

Filtration

Recommendations



for Oilgear Equipment

March, 2004

“Contaminated hydraulic fluid is the designated culprit more than half of the time when premature break down of a system component occurs.

As a result, customers, distributors, and often we ourselves are skeptical when dirt is blamed for hydraulic equipment failures.”

I. Purpose

- Define the problem
- Educate
- Latest standards update
- Guide correct procedures

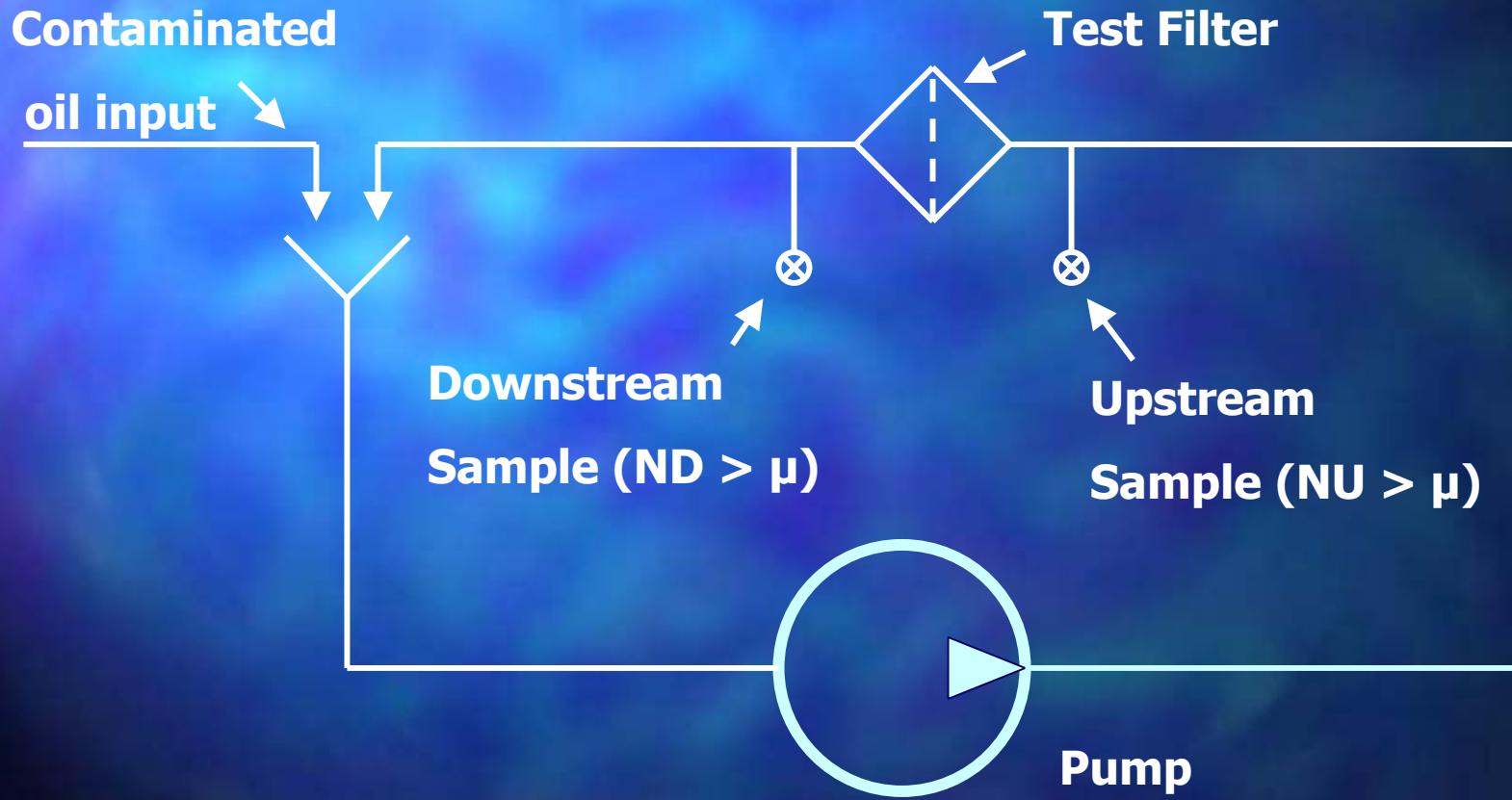
Typical Filter with by-pass indicator



II. Dirt removal ratings

- **Multi-pass Filter Performance Beta Test**
 - Measures the efficiency of filter element
 - New International Standard ISO 16889
 - Expressed as a Ratio
 - **NOTE!** Defines filter media efficiency only
NOT how clean the fluid is

Test Set up



Beta Ratio

$$\text{Beta } x(c) = \frac{\text{Number of upstream particles } > x(c)}{\text{Number of downstream particles } > x(c)}$$

$x(c)$ = particle size

Beta Ratio vs. Efficiency

<u>Beta Ratio</u>	<u>Efficiency</u>
1	0.00%
<u>2</u>	<u>50.00%</u>
5	80.00%
<u>10</u>	<u>90.00%</u>
20	95.00%
<u>75</u>	<u>98.70%</u>
100	99.00%
<u>200</u>	<u>99.50%</u>
1000	99.90%
5000	99.98%

Example:

Beta Ratio vs. Efficiency

- 1) Beta of 1 = no (none) particles are stopped**
- 2) Beta ratio of 100 (100 to 1 ratio) means that for every 100 particles up-stream, 99 particles are trapped for every 1 that gets through.**

III. Contamination Standard Changes

- AC Fine Test Dust (ACFTD) Obsoleted
- New replacement test dust
- Four (4) new ISO Standards
 - Filter performance testing
 - Particle counting
 - Data reporting

III. Contamination Standard Changes (continued)

- **ISO 12103-1 (new) defines 4 dust grades**
- **ISO Medium Test Dust (ISO MD) selected**
 - **Particle sizes very similar to ACFTD**
 - **Test results differ slightly - especially Automatic particle counts (APC)**
 - **Test results are an artifact, i.e., Filter performance and actual contamination levels remain the same**

IV. NIST Certification of ISO MTD

- **NIST = US National Institute of Standards and Technology**
- **Established traceable “Standard Reference Material” - SRM 2806**
- **SRM 2806 = 2.8 mg/l of ISO MTD suspended in MIL-H-5606 fluid**
- **NIST reports $> x \mu\text{m}$ (c)**
(c) = certified calibration and sizes traceable to NIST standard

ACFTD compared to NIST

Comparison of APC measured Particle sizes

<u>ACFTD (μ m)</u>	vs.,	<u>NIST [μm(c)]</u>
0.8		4.0
1.0		4.2
2.0		4.6
2.7		5.0
3.0		5.1
4.3		6.0
5.0		6.4
7.0		7.7
10.0		9.8
12.0		11.3
15.0		13.6
15.5		14.0
20.0		17.5
25.0		21.2
30.0		24.9
40.0		31.7
50.0		38.2

Ref.: ISO 4406:1999 (E)

V. Filter media (mat)

- **Any Material used to filter particles out of a fluid flow stream**
- **Media captures dirt particles allows the fluid to flow through**
- **Fluid changes direction continuously and gets cleaner as it works its way through the mat**
- **The thicker the mat the greater the dirt holding capacity**

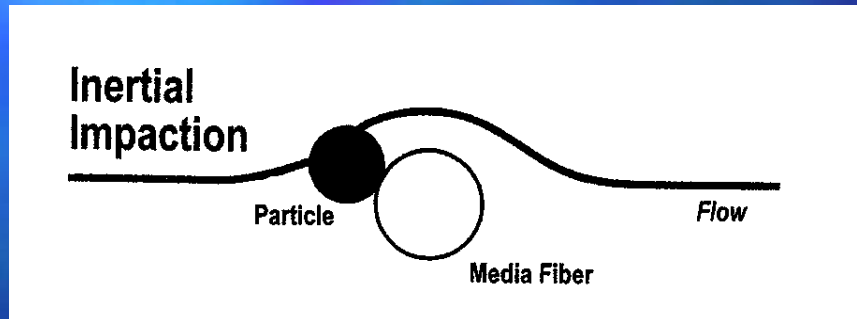
VI. How media collects dirt particles

- Inertia
- Diffusion
- Interception
- Sieving



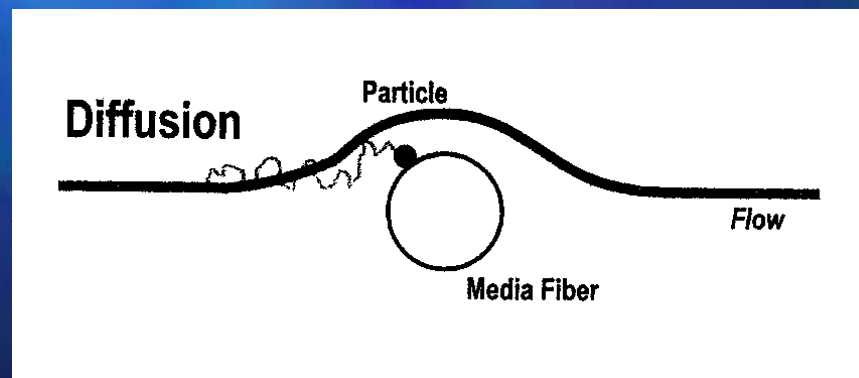
1. Inertia

- Heavy particles collide with media as fluid rapidly changes direction



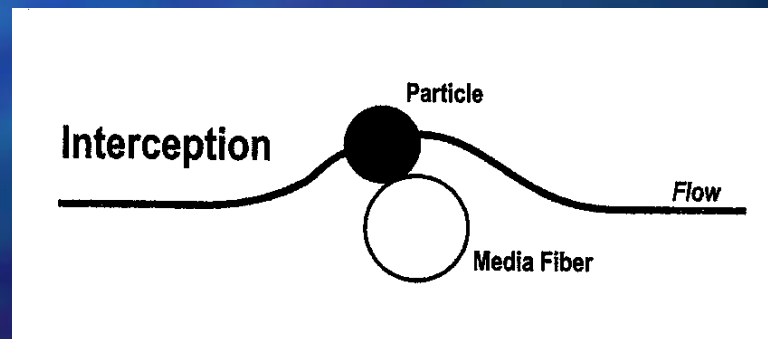
2. Diffusion

- **Smallest particles**
 - Diffuse within fluid stream
 - Not held in place by viscous fluid
- **Particles collide with media fibers and are collected**



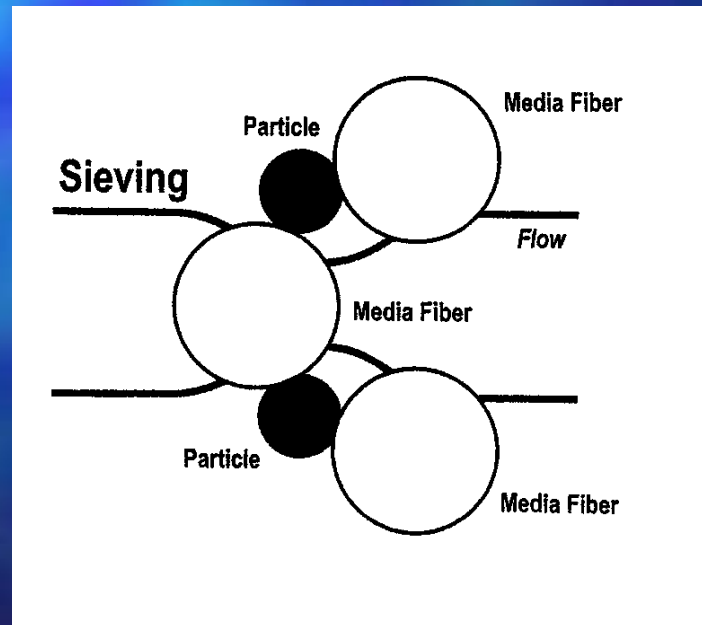
3. Interception

- Mid size range of particles
 - Not quite large enough to have inertia
 - Not small enough to diffuse within flow stream
- Follow fluid stream and are intercepted or captured when they touch a fiber



4. Sieving

- Most common mechanism
- Particles removed because they are too large to fit between fiber spaces



VII. Typical Factors in component life

- **70% surface degradation**
Mechanical wear from:
 - **Abrasion**
 - **Fatigue**
 - **Adhesion**
- **Obsolescence**
- **Accidents**

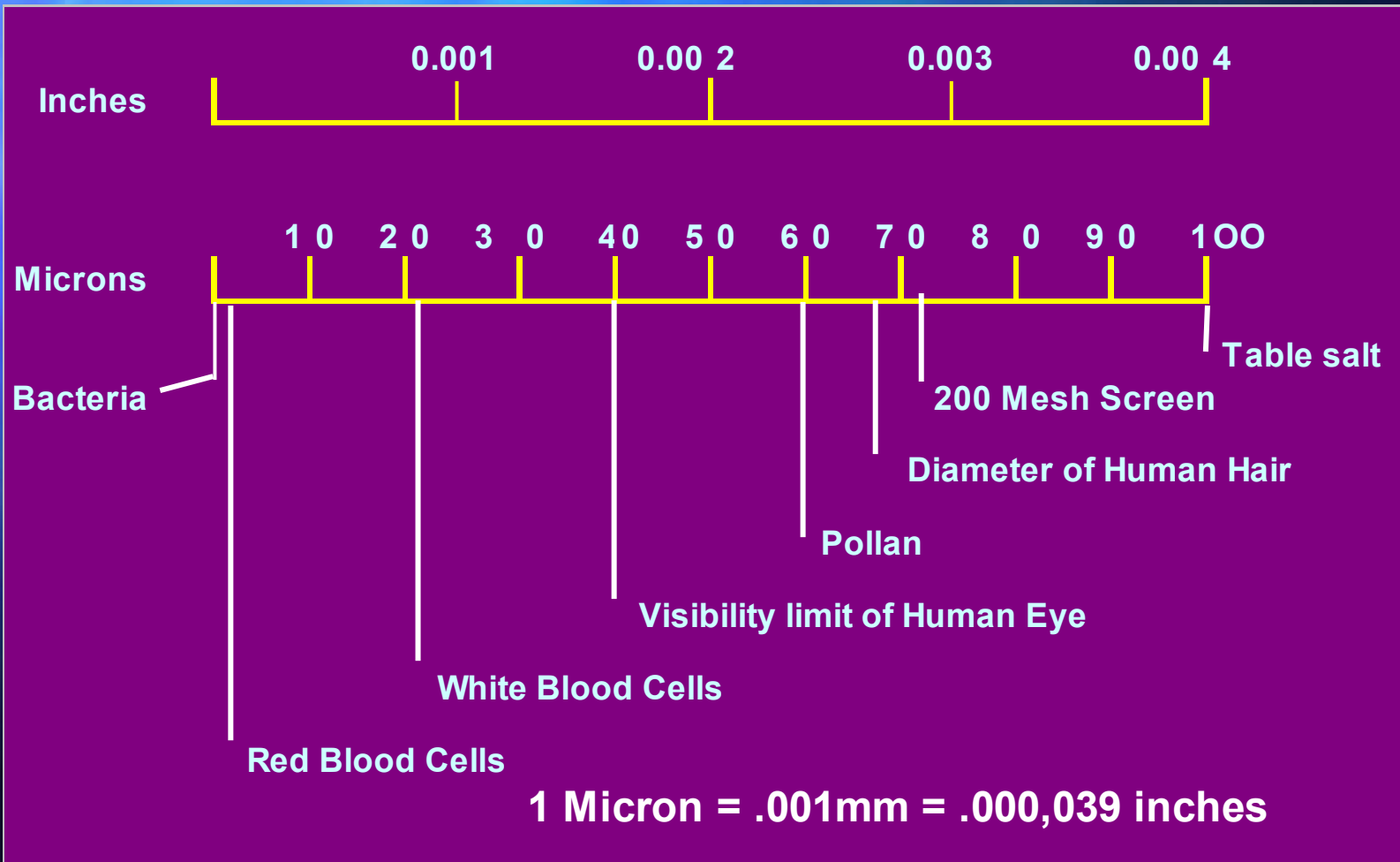
VIII. Sources of Contamination

- **Built in from components**
- **Generated**
- **External ingress**
- **Introduced during maintenance**

Built in from components

- **Cylinders**
- **Fluid [5- 25 μm]**
- **Hoses**
- **Pumps**
- **Hydraulic motors**
- **Valves**
- **Piping**
- **Reservoir**
- **Other**

Sizes of known particles



Generated

- **System assembly**
- **System break-in**
- **System operation**
- **Breakdown of elastomers**
- **Fluid breakdown**
- **Catastrophic component failure**

External ingression

- **Reservoir breathers**
- **Cylinder rod seals or packings**
- **Other components**
Example: reservoir cover gaskets
- **Special precautions are needed in particularly dirty environments**
Example: Foundries

Introduced during maintenance

- **Disassembly or assembly**
- **Fluid fill or make-up CAUTION!**
- **Replacement of failed components**
Failure to protect fluid conductor
lines and to clean them
BEFORE re-assembly

IX. Cleanliness Classification Standards

- **ISO 4406-1999**
**“Hydraulic Fluid Power-Fluids-
Method for coding the level of
contamination by solid particles”**
 - **Defines the quantity of solid particles
in the fluid in a given hydraulic fluid
power system.**

Normative references

- **ISO 4407:1991**
 - **Determination of particulate contamination by the counting method using a microscope**
- **ISO 11171:1999**
 - **Calibration of automatic particle counters for liquids**

Normative references (continued)

- **ISO 11500:1997**
 - **Determination of particulate contamination by automatic counting using the light extraction method**
 - The principle is based upon the fact that particles absorb or scatter light in proportion to their size. This changes the amount of light received by the APC photo-detector.

Basis of code

- **APC (ISO 4406:1999)**
 - **Method for Coding the level of contamination by solid particles**

19/16/13

(1) (2) (3)

(1) = particles $> 4 \mu\text{m}$ (c)

(2) = Particles $> 6 \mu\text{m}$ (c)

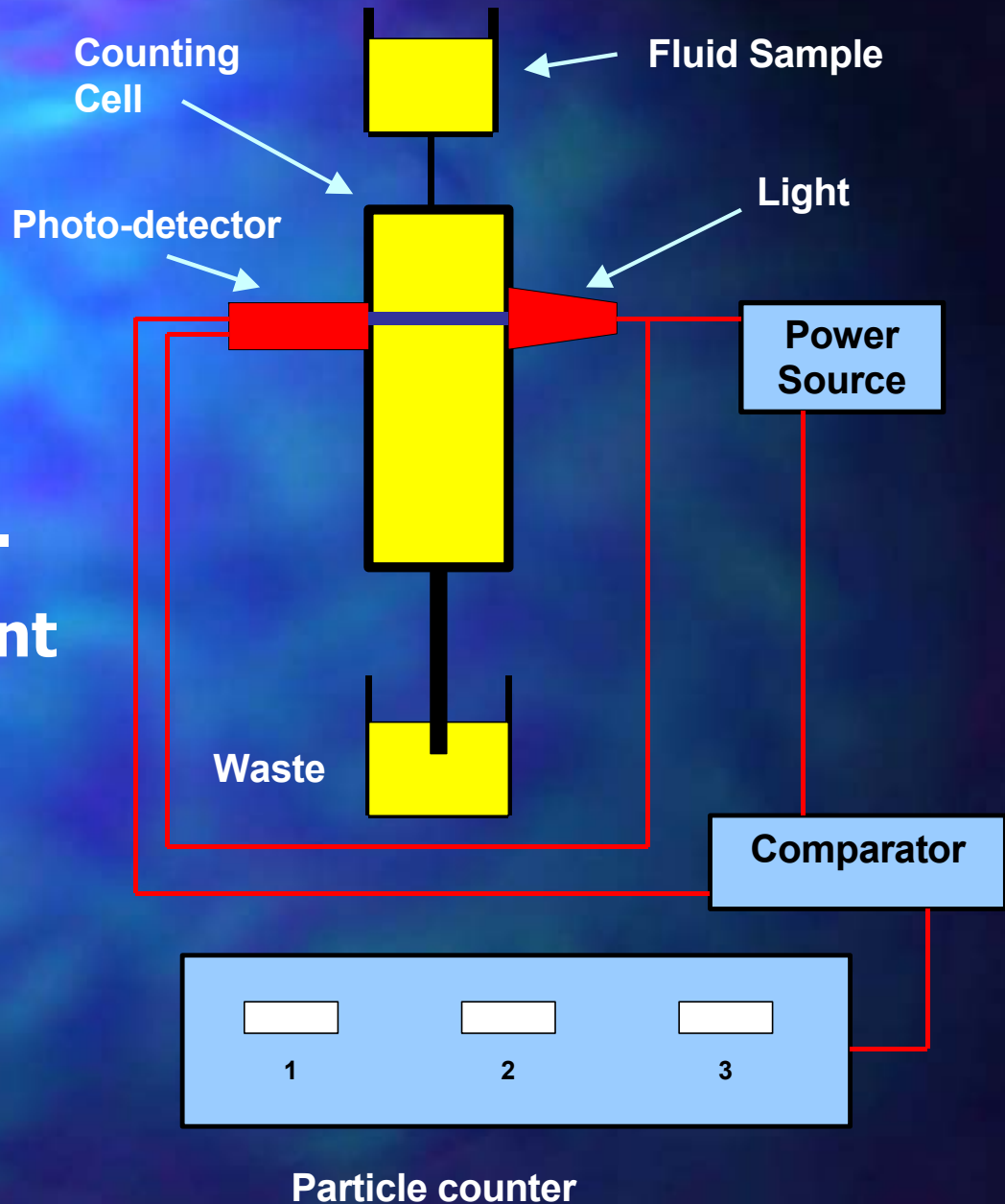
(3) = Particles $> 14 \mu\text{m}$ (c)

APC Calibration

Batch Counting

Particles absorb or scatter light in proportion to their size.

This changes the amount of light received by the photo-detector.



Basis of code (continued)

- **Manual microscopic counting (ISO 4407:1991)**
 - **Code comprised of two scales**

18/15

(1) (2)

(1) = particles $> 5 \mu\text{m}$ (c)

(2) = particles $> 15 \mu\text{m}$ (c)



Basis of code (continued)

- **Manual microscopic counting (ISO 4407:1991) (continued)**
 - **Where applicable**

Example 1: */18/15

*** = too many particles equal or larger than 4 μm (c) to count**

Example 2: - /18/15

(-) = There is no requirement to count particles equal or larger than 4 μm (c)

Test value relationships

- **If scale number is greater:**
 - **1 = 2x the amount of dirt**
 - **2 = 4x the amount of dirt**
 - **3 = 8x the amount of dirt**
 - **4 = 16X the amount of dirt**
- **If scale number is smaller:**
 - **1 = 1/2 the amount of dirt**
 - **2 = 1/4 the amount of dirt**
 - **3 = 1/8 the amount of dirt**

Allocation of scale numbers

Number of particles per milliliter

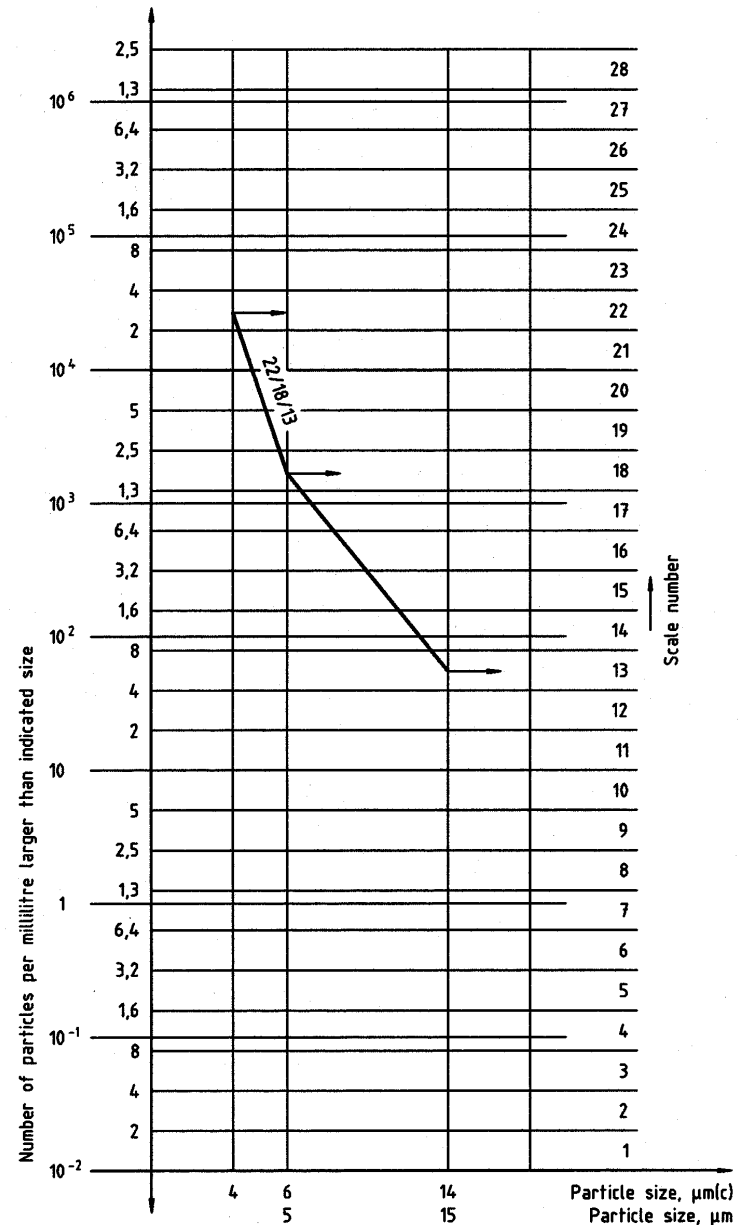
Scale number

More than

Up to and including

2 500 000		>28
1 300 000	2 500 000	28
640 000	1 300 000	27
320 000	640 000	26
160 000	320 000	25
80 000	160 000	24
40 000	80 000	23
20 000	40 000	22
10 000	20 000	21
5 000	10 000	20
2 500	5 000	19
1 300	2 500	18
640	1 300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.2	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
0.00	0.01	0

Graphical presentation of the cleanliness code number



NOTE Quote scale number at 4 μm (c), 6 μm (c) and 14 μm (c) levels for automatic particle counters, and at 5 μm and 15 μm for microscope counting.

X. System Filtration Considerations

■ Flow Rate

- Non-differential drives:
30% of high pressure pump capacity
- Normal differential system:
30 to 100% of high pressure pump flow volume capacity
- High differential operating in a contaminated atmosphere:
100% of high pressure pump capacity used to supercharge the high pressure pump
- The need for return line filtration

X. System Filtration

Considerations (continued)

- **Effective in a circuit**
 - **Warm oil is easier to filter due to its lower viscosity.**
 - **Filters will often by-pass cold oil due its higher viscosity**
 - **Warm reservoir bulk oil to 65 to 70 F. to facilitate filtration and pump start suction**
 - **Water base fluids normally do not require special heating due to their physical properties**

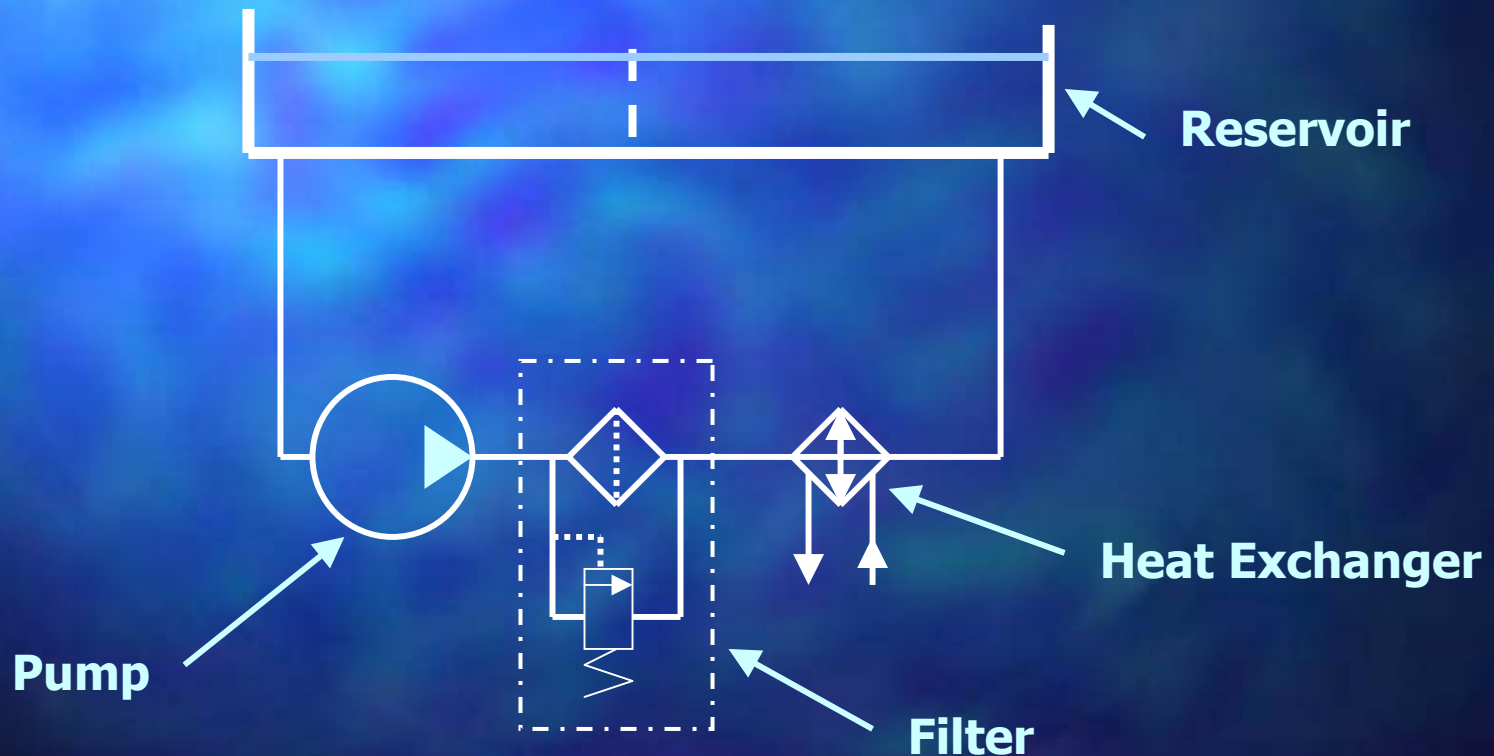
X. System Filtration

Considerations (continued)

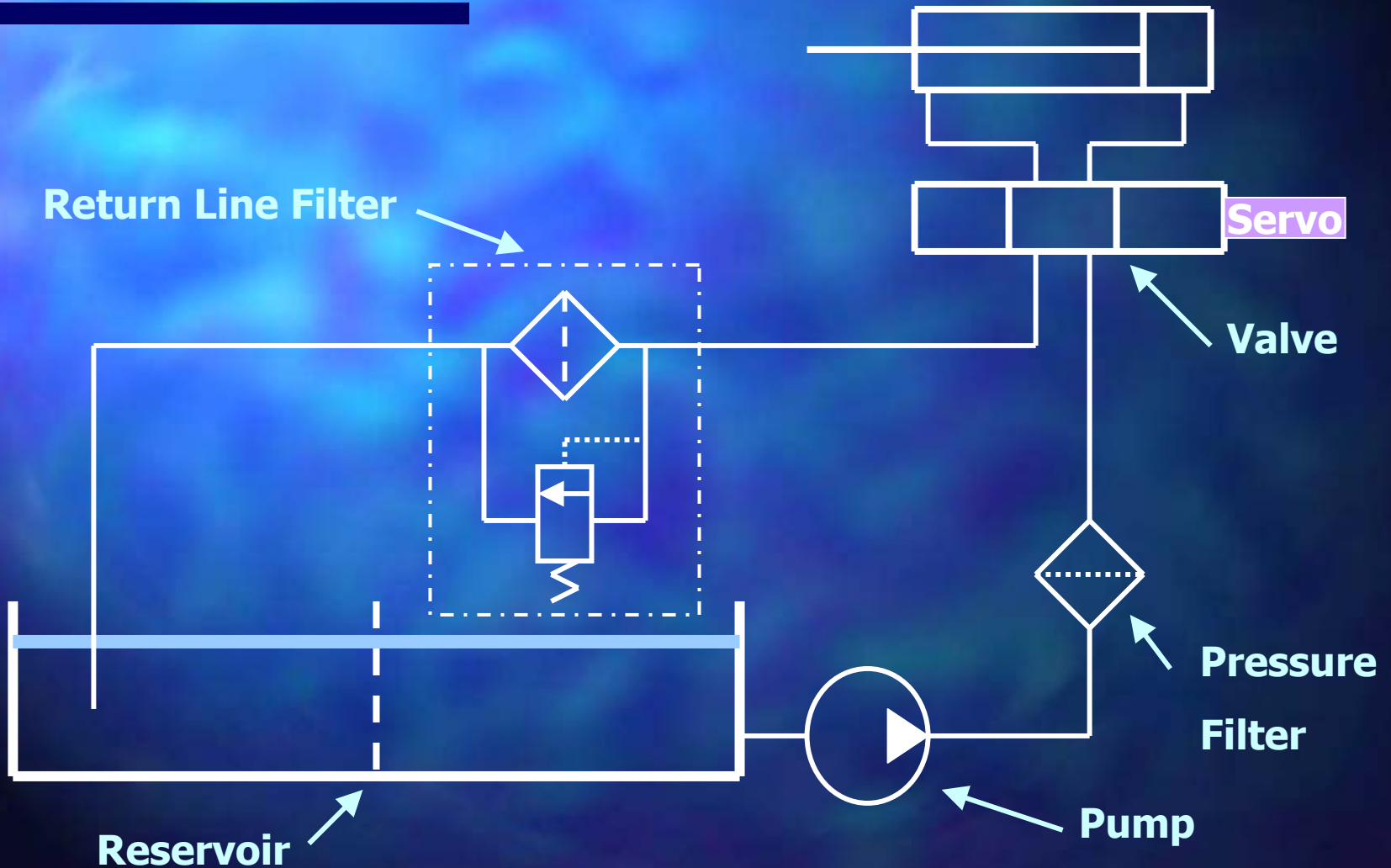
- **Location / placement**
 - **Advantages of circulation filtering systems**
 - **Can run continuously**
 - **Separate filtering system can be shut down for maintenance without affecting production**
 - **Facilitates heating and cooling function during production and idle times**
 - **Control circuits with sensitive equipment (servo valves)**

Filter placement in a circuit

Independent circulation filtration



Filter placement in a circuit



X. System Filtration

Considerations (continued)

- **Filters or strainers in a pump suction line are not recommended**
- **Main pump delivery lines**
 - **Expensive due to pressure rating**
 - **Special piping in a 2-way circuit**
- **Return line filtration**
 - **WATCH PULSING FLOW**
Size conservatively

*** For most hydraulic systems,
preventing contamination
from entering the system
is much more cost effective
than removing it.**

XI. Oilgear system and component Cleanliness Level Guideline

- Filter elements with B10 (c) = 75 (98.7 efficiency or better)
- Fluid cleanliness target ISO (c) 19/16/13 or better
- ISO (c) 21/18/15 maximum

XII. Water Base and Synthetic Fluids

- **Water base and some synthetic fluids require special precautions due to their specific properties**
- **Watch compatibility with the fluid**
- **Often contain additives which may filter out if filtration level is too fine**
- **Do not use aluminum with water base fluids**
- **Fluid conversion: Follow fluid manufacturer specific recommendations**
 - **Example: conversion from oil to water base fluid**

XIII. Filter Installation

- **Suitable pressure rating**
- **Locate physically so it is protected**
- **Dirt indicator easy to see and have alarm to signal when element is being by-passed**
- **Accessible for service / maintenance**
- **Easy to take precautions during element change to prevent re-introduction of dirt into the system**

Base mounted filters

- **Drain housing first**

- **Open air bleed at top**

- **Open Drain**

NOTE: Drain port should be located, or piped, so the dirty fluid can be drained into a bucket and not onto the reservoir or factory floor

- **Wipe the inside of the filter housing clean before installing new element**
CAUTION: Outlet port

“Top” mounted filters

- Remove filter housing and dispose of its dirty fluid and element
- Thoroughly wipe out or flush the housing BEFORE re-installation of the clean element and housing

Acknowledgements

- **Donaldson Company, Inc.**
- **Fluid Technologies, Inc -Filtran Business**
- **Hydac International**
- **Pall Industrial Hydraulics Company**
- **Schroeder Industries**



Oilgear
PERFORMANCE
ASSURANCE