Detailed Design Solutions for Residue Hydrocracking Purge Systems

REFCOMM Galveston

2019

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Safety

- Residue hydrocracking operates under severe conditions
- Industry trend towards higher conversion
- More severe conditions lead to:
  - Increased operational complexity
  - Decreased reliability

Key Points:

- Residue hydrocracking presents unique engineering design challenges
- Operability and reliability are closely linked to safety

ENI Slurry Hydrocracker Fire – December 1, 2016 (Youtube)

Fluor Energy & Chemicals

Serves global oil and gas production/processing for the upstream, downstream and integrated petrochemicals industries.

- Full range of services including design, engineering, procurement, fabrication and construction
- Global execution platform
- Project and program management
- Proprietary and commercially available technologies (e.g., carbon capture, sulfur recovery, gas processing & gas treating)
- Operations & maintenance/sustaining capital
- Chemicals & petrochemicals
- Heavy oil upgrading & oil sands
- Hydrocarbon transportation – pipelines
- Liquefied natural gas
- Onshore & offshore oil and gas production
- Petroleum refining
- Utilities & offsites

Residue Hydrocracking Experience Highlights

OWNER	LOCATION	CAPACITY, KBD	UNIQUE FEATURE
KNPC	Shuaiba, Kuwait	25x2=50	Word's first commercial unit in 1968
Motiva	Convent, Louisiana, USA	43 (Axens)	
Slovnaft	Bratislava, Slovakia	25 (CLG)	First European LC Finer
Shell	Scotford, Alberta, Canada	2 x 41 = 82 (CLG)	World's first LC Finer w/ Integrated HT
North West	Redwater, Alberta, Canada	30 (CLG)	Latest generation LC Finer
Sincier	China	46 (CLG)	World's first LCMax unit
Eni	Sannazaro, Italy	24 (Eni Slurry)	Re-engineering post fire

Why Purge Systems?

KEY RELIABILITY AND ON STREAM FACTOR ASPECTS

- ✓ Solid management
- ✓ Fouling due to asphaltenes precipitation
- ✓ Fouling due to coke formation
- ✓ Services subject to erosion (i.e. letdown valves)
- ✓ Frequent upsets
- ✓ High viscosity fluids prone to plugging
- ✓ Unreliable measurements

SOLUTIONS: 'Tools in the Toolbox'

- ✓ Reliability, Availability & Maintainability Analysis (RAM Model)
- ✓ Minimum particles settling velocities in line sizing
- ✓ Selection of specific instruments and equipment for severe fouling conditions (i.e. Spiral exchangers, slurry valves, ball valves)
- ✓ Design to avoid dead zones
- ✓ Online maintenance of letdown valves
- ✓ Upset automated process control management system: Cutback System
- ✓ **Continuous purging of critical instruments, equipment and piping**

Purge or “Continuous Flushing” System Features

- Purpose
  - Minimize or eliminate plugging due to coke accumulation or other solids deposition
  - Enhance reliability and availability of critical services
  - Reduce maintenance time by improving service life of components
  - Avoid thermal shock from high temperature differentials
- Typical applications
  - Piping dead legs
  - Valves (seat, body, throat)
  - Pump seals
  - Instruments impulse lines
- Key design basics
  - Liquid flushing medium shall be compatible (composition and process conditions)
  - Gas phase (H_2, N_2) or liquid phase (VGO, ATM GO, cycle oil, etc.) flushing fluid
  - Minimum velocity of the flushing fluid to guarantee effectiveness
  - Applicable for high pressure and low pressure sections in continuous service

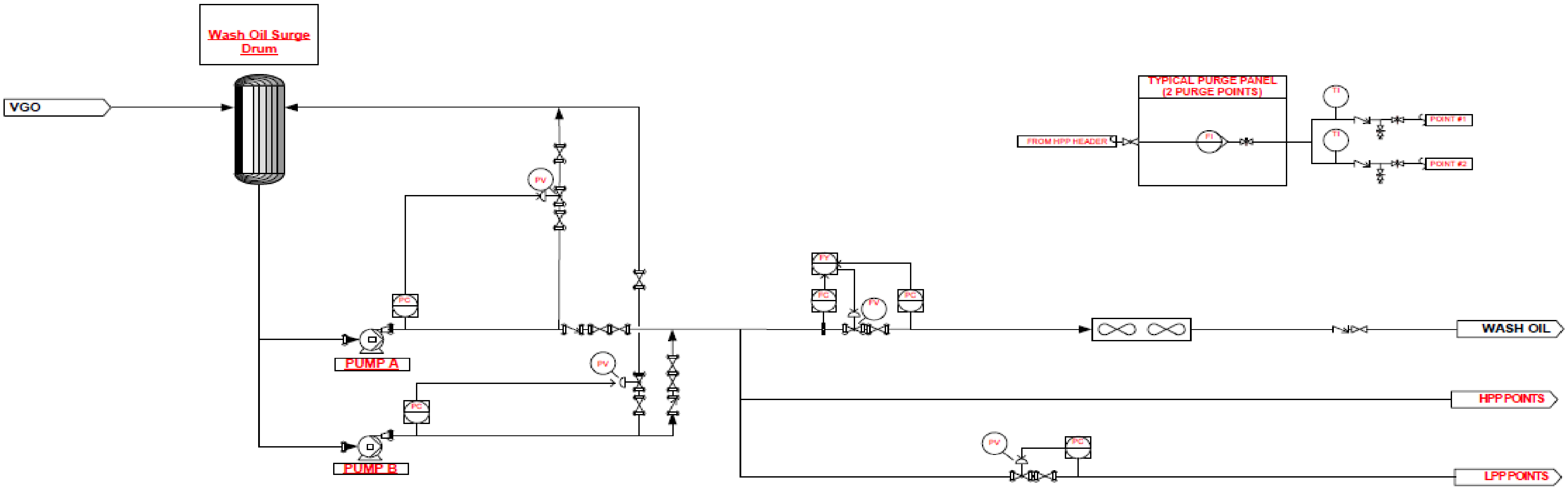
Purge System: Applications

- Hydrogen purges
  - Instrument impulse lines
  - ‘Bubbler’ level instruments
  - High temperature hydrogen service isolation valves potentially oil contaminated
- Steam purges
  - Fractionator bottoms systems (instruments and tower dead-space)
  - Vacuum bottoms systems (instruments and vacuum tower dead-space)
- Oil purges
  - PSV inlet lines (dead-legs)
  - Ball valves (body, seat and/or throat)
  - Instrument impulse lines
  - Control valve stem
  - Spare high pressure letdown valve station

Purge System: Applications

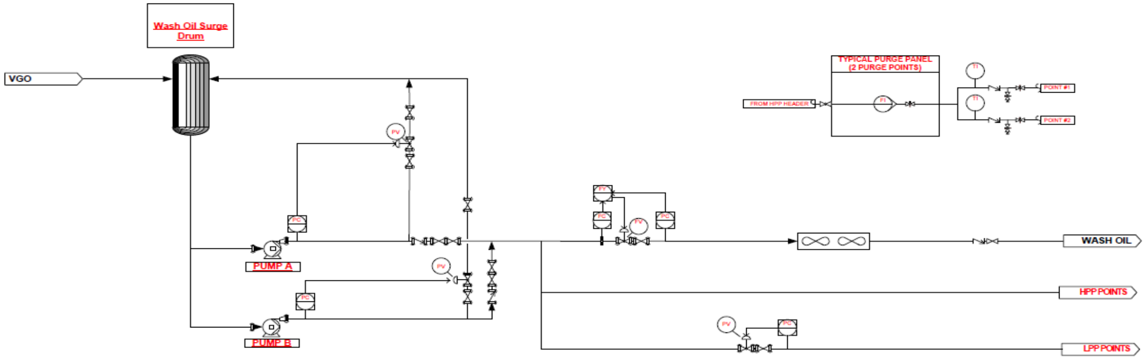
- Purging applications applied to:
  - Outlet of reactor heaters through reaction section
  - High temperature systems of the low pressure separation section
  - Catalyst/solids slurry system
- In these services, purge applications include: piping dead legs, valves (seat, body, throat), pump seals and instruments impulse lines
- Considering the above, leads to **500+** purge connections
  (3x the number of drain connections in the same unit)

Oil Purge System: Typical Scheme



Oil Purge System: Typical Scheme

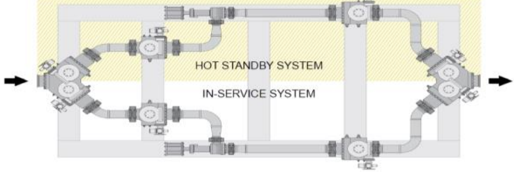
- Simple scheme hot VGO system
- Can be integrated with wash oil, quench oil or seal oil services
- Low capacity (typically <1-2% of unit rates)
- Purge rates set by licensors and vendors
  - Typically 0.5-1 ft/s for dead legs
  - Rates for valves proportional to size



Oil Purge System: Example

- High pressure letdown valves
  - Hot standby of the spare branch to avoid thermal stress
  - Online flushing and depressuring
  - Limit personnel exposure to high pressure/temperature components
  - Increased availability of the plant with online maintenance

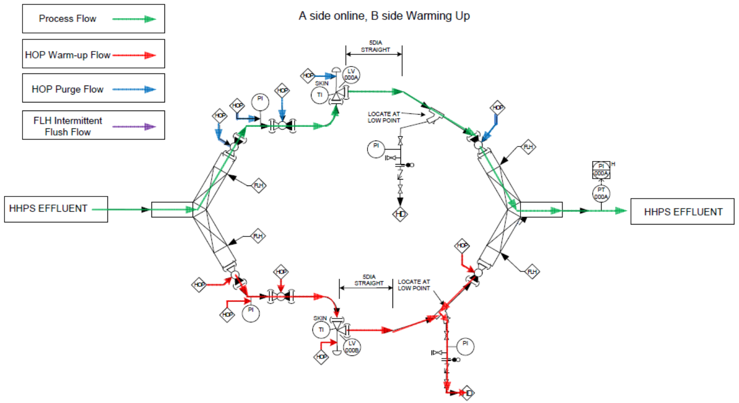
Source: *MOGAS Industries*



Hot High Pressure Separator (HHPS) Flushing/Purging Schematic

HOP with DBB Isolation (Online Maintenance)

A side online, B side Warming Up



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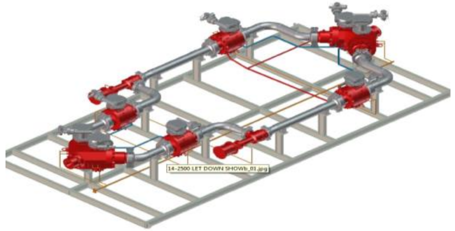

other Vendors can provide purged severe service ball valves i.e. Valve technologies

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Purge System Design

- A well designed purge system considers
  - Temperature
    - Above heavy oil pour point
  - Pressure
    - Above injection point pressure
    - Avoid overpressure
  - Layout and footprint limitations
  - Installation, testing and commissioning
  - Operability and maintenance
  - Cost
- Both piping and tubing designs are proven in industry

Piping vs. Tubing

Piping vs. Tubing	Piping	Tubing
Size	1”-2” governed by span	½”-2” governed by flow req.
Material	CS or SS depending temperature application	Stainless steel
Rating	600# - 2500#	Tubing rating – wall thickness selection
Distance between supports	10 ft for 1”, 20 ft for 2” typ.	Tubing routed in tray (20 ft for tray typ.)
Elbows	Fittings	Tube bending
Connection Fittings	Flanges and bolt up	Compression fittings
Stress Analysis	Stress analysis where required	Included in installation detail (Additional stress analysis where required)
ASME B31.1 & B31.3	Compliant	Compliant

Safety and Reliability

- Piping and tubing both fabricated and tested compliant with applicable piping design code (ASME B31.1 and B31.3)
- Advantages of tubing
  - Fewer connections reducing potential leak points
  - Minimal welding, minimizing hot work requirement
  - Tubing tested burst pressure significantly higher than allowable working pressure (21000psig vs. 4900 psig for 1 ½ in. x 0.188 wall)
  - Compression fitting joint integrity exceeds burst pressure of the tubing

Layout and Footprint

Tubing Purge Panel Design

Installation, Testing, Commissioning

Piping	Tubing
1. Pipe fitting scope including piping QC/QA (weld mapping, component verification, torque records, etc.)	1. Purge panel and tubing scope including QC/QA (component verification, compression fitting verification, etc.)*
2. Piping system pressure test program and reinstatement	2. System pressure test program and reinstatement
3. Extensive EHT installation scope and electrical QC/QA	3. EHT termination scope and electrical QC/QA
4. Full system insulation installation scope and associated QC/QA	4. Soft cover installation at system boundaries
5. Oil flush and system inventory	5. System inventory (oil flush optional)

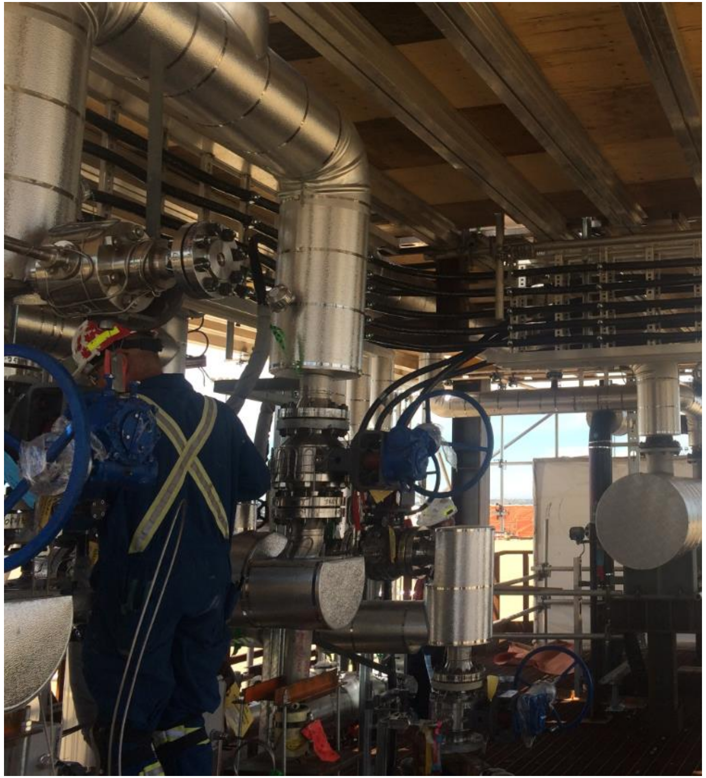
**Purge panels purchased as preassembled and tested units. Tubing is available pretested, traced and insulated.*

Operability and Maintenance

Tubing design advantages

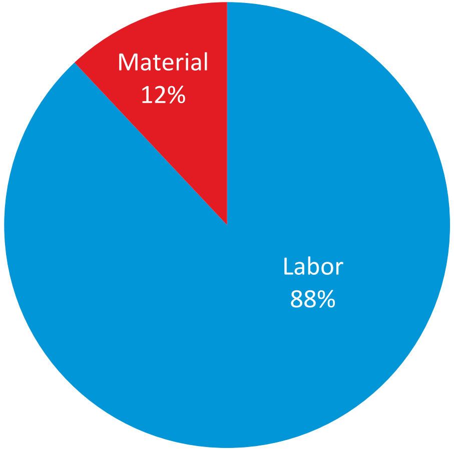
- Operability
  - Compact design
  - Purge panels heated in extreme climates
  - 100% stainless steel
- Maintenance
  - Small fittings
  - Connections for component removal
  - No hot work
  - No welding, no grinding

*However, tubing fittings are not universal



Cost

Piping Purge System Design



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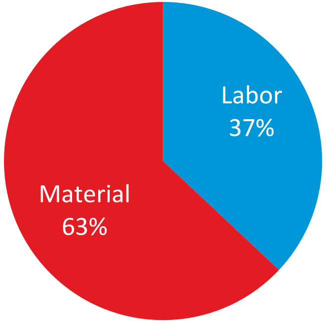
Tubing Purge System Design



*Cost data courtesy of Swagelok

Conclusions and Take-Aways

- Purge systems **improve integrity** of instruments and translate to reliability and overall plant safety
- Use **tubing** for purge systems to
  - optimize layout and accessibility
  - facilitate installation
  - improve operation and maintenance
  - reduce capital cost
- Fluor offers **innovative solutions** for delivering residue hydrocracking projects with best-in-class safety and reliability