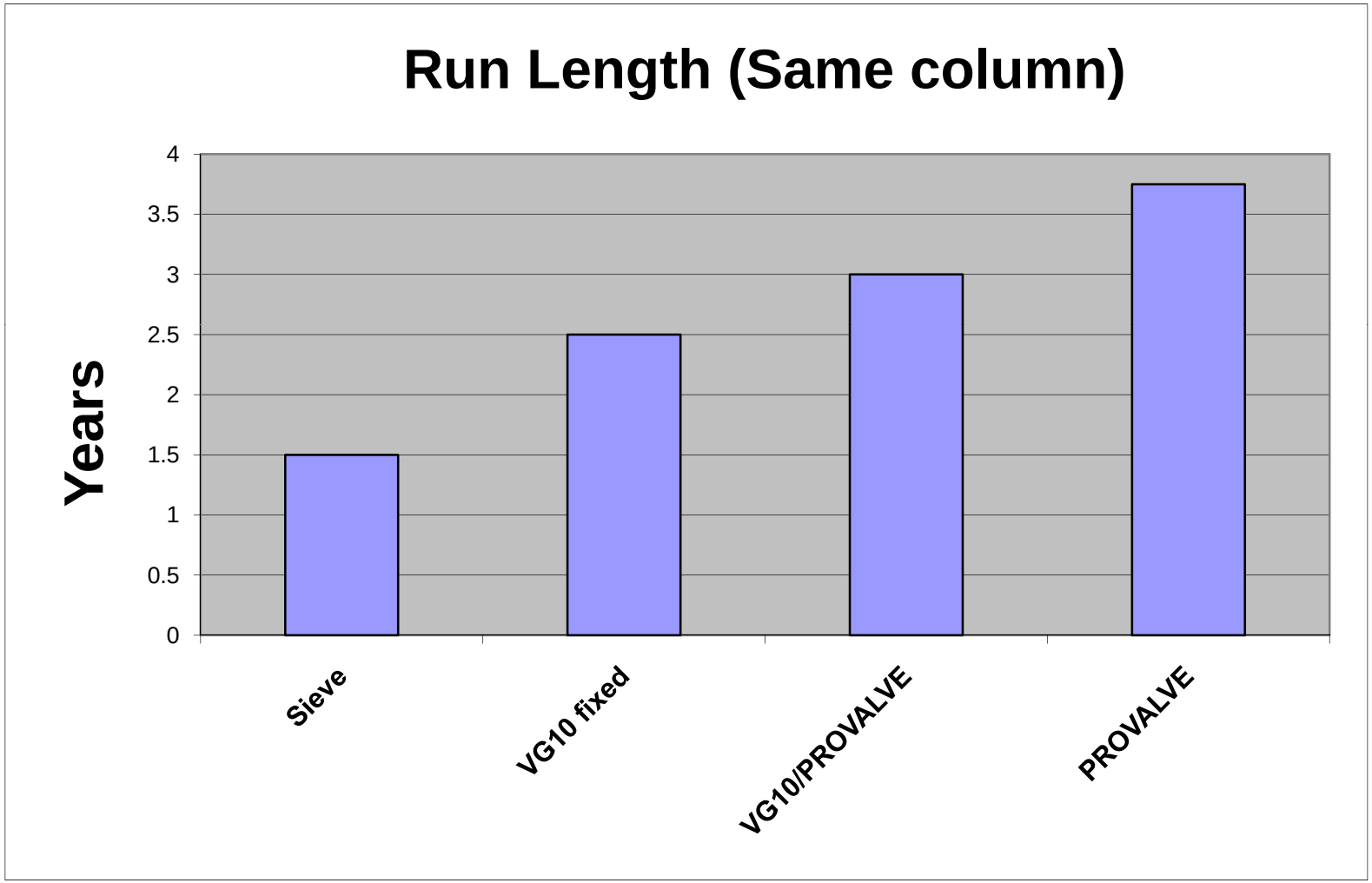
# Improved Fractionator Performance

## Severe Service Trays - PA, Fractionating Zones

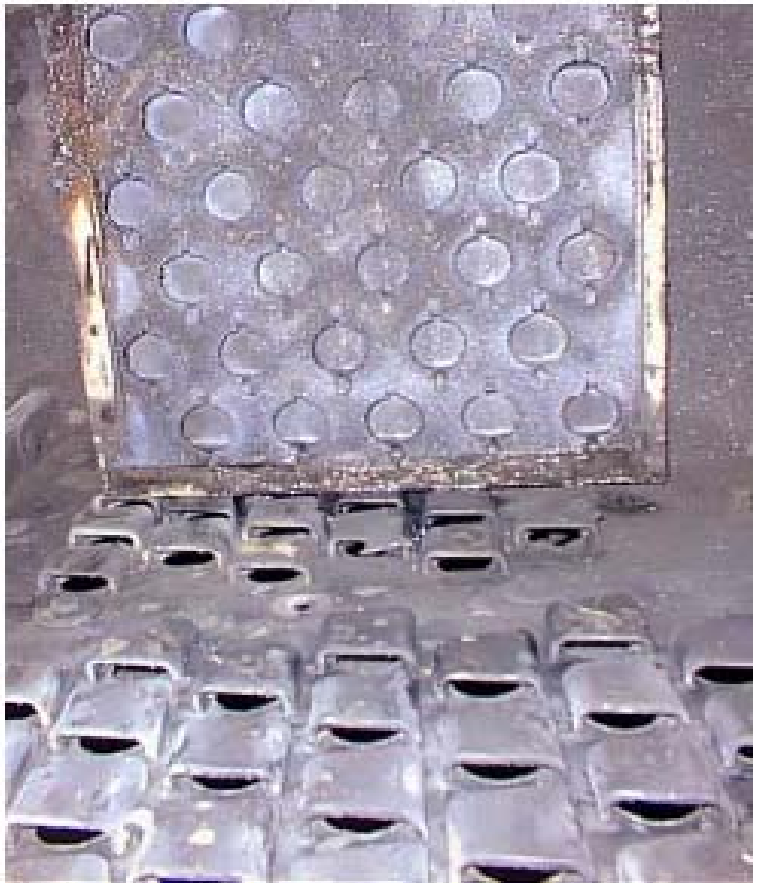


# Improved Fractionator Performance

## Severe Service Trays - PA, Fractionating Zones

Sieve

PROVALVE® Fixed Valve





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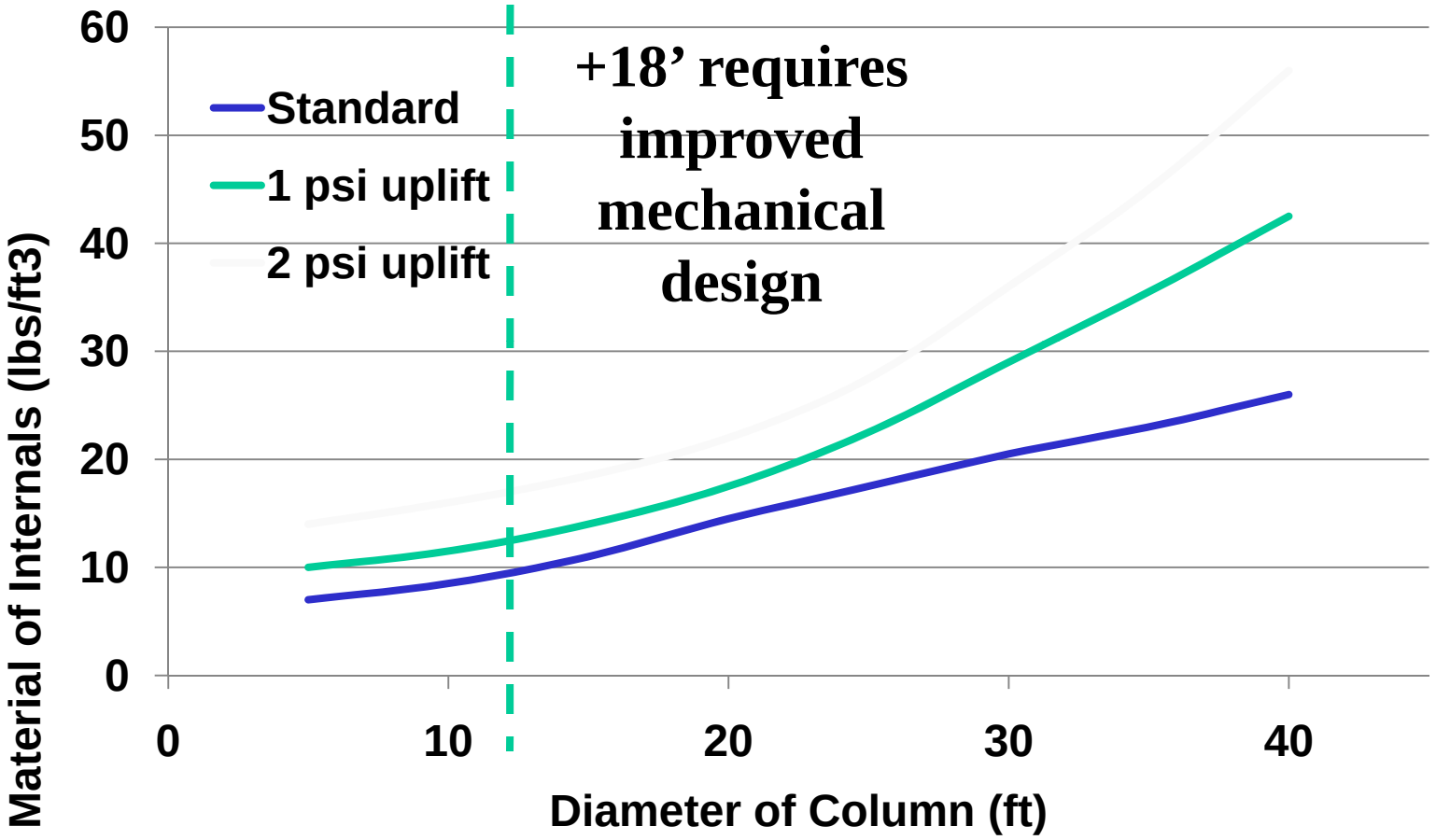
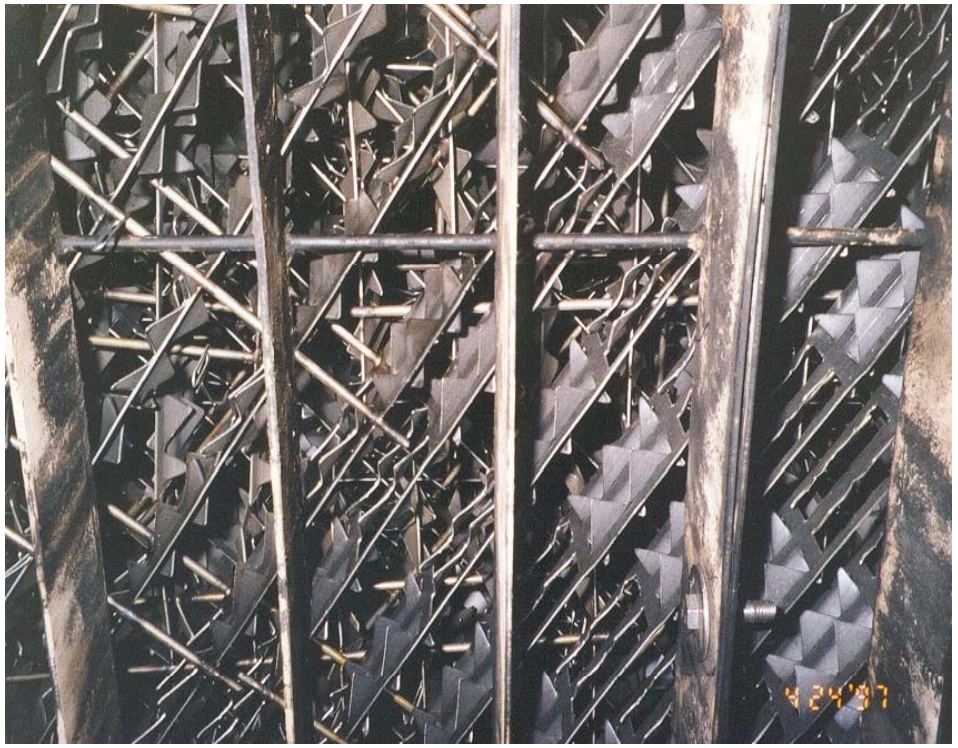
# Tray Design for Reliability
## More uplift protection = more metal




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

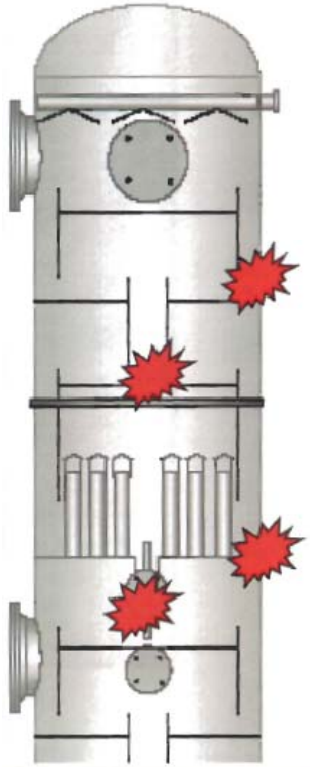
- **Sloped Collector Trays**
  - reduce residence time of liquid in column
- **Downcomers**
  - "funnel" designs to prevent particle accumulation
- **Tray Active Areas - "push" valves**
  - to limit accumulation of solid material on tray
  - to limit stagnant zones; better contact
- **Reinforced Grid**
  - 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



## 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**
  - Michael Krela
    - Michael.Krela@kochglitsch.com
    - 403-266-1830

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