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Service
Advanced Fluid Care & Diagnostics

Hydraulic Fluid Service

Area Sales Manager - Refuse/David Spadell

Physical Laws of Hydraulics

- Hydraulic pumps create flow – not pressure
- Resistance to flow creates pressure
- Pressure determines cylinder force and motor torque
- Flow determines cylinder or motor speed
- Fluid under pressure always takes the path of least resistance
- When liquid moves from an area of high pressure to an area of low pressure without doing useful work, heat is generated
- Hydraulic fluids are compressible – not highly compressible, but compressible nonetheless

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Tribology

Friction and Lubrication

Lubrication

Hydraulic Lube Best Practices

- Keep fluid clean, cool, and dry
- Use correct viscosity
- Check oil temperature regularly
- Use quality filters that assure required protection
- Use high-efficiency offline filters or carts

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Lubrication

Function

- Friction Control, reduces heat generation and energy consumption
- Wear Control, reduces mechanical and corrosive wear
- Corrosion Control, protects surfaces from corrosive substances
- Temperature Control, absorbs and transfers heat
- Contamination Control, transports particles and other contaminates to filters/ separators
- Power Transmission, in hydraulics, transmits force and motion

Lubrication

Viscosity: An oils resistance to flow and shear.

Viscosity is the most important physical property of a lubricant.

Viscosity is influenced by:

- Temperature
- Water
- Contamination
- Pressure
- Shear
- Chemical changes

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Friction

Types of Friction

- Sliding: Forces that resist motion between sliding solid surfaces that are clean and dry.
- Rolling: Forces that resist relative motion between two solid bodies when one or both are rolled over the surface of each other.
- Fluid: Force that resists the flow of liquids or gases. Such a force opposes the sliding action, one over the other.
- Boundary: Force that resists relative motion between two solid bodies that are wetted by a fluid film.
- Mixed-film: Forces that resist relative motion between two solid bodies that are partially separated by a full fluid.

Results of Friction

Wear

- Surface Fatigue
- Cutting
- Sliding
- Adhesion

Heat

- Loss of viscosity
- Increased additive depletion
- Increased oil oxidation
- Increased varnish potential

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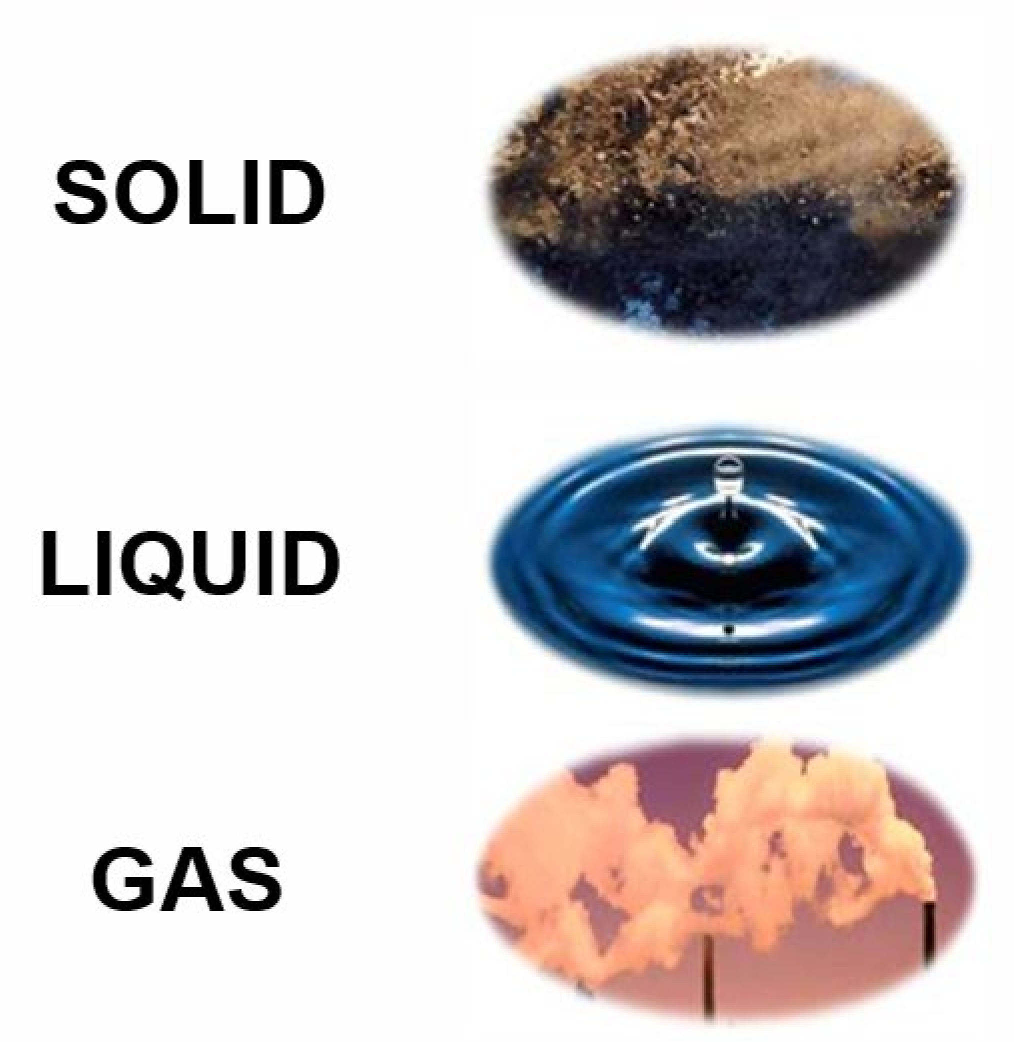
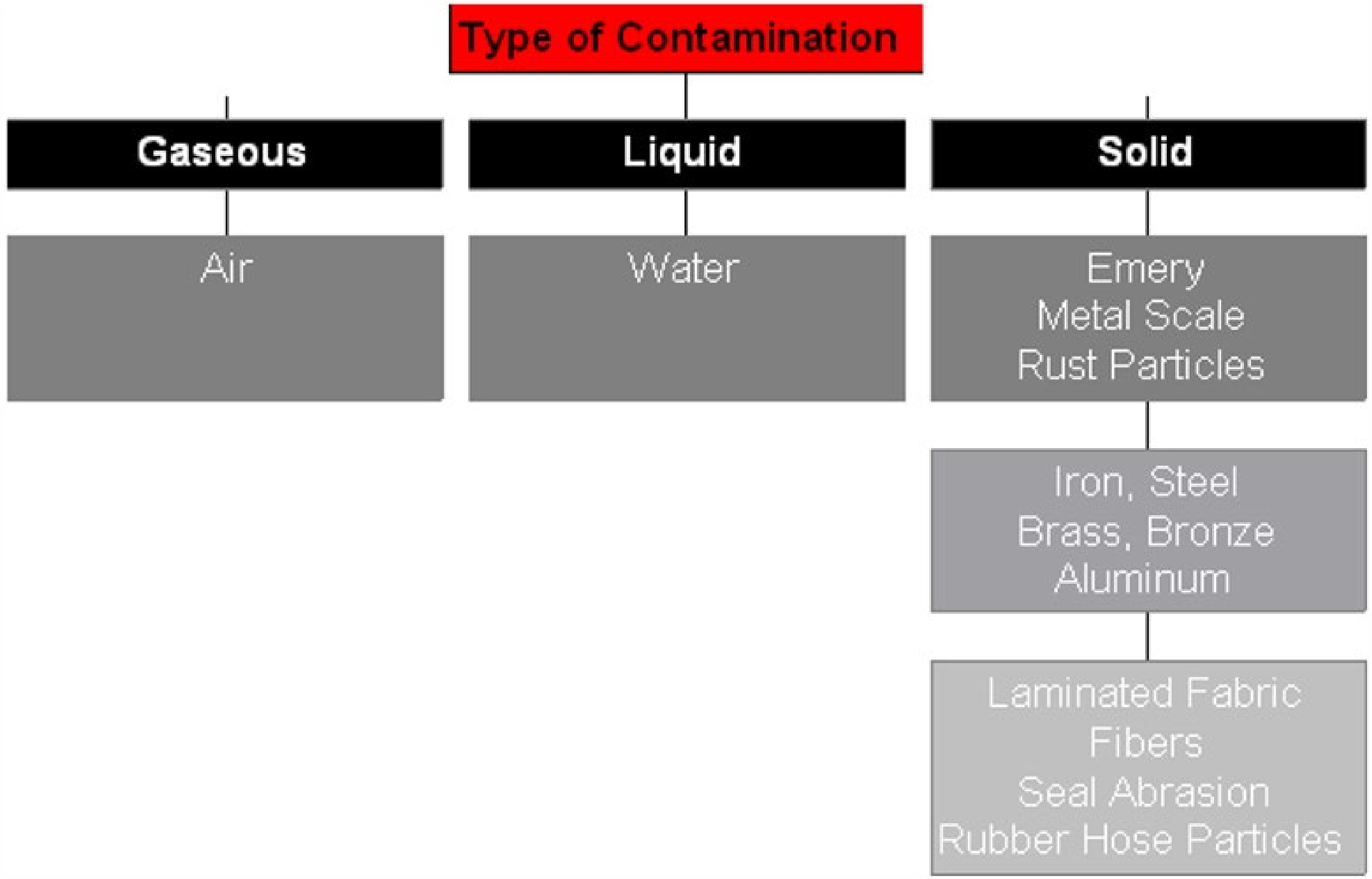
Contamination

Types of Contamination



Types of Contamination



Type of Contamination

- **Gaseous**
  - Air
- **Liquid**
  - Water
- **Solid**
  - Emery
Metal Scale
Rust Particles
  - Iron, Steel
Brass, Bronze
Aluminum
  - Laminated Fabric
Fibers
Seal Abrasion
Rubber Hose Particles

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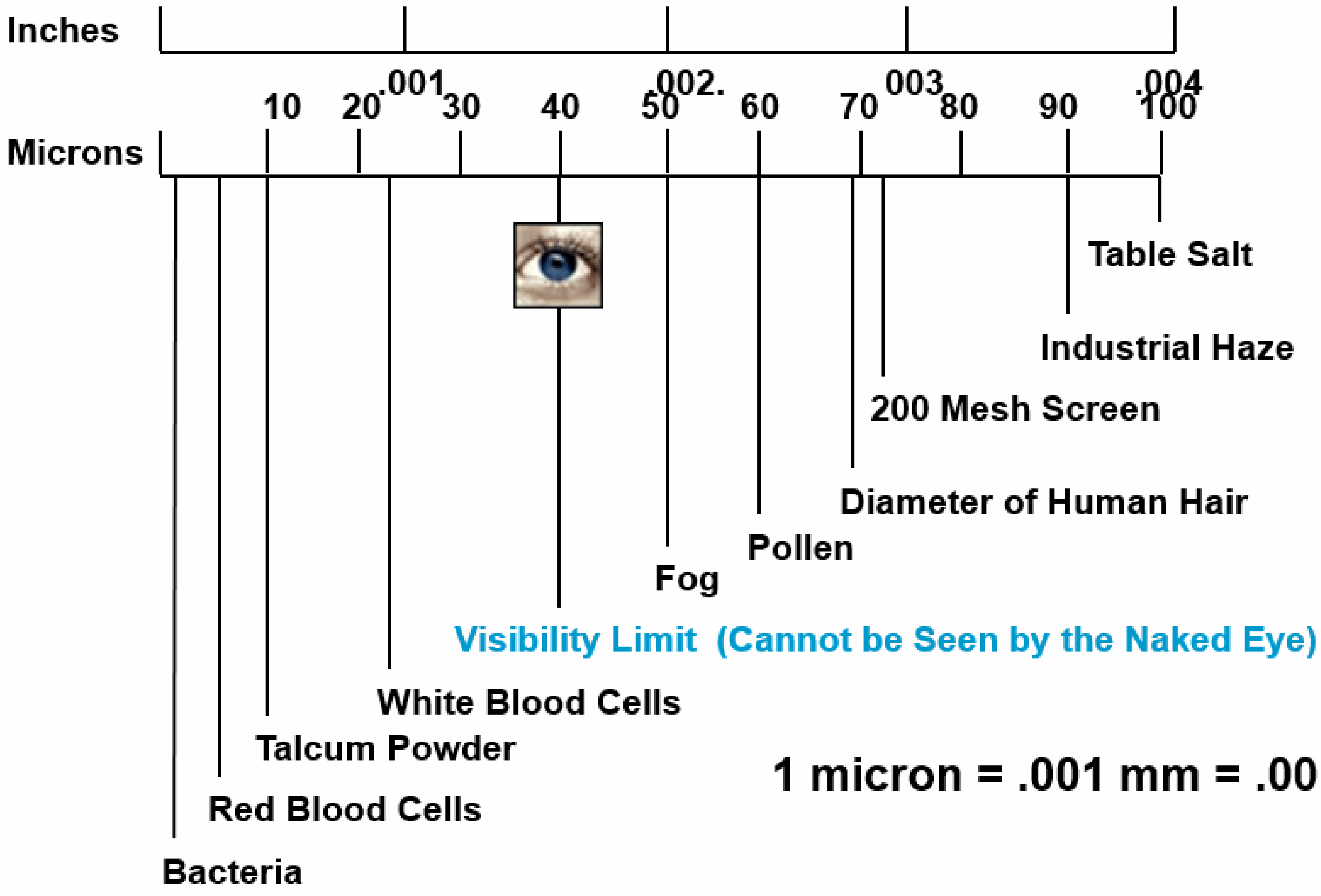
Particle Sizes



Inches

.001 .002. .003 .004

Microns

10 20 30 40 50 60 70 80 90 100

Table Salt

Industrial Haze

200 Mesh Screen

Diameter of Human Hair

Pollen

Fog

Visibility Limit (Cannot be Seen by the Naked Eye)

White Blood Cells

Talcum Powder

Red Blood Cells

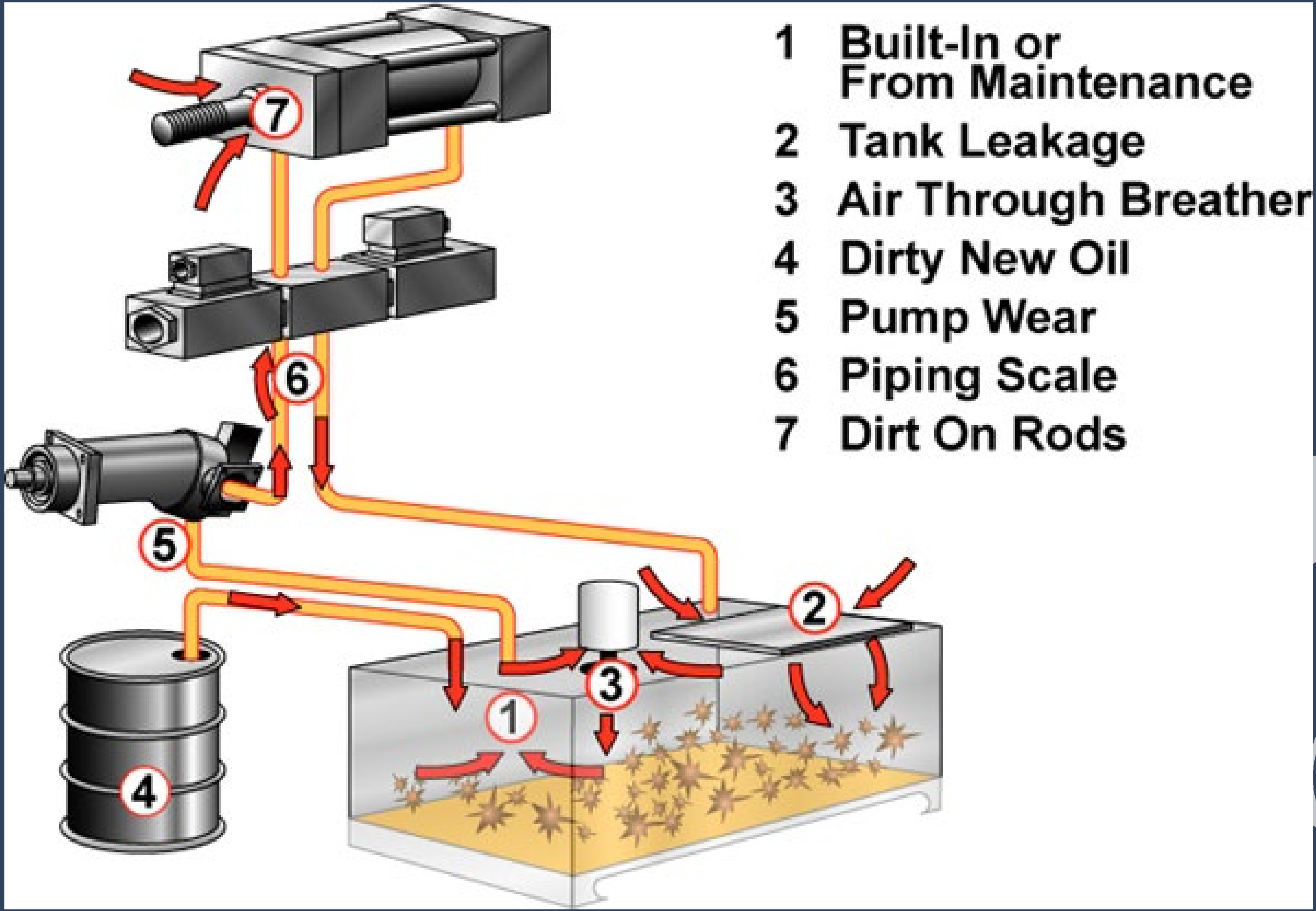
Bacteria

1 micron = .001 mm = .000039 inches

Sources of Contamination

- **Built-in**
  - During manufacturing/assembly
- **Ingression**
  - Leaking seals, breather caps, worn fittings, cylinders
- **Internally Generated**
  - System contaminants interact with components and other contaminants
- **Introduced During Repair**
  - Dirty parts on shelves, dust/dirt in the air, inadequate cleaning during re-assembly

Sources of Contamination



1 Built-In or From Maintenance
2 Tank Leakage
3 Air Through Breather
4 Dirty New Oil
5 Pump Wear
6 Piping Scale
7 Dirt On Rods

Damage Caused by Contamination

- Surface scoring and wear results in:
  - Loss of oil though internal leakage
  - Loss of efficiency
  - Loss of position holding characteristics
- Fine particle build-up results in:
  - Erratic hydraulic system performance
- Fluid degradation results in:
  - Particulate contamination which speeds up rust and corrosion

Types of Potential System Failures

Surface Scoring and Wear
Can Lead to
Internal Leakage

Clearance Honing
Can Cause
Loss of Control and Leakage

Fluid Degradation
Can Lead to
Rust and Corrosion

Fine Particle Build-up
Can Cause
Parts to Stick

Contamination

Cause

- Improper filtration
- Low oil level - concentration of contaminant
- Loose or lost breather cap
- Leaking fittings, seals, wipers
- Missing or collapsed inlet strainer
- Poor fill practices
- Clogged filter - by-pass

Effect

- Accelerated wear bearings, thrust plates, housing
- Bearing / bushing failure
- Reduced pump efficiency
- Reduced life
- Heat
- Internal leaks
- Failed pump

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Cavitation Damage

Cause - Inlet restriction

- Clogged inlet strainer / breather
- Inlet strainer too small
- Inlet line too long
- Inlet line bore too small
- Excessive engine speed
- Collapsed inlet hose
- Suction head too great
- Oil too viscous (cold weather)

Effect

- Noise
- Heat
- Accelerated wear thrust plates / housing
- Internal leaks
- Reduced pump efficiency
- Erratic actuator performance
- Failed pump

Aeration Damage

Cause - Air enters Oil

- Low oil level
- Vortexing of oil above strainer - whirlpool
- Loose inlet fittings
- Worn pump shaft seal
- Worn cylinder rod seal
- Foam suspended in oil due to sloshing in the reservoir

Effect

- Noise
- Heat
- Accelerated wear thrust plates / housing
- Internal leaks
- Erratic actuator performance
- Reduced pump efficiency
- Failed pump

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Pressure Damage

Cause

- Improper relief valve setting
- Relief valve malfunctioned
- Slow acting relief valve
- Absence of a relief valve
- Improper size elbow or fitting downstream of the valve affecting the relief valve performance

Effect

- Accelerated wear
- Cracked housings
- Excessive housing cut-out
- Reduced efficiency
- Internal leakage
- Bearing / bushing failure
- Thrust plates coined, warped or cracked
- Broken drive / connecting shaft

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Heat Damage

Cause

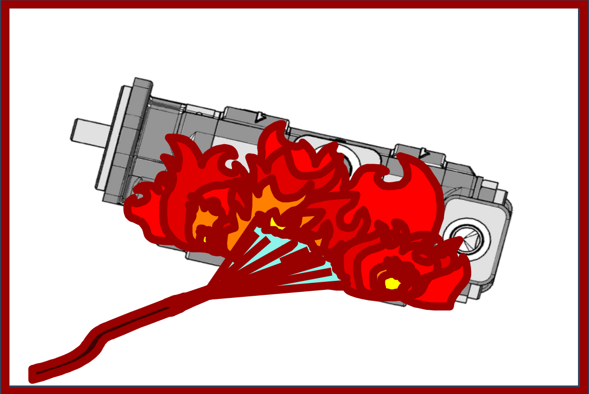
- Low oil level
- Cavitation / aeration / water
- Contamination
- Inlet restriction
- Relief valve
- Incorrect fluid
- Poor reservoir design
- Undersized fittings, hoses, components

Effect

- Breakdown of oil
- Loss of lubricity
- Accelerated wear
- Reduced efficiency
- Leakage
- Varnish / sludge
- Internal seal destruction
- Seizure

Heat

- **Thins system oil**
  - increasing friction
- **Accelerates breakdown of oil**
  - causing sludge to form
- **Can be caused by worn components**
- **Every 18˚ F rise in oil temp**
  - doubles the rate of corrosion on exposed surfaces



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Wear Modes

Fatigue, Sliding, Cutting,

Rubbing Wear and Break-In Wear

- Particles are platelets typically ranging in size from 15um down to 0.5um, or less, in dimension.
- Smooth surface and range between 0.15um and 1um in thickness.
- Excess quantity of particulate contamination, such as sand in a lube system, can increase the rubbing wear generation without completely removing the shear mixed layer.
- Catastrophic failure is unlikely, impending trouble can be forecast by a dramatic increased quantity of particles.

Components Prone:
Components with roughly the same opposing surface hardness (ex. Engine cylinder wall and piston ring)

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Cutting Wear

- Wear particles generated as a result of one surface penetrating another.
- Particles generated resemble machining swarf, except on a microscopic scale.
- Generated by misalignment or fracture, resulting in a hard sharp edge penetrating a softer surface.
- Particles generally, course and large, averaging 2um to 5um wide and 25um to 100um long.

Note:
Cutting wear is abnormal. Presence and quantity should be monitored closely. If the majority of particles are a few microns long and a fraction wide, particulate contamination should be suspected. If a system shows increasing large quantity (50um) wear particles, component failure is potentially imminent.

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Fatigue Wear

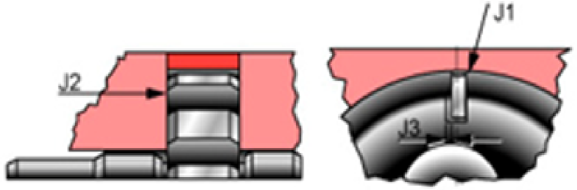
Fatigue wear involves a repeated number of cycles, where surface crack formation along grain boundaries can develop and the resulting debris gradually build up within a system. While the initial surface crack may appear small, this can propagate deep within the sub surface and fracture.

- Spall particles – Initial abnormality can be deduced from the increasing quantity of particles larger than 10um.
- Spherical particles – generally associated with roller bearing failure. Although, bearing fatigue is not the only source. Cavitation erosion is also a source associated with spherical particles

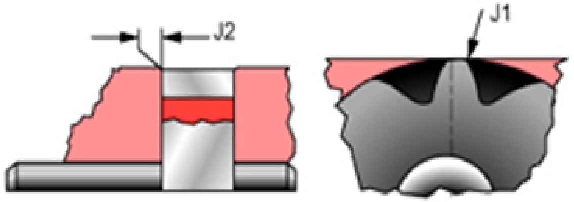
Sliding Wear

Sliding wear is caused by relative motion between two smooth solid surfaces in contact under load. This will typically result in the removal of material in the form of debris and ploughing of one or both surfaces.

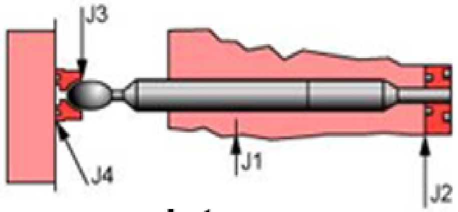
Critical Component Clearances



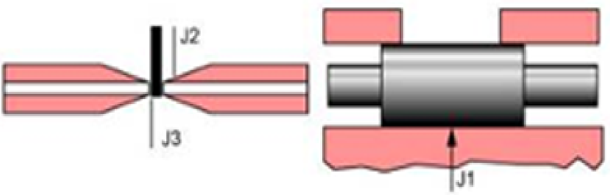
vane pump
J1: 0.5 - 5µm
J2: 5 - 20µm
J3: 30 - 40µm



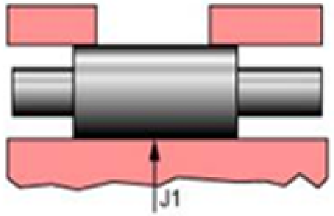
gear pump
J1: 0.5 - 5µm
J2: 0.5 - 5µm



piston pump
J1: 5 - 40µm
J2: 0.5 - 1µm
J3: 20 - 40µm
J4: 1 - 25µm



servo valve
J1: 5 - 8µm
J2: 100 - 450µm
J3: 20 - 80µm



valve
J1: 5 - 25µm

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ISO Code

ISO Contamination Level Code

Based on Amount of Contaminant in 1 ml of Fluid Sample in Three Size Ranges

Number of Particles $\geq 4_{(c)}$ Microns in Size

Number of Particles $\geq 6_{(c)}$ Microns in Size

Number of Particles $\geq 14_{(c)}$ Microns in Size

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Measuring Fluid Contamination

Structure of ISO-Code:

amount of dirt particles
in a **100 ml** sample
larger than these specified sizes:
4µm / 6µm / 14µm

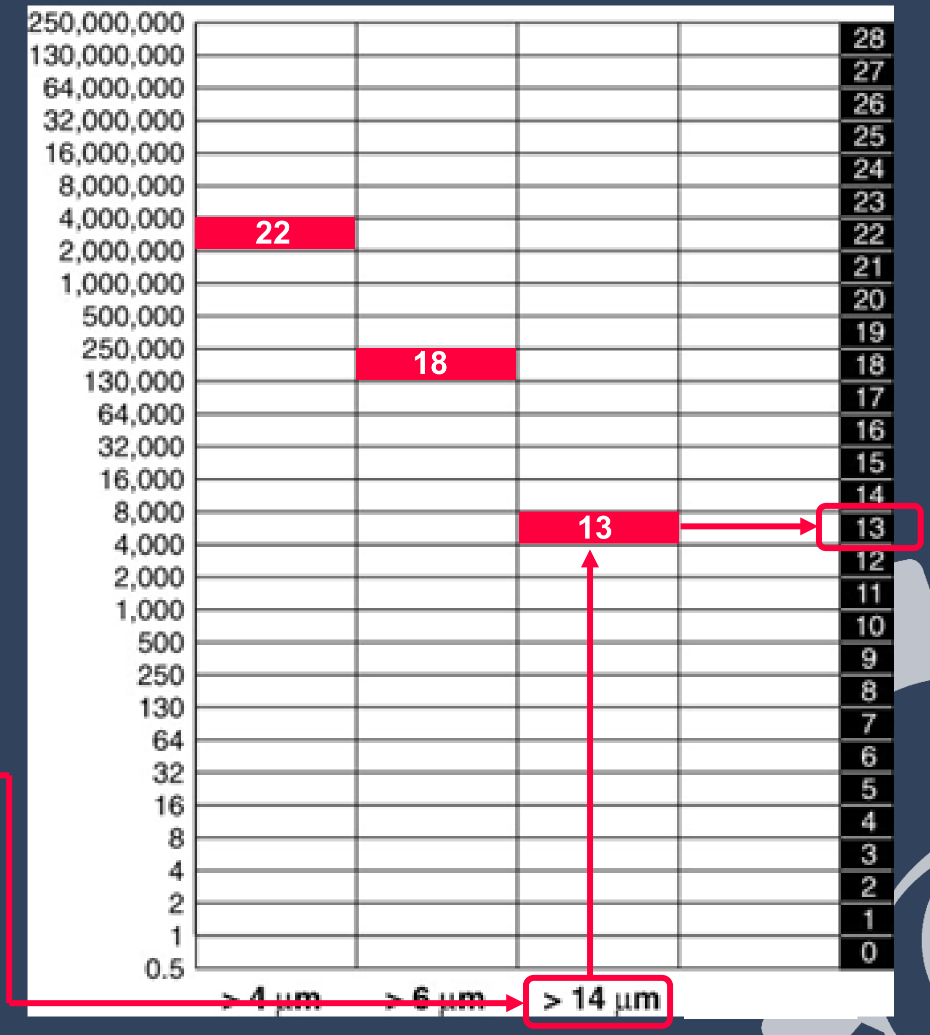
Example:

larger than 4µm = 2,234,000

larger than 6µm = 172,000

larger than 14µm = 4,250

ISO Code = 22 / 18 / 13



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Element Overview

Element Performance

- The BEST Element is one that…
  - achieves the systems target fluid cleanliness level
  - does not fail structurally
  - lasts as long as possible

- This means that at any given level of filtration (say 10_{um}) the best element has …the best combination of…

1) The lowest ΔP over the life of the element
2) The highest dirt holding capacity measured in grams
3) The highest beta stability when subjected to changes in Hydraulic Load & High ΔP *(the media, the seam, the end caps & support do not fail!)*

Element Performance

SO… The BEST Element is one where …

Users gain more value

&

OEM’s gain warranty protection

… and customers are satisfied

Why Beta Stability Matters

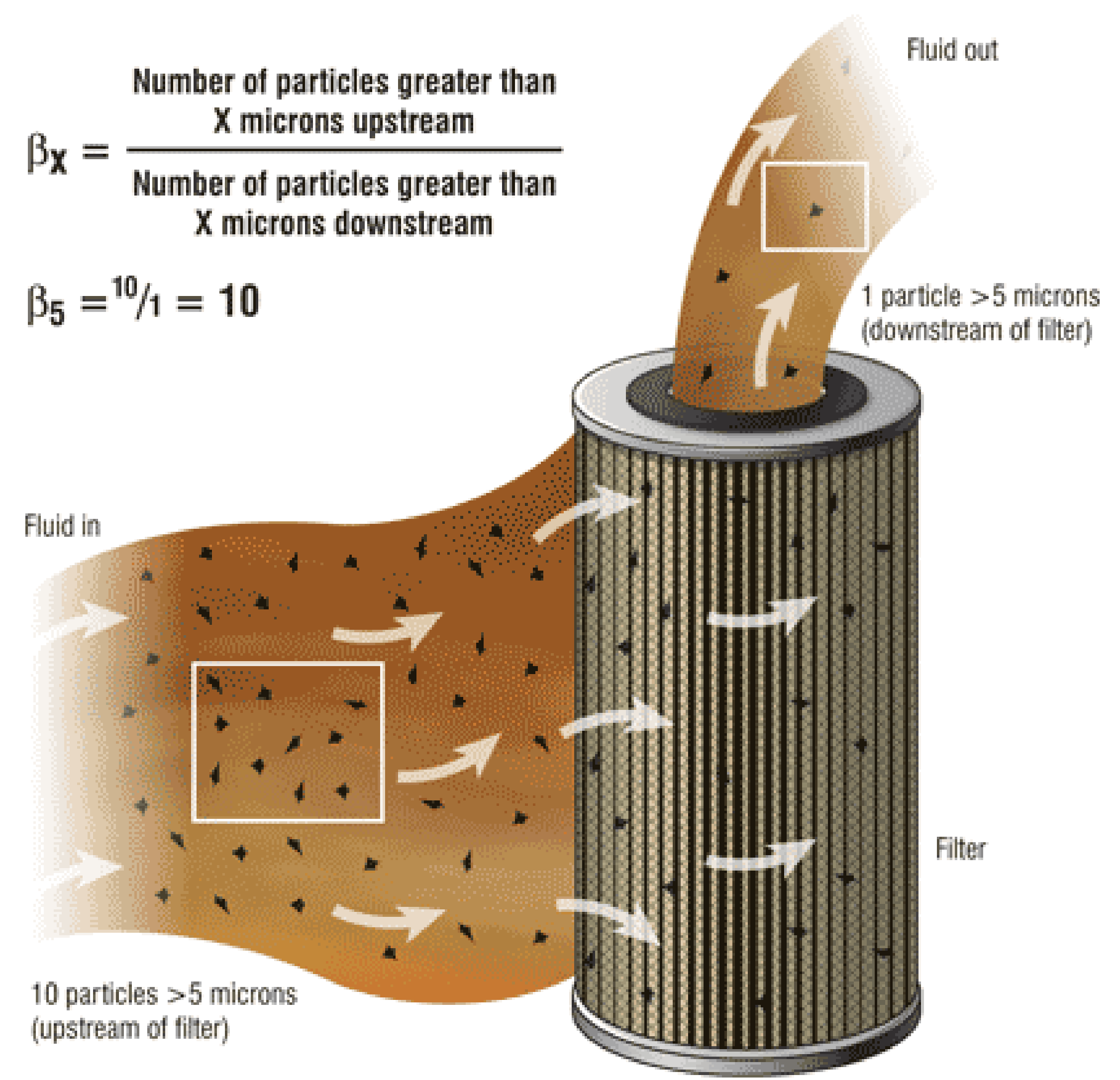
Beta stability is defined as an element’s ability to maintain its expected efficiency as differential pressure across the element increases.

Differential pressure will increase as contamination is trapped, or with an increase in fluid viscosity (cold start).

Beta stability is important because it relates to how well an element will perform in service over time.

When the element is loaded with contamination, or when it is subjected to cold starts, will it perform as well as it did when new? If not, contamination can pass, and equipment problems begin.

Filtration Ratio Example



Source: Understanding Filter Efficiency and Beta Ratios

Jeremy Wright, Noria Corporation

Filtration Ratio or Rating

The Particle Size Where the Beta Micron Rating for the Element is Greater Than a Given Number

$$\beta_{(10)} \geq 1000$$

Micron (Beta)

Filtration Ratio

Beta Ratios and Equivalent Efficiencies

$\text{ß}_{10} \geq 1$ → **0.0% Efficiency**

$\text{ß}_{10} \geq 2$ → **50.0% Efficiency**

$\text{ß}_{10} \geq 10$ → **90.0% Efficiency**

$\text{ß}_{10} \geq 20$ → **95.0% Efficiency**

$\text{ß}_{10} \geq 75$ → **98.7% Efficiency**

$\text{ß}_{10} \geq 100$ → **99.0% Efficiency**

$\text{ß}_{10} \geq 200$ → **99.5% Efficiency**

$\text{ß}_{10} \geq 1000$ → **99.9% Efficiency**

Dirt Holding Capacity

The Amount of Contaminant the Element Will Retain Before it Goes Into Bypass

- Mean Time Between Filter Changes
- Filter Operational Cost
- Capacity Based on “Multi-Pass” Test

Why Schroeder Z Media …

- **High media area**
  - **Less restriction, lower DP, lower hydraulic load**
- **Wire mesh upstream and downstream**
  - **Better pleat stability**
- **Multi-layered filter media**
  - **Provides strength and high DHC**
- **Multi-Layered support layers**
  - **Provide protection and support to media layers**

- ***All of these factors contribute to superior Beta Stability***

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Competitor Element Construction Review

1. Schroeder KZ10
2. Hy-Pro HPKL9-12MB
3. Pall HC9700FKS9H
4. Parker HF41L10VQ
5. Donaldson P163903
6. Donaldson P566272 (DT High Performance)

COMPETITOR	PLEAT DEPT MM	PLEAT COUNT	MEDIA AREA SQ FT
SCHROEDER	16.4	80	6.3
HY-PRO	14.7	66	4.7
PALL	15.2	86	6.3
PARKER	13.7	81	5.2
DONALDSON	17.8	43	3.6
DONALDSON	11.7	89	3.6

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Competitor Element Comparative Review

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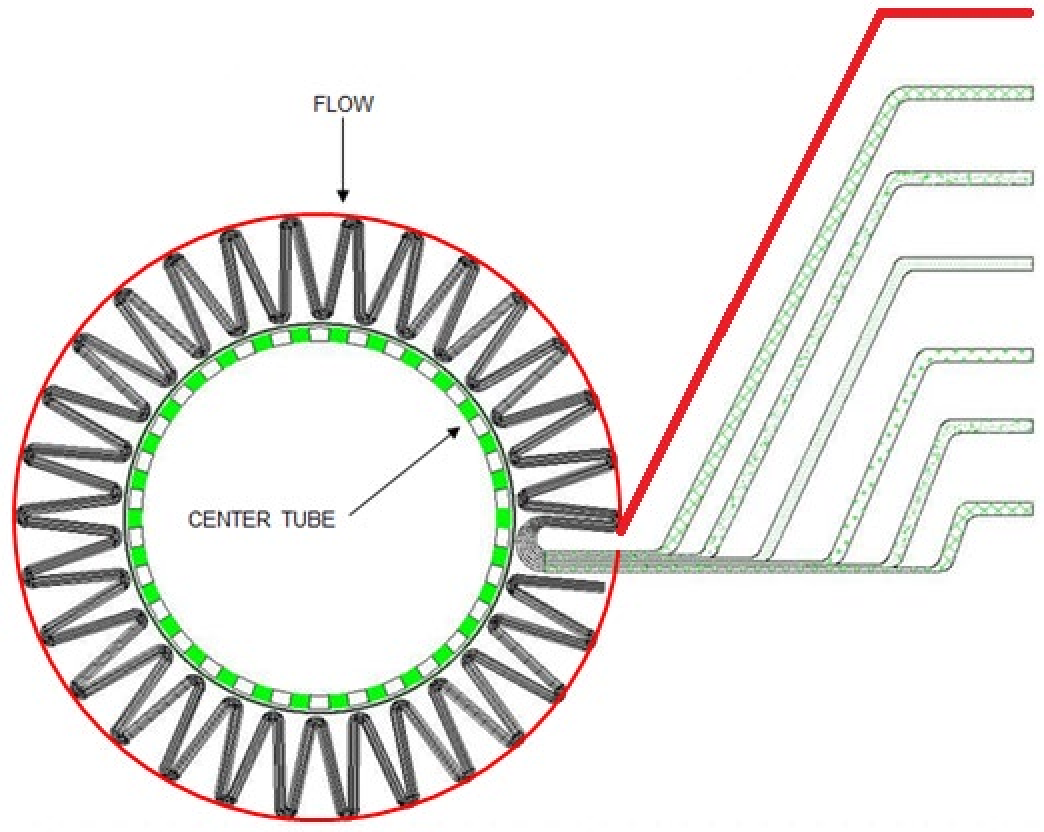
Media Layers



1	**Outer wrap**
2	**Upstream Epoxy-Coated Wire Mesh**
3	**Upstream Scrim Layer**
4	**Pre-Filter**
5	**Main Filter Layer**
6	**Downstream Scrim Layer**
7	**Downstream Epoxy-Coated Wire Mesh**

Competitor Element Comparative Review

HPKL9-12MB

Core

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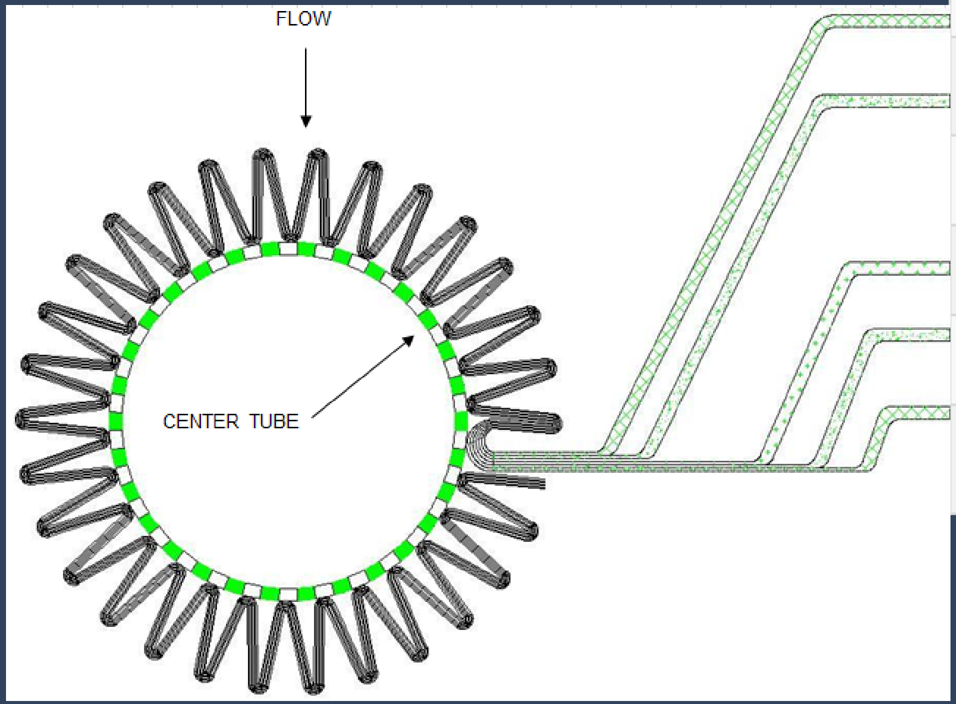
Competitor Element Comparative Review



1	**Upstream Epoxy-Coated Wire Mesh**
2	**Pre-Filter**
3	**Main Filter Layer**
4	**Downstream Scrim Layer**
5	**Downstream Epoxy-Coated Wire Mesh**

Note: Lacks upstream scrim layer to protect the pre-filter from the wire mesh. The pleats will move throughout the elements life and this movement can potentially cause the wire mesh to damage the pre-filter.

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Competitor Element Comparative Review

HC9700FKS9H

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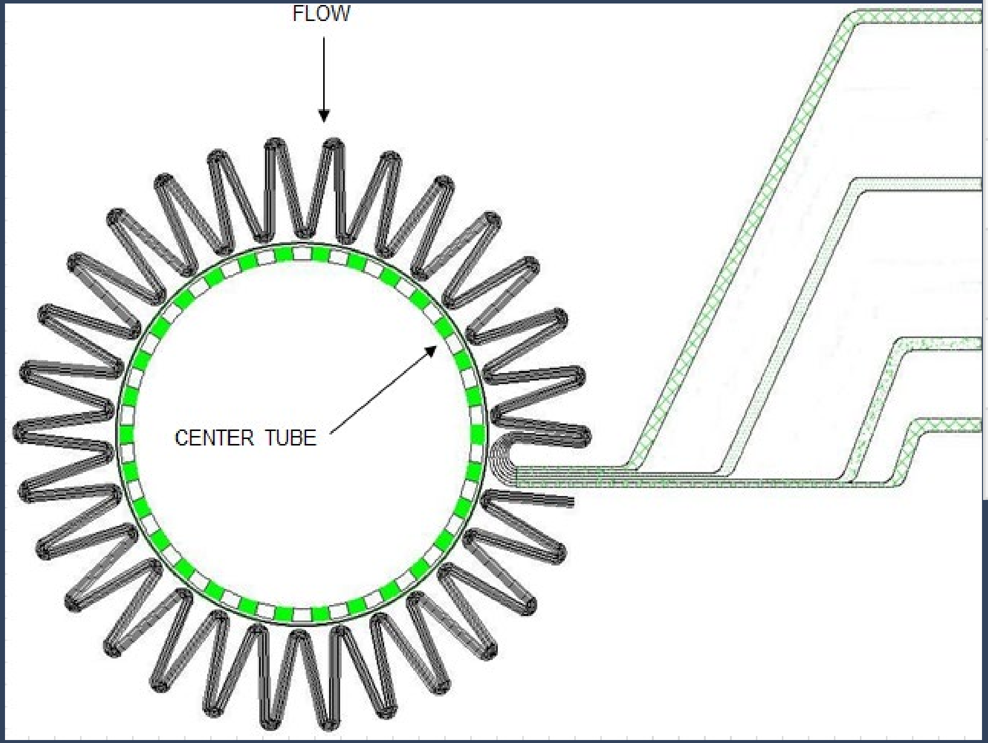
Competitor Element Comparative Review



1	**Upstream Plastic Mesh**
2	**Upstream Scrim**
3	**Main Filter Layer**
4	**Downstream Plastic Mesh**

Note: Using plastic mesh upstream and downstream versus epoxy-coated wire mesh typically results in less pleat support which can allow for more pleat movement and can potentially result in lower efficiencies.

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Competitor Element Comparative Review

HF41L10VQ

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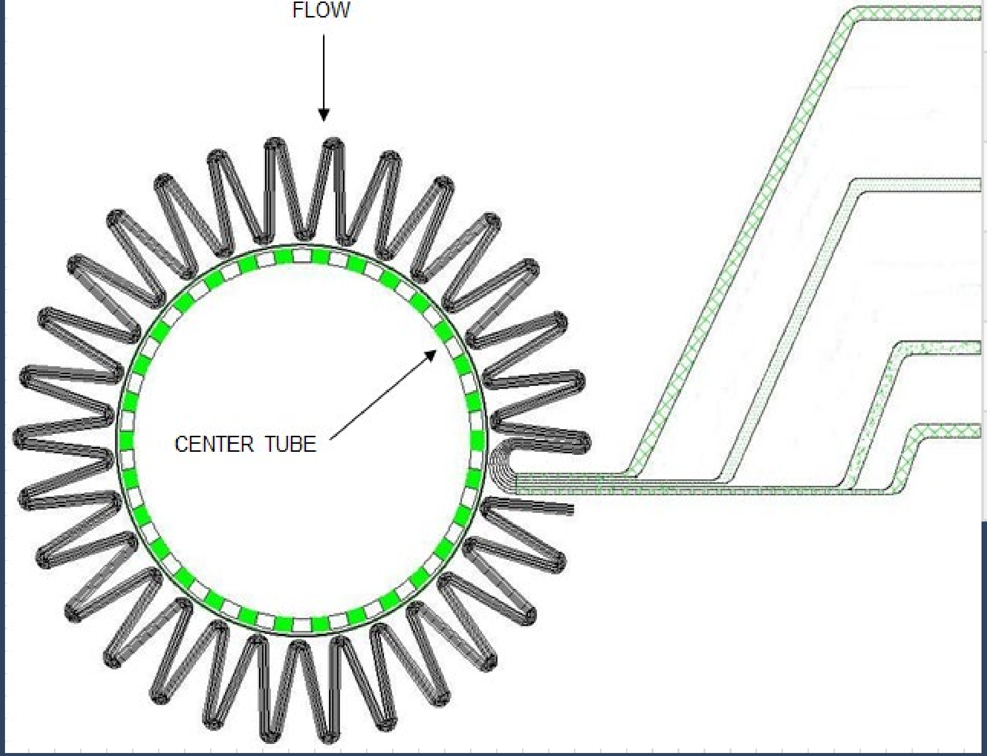
Competitor Element Comparative Review



1	**Upstream Epoxy-Coated Wire Mesh**
2	**Pre-Filter**
3	**Main Filter Layer**
4	**Downstream Epoxy-Coated Wire Mesh**

Note: Lacks both upstream scrim layer to protect the pre-filter and main filter layer from the wire mesh. The pleats will move throughout the elements life and this movement can potentially cause the wire mesh to damage the pre-filter and/or the main filter layer.

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Competitor Element Comparative Review

P163903

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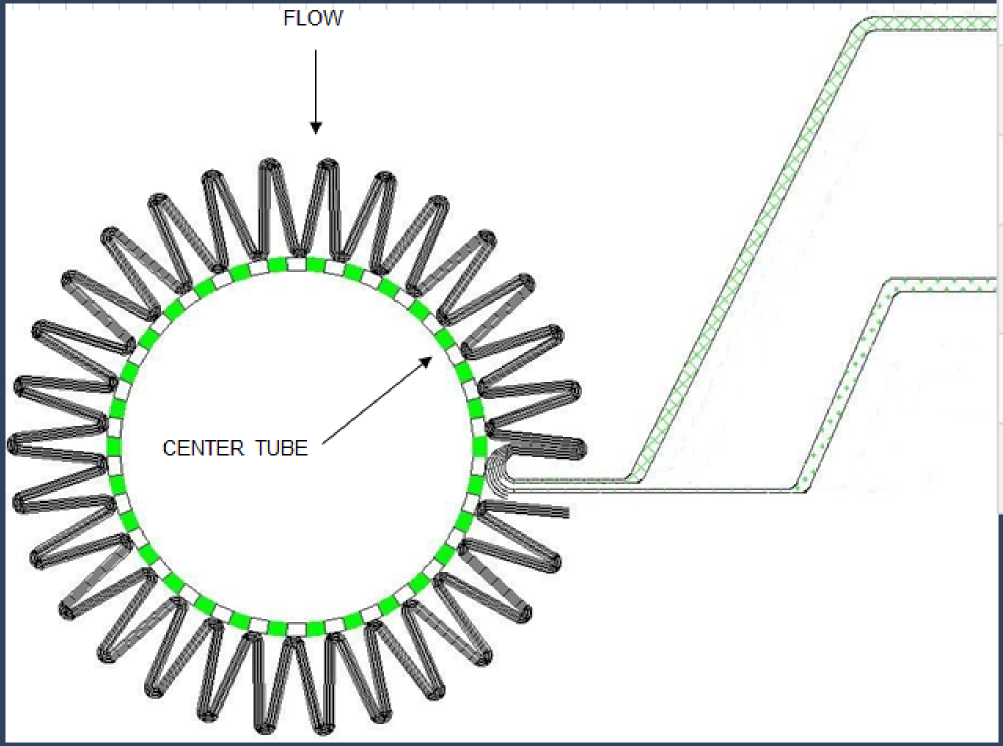
Competitor Element Comparative Review



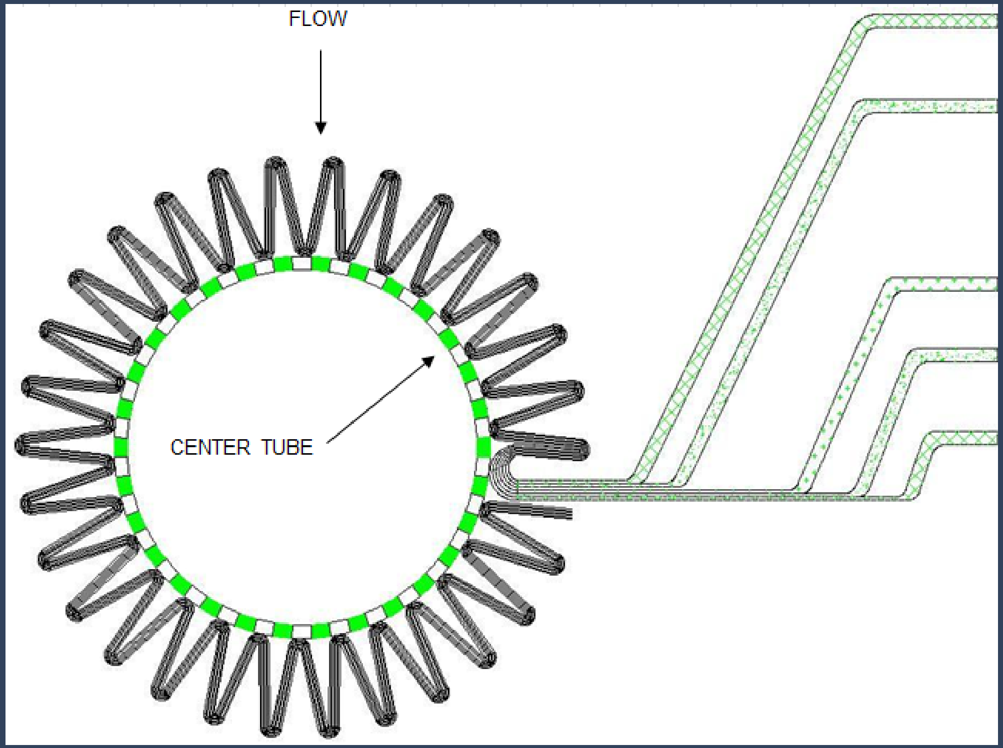
1	**Main Filter Layer**
2	**Downstream Epoxy-Coated Wire Mesh**

Competitor Element Comparative Review

P566272

Core

Competitor Element Comparative Review



1	Upstream Epoxy-Coated Wire Mesh
2	Upstream Scrim Layer
3	Main Filter Layer
4	Downstream Scrim Layer
5	Downstream Epoxy-Coated Wire Mesh

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Thank you for your time!

Market Manager - Refuse/David Spadell