Pall Corporation

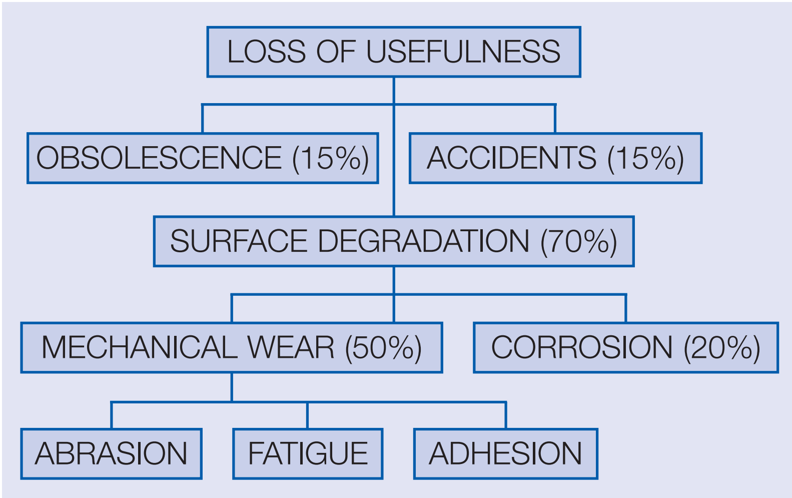
# Pocket Book


*Filtration. Separation. Solution.*SM

# Equipment Life Expectancy Factors

A study by Dr. E Rabinowicz at M.I.T. observed that 70% of component replacements or 'loss of usefulness' is due to surface degradation. In hydraulic and lubricating systems, 20% of these replacements result from corrosion with 50% resulting from mechanical wear.

Presented at the American Society of Lubrication Engineers, Bearing Workshop, 1981.




# Sources of Contamination

### Built in contaminants from components:

- Cylinders, fluids, hydraulic motors, hoses and pipes, pumps, reservoirs, valves, etc.

### Generated contaminants:

- Assembly of system
- Operation of system
- Break-in of system
- Fluid breakdown

### External ingression:

- Reservoir breathing
- Cylinder rod seals
- Bearing seals
- Component seals

### Contaminants introduced during maintenance:

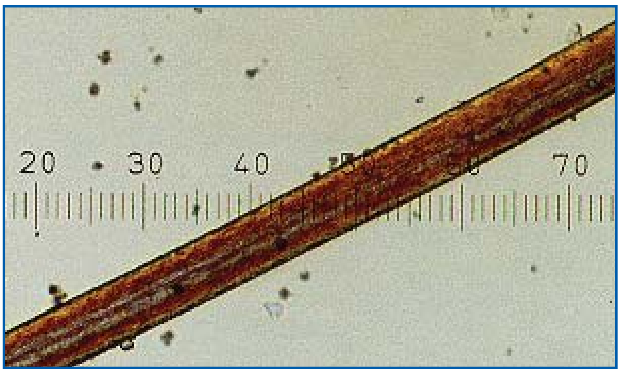
- Disassembly/assembly
- Make-up oil

# The Micrometre "µm"

'Micron' = micrometre = µm
1 micron = 0.001 mm (0.000039 inch)
10 micron = 0.01 mm (0.0004 inch)

Smallest dot you can see with the naked eye = 40 µm
Thickness of a sheet of looseleaf note paper = 75 µm

The micrometre is the standard for measuring particulate contaminants in lubricating and fluid power systems.




Human hair (75 µm), particles (10 µm) at 100x (14 µm/division)

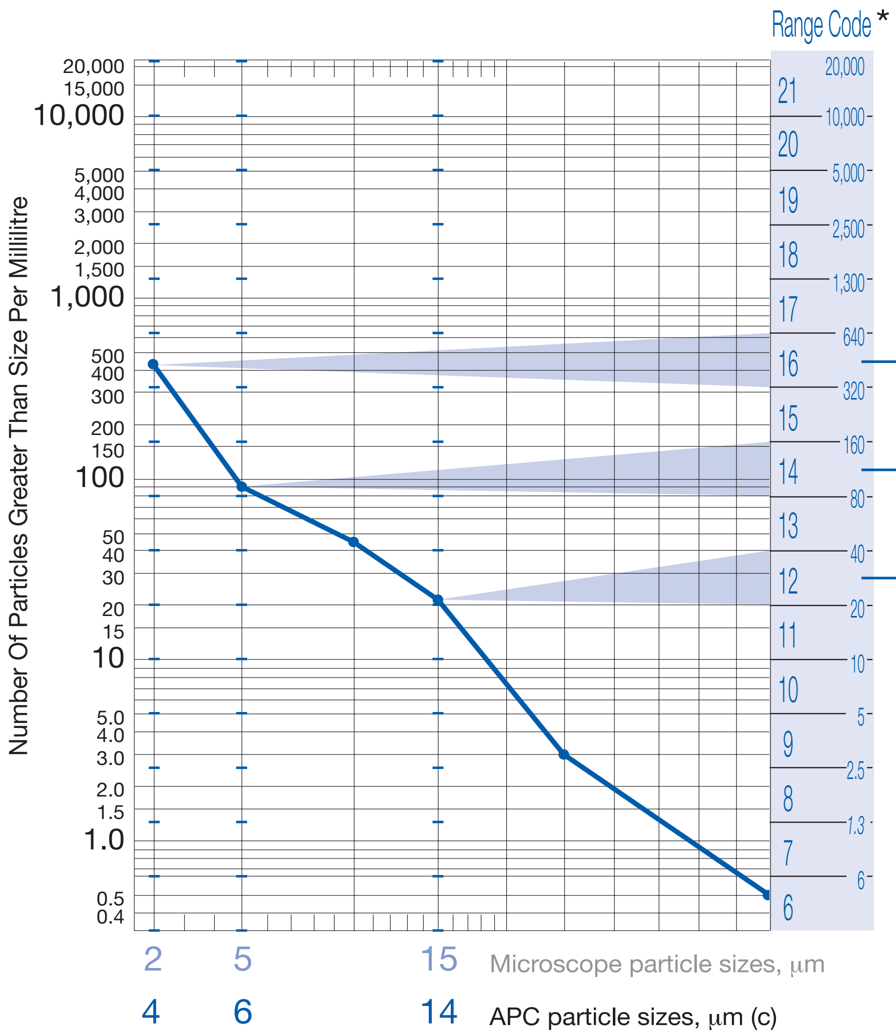
# Relevant Filtration & Contamination Standards

| | |
|---|---|
| ISO 2941 | Filter elements - verification of collapse/burst pressure rating |
| ISO 2942 | Filter elements - verification of fabrication integrity and determination of the first bubble point |
| ISO 2943 | Filter elements - verification of material compatibility with fluids |
| ISO 3722 | Fluid sample containers - qualifying and controlling cleaning methods |
| ISO 3724 | Filter elements - determination of resistance to flow fatigue using particulate contaminant |
| ISO 3968 | Filters - Evaluation of differential pressure versus flow characteristics |
| ISO 4021 | Extraction of fluid samples from lines of an operating system |
| ISO 4405 | Determination of particulate contamination level by the gravimetric method |
| ISO 4406 | Method for coding the level of contamination by solid particles |
| ISO 4407 | Determination of particulate contamination by the counting method using an optical microscope |
| ISO 10949 | Guidelines for achieving and controlling cleanliness of components from manufacture to installation |
| ISO 11170 | Filter Elements - sequence of tests for verifying performance characteristics |
| ISO 11171 | Calibration of automatic particle counters for liquids |
| ISO 11500 | Determination of particulate contamination by automatic particle counting using the light extinction principle |
| ISO 11943 | Methods for calibration and validation of on-line automatic particle-counting systems |
| ISO 16889 | Filter elements - Multi-pass method for evaluating filtration performance of a filter element |
| ISO 18413 | Component cleanliness - Inspection document and principles related to contaminant collection, analysis and data reporting |
| ISO 23181 | Filter elements - determination of resistance to flow fatigue using high viscosity fluids |
| SAE ARP4205 | Filter elements - method for evaluating dynamic efficiency with cyclic flow |

# Fluid Analysis Methods for Particulate

| Method | Units | Benefits | Limitations |
|---|---|---|---|
| Optical Particle Count | Number/mL | Provides size distribution. unaffected by fluid opacity, water and air in fluid sample | Sample preparation time |
| Automatic Particle Count | Number/mL | Fast and repeatable | Sensitive to 'silts', water, air and gels |
| Patch test and fluid contamination comparator | Visual comparison/ cleanliness code | Rapid analysis of systems fluid cleanliness levels in field. Helps to identify types of contamination | Provides approximate contamination levels |
| Ferrography | Scaled number of large/small particles | Provides basic information on ferrous and magnetic particles | Low detection efficiency on non-magnetic particles e.g. brass, silica |
| Spectrometry | PPM | Identifies and quantifies contaminant material | Cannot size contaminants; limited above 5 µm |
| Gravimetric | mg/L | Indicates total mass of contaminant | Cannot distinguish particle size. Not suitable for moderate to clean fluids. i.e. ISO 18/16/13 |

# Understanding the ISO Cleanliness Code




## Particle Count Summary

| Particle count per mL greater than size code | | ISO 4406 Range code |
|---|---|---|
| 4 µm(c) | 430 | 16 |
| 6 µm(c) | 90 | 14 |
| 14 µm(c) | 22 | 12 |

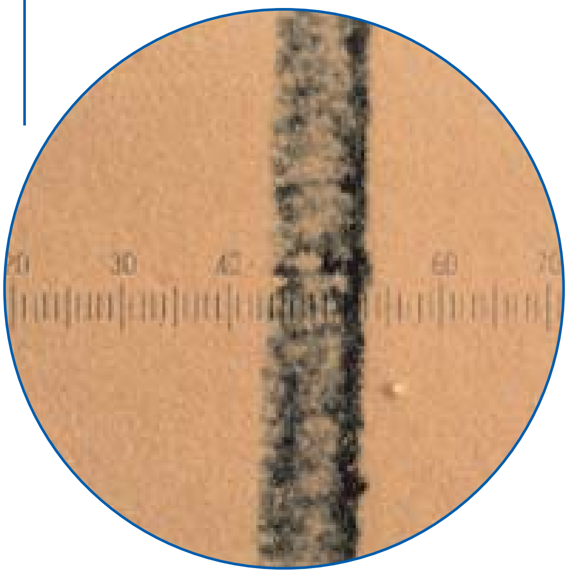
(c) designates 'certified calibration per ISO 11171, traceable to NIST

* Note: each increase in range number represents a doubling of the contamination level.

The ISO code references the number of particles greater than 4, 6 and 14 µm(c) in one millilitre of sample fluid.

To determine the ISO Cleanliness code for a fluid, the results of particle counting are plotted on a graph. The corresponding range code, shown at the right of the graph, gives the cleanliness code number for each of the three particle sizes.

# ISO 4406 Cleanliness Code 13/12/10



**Sample Volume:** 100 mL
**Magnification:** 100x
**Scale:** 1 division = 10 µm

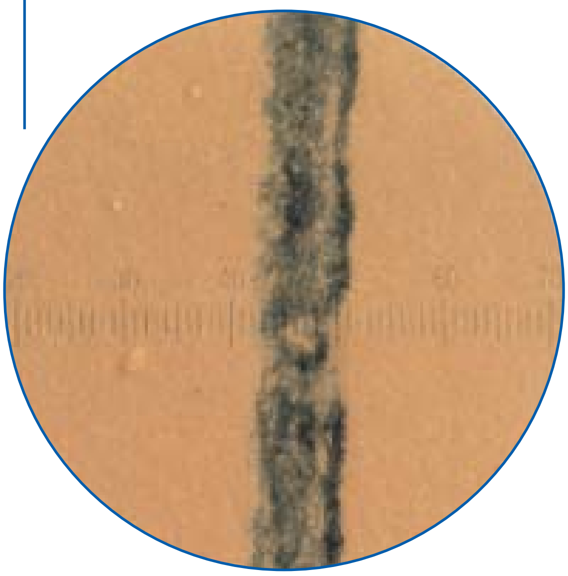
### Particle Count Summary

| Size | Particle Count Range per mL | ISO 4406 Code | NAS1638 (SAE AS4059) |
|---|---|---|---|
| >4 µm(c) | 40 - 80 | 13 | 4 |
| >6 µm(c) | 20 - 40 | 12 | 4 |
| >14 µm(c) | 5 - 10 | 10 | 4 |

### Photo Analysis

Very little contamination is present.
The visible particle is silica.

# ISO 4406 Cleanliness Code 15/14/12



**Sample Volume:** 100 mL
**Magnification:** 100x
**Scale:** 1 division = 10 µm

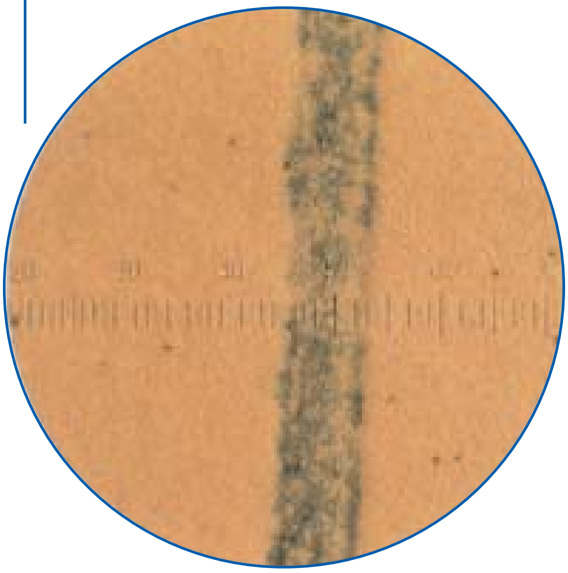
### Particle Count Summary

| Size | Particle Count Range per mL | ISO 4406 Code | NAS1638 (SAE AS4059) |
|---|---|---|---|
| >4 µm(c) | 160 - 320 | 15 | 6 |
| >6 µm(c) | 80 - 160 | 14 | 6 |
| >14 µm(c) | 20 - 40 | 12 | 6 |

### Photo Analysis

Little contamination is present.
The visible contamination is silica.

# ISO 4406 Cleanliness Code 17/15/13



**Sample Volume:** 100 mL
**Magnification:** 100x
**Scale:** 1 division = 10 µm

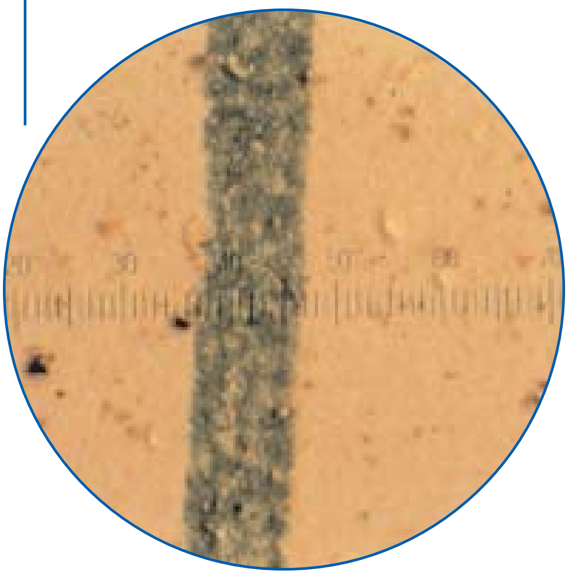
### Particle Count Summary

| Size | Particle Count Range per mL | ISO 4406 Code | NAS1638 (SAE AS4059) |
|---|---|---|---|
| >4 µm(c) | 640 - 1,300 | 17 | 7 |
| >6 µm(c) | 160 - 320 | 15 | 7 |
| >14 µm(c) | 40 - 80 | 13 | 7 |

### Photo Analysis

Very little contamination is present.
The visible particle is black metal.

# ISO 4406 Cleanliness Code 20/17/15



**Sample Volume:** 100 mL
**Magnification:** 100x
**Scale:** 1 division = 10 µm

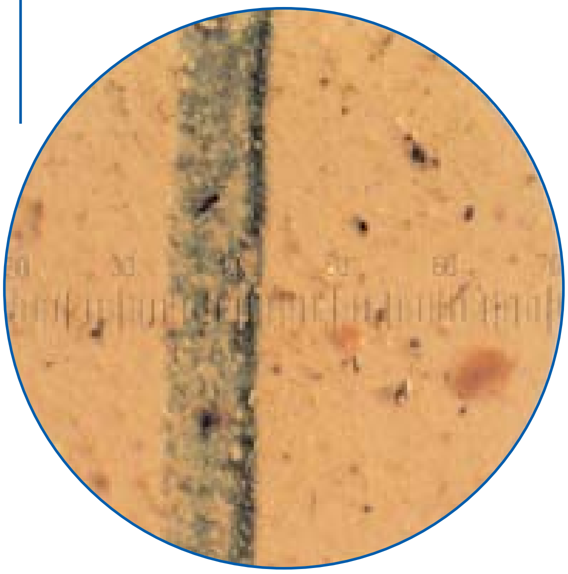
### Particle Count Summary

| Size | Particle Count Range per mL | ISO 4406 Code | NAS1638 (SAE AS4059) |
|---|---|---|---|
| >4 µm(c) | 5,000 - 10,000 | 20 | 10 |
| >6 µm(c) | 640 - 1,300 | 17 | 9 |
| >14 µm(c) | 160 - 320 | 15 | 9 |

### Photo Analysis

Little contamination is present.
The visible contamination is silica and black metal.

# ISO 4406 Cleanliness Code 20/19/16



**Sample Volume:** 100 mL
**Magnification:** 100x
**Scale:** 1 division = 10 µm

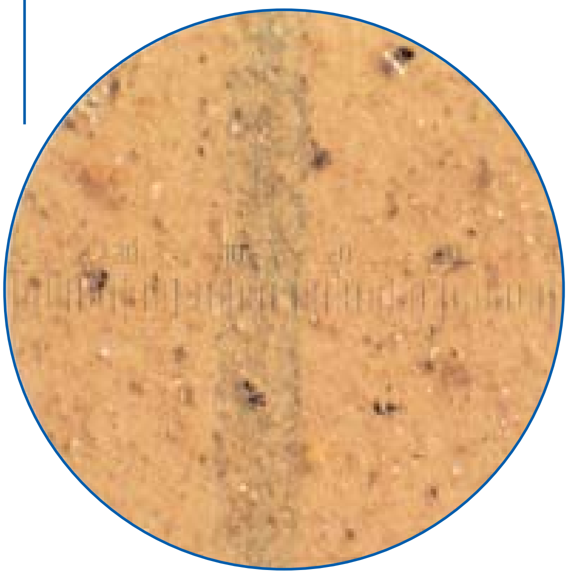
### Particle Count Summary

| Size | Particle Count Range per mL | ISO 4406 Code | NAS1638 (SAE AS4059) |
|---|---|---|---|
| >4 µm(c) | 5,000 - 10,000 | 20 | 11 |
| >6 µm(c) | 2,500 - 5,000 | 19 | 11 |
| >14 µm(c) | 640 - 1,300 | 16 | 11 |

### Photo Analysis

The visible contamination is mainly silica with some metallic and rust particles.

# ISO 4406 Cleanliness Code 21/20/18



**Sample Volume:** 100 mL
**Magnification:** 100x
**Scale:** 1 division = 10 µm

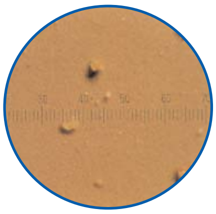
### Particle Count Summary

| Size | Particle Count Range per mL | ISO 4406 Code | NAS1638 (SAE AS4059) |
|---|---|---|---|
| >4 µm(c) | 10,000 - 20,000 | 21 | 12 |
| >6 µm(c) | 5,000 - 10,000 | 20 | 12 |
| >14 µm(c) | 1,300 - 2,500 | 18 | 12 |

### Photo Analysis

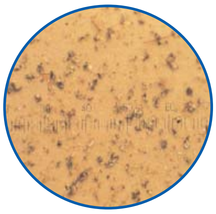
The visible contamination is mainly silica with some metallic and rust particles.

# Types of Contamination



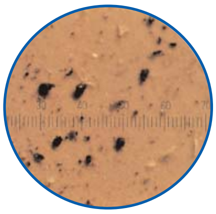
## Silica

Hard, translucent particles often associated with atmospheric and environmental contamination, e.g., sand, dust.



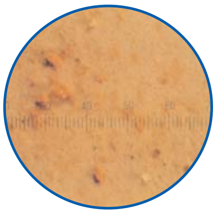
## Bright Metal

Shiny metallic particles, usually silver or gold in colour, generated within the system. Generated contaminants are products of wear and often cause additional component wear and accelerated fluid breakdown.



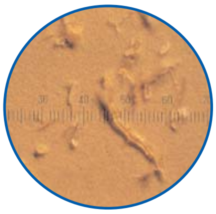
## Black Metal

Oxidized ferrous metal inherent in most hydraulic and lubricating systems; built-in contaminant and genereated within the system by wear.



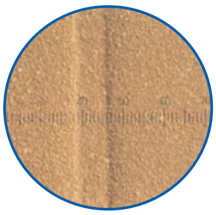
## Rust

Dull orange/brown particles often seen in oil from systems where water may be present, e.g., oil storage tanks.



## Fibers

Contaminants most commonly generated from paper and fabrics, e.g., shop rags.



## Cake of Fines

Very large concentrations of ‘silt’-size particles coat the analysis membrane and build-up into a cake. The cake obscures the larger particles on the membrane making contamination evaluation impossible.

**Magnification:** 100x

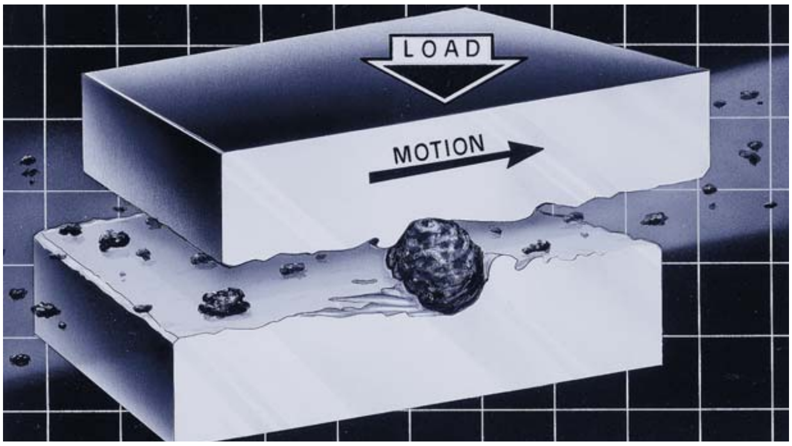
**Scale:** 1 Division = 10 μm

# Typical Dynamic (Operating) Clearances

| Component | Details | Clearances |
|---|---|---|
| Valves | Servo | 1 - 4 µm |
| | Proportional | 1 - 6 µm |
| | Directional | 2 - 8 µm |
| Variable Volume Piston Pumps | Piston to Bore | 5 - 40 µm |
| | Valve Plate to Cyl | 0.5 - 5 µm |
| Vane Pumps | Tip to Case | 0.5 - 1 µm |
| | Sides to Case | 5 - 13 µm |
| Gear Pumps | Tooth Tip to Case | 0.5 - 5 µm |
| | Tooth to Side Plate | 0.5 - 5 µm |
| Ball Bearings | Film Thickness | 0.1 - 0.7 µm |
| Roller Bearings | Film Thickness | 0.4 - 1 µm |
| Journal Bearings | Film Thickness | 0.5 - 125 µm |
| Seals | Seal and Shaft | 0.05 - 0.5 µm |
| Gears | Mating Faces | 0.1 - 1 µm |

*Data from STLE Handbook on Lubrication & Tribology (1994)

**To determine the recommended cleanliness level for a component use the 'Fluid Cleanliness Level Worksheet' on page 27.**




**"No system has ever failed from being too clean"**

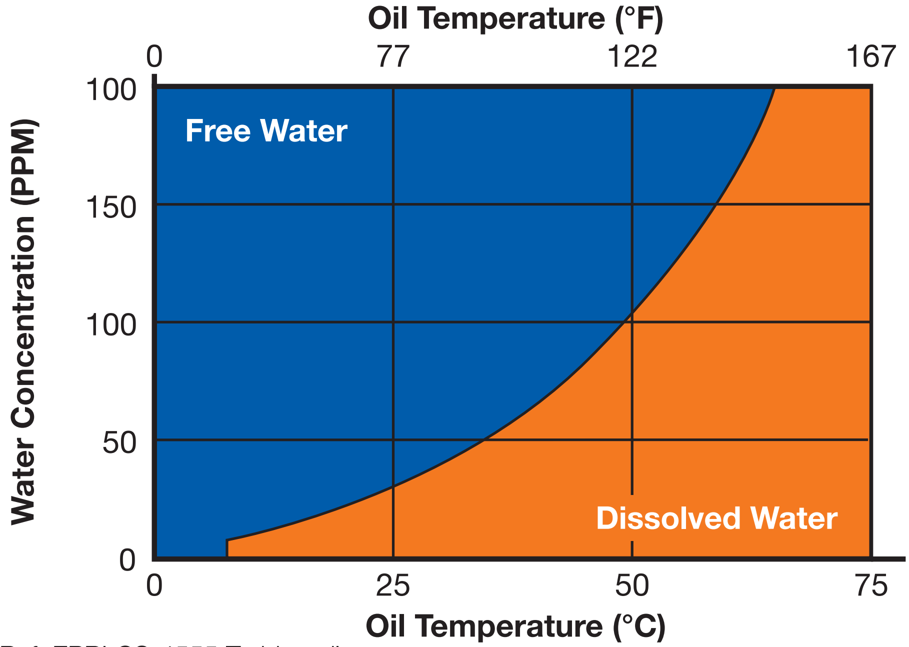
# Water Contamination in Oil

### Water contamination in oil systems causes:

- Oil breakdown, such as additive precipitation and oil oxidation
- Reduced lubricating film thickness
- Accelerated metal surface fatigue
- Corrosion

### Sources of water contamination:

- Heat exchanger leaks
- Seal leaks
- Condensation of humid air
- Inadequate reservoir covers
- Temperature reduction causes dissolved water to turn into free water



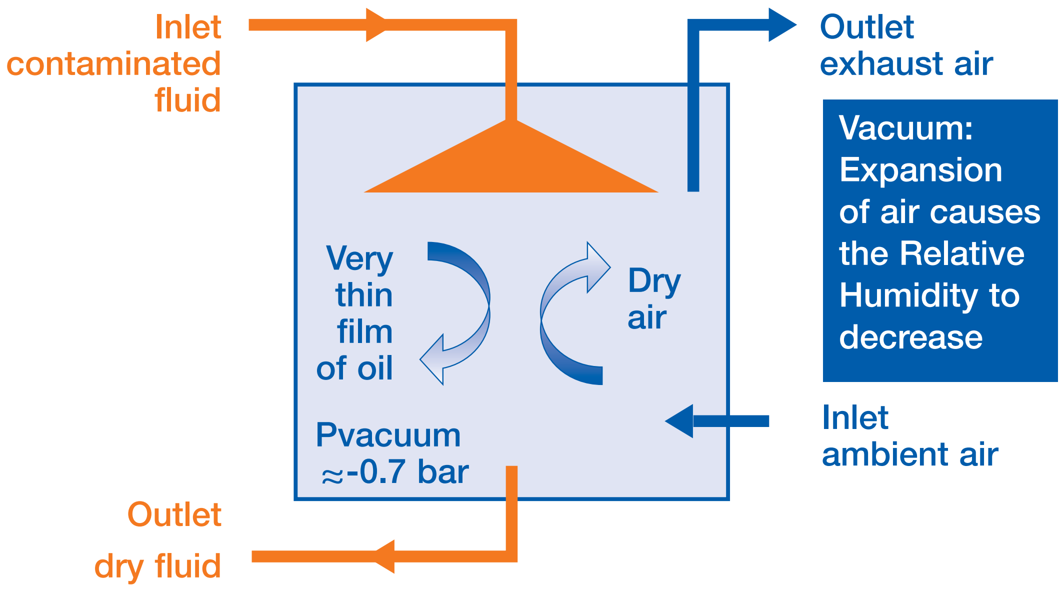

Ref: EPRI CS-4555 Turbine oil

To minimise the harmful effects of free water, water concentration in oil should be kept as far below the oil saturation point as possible.

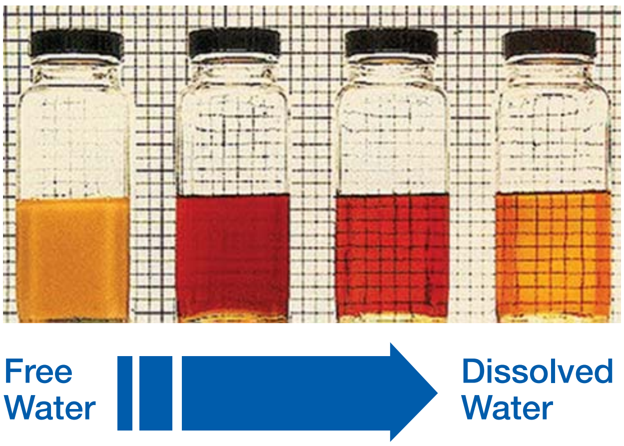
| | |
|---|---|
| 10,000 PPM | 1% |
| 1,000 PPM | 0.1% |
| 100 PPM | 0.01% |

# Operating Principle of Pall Fluid Conditioning Purifiers

**Principle:** Mass transfer by evaporation under vacuum




Pall HNP006 Oil Purifier




## Pall Fluid Conditioning Purifiers remove 100% of free water and entrained gases, and up to 90% of dissolved water and gases

### Typical Applications

- Hydraulic oils
- Lubrication oils
- Dielectric fluids
- Phosphate-esters
- Quenching fluids

## Water Content Analysis Methods

| Method | Units | Benefits | Limitations |
|---|---|---|---|
| Crackle Test | None | Quick indicator of presence of free water | Does not permit detection below saturation |
| Chemical (Calcium hydride) | Percentage or PPM | A simple measurement of water content | Not very accurate on disolved water |
| Distillation | Percentage | Relatively unaffected by oil additives | Limited accuracy on dry oils |
| FTIR | Percentage or PPM | Quick and inexpensive | Accuracy does not permit detection below 0.1% or 1,000 PPM |
| Karl Fischer | Percentage or PPM | Accurate at detecting low levels of water (10 - 1,000 PPM) | Not suitable for high levels of water. Can be affected by additives |
| Capacitive Sensors (Water Sensors) | Percentage of saturation or PPM | Very accurate at detecting dissolved water, 0 - 100% of saturation. | Cannot measure water levels above saturation (100%) |


**WS04 Portable Water Sensor**


**WS08 In-line Water Sensor**

# Monitoring and Measurement

Obtaining accurate and reliable fluid cleanliness data quickly in order to detect abnormal contamination is a key factor in ensuring the efficiency of industrial processes and reducing downtime.

## **Reliable** Monitoring **Solutions**...
## ...**Whatever** the Conditions...**Whatever** the Fluid

PCM400W

### PCM400W Portable Cleanliness Monitor

Provides an assessment of system fluid cleanliness

- Proven multiple mesh blockage technology.
- Results not affected by water or air contamination.
- Designed for use with dark or cloudy fluids.
- ISO 4406, NAS 1638 or SAE AS4059 data output.

PFC400W

### PFC400W Portable Particle Counter

Measures the size and quantity of particles in industrial system fluids

- Proven laser light blockage technology.
- Measures the size and quantity of particles in industrial fluids.
- ISO 4406, NAS 1638 or SAE AS4059 data output.

WS08

WS04

### Pall Water Sensor

The next generation of in-line monitors for water contamination in system fluids

- Measures dissolved water content as % of saturation(%sat) or PPM.
- Portable and in-line models.

# Component Cleanliness Measurement

## Extraction

Component Cleanliness Cabinets facilitate the accurate, reliable and repeatable determination of component cleanliness.

PCC030

All stainless steel cabinets feature:

- Controlled extraction environment
- Automated cleaning to ‘blank’ values
- Pressurised solvent dispensing and recycling circuits.
- Meet ISO 18413, ISO 16232 and VDA 19 procedures.


PCC041

## Analysis

The **Pall** PCC 500 series cabinets combined extraction and analysis using filter blockage measurement techniques which are not affected by the presence of water or air in fluids.

PCC500

Blank

Component Contamination

Component Contamination

Microscopic Analysis

## Process Optimization

- Developing optimization
- Developing and validation of cleanliness standard
- Cleaner fluids
- Laboratory services

**Pall Consultancy**
**Build it Clean**
**Keep it Clean**

# Fluid Sampling Procedure

## Introduction

There are 4 methods for taking fluid samples. Method 1 is the best choice followed by Method 2. Method 3 should only be used if there is no opportunity to take a line sample, and Method 4 should only be used if all others are impracticable.

DO NOT obtain a sample from a reservoir drain valve. Always take the sample under the cleanest possible conditions, and use pre-cleaned sample bottles.

**If there are no line mounted samplers, fit a Pall sampling device to the Pall filter.**

## Method 1

### Small ball valve with PTFE or similar seats, or a test point

1. Operate the system for at least 30 minutes prior to taking sample in order to distribute the particulate evenly.
2. Open the sampling valve and flush at least 1 litre of fluid through the valve. Do not close the valve after flushing.
3. When opening the sample bottle, be extremely careful not to contaminate it.
4. Half fill the bottle with system fluid, use this to rinse the inner surfaces and then discard.
5. Repeat step 4 a second time without closing the valve.
6. Collect sufficient fluid to fill 3/4 of bottle (to allow contents to be redistributed).
7. Cap the sample immediately and then close the sample valve.
   **Caution: Do not touch the valve while taking the sample.**
8. Label the sample bottle with system details and enclose in a suitable container for transport.

## Method 2

### Valve of unknown contamination shedding capabilities

1. Operate the system for at least 30 minutes prior to taking sample in order to distribute particulate evenly.
2. Open the sampling valve and flush at least 3 to 4 Litres of fluid through the valve. (This is best accomplished by connecting the outlet of the valve back to the reservoir by using flexible tubing). Do not close the valve.
3. Having flushed the valve, remove the flexible tubing from the valve with the valve still open and fluid flowing. Remove the cap of the sample bottle and collect sample according to instructions 4 to 6 of Method 1.
4. Cap the sample immediately and then close the sample valve.
   **Caution: Do not touch the valve while taking the sample.**
5. Label the sample bottle with system details and enclose in a suitable container for transport.

# Fluid Sampling Procedure (continued)

## Method 3

### Sampling from Reservoirs and Bulk Containers

Applicable only if Methods 1 and 2 cannot be used

1. Operate the system for at least 30 minutes prior to taking sample in order to distribute the particles evenly.
2. Clean the area of entry to the reservoir where sample will be obtained.
3. Flush the hose of the vacuum sampling device with filtered (0.8 μm) solvent to remove contamination that may be present.
4. Attach a suitable sample bottle to the sampling device, carefully insert the hose into the reservoir so that it is mid-way into the fluid. Take care not to scrape the hose against the sides of the tank or baffles within the tank as contamination may be sucked into the hose.
5. Pull the plunger on the body of the sampling device to produce vacuum and half fill the bottle.
6. Unscrew bottle slightly to release vacuum, allowing hose to drain.
7. Flush the bottle by repeating steps 4 to 6 two or three times.
8. Collect sufficient fluid to 3/4 fill the sample bottle, release the vacuum and unscrew the sample bottle. Immediately recap and label the sample bottle.

## Method 4

### Bottle Dipping

Least preferred method

1. Operate the system for at least 30 minutes prior to taking sample in order to distribute particulate evenly.
2. Clean the area of entry to the reservoir where sample will be obtained.
3. Ensure the outside of the bottle is clean by flushing with filtered solvent.
4. Remove cap from the sample bottle. Carefully fill the sample bottle by dipping it into the reservoir and then discard the fluid after rinsing the inside of the sample bottle.
5. Repeat step 4.
   Carefully fill the sample bottle, cap immediately and wipe the outside.
6. Secure any openings in the reservoir.

**Note: Incorrect sampling procedures will adversely effect the cleanliness level in the sample bottle.**

**It is impossible to make a sample cleaner than the actual system but very easy to make it dirtier.**

# Filter location

## Flushing Filter

- To remove particles that have been built-in to the system during assembly or maintenance before start-up.
- To remove large particles that will cause catastrophic failures.
- To extend 'in-service' filter element life.

## Pressure Line

- To stop pump wear debris from travelling through the system.
- To catch debris from a catastrophic pump failure and prevent secondary system damage.
- To act as a Last Chance Filter (LCF) and protect components directly downstream of it.

## Return Line

- To capture debris from component wear or ingression travelling to the reservoir.
- To promote general system cleanliness.

## Air breather

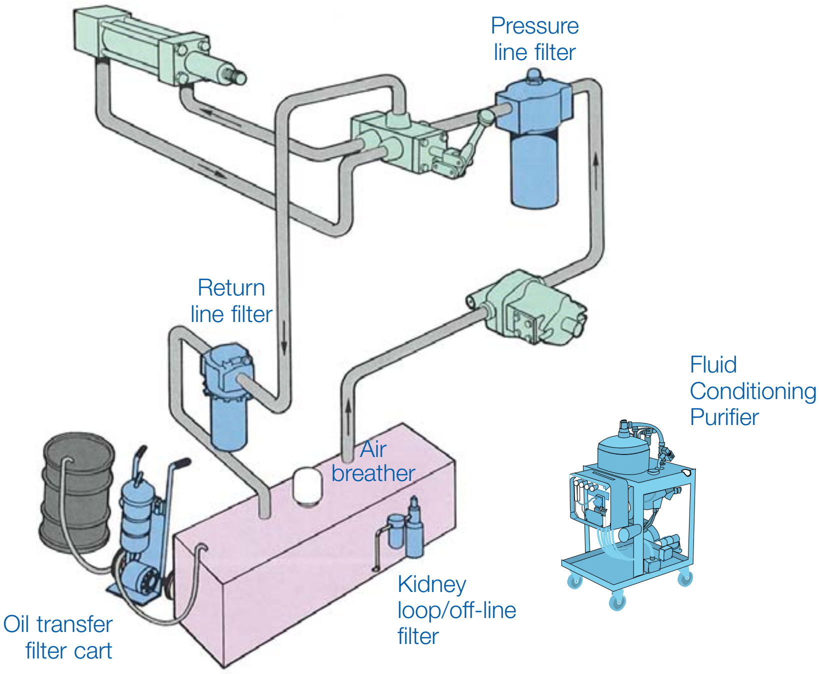
- To prevent ingression of airborne particulate contamination.
- To extend filter element service life.
- To maintain system cleanliness.

## Kidney loop/off-line

- To control system cleanliness when pressure line flow diminishes (i.e. compensating pumps).
- For systems where pressure or return filtration is impractical.
- As a supplement to in-line filters to provide improved cleanliness control and filter service life in high dirt ingression systems.

## Additional filters should be placed ahead of critical or sensitive components

- To protect against catastrophic machine failure (often non-bypass filters are used).
- To reduce wear
- To stabilize valve operation (prevents stiction).



# The Pall concept of Total Cleanliness Management in practice

**Water Supply**
**Pall** Microfiltration systems

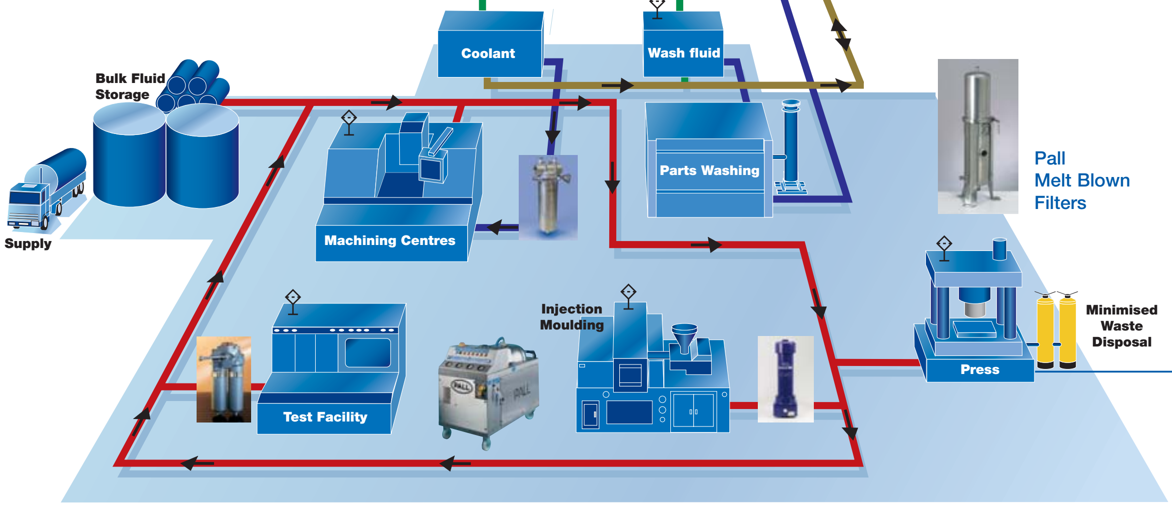
**Pall Reverse Osmosis Water Clarification**

**Pall Air Breathers**

**Pall Cross Flow Filtration Systems**

**Waste Disposal**
**Pall DT Module** reverse osmosis systems

**Pall Ultipleat® SRT**
On-line filling filtration





**Pall Melt Blown Filters**

**Pall Fluid Management Services**

**Coolant Cleanliness**
**Pall** Filters for through tool coolant

**Pall Off-line filtration**

**Pall Fluid Conditioning Purifiers**
Removal of water, gases and solid contamination

**Component Cleanliness Measurement**
**Pall** Cleanliness Cabinets

**Pall Ultipleat® SRT**
Filters for hydraulic and lubricating oils

## Pall Condition Monitoring equipment

Remaining Life Indicator

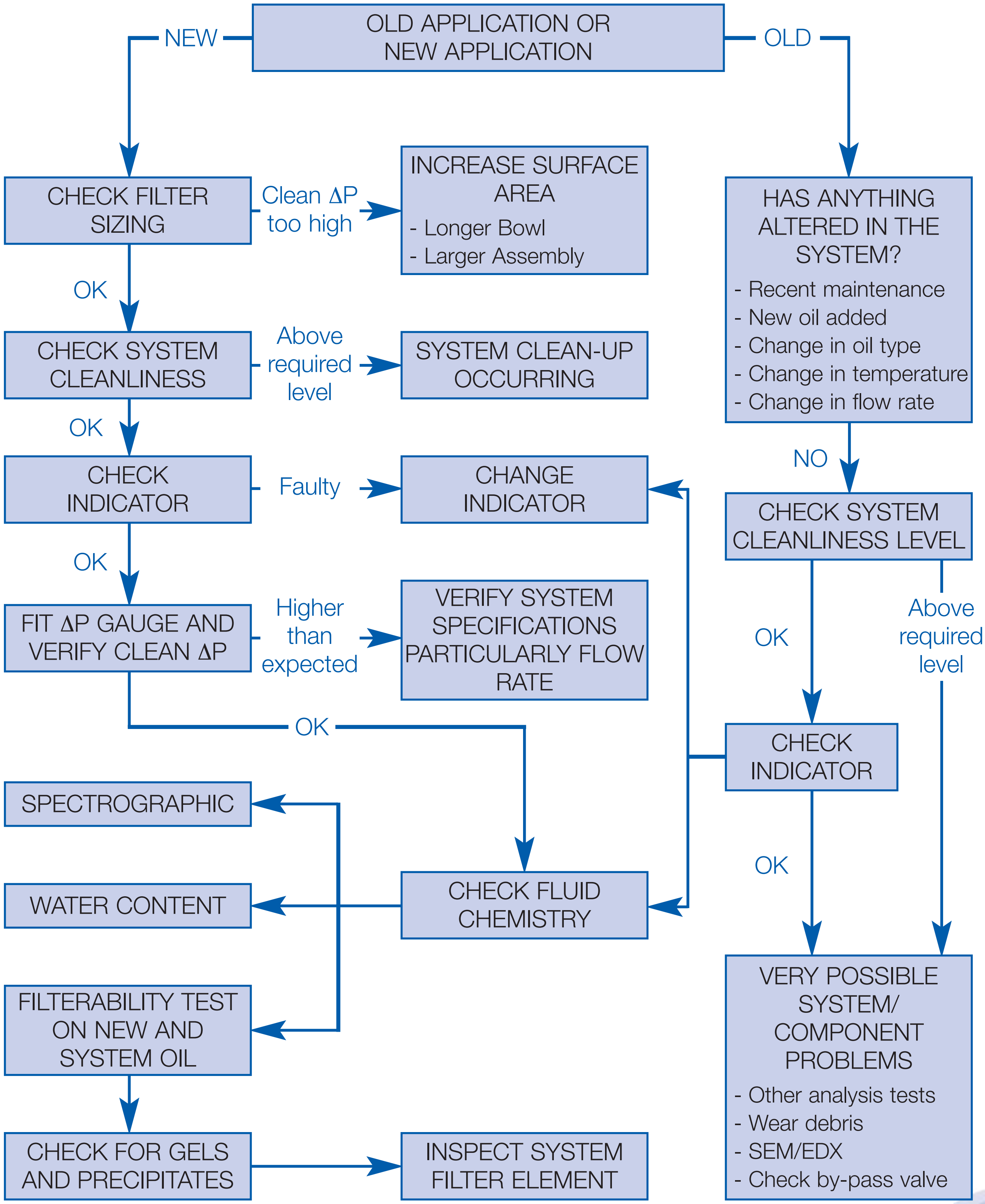
Water Sensor

Fluid Cleanliness Monitor

Particle Counter

**Pall Scientific and Laboratory Services**

# Short Element Life Checklist



## A revolutionary filter technology for hydraulic and lube applications

- Smaller size
- Increased resistance to system stresses
- High flow capability
- Improved cleanliness control
- Increased equipment protection

PALL
Ultipleat® SRT
FILTRATION

**Media Substrate Support Layer** (not shown): Provides support for the media and aids in drainage flow.

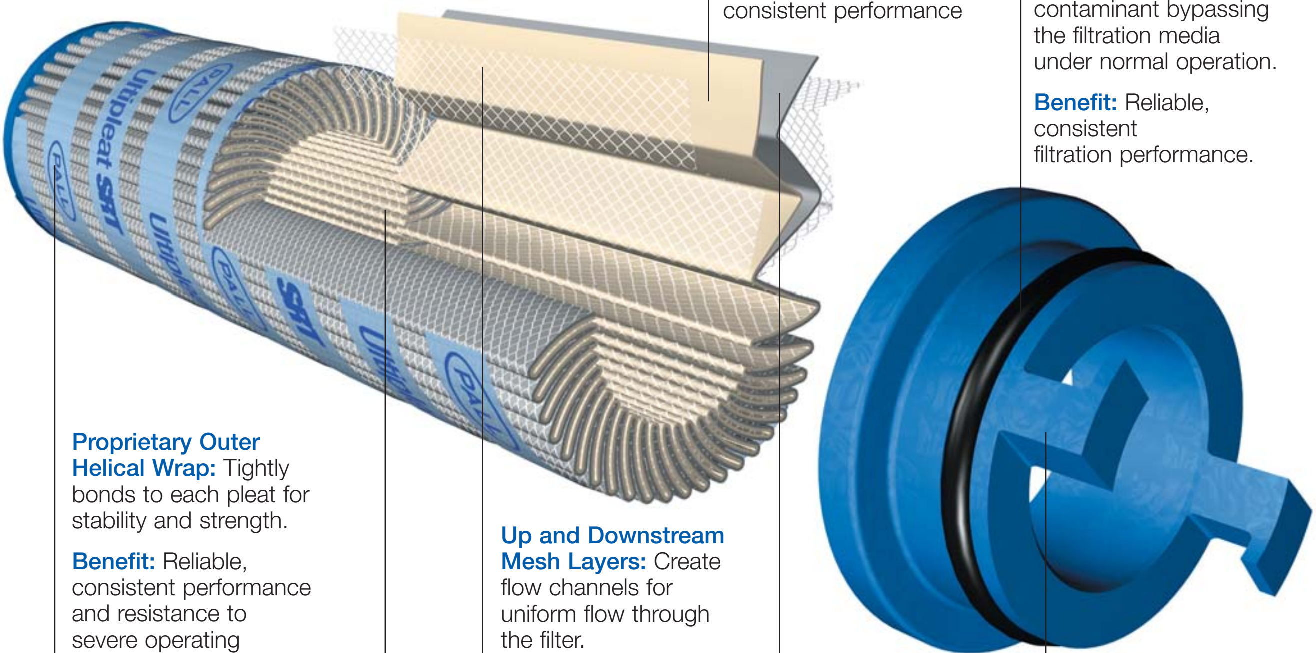
**Benefit:** Reliable, consistent performance

**Proprietary Cushion Layer:** Provides support for the media and protection from handling.

**Benefit:** Reliable, consistent performance

**O-ring Seal:** Prevents contaminant bypassing the filtration media under normal operation.

**Benefit:** Reliable, consistent filtration performance.



**Proprietary Outer Helical Wrap:** Tightly bonds to each pleat for stability and strength.

**Benefit:** Reliable, consistent performance and resistance to severe operating conditions.

**Up and Downstream Mesh Layers:** Create flow channels for uniform flow through the filter.

**Benefit:** Extended element life for lower operating costs.

**Coreless/Cageless Design:** Outer element cage is a permanent part of the filter housing

**Benefit:** Lighter, environmentally friendly element for reduced disposal costs and ease of element change-out.

**SRT Media:** Inert, inorganic fibers securely bonded in a fixed, tapered pore structure with increased resistance to system stresses such as cyclic flow and dirt loading.

**Benefit:** Improved performance over the life of the filter and more consistent fluid cleanliness.

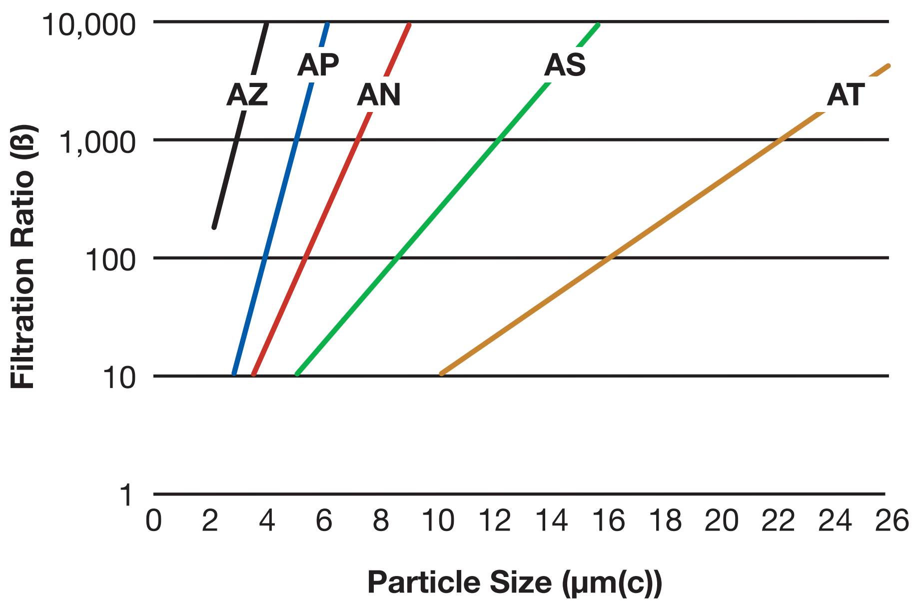
**Auto-Pull Element Removal Tabs:** Corrosion-resistant endcaps feature exclusive Auto-Pull tabs for automatic element extraction upon opening the housing.

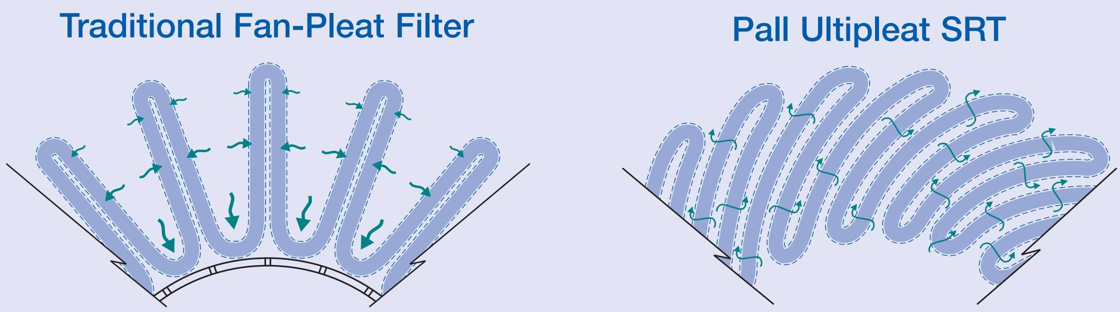
**Benefit:** Ease of element change-out.

# Pall Ultipleat® SRT Filter Performance Data

| Ultipleat SRT Grade | Cleanliness Code Rating (ISO 4406) based on SAE ARP 4205 |
|---|---|
| AZ | 08/04/01 |
| AP | 12/07/02 |
| AN | 15/11/04 |
| AS | 16/13/04 |
| AT | 17/15/08 |

**Multi-Pass Filter Rating (ISO 16889)**




**The optimized fan-pleat geometry of SRT filtration provides:**

- Uniform flow distribution and increased capacity
- Maximum filter surface area and element life

Other series or configurations available, consult Pall for further details.

# Pall Ultipleat® SRT Housing Range

## High Pressure Series


UH219 UH319

| UH Series | Flow Rate L/min | USgpm | Pressure Rating bar | psi |
|---|---|---|---|---|
| 209 | 110 | 30 | 350 | 5,075 |
| 219 | 230 | 60 | 420 | 6,100 |
| 239 | 350 | 90 | 420 | 6,100 |
| 319 | 600 | 160 | 420 | 6,100 |

| UH Series | Port Sizes (inches) | Length (inches) |
|---|---|---|
| 209 | 3/4, 1 | 3, 7 |
| 219 | 1, 1 1/4 | 4, 8, 13, 20 |
| 239 | 1 1/4, 1 1/2 | 8, 13, 20 |
| 319 | 1 1/4, 1 1/2, 2 | 8, 13, 20, 40 |

## Return Line Series


UR619 UR319 UR209

| UR Series | Flow Rate L/min | USgpm | Pressure Rating bar | psi |
|---|---|---|---|---|
| 209 | 130 | 35 | 41 | 600 |
| 219 | 265 | 70 | 41 | 600 |
| 319 | 760 | 200 | 41 | 600 |
| 619 | 835 | 220 | 28 | 400 |
| 629 | 1050 | 280 | 28 | 400 |
| 649 | 1500 | 400 | 28 | 400 |
| 699 | 835 | 220 | 28 | 400 |

| UR Series | Port Sizes (inches) | Length (inches) |
|---|---|---|
| 209 | 3/4, 1 | 3, 7 |
| 219 | 3/4, 1, 1 1/4 | 4, 8, 13, 20 |
| 319 | 1 1/2, 2, 2 1/2 | 8, 13, 20, 40 |
| 619 | 1 1/2, 2, 2 1/2 | 20, 40 |
| 629/49 | 3, 4 | 20, 40 |
| 699 | 2, 2 1/2, 3 | 20, 40 |

# Pall Ultipleat® SRT Housing Range (continued)

## In-Tank Series

UT319 UT279

| UT Series | Flow Rate L/min | USgpm | Pressure Rating bar | psi |
|---|---|---|---|---|
| 279 | 130 | 35 | 10 | 150 |
| 319 | 760 | 200 | 10 | 150 |

| UT Series | Port Sizes (inches) | Length (inches) |
|---|---|---|
| 279 | $\frac{3}{4}$, 1, $1\frac{1}{4}$ | 4, 8, 13, 20 |
| 319 | $1\frac{1}{2}$, 2, $2\frac{1}{2}$ | 8, 13, 20, 40 |

**Auto-Pull** tab on filter element


**Auto-Pull** tab on filter housing cover

## Auto-Pull Element Removal Mechanism

**Ultipleat** SRT filter assemblies feature Pall's unique Auto-Pull element removal mechanism, allowing easy element removal from the filter housing.

When the cover or tube (depending on assembly design) is unscrewed from the housing, tabs on the filter element endcaps fit into hooks in the housing. Thus, as the cover or tube is unscrewed, the element is automatically pulled from the tube. This eliminates the need to reach into the tube to grab an endcap or handle and manually pull out the element.

# Pall Ultipleat® SRT Filter Part Numbering

**Housings:** UH 219C G20 AP 08 Z G P

UH = **Ultipleat** high pressure housing
UR = **Ultipleat** return housing
UT = **Ultipleat** in-Tank housing

2 = 2" diameter element
3 = 3" diameter element
6 = 6" diameter element

2 = Duplex: 2 housing total
4 = Duplex: 4 housing total
6 = Duplex: 6 housing total
8 = Duplex: 8 housing total
Other = Simplex: 1 housing

9 = In-to-out flow, 10 bar collapse

C = Cap service (bowl up)
H = Head service (bowl down)

UE = Ultipleat element

P = Indicator (standard options)

G = Bypass Valve (standard options)

Z = Fluorocarbon Seals

08 = Element Length (standard options)

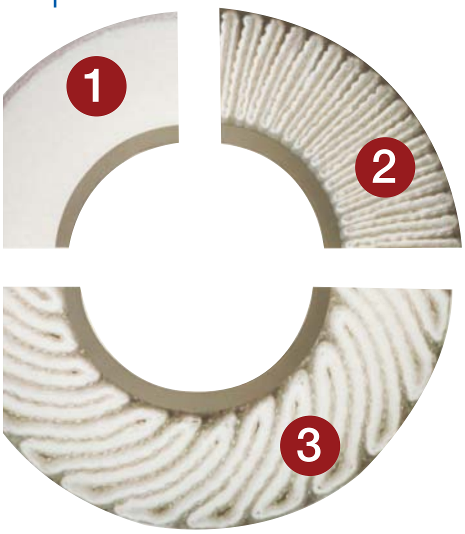
AP = Media Grade (standard options)

G = Port style (standard options)
20 = Port size (standard options)

**Elements:** UE 219 AP 08 Z

# Melt Blown Filter Technology

**Recommended for industrial applications to treat water, fuels, aqueous solutions and low viscosity process fluids.**




1. Depth Filter
2. Fan pleat geometry
3. Laid-over pleat geometry

## Melt Blown Technology

The term 'Melt blown' means the filter has been manufactured using a computer controlled process where fibers are collected to produce in a graded pore structure about a moulded core.

Different media configurations are suited to different applications and specific user requirements. The **Pall** Melt Blown filter element range is available in depth, fan pleated and patented laid over pleat (**Ultipleat**) designs.

Recognizing that different applications have different fluid cleanliness and filtration requirements, the **Pall** range of Melt Blown filter products are simply defined to help you choose the best solution at the most economic cost.

| Particulate Control | Efficiency Rating% | Recommended Range (µm) |
|---|---|---|
| Highly Critical | 99.98% | 1, 3, 6, 12, 20 |
| Critical to General | 99.9% | 40, 70, 90 |
| General | 90% | 100, 150, 200 |

A wide range of filter housings are also available.

# Recommended Fluid Cleanliness Level Worksheet*

Selection of the appropriate cleanliness level should be based upon careful consideration of the operational and environmental conditions. By working through this list of individual parameters, a total weighting can be obtained which when plotted on the graph on page 27, provides a Recommended Cleanliness Level (RCL).

**Table 1. Operating Pressure and Duty Cycle**

| Duty | Examples | Operating Pressure (bar (psi)) 0-70 (0-1000) | >70-170 (>1000-2500) | >170-275 (>2500-4000) | >275-410 (>4000-6000) | >410 (>6000) | Actual |
|---|---|---|---|---|---|---|---|
| Light | Steady duty | 1 | 1 | 2 | 3 | 4 | |
| Medium | Moderate pressure variations | 2 | 3 | 4 | 5 | 6 | |
| Heavy | Zero to full pressure | 3 | 4 | 5 | 6 | 7 | |
| Severe | Zero to full pressure with high frequency transients | 4 | 5 | 6 | 7 | 8 | |

**Table 2. Component Sensitivity**

| Sensitivity | Examples | Weighting | Actual |
|---|---|---|---|
| Minimal | Ram pumps | 1 | |
| Below average | Low performance gear pumps, manual valves, poppet valves | 2 | |
| Average | Vane pumps, spool valves, high performance gear pumps | 3 | |
| Above average | Piston pumps, proportional valves | 4 | |
| High | Servo valves, high pressure proportional valves | 6 | |
| Very high | High performance servo valves | 8 | |

**Table 3. Equipment Life Expectancy**

| Life Expectancy (hours) | Weighting | Actual |
|---|---|---|
| 0-1,000 | 0 | |
| 1,000-5,000 | 1 | |
| 5,000-10,000 | 2 | |
| 10,000-20,000 | 3 | |
| 20,000-40,000 | 4 | |
| >40,000 | 5 | |

**Table 4. Component Replacement Cost**

| Replacement Cost | Examples | Weighting | Actual |
|---|---|---|---|
| Low | Manifold mounted valves, inexpensive pumps | 1 | |
| Average | Line mounted valves and modular valves | 2 | |
| High | Cylinders, proportional valves | 3 | |
| Very high | Large piston pumps, hydrostatic transmission motors, high performance servo components | 4 | |

**Table 5. Equipment Downtime Cost**

| Downtime Cost | Examples | Weighting | Actual |
|---|---|---|---|
| Low | Equipment not critical to production or operation | 1 | |
| Average | Small to medium production plant | 2 | |
| High | High volume production plant | 4 | |
| Very high | Very expensive downtime cost | 6 | |

**Table 6. Safety Liability**

| Safety Liability | Examples | Weighting | Actual |
|---|---|---|---|
| Low | No liability | 1 | |
| Average | Failure may cause hazard | 3 | |
| High | Failure may cause injury | 6 | |

* Adapted from BFPA/P5 Target Cleanliness Level Selector 1999 Issue 3.

### Table 7. Cleanliness Requirement Total

| Cleanliness Requirement Total Weighting | Total |
|---|---|
| Sum of 'Actual' weighting from sections 1 through 6 | |

Using the chart below, determine where the 'Cleanliness Requirement Total Weighting' number from Table 7 intersects the red line. Follow across to the **left** to find the recommended ISO 4406 Code.

### Table 8. Environmental Weighting

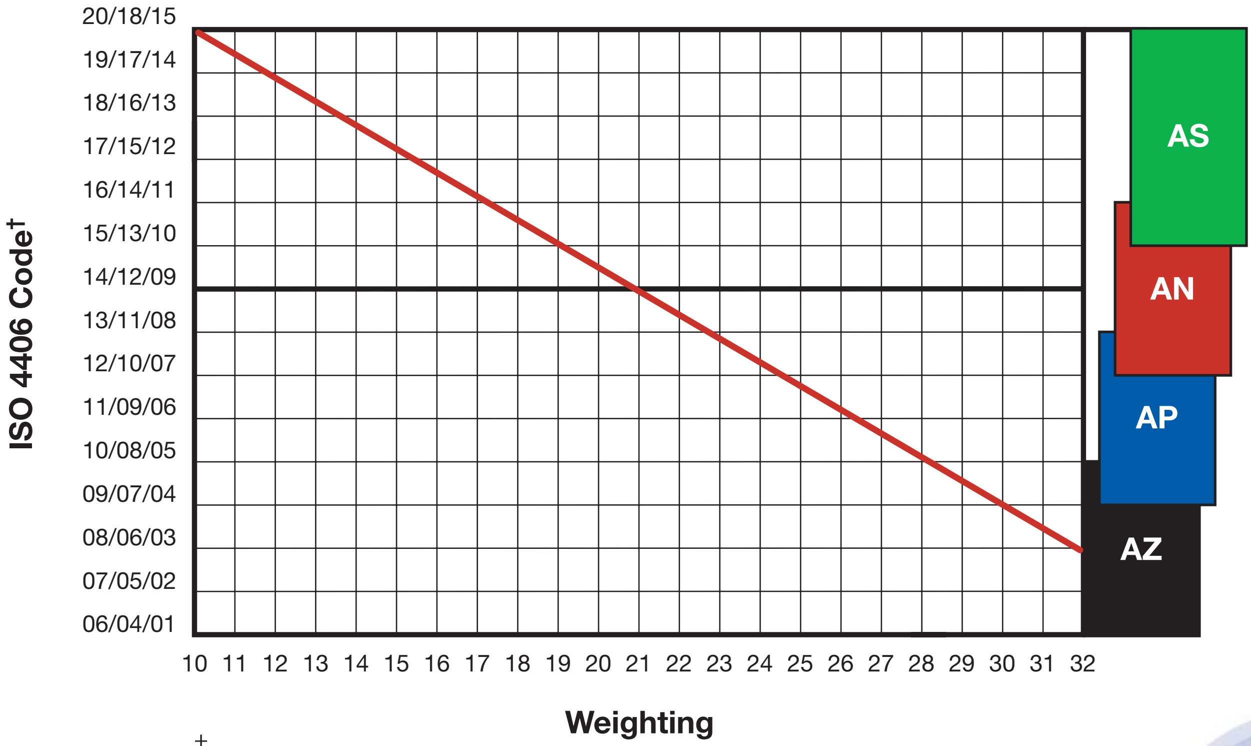
| Environment | Examples | Weighting Single Filter | Weighting Multiple Filters | Actual |
|---|---|---|---|---|
| Good | Clean areas, few ingression points, filtered fluid filling, air breathers | 0 | -1 | |
| Fair | General machine shops, some control over ingression points | 1 | 0 | |
| Poor | Minimal control over operating environment and ingression points e.g. on-highway mobile equipment) | 3 | 2 | |
| Hostile | Potentially high ingression (e.g. foundries, concrete mfg., component test rigs, off-highway mobile equipment) | 5 | 4 | |

* Single filter or multiple filters with the same media grade on the system.

### Table 9. Required Filtration Level

| Filtration Requirement Total Weighting | Total |
|---|---|
| Add Environmental Weighting (Table 8) to Cleanliness Requirement Total (Table 7) | |

Using the chart below, determine where the 'Required Filtration Level' total in Table 9 intersects the red line. Follow across to the **right** to find the corresponding recommended Pall filter grade.




† Using on-line particle counting

# Viscosity Conversions

| Kinematic cSt (mm²/s) | Saybolt Universal Seconds (SUS) 40°C (104°F) | 100°C (212°F) |
|---|---|---|
| 5 | 42 | 43 |
| 10 | 59 | 59 |
| 15 | 77 | 78 |
| 20 | 98 | 99 |
| 25 | 119 | 120 |
| 30 | 142 | 143 |
| 35 | 164 | 165 |
| 40 | 187 | 188 |
| 45 | 210 | 211 |
| 50 | 233 | 234 |
| 55 | 256 | 257 |
| 60 | 279 | 280 |
| 65 | 302 | 303 |
| 70 | 325 | 326 |
| 75 | 348 | 350 |
| 100 | 463 | 466 |
| 200 | 926 | 933 |
| 400 | 1853 | 1866 |
| 600 | 2779 | 2798 |

| To Convert to | at | Multiply cSt at same temperature by |
|---|---|---|
| SUS | 40°C (104°F) | 4.63 |
| SUS | 100°C (212°F) | 4.66 |
| Redwood N°1 | 60°C (140°F) | 4.1 |
| Engler | All temperatures | 0.13 |

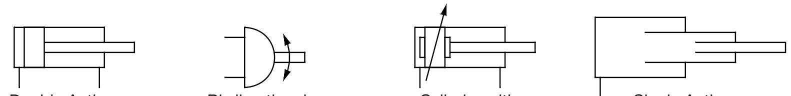
$$\nu = \frac{\mu}{\rho}$$

$\nu$ = Kinematic viscosity of fluid in cSt ($mm^2/s$)
$\mu$ = Dynamic viscosity of fluid in cP (Pa.s)
$\rho$ = Density of fluid ($kg/m^3$)

# Common Fluid Power Circuit Diagram Symbols

ISO1219-1: Fluid power systems and components - Graphic symbols and circuit diagrams - Part 1: Graphic symbols for conventional use and data processing applications.

## Cylinders & Semi-rotary Actuators

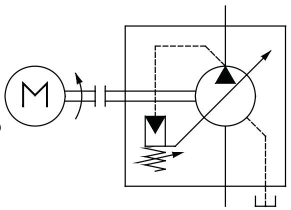


Double Acting Cylinder | Bi-directional Semi-rotary Actuator | Cylinder with Adjustable Cushioning | Single Acting Telescopic Cylinder

## Pumps & Motors

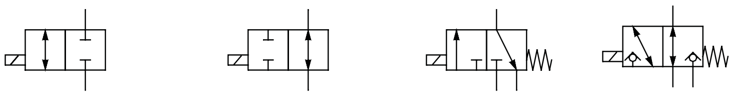
Fixed Displacement Pump Uni-directional Flow Bi-directional Rotation | Variable Displacement Pump Bi-directional Flow Anti-clockwise Rotation

Fixed Displacement Motor Anti-clockwise Rotation | Variable Displacement Motor Bi-directional Rotation External Case Drain



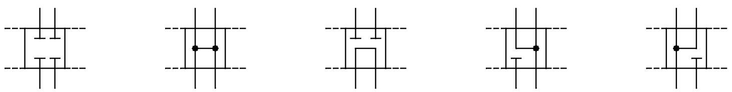
Pressure Compensated Pump [Shortform Symbol] Uni-directional Flow External Case Drain Clockwise Rotation Electric Motor Driven

## Directional Control Valves (Unspecified Actuation)



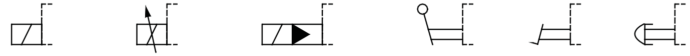
2 Port, 2 Position Normally Closed | 2 Port, 2 Position Normally Open | 3 Port, 2 Position Spring Return | 3 Port, 2 Position Spring Return [Poppet type]

4 Port, 2 Position Spring Return | 4 Port, [3 Position] Proportional | 4 Port, 3 Position, Spring Centred (See Below for Centre Conditions)



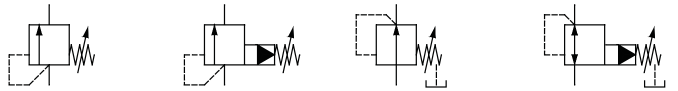
Closed Centre | Open Centre | Tandem Centre | Float Centre | Regeneration Centre

## Directional Control Valve Actuation



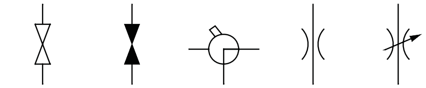
Switching Solenoid | Proportional Solenoid | Electro-Hydraulic (Pilot) Operation | Hand Lever | Foot Pedal | Palm Button

## Pressure Control Valves

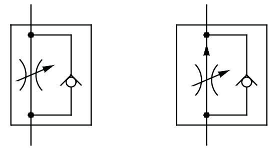


Direct Operated Relief Valve | Pilot Operated Relief Valve | Direct Operated Reducing Valve | Direct Operated 3 Way Reducing Valve

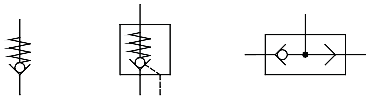
## Isolation & Flow Control Valves



Isolator (Open) | Isolator (Closed) | Diverter Valve | Orifice (Jet) | Throttle Valve

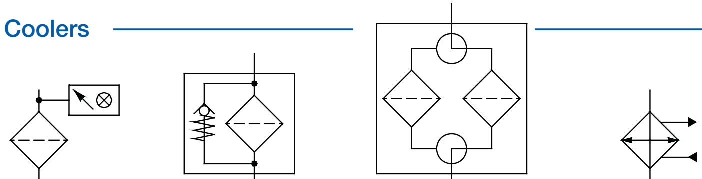


Throttle-Check Valve | Pressure Compensated Flow Control Valve



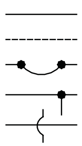
Check Valve | Pilot-to-Open Check Valve | Shuttle Valve

## Filters & Coolers

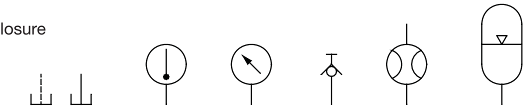


Filter with Visual Clogging Indicator | Filter with Bypass Valve | Duplex Filter with Manual Valve | Cooler (Heat Exchanger)

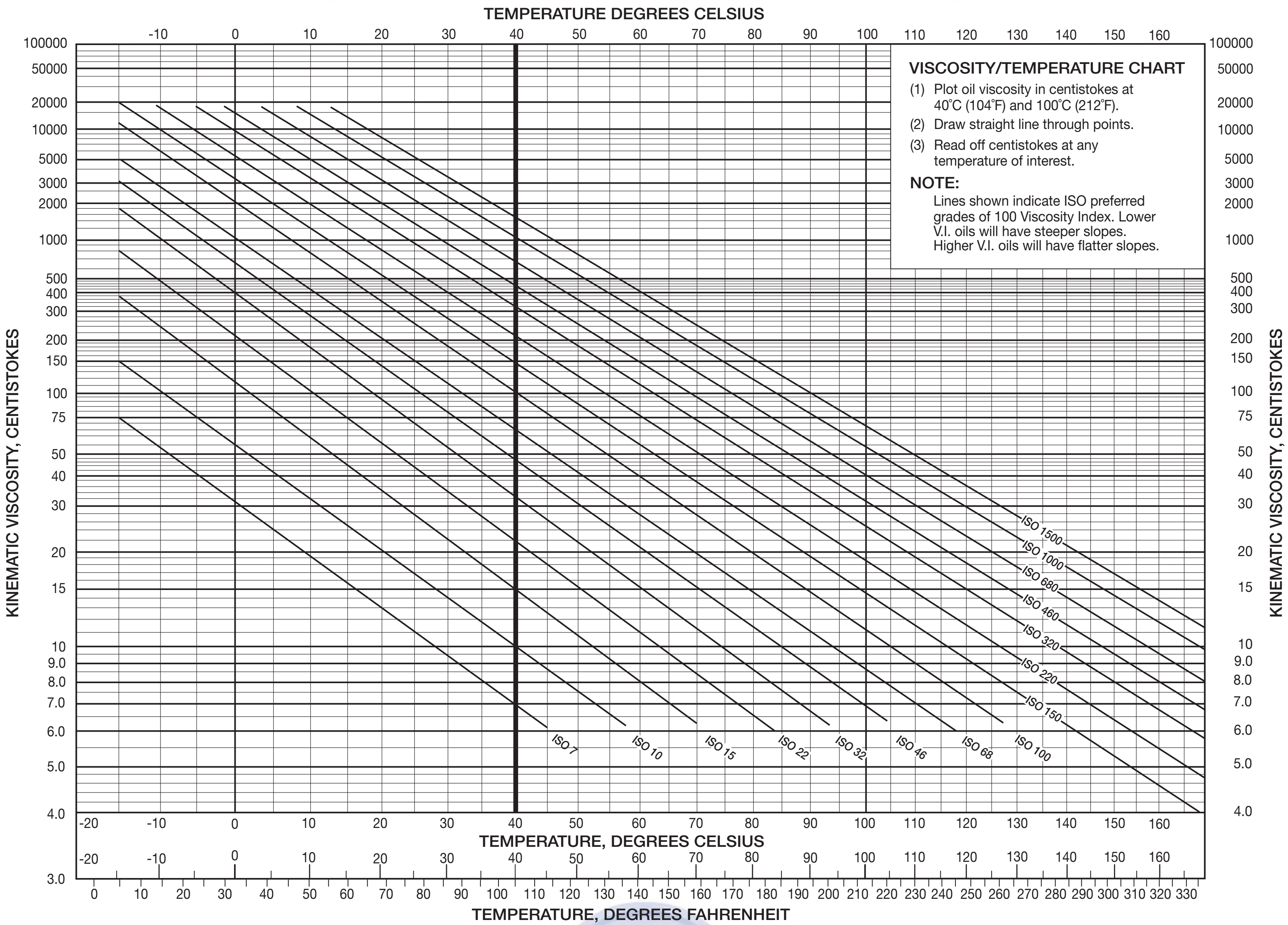
## Instrumentation & Pipeline Components



Flow Line, Symbol Enclosure
Pilot Line, Drain Line
Flexible Hose
Lines Connecting
Lines Crossing



Connections To Tank | Temp. Gauge | Pressure Gauge | Test Point | Flow meter | Accumulator



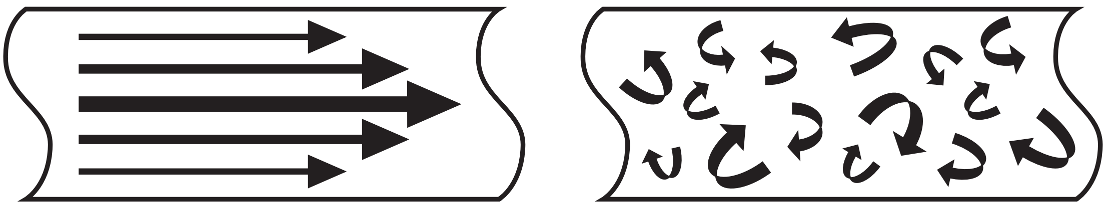
TEMPERATURE DEGREES CELSIUS
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
KINEMATIC VISCOSITY, CENTISTOKES
100000 50000 20000 10000 5000 3000 2000 1000 500 400 300 200 150 100 75 50 40 30 20 15 10 9.0 8.0 7.0 6.0 5.0 4.0 3.0
VISCOSITY/TEMPERATURE CHART
(1) Plot oil viscosity in centistokes at 40˚C (104˚F) and 100˚C (212˚F).
(2) Draw straight line through points.
(3) Read off centistokes at any temperature of interest.
NOTE:
Lines shown indicate ISO preferred grades of 100 Viscosity Index. Lower V.I. oils will have steeper slopes. Higher V.I. oils will have flatter slopes.
ISO 1500
ISO 1000
ISO 680
ISO 460
ISO 320
ISO 220
ISO 150
ISO 7
ISO 10
ISO 15
ISO 22
ISO 32
ISO 46
ISO 68
ISO 100
-20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
TEMPERATURE, DEGREES CELSIUS
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330
TEMPERATURE, DEGREES FAHRENHEIT

# Flushing Procedures and Formula

The aim of flushing is to remove contamination from the inside of pipes and components which are introduced during system assembly or maintenance. This is accomplished by passing fluid through the system, usually at a velocity higher than that during normal operation.

**Omission or curtailment of flushing will inevitably lead to rapid wear of components, malfunction and breakdown.**

**Reynolds N$^{O}$ (Re):** A non-dimensional number that provides a qualification of the degree of turbulence within a pipe or hose.




Laminar Flow - Reynolds N$^{o}$ < 2,000

Transitional Flow - Reynolds N$^{o}$ 2,000 - 4,000

Turbulent Flow - Reynolds N$^{o}$ > 4,000

The flow condition in a pipe or hose can be assessed using Reynolds N$^{o}$ as follows:

$$Re = \frac{Ud}{\nu} \times 1{,}000$$

or

$$Re = 21{,}200 \times Q / (\nu \times d)$$

Re = Reynolds N$^{o}$

U = Mean flow velocity (m/s)

d = Pipe internal diameter (mm)

$\nu$ = Kinematic viscosity of fluid in cSt ($mm^2/s$)

Q = Flow rate (L/min)

# English / Metric Conversions

## Pressure - psi and bar

1 psi = 0.067 bar 1 bar = 14.5 psi

| psi | bar | bar | psi |
|---|---|---|---|
| 20 | 1.38 | 1 | 14.5 |
| 30 | 2.07 | 2 | 29.0 |
| 40 | 2.77 | 3 | 43.5 |
| 50 | 3.45 | 4 | 58.0 |
| 60 | 4.14 | 5 | 72.5 |
| 70 | 4.83 | 6 | 87.0 |
| 80 | 5.52 | 7 | 102 |
| 90 | 6.21 | 8 | 116 |
| 100 | 6.90 | 9 | 131 |
| 200 | 13.8 | 10 | 145 |
| 300 | 20.7 | 15 | 218 |
| 400 | 27.6 | 20 | 290 |
| 500 | 34.5 | 25 | 363 |
| 600 | 41.4 | 30 | 435 |
| 700 | 48.3 | 35 | 508 |
| 800 | 55.2 | 40 | 580 |
| 900 | 62.1 | 45 | 653 |
| 1,000 | 69 | 50 | 725 |
| 1,100 | 75.9 | 55 | 798 |
| 1,200 | 82.8 | 60 | 870 |
| 1,300 | 89.7 | 65 | 943 |
| 1,400 | 96.6 | 70 | 1,015 |
| 1,500 | 104 | 75 | 1,088 |
| 1,600 | 110 | 80 | 1,160 |
| 1,700 | 117 | 85 | 1,233 |
| 1,800 | 124 | 90 | 1,305 |
| 1,900 | 131 | 95 | 1,378 |
| 2,000 | 138 | 100 | 1,450 |
| 2,250 | 155 | 150 | 2,175 |
| 2,500 | 172 | 200 | 2,900 |
| 2,750 | 190 | 250 | 3,630 |
| 3,000 | 207 | 300 | 4,350 |
| 3,500 | 241 | 350 | 5,080 |
| 4,000 | 258 | 400 | 5,800 |
| 4,500 | 310 | 450 | 6,530 |
| 5,000 | 345 | 500 | 7,250 |

## Hydraulic Flow - USgpm and litres/minute

1 USgpm = 3.79 litres/min 1 litre/min = 0.264 USgpm

| USgpm | L/min | L/min | USgpm |
|---|---|---|---|
| 5 | 18.9 | 5 | 1.3 |
| 10 | 37.9 | 10 | 2.6 |
| 15 | 56.8 | 20 | 5.3 |
| 20 | 75.7 | 30 | 7.9 |
| 25 | 94.6 | 40 | 10.6 |
| 30 | 114 | 50 | 13.2 |
| 35 | 133 | 60 | 15.9 |
| 40 | 151 | 70 | 18.5 |
| 45 | 170 | 80 | 21.1 |
| 50 | 189 | 90 | 23.8 |
| 55 | 208 | 100 | 26.4 |
| 60 | 227 | 125 | 33.0 |
| 65 | 246 | 150 | 39.6 |
| 70 | 265 | 200 | 52.8 |
| 75 | 284 | 250 | 66.1 |
| 80 | 303 | 300 | 79.3 |
| 85 | 322 | 350 | 92.5 |
| 90 | 341 | 400 | 105.7 |
| 95 | 360 | 450 | 118.9 |
| 100 | 379 | 500 | 132.1 |
| 125 | 473 | 550 | 145.3 |
| 150 | 568 | 600 | 158.5 |
| 175 | 662 | 650 | 171.7 |
| 200 | 757 | 700 | 184.9 |
| 225 | 852 | 750 | 198.2 |
| 250 | 946 | 800 | 211.4 |
| 275 | 1,040 | 900 | 237.8 |
| 300 | 1,140 | 1,000 | 264.2 |

1 gpm (US) = 0.832 gpm (UK)

Note: Values to 3 significant figures

# Measurement Conversion Factors

| To Convert | Into | Multiply By |
|---|---|---|
| **Into** | **To Convert** | **Divide By** |
| Litre | Cubic metre | 0.001 |
| Litre | Gallon (US) | 0.2642 |
| Litre | Gallon (UK) | 0.22 |
| Micrometre (Micron) | Inch | 0.000039 |
| Foot | Inch | 12 |
| Inch | Millimetre | 25.4 |
| Metre | Foot | 3.28 |
| Metre | Yard | 1.09 |
| Mile | Kilometre | 1.609 |
| Litre/sec | Cubic metre/min | 0.06 |
| Metre/sec | Kilometre/hour | 3.6 |
| Kilogram | Pound | 2.205 |
| Pound | Ounce | 16 |
| Kilowatt | Horsepower | 1.341 |
| Kilowatt | BTU/hour | 3412 |
| Atmosphere | PSI | 14.7 |
| Bar | PSI | 14.5 |
| KiloPascal | PSI | 0.145 |
| Bar | KiloPascal | 100 |
| Bar | Inches of mercury (Hg) | 29.53 |
| Inches of Water | Pascal (Pa) | 249 |
| Celsius (Centigrade) | Fahrenheit | °C x 1.8 + 32 |
| Degree (Angle) | Radian | 0.01745 |

To convert units appearing in column 1 (left column) into equivalent values in column 2 (centre column), **multiply** by factor in column 3.

Example: To convert 7 Litres into Cubic Metres, **multiply** 7 by 0.001 = 0.007.

To convert units appearing in column 2 (centre) into equivalent values of units in column 1 (left column), **divide** by factor in column 3.

Example: To convert 25 psi into bar, **divide** 25 by 14.5 = 1.724.

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