The Benefits & Challenges of Filter Cleaning & Testing in Fluidized Catalytic Cracking Applications

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Needs & Questions

The global demand for transportation fuels & high quality diesel will drive the need for ***increases in clean fuel production levels*.**

As the feedstock moves toward a varied & unpredictable supply quality, current & new FCC units will be challenged with frequent filter fouling resulting in ***shorter on-stream life and more frequent change-outs and/or cleaning*** than in the past.

When metal filters are used to remove contaminants, the filters may be cleanable, ***reducing investments into new purchases*** and **providing an environmental *alternative to disposing of contaminated parts*.**

There are primarily 3 considerations pertaining to whether fouled metal filters can be recovered for reuse:

Filters & Configuration, Media & Metallurgy, Contaminant Properties & Loading

Challenge: Filters & Configuration

Handling Methods are related to the configuration of filter received for cleaning such as individual filters or filter assemblies in tubesheets or housings.

- Racking for cleaning
- Connectors for flushing & test stands
- Welders for disassembly/reassembly into tubesheets

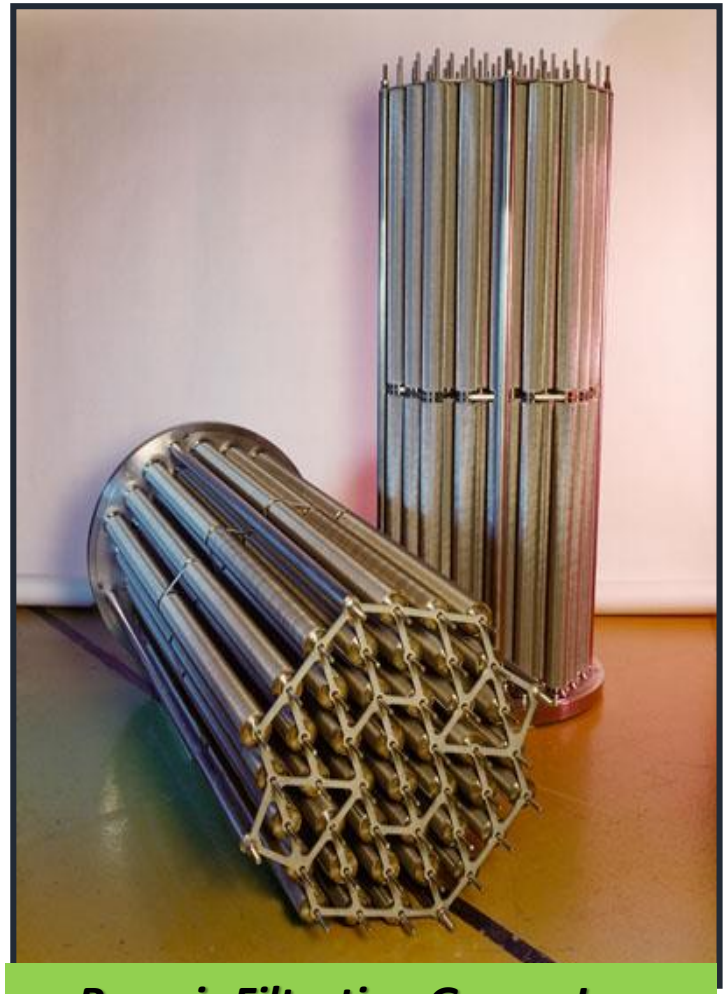
Process Equipment such as ovens, chemical & testing vats will be determined by configuration.

Packaging & Shipping Methods are determined by configurations

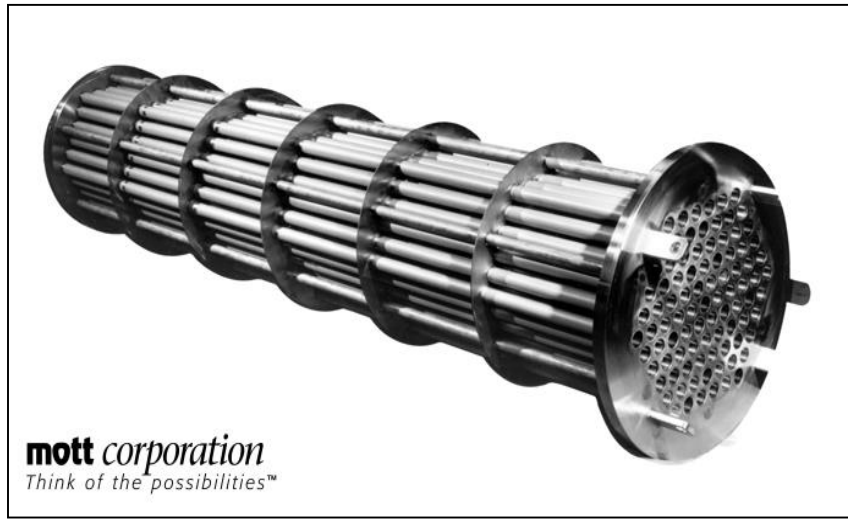
- Boxes
- Trucking

Filters & Configuration

GKN SINTER METALS

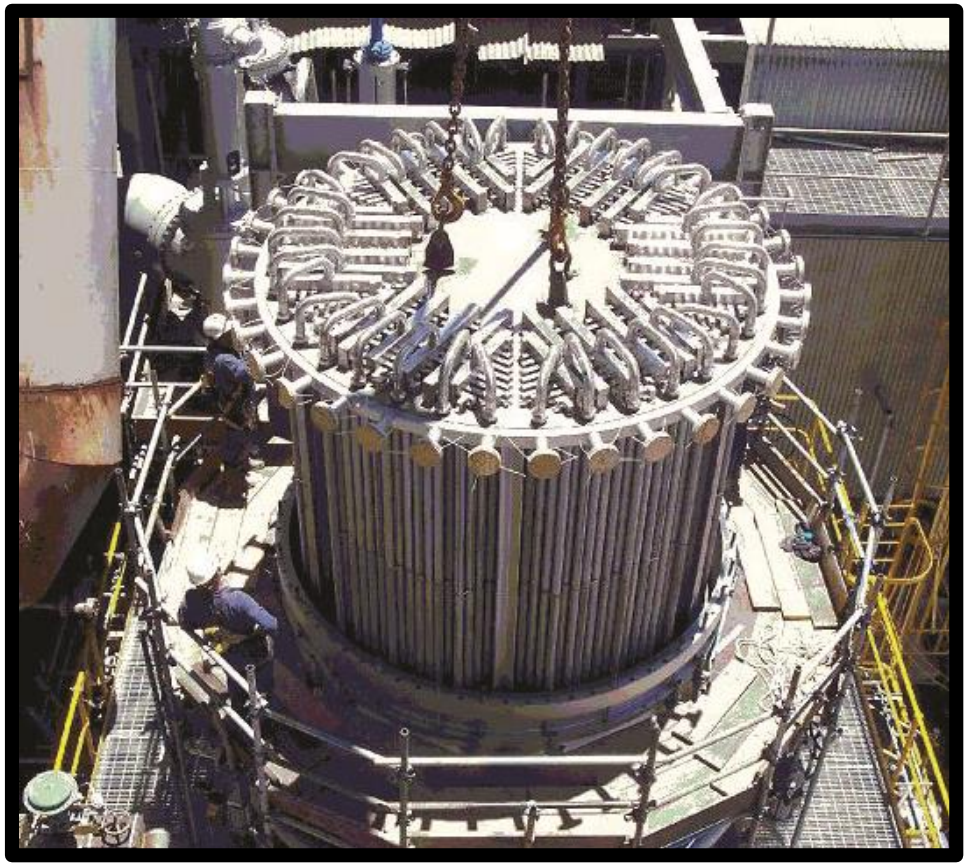


Porvair Filtration Group, Inc.



Filters & Configuration - Installations

mott *corporation*
ProcessSystems



PALL

Challenge: Media & Metallurgy

Media structure & types of contaminants will impact cleaning methods

- For systems where catalyst fines could be an issue, selection of the type of media, micron rating, & pore structure will be important.

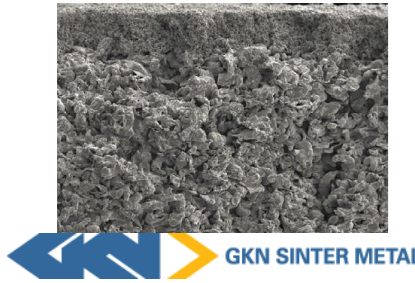
Metallurgical considerations when selecting cleaning processes & parameters.

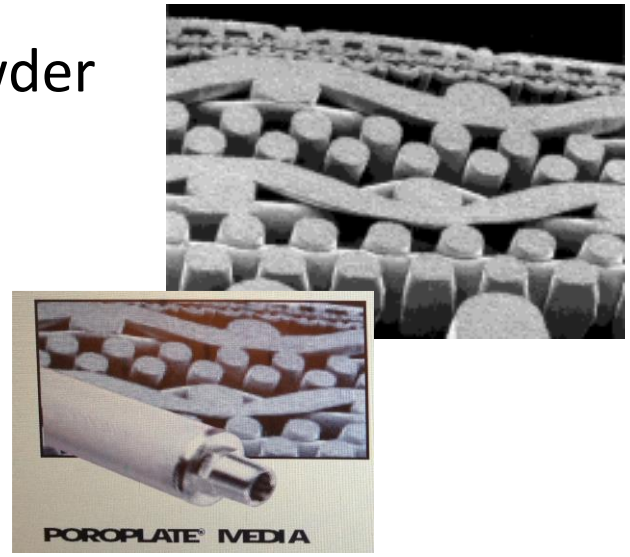
- For heavily loaded asphaltene contamination, HTO processes are necessary. The selected metallurgy must withstand the temperatures without loosing integrity.
- For sulfur compounds and other metallic salts, target chemistries required for cleaning must not corrode or compromise media metallurgy.

Media & Metallurgy

Media: For FCCU applications, media is selected with cake building & blowback capabilities.

- Multi-layer Wire Mesh/Sintered Fiber/Sintered Powder Combinations
- Porous Sintered Powder





Metallurgy: Refinery streams can be aggressive toward metallurgies to varying degrees. Typical materials for filter media and hardware are

- 300 Series (304, 310, 316), Nickel alloys, Iron Aluminide
- Selection is dependent on composition of filtered stream and process conditions as related to temperature.

Challenge: Contaminants & Contaminant Loading

Catalyst Fines can be created from catalyst used in the FCCU and may be embedded within a few angstroms of the filtration surface.

✓ **Solution** – Use cleaning processes that can potentially break-down the catalyst fines and then flush in the reverse direction to the process flow.

Most catalyst are inert which dictates a surfactant/ultrasonic removal process.

Organics such as ashphaltenes, aromatics, and other long-chain heavies are embedded throughout the media matrix.

✓ **Solution** –High Temperature Oxidation (HTO) processes w/washing and flushing to remove ash.

Metallurgical considerations are important when using HTO process.

Inorganics such as sulfur compounds and other metallic salts are embedded throughout the media matrix.

✓ **Solution** - *Chemomechanical system* that provides chemical delivery to the embedded contaminants.

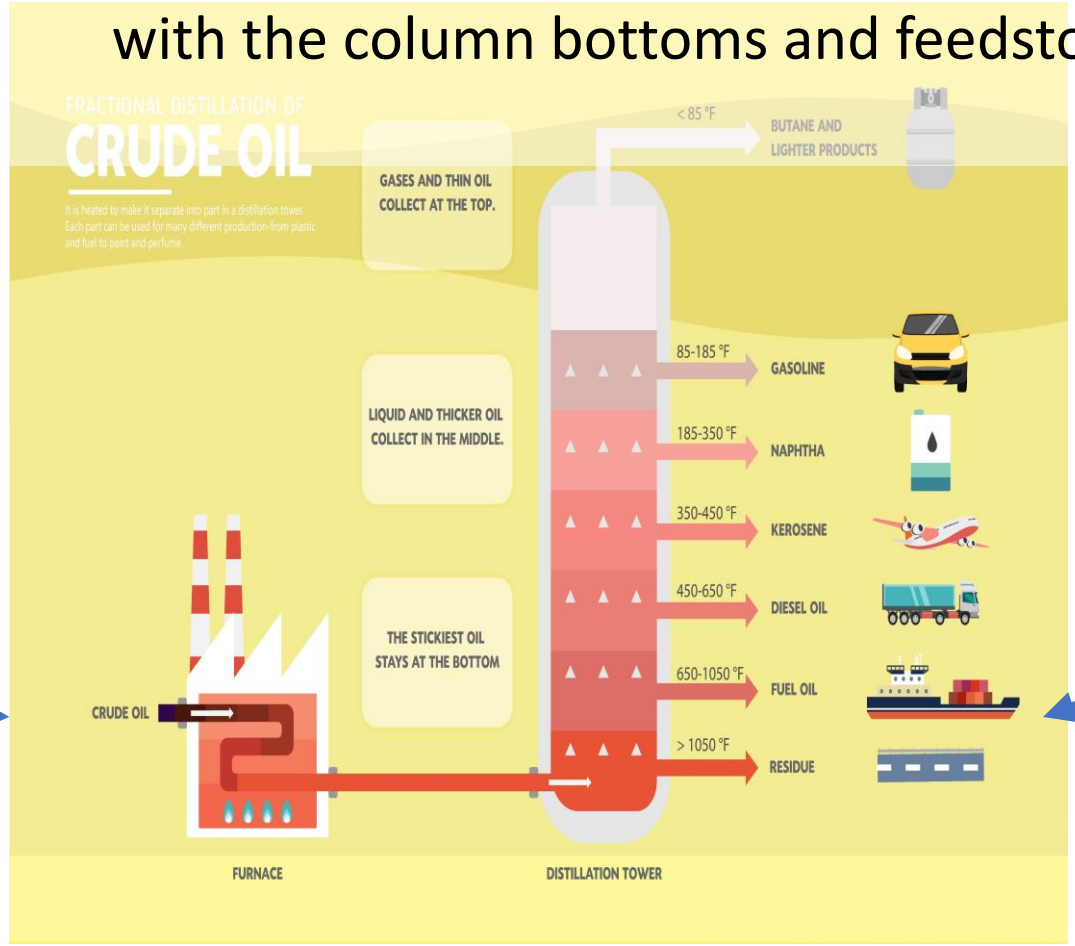
Soaking filters will not assure proper penetration of the chemicals throughout the media matrix.

Challenge: Contaminants

Along with FCCU operation, there is a push to convert more of the Residue & Fuel Oil streams into diesel and other lights.

The resulting filtration issues are related to the heavy organics such as asphaltenes associated with the column bottoms and feedstock.

Varied feedstock will have range of un predicted heavy contaminants.



Column bottoms will become a challenge to filter cleaning.

Contaminants

For FCCU applications, feedstock includes bottoms and residuals, whereby, these streams will be heavily loaded with contaminants that can easily foul a filter system.

Catalyst Fines, Resins,

Ashphaltenes of varying Composition & Aggregations,

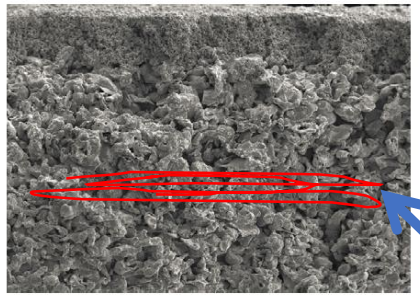
Aromatics & Ring Structures,

Cycloalky Groups, Long Chain Alkanes,

Inorganics such as sulfur,

Organometallic Structures w/metals related to geographical location of well

Contaminant Loading

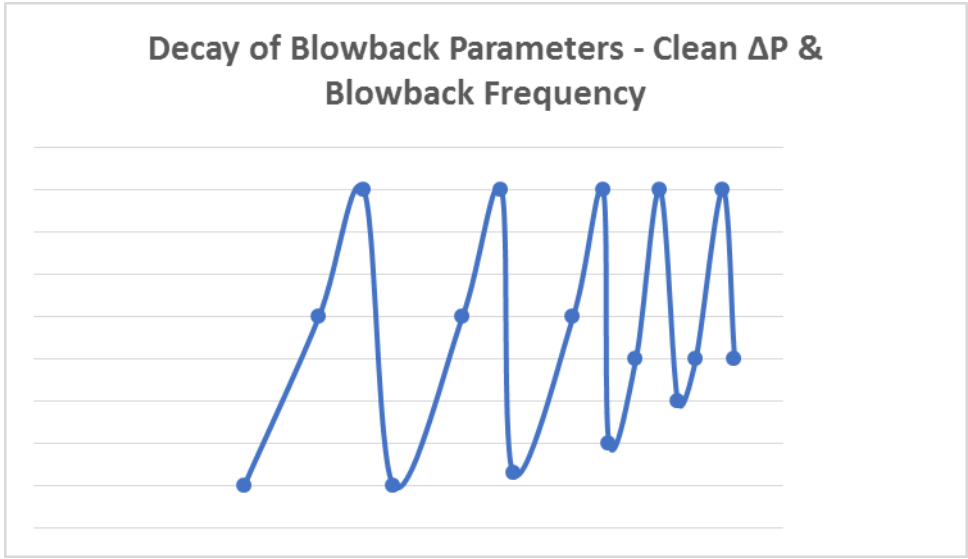


Metallic membrane „SIKA R AS“

The degree of contaminant loading can be related to the process, along with, the operation of the backflush/backwash system.

Filter media with embedded materials will prevent optimum backwash of the filter elements. Clean ΔP will not return to original ΔP and frequency of blowbacks will increase.

Process conditions will decay to the point that the filters must be replaced and either disposed or cleaned.



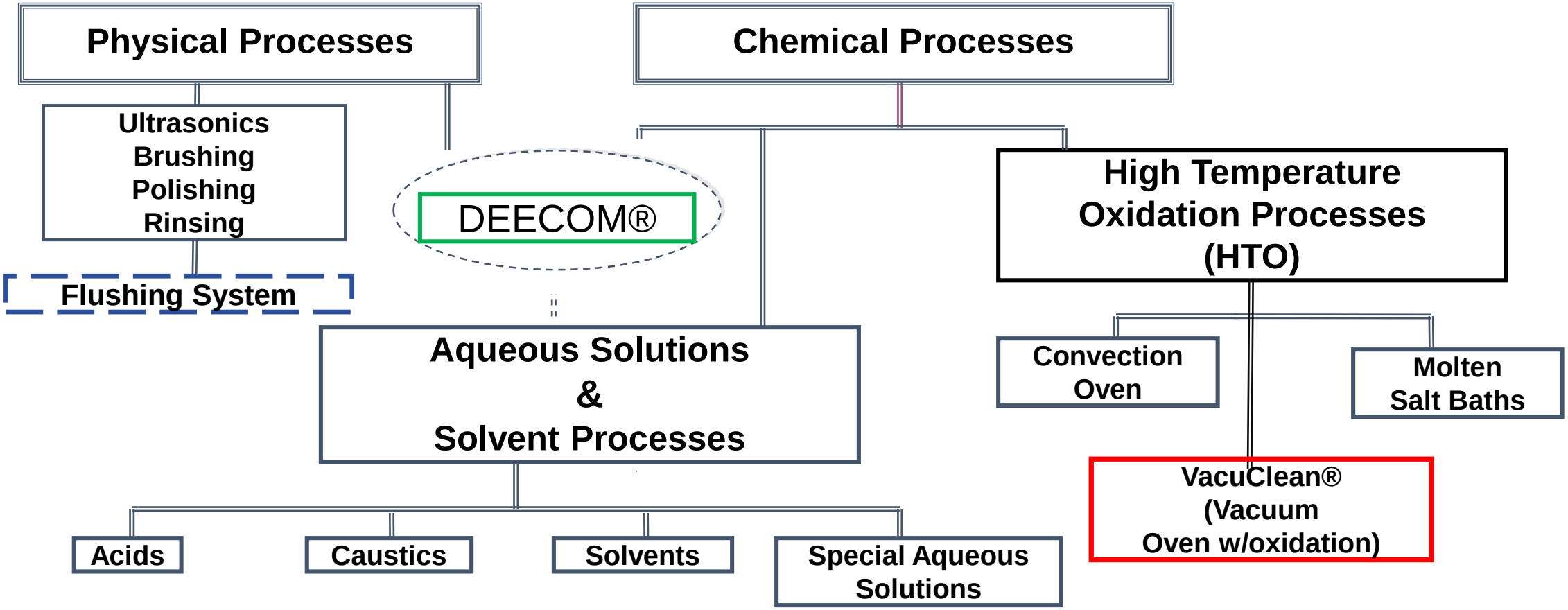
What are the Goals in Filter Cleaning?

….To ***understand*** the chemistry of the contaminant being removed from the filter and the construction & restraints of the filter media.

….To ***develop*** a process that removes the contaminant without damaging the filter media.

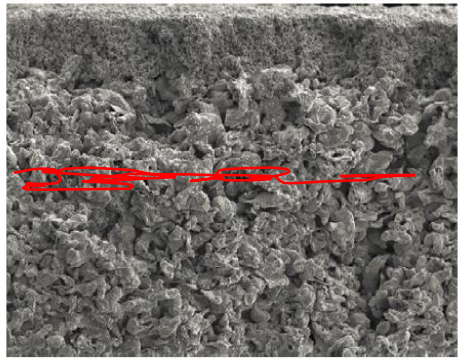
….To ***control*** the process conditions during cleaning.

Filter Cleaning Processes

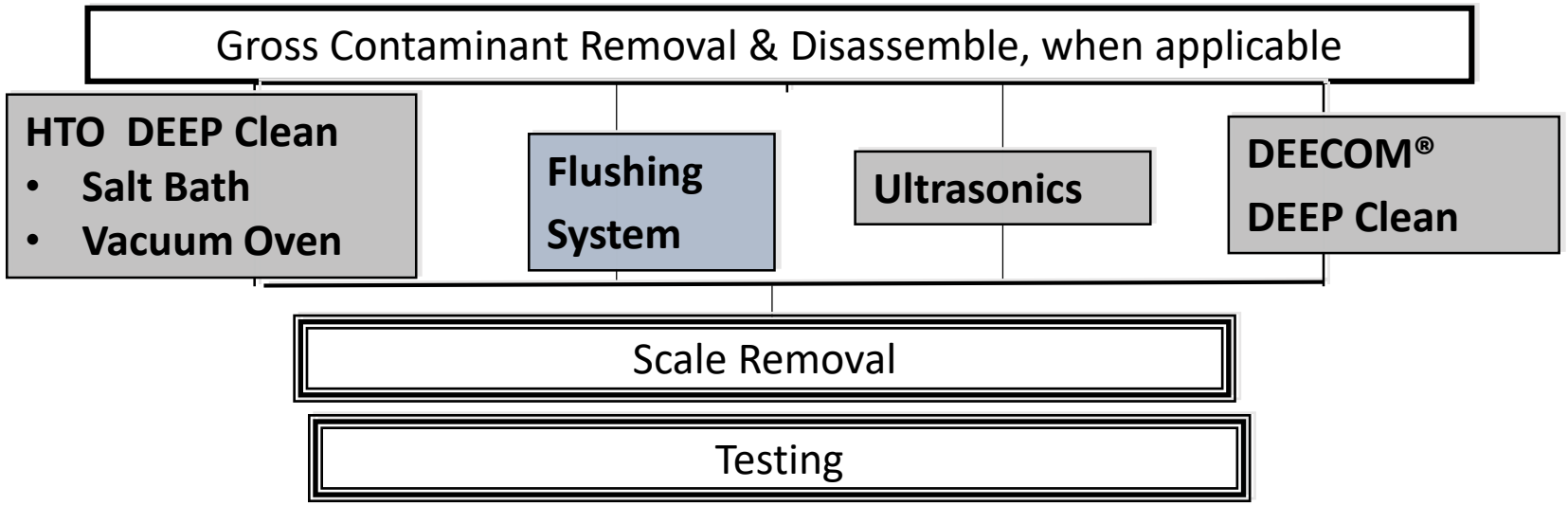


“DEEP” Cleaning Processes

(removes carbon, degraded organics, inert additives, & media embedded additives that can result in short filter life, high initial ΔP, weight gain, and quality issues)



Metallic membrane „SIKA R AS“



What are the Goals in Testing?

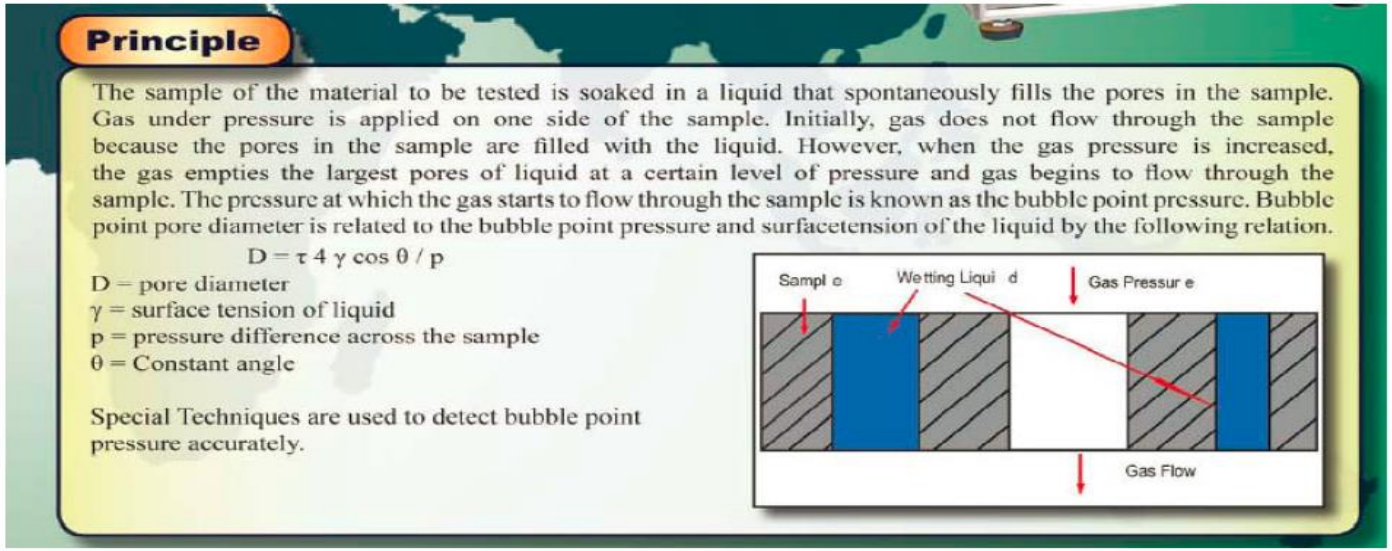
.... To ***validate*** that the integrity of the filter is such that the filter can be put back into service and produce non-defective product.

….To ***evaluate*** the filter non-destructively to ensure cleanliness.

Evaluation Testing

References: ASMT Method F316, ARP901, ISO4003

From PMI Website: Bubble Point Theory



Integrity:

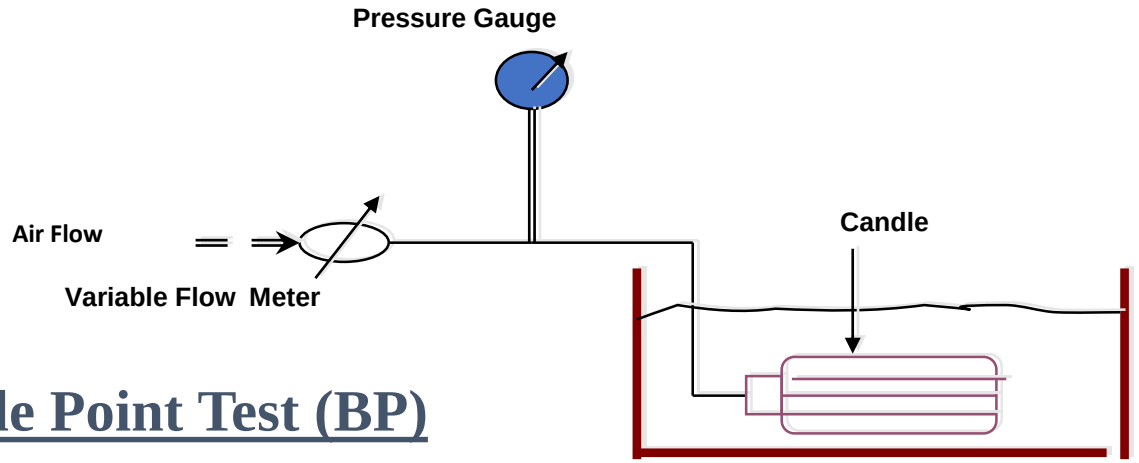
Bubble Point (BP):
Measures pressure required to force the 1st stream of air through the medi under a specified depth and wetting medium.

Wetted Airflow (WAF):
Provides a measure of overall pore size within the filter media – is best interpreted by comparison of data after multiple cleanings to baseline data

Cleanliness:

Dry Air Δ Pressure (DAP): Measures restrictions in dry filter media – can be correlated to the amount of embedded material left in filter media after cleaning.

Integrity Testing: BP and WAF Tests



Bubble Point Test (BP)

Filter is soaked in IPA to wet pores

Air slowly fills interior of filter

Pressure recorded when first stream of air bubbles breaks through largest pore/opening

Wetted Airflow Air Flow Test (WAF)

Air flow set at specified rate

Resulting pressure recorded

Flow pattern noted

Cleanliness Testing: % Improvement, %Recovery

% Improvement:

Comparison of Pre-Cleaning and Post-Cleaning DAP data to provide indication of particulate removal.

- Used when baseline data is not available.
- Does not provide information on cleanliness level vs baseline.

% Recovery:

Evaluation of %Recovery to determine the degree of removal of contamination.

% Recovery = (D-C)/(D-B) x 100, where

D = DAP of Dirty Filter, ***C***= DAP of Cleaned Filter, ***B*** = DAP at Baseline.

Note, the goal is for [D-C] ⟶ [D-B] at 100% Recovery

The ***Target*** is for ***% Recovery > 90%***. If not, re-cleaning or disposition will be considered.

Benefits of Filter Cleaning

In metal filtration applications, filter cleaning is typically required due to the expense & timing for fabrication of new filters.

Benefits for the user are realized in the

- Economics of using filters multiple times before discarding.
- Turnaround as cleaning can be done in less time than fabricating new filters.
- Environmentally Responsible alternative to disposal.

For Fluidized Catalytic Cracking and other applications associated with maximizing the conversion of residual streams into diesel and other light liquids,
CFI has developed a filter cleaning process that has

- improved the quality of cleaning
- defined cleanliness
- reduced turnaround
- reduced internal costs associated with new filter purchases.

Filter cleaning also provides the user with an environmentally responsible alternative to filter disposal.