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FILTRATION SOLUTIONS

NSA / INPO INNOVATION EXPO

May 21 - 22, 2018

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Framatome Nuclear Products

Introduction

- Current US Nuclear Reactor population is a result of widespread development of Gen II reactors from 1965 to 1985
- Most nuclear plants operated at refueling cycles of 12 months and refueling durations of 3 months between 1980 and 1990.
- Fuel technology improvements have allowed the ability to now operate today at 18 to 24 month refueling cycles and outages averaging just over 30 days.
- Changes to the fuel operations, however, have resulted in needed chemistry changes.
- These changes have resulted in a need to place consideration on plant filtration.

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Role of Filtration

- Filtration systems originally consisted of mainly strainer assemblies, not critical to plant operations.
- Filtration now considered critical to plant operations due to role they play in removing foreign material, corrosion products, and maintenance/reduction of plant radiation levels.
- Cost of disposal of nuclear waste is also rising, so protection of costly plant systems is of growing importance.

Plant Filtration Development

- **FRAMATOME (originally B&W) is an OEM for seven US reactors (six operational)**
- **In 1983, FRAMATOME evaluated the supply of filters from the OEM PALL, and determined that a more cost effective and improved product was needed.**
- **Special consideration of filtration for nuclear applications:**
  - **High Flow Rates**
  - **Extended Filter Life**
  - **Remote Handling Requirements**
  - **Configuration Problems**
  - **System Upgrade**

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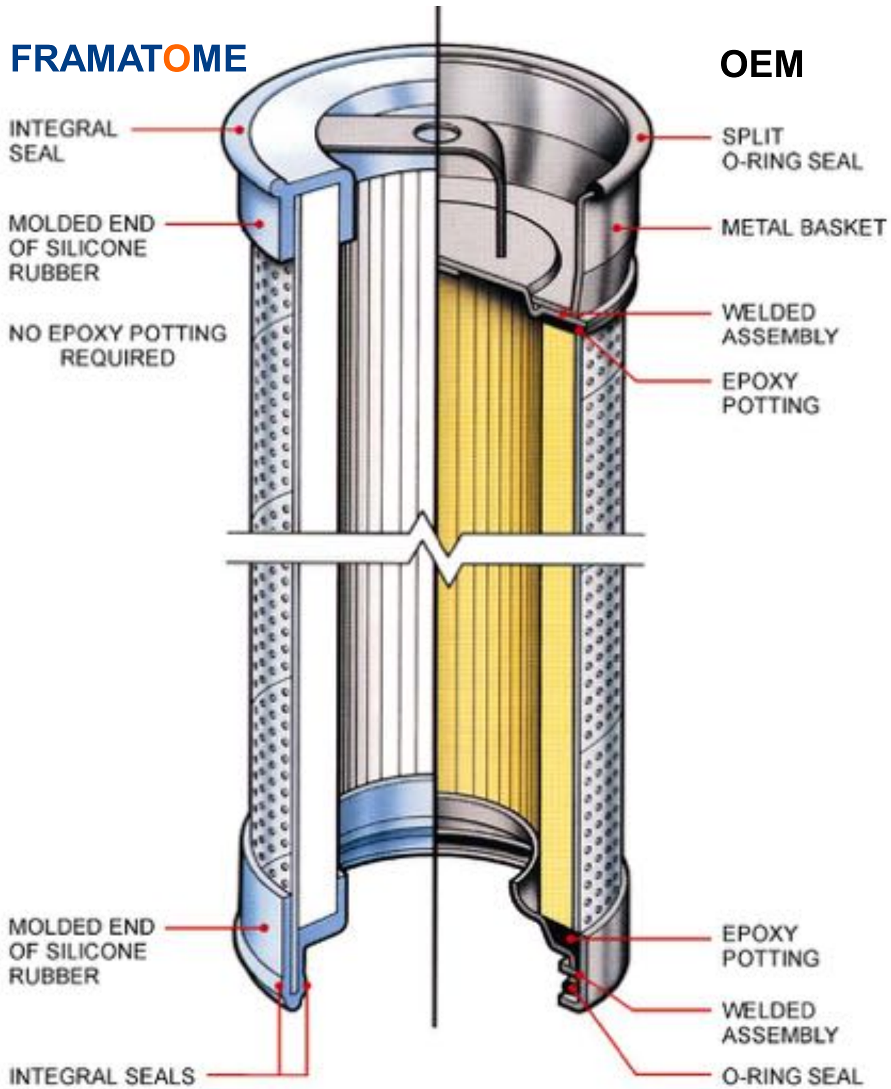
Cartridge Filter Development



Specialty Adaptor Development

- **Multiple Cartridge OEM Designs**
- **Spent Cartridge Handling Difficulty**
- **Filter Basket Disposal Usually Required**
- **Requires Significant Pre-Assembly**
- **High Potential for By-Pass**

Specialty Adapter Development – The Condition

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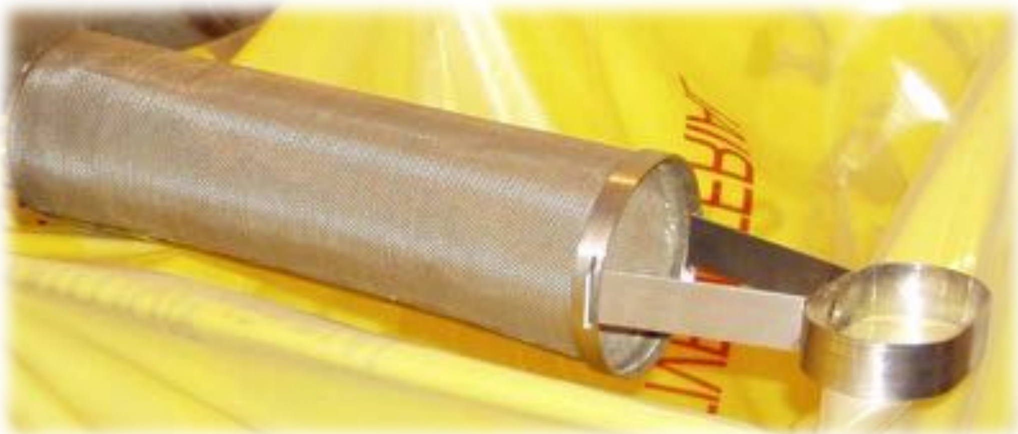
Specialty Adapter Development – The Solution

Disposable Media Filtration

- Waste Volume Reduction
- Reduced Waste Disposal Costs
- Equivalent OEM Filter Performance
- Reduced Filter Costs
- No Vessel Modification Required

Disposable Media Filtration – Andale Strainer Condition



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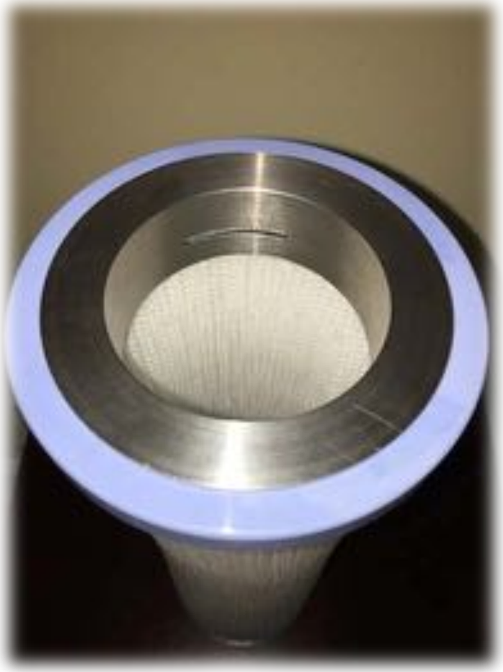
Disposable Media Filtration – Andale Strainer Solution



Disposable Media Filtration – PALL 007 & 022 Applications

- 300 series stainless steel adapter insert
- Provides needed structural integrity and sealing
- Prevents bypass
- Internal or external bottom Adapter to Vessel seal
- Seal material Silicon RTV
- Handling Tools Included

Disposable Media Filter Cartridge Installation & Removal

- **With the Adapter Seated Securely in Vessel, Disposable Media Pack is Inserted and Removed into Adapter Either Manually or with Remote Tooling**

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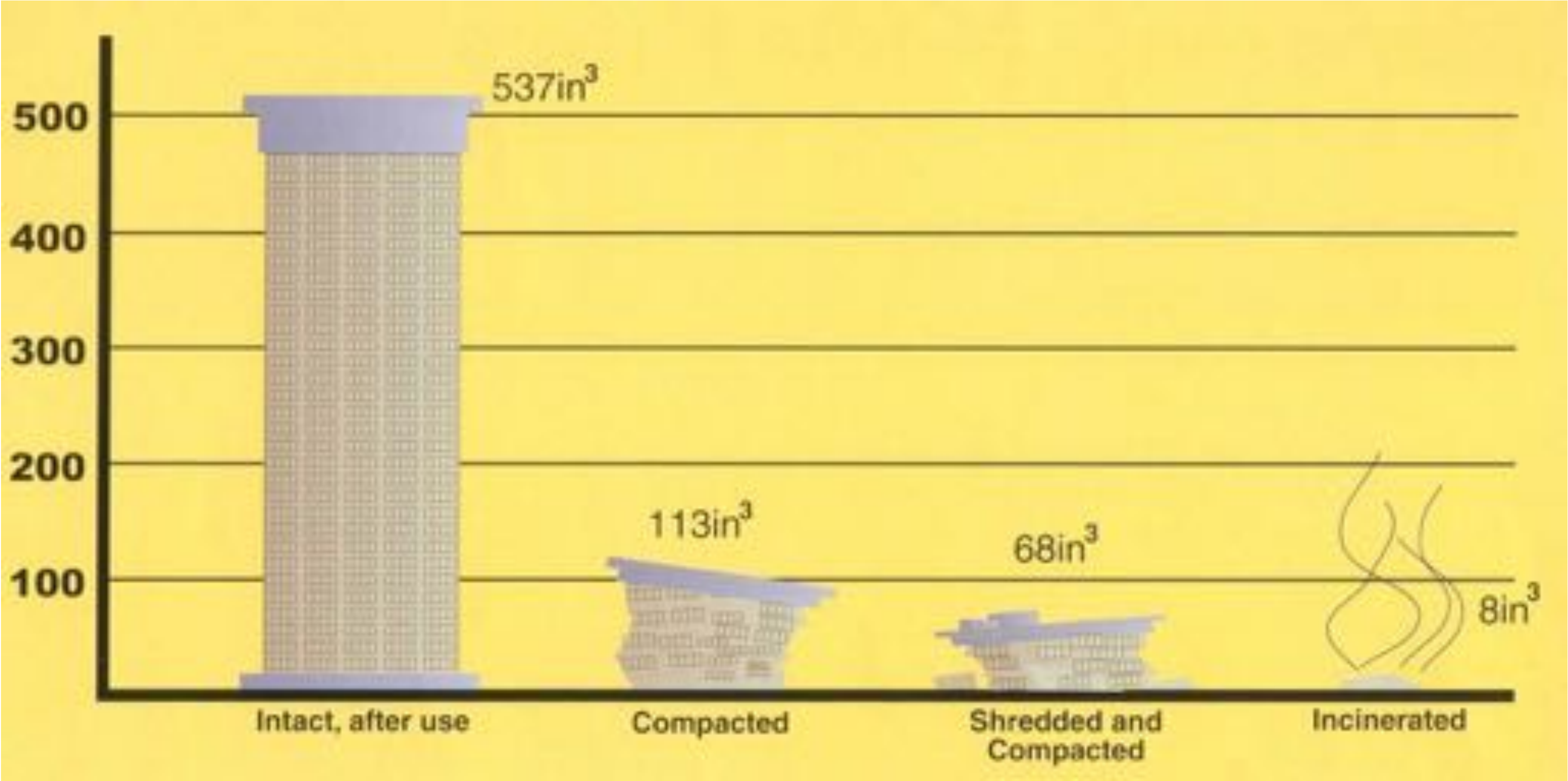
Disposable Media Filtration – Waste Reduction

- **Net Volume Reduction Ratio from 33:1 to potential 54:1**



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Traditional Bag Filtration

- **Pros**
  - **Readily Available**
  - **Easy to Install**
  - **Inexpensive**
  - **Long History of Use**
- **Cons**
  - **Limited Filtering Ability for Lower Micron Applications**
  - **Large Volume of Waste Generated**
  - **Easily Bypassed**
  - **Easily Blinds Off**

Traditional vs. Pleated Bag Filtration

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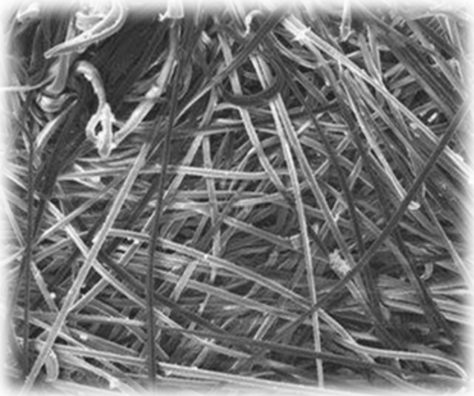
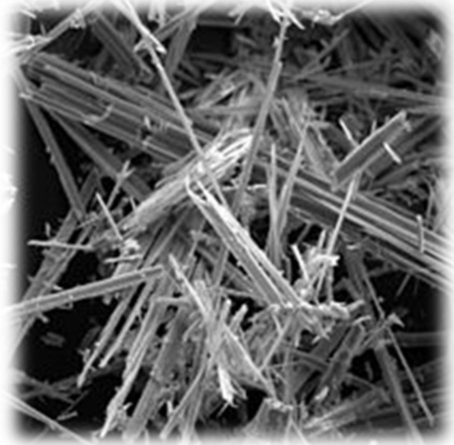
Evolution of Mechanical Filtration Media



- **Cellulose – 1838**



- **Glass Fiber – 1932**

- **Polypropylene – 1954**

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Fundamentals of Mechanical Filtration – Billiard Ball Effect

Fundamentals of Mechanical Filtration – Excessive Flux Degradation

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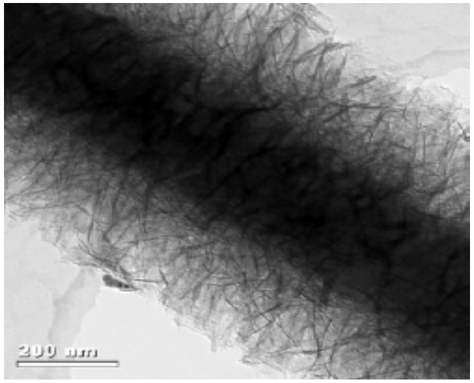
Fundamentals of Mechanical Filtration – Submicron Filtration

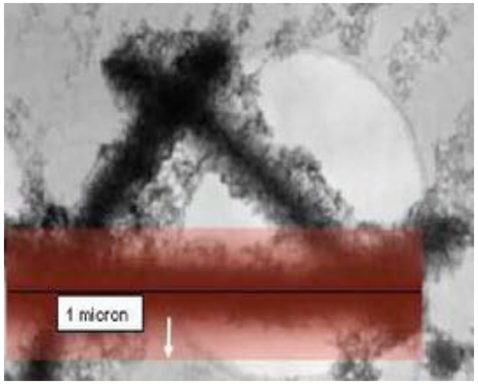
Nanofiber Filtration

- Designed for removal of activated colloids and sub-0.1 micron water-borne contaminants
- Ceramic nanofibers are grafted onto structural backbone of microfibers to for pore structure
- Submicron particle capture via electro-adsorption

NTI Nanofiber Media



Boehmite "needles" grafted to backbone

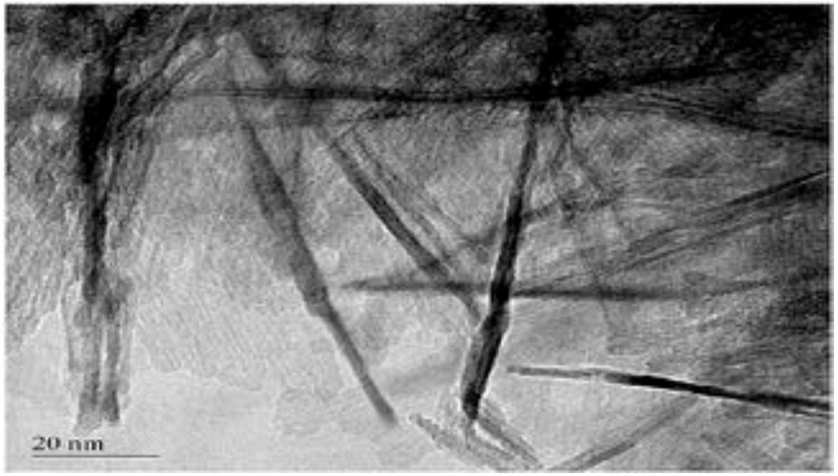


Contaminant Removal via Electroadsorption

Nanofiber Filtration

- Nanofiber media flows like higher micron mechanical filter, yet captures submicron particles.
  - NANO-424, average pore size ~ 2.7 micron with removal efficiency > 99.99% at 0.027 micron
  - NANO-421, average pore size ~ 9 micron with removal efficiency > 99 % at 0.027 micron
- Outperforms industry recognized 0.1 µm resin impregnated glass fiber media in all critical metrics

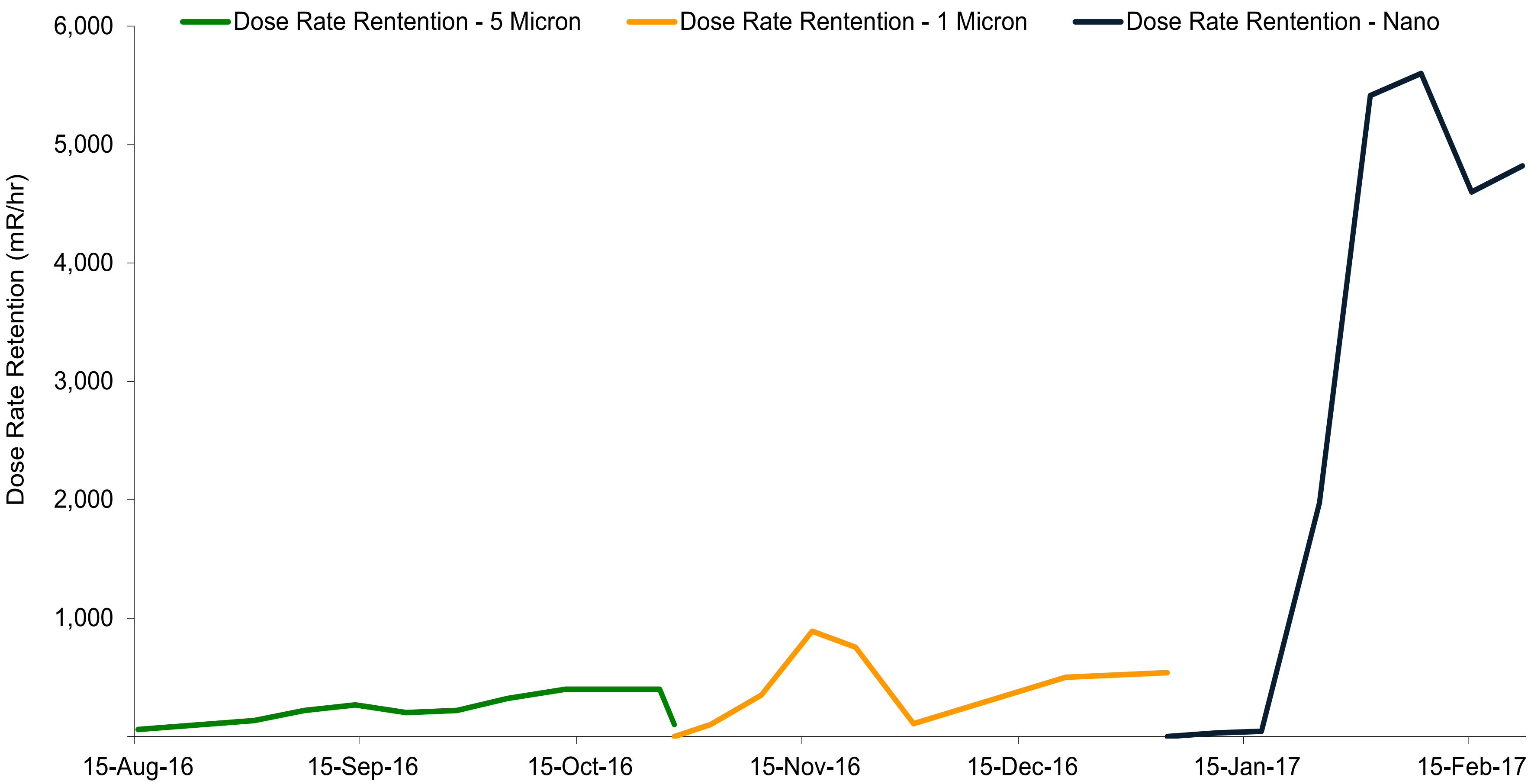
Nanofiber Fiber Technology



Boehmite nanofibers 2 nm dia x 250 nm lg

Nanofiber Filtration – Media Performance Comparison

Comparative OE for 5 & 1 µm Conventional vs. Nanofiber Filters



Data provided by: Entergy Palisades

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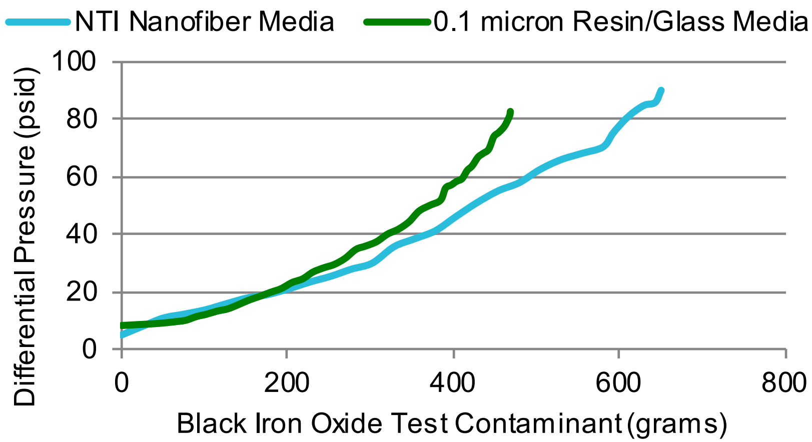
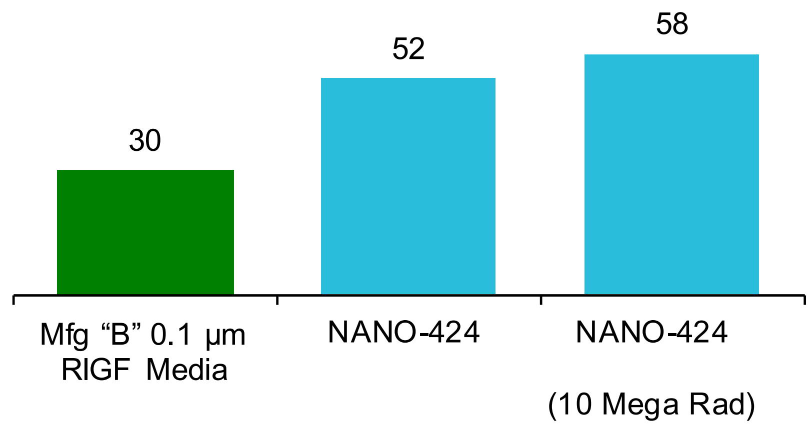
Nanofiber Filtration – Test Performance Data

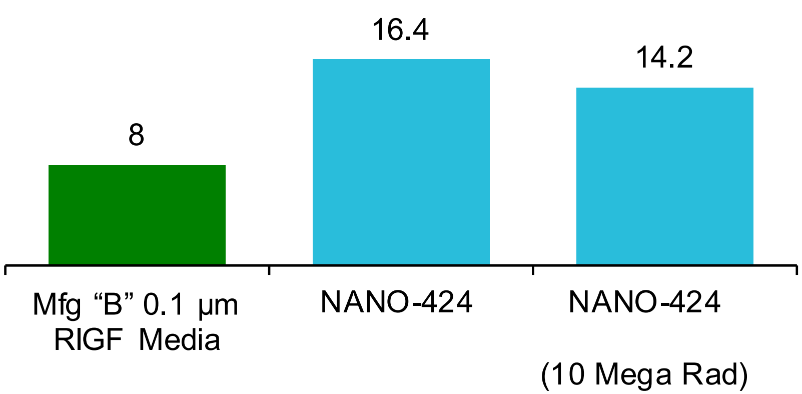
Dirt Holding Capacity



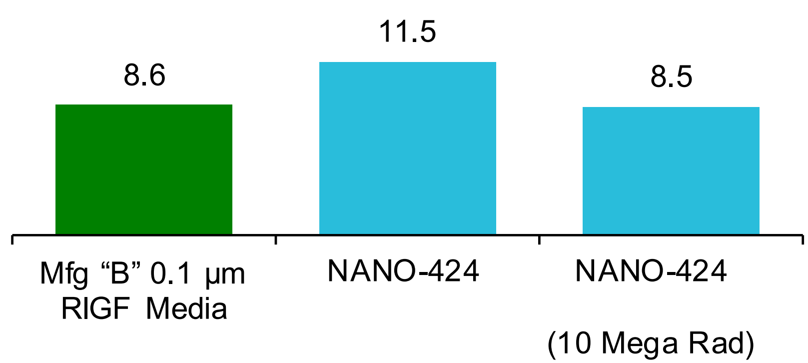
Wet Mullen (psi)



Wet Tensile Machine



Wet Tensile Cross



Data provided by: IBR Laboratories (Grass Lake, MI)

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Filtration Strategy Development

- Plant Operations
- Chemistry Changes
- Radiation Level Management
- Radwaste Generation & Processing

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Filtration System Development

- **FRAMATOME has developed the following systems to support the current filtration system needs:**
  - **Source Term Extended Reduction (STER)**
  - **OPTIMIZER**
  - **DECOM-EX Decontamination System**
  - **Skid Mounted High Filtration & Media System (HFM)**

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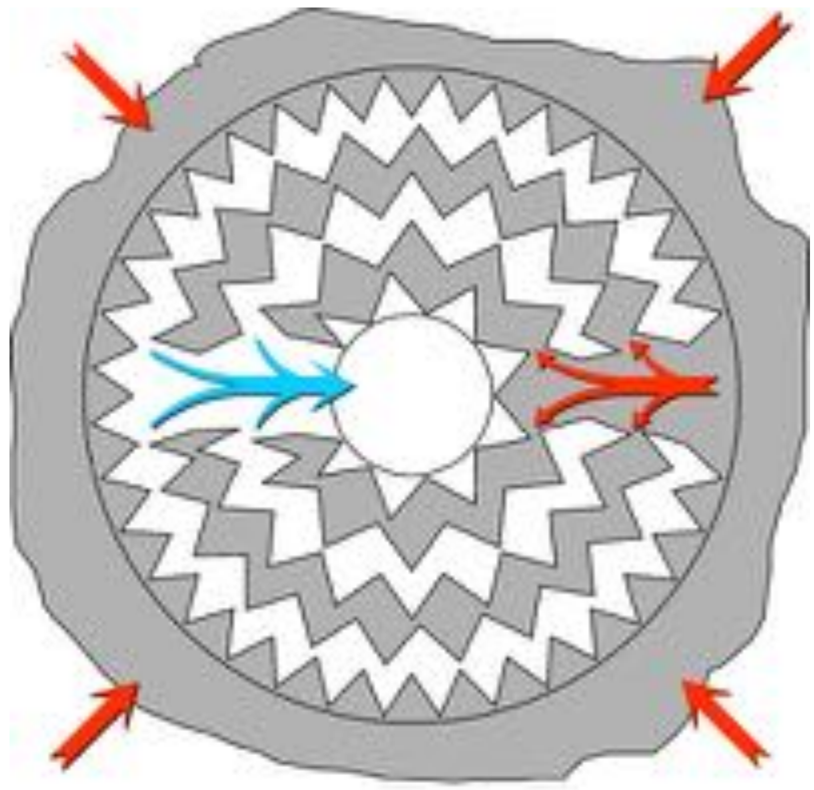
Source Term Extended Reduction (STER)

- **A modularly designed filtration vessel specifically to meet the need for large volume of plant water and wastewater cleanup.**

Source Term Extended Reduction (STER) - Filter

- **Uses high capacity out-to-in filter with unique flow design**



OPTIMIZER Filtration System

- **Designed specifically to meet the need of submicron filtration by reducing filter flow rate per square inch to optimal level without degradation of overall water cleaning capability.**

DECOM-EX Decontamination System

- **Designed for capturing a large volume of low-level radioactive waste (LLRW) solids in a clean-up operation, Decom-EX™ provides significant collection space within the filter to accomplish the task.**

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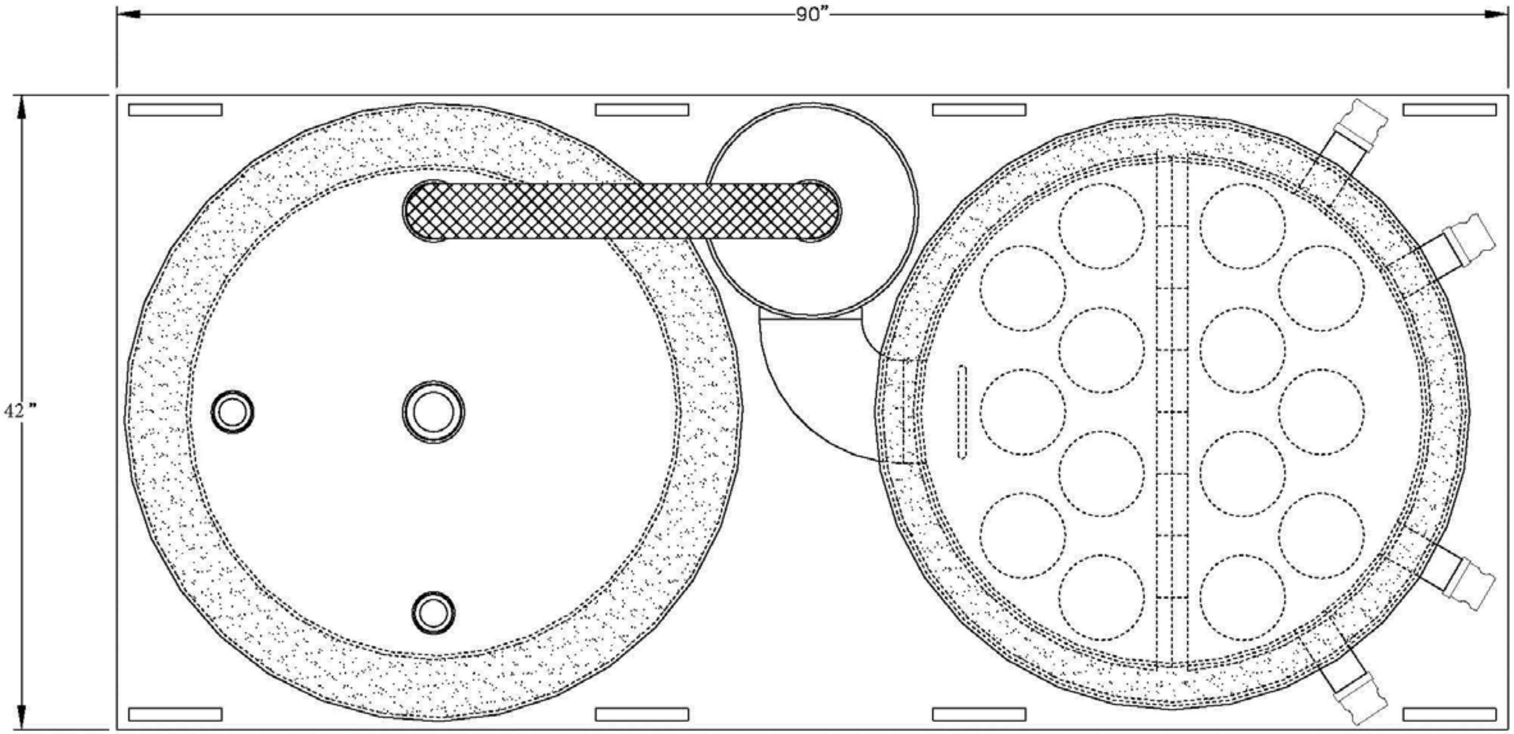
High Filtration & Media System

- **An all-in-one two-stage filtration and ion-exchange vessel combination, with variable speed control and shielding, designed to operate the entire duration of a refueling outage and be installed and removed using one crane pick for each.**



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Questions?