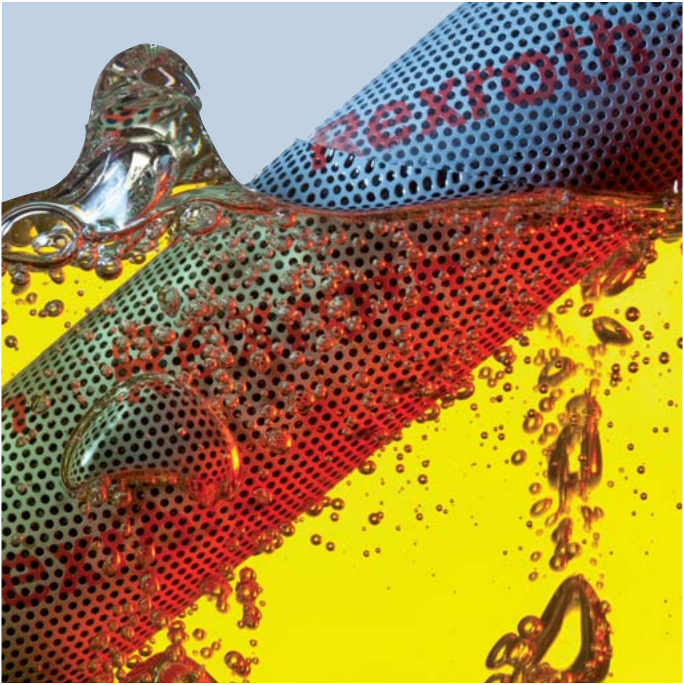
Rexroth
Bosch Group

Rexroth Oil Cleanliness Booklet



Introduction

Oil is the central component of any hydraulic system.
If a system fails, contamination is one of the major reasons.
This booklet explains the basics of contamination control and serves as a reference and information tool.

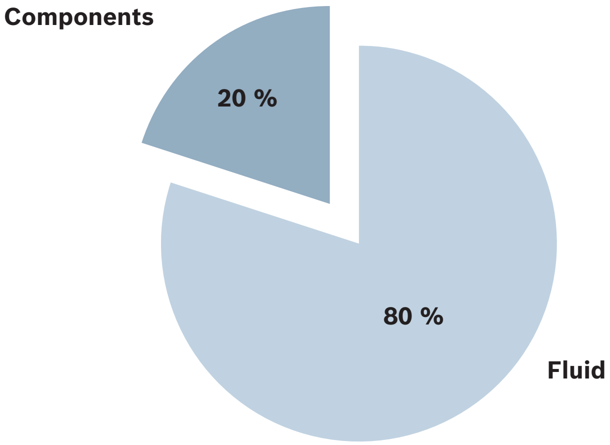
Need for Hydraulic Filtration

Inspecting contamination in hydraulic systems is a major aspect when designing a filter concept.

Sources of Problems in Fluid Systems

More than ¾ of all problems can be traced back to contaminated oil. Monitoring oil cleanliness is therefore the most important factor in preventing system failures.

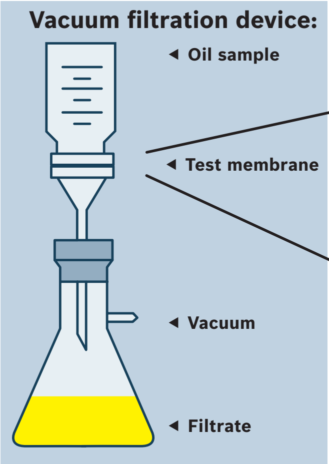
Monitoring hardware only detects around 20 % of all unplanned downtimes.

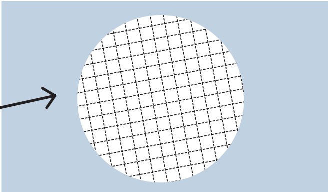


Oil Analysis

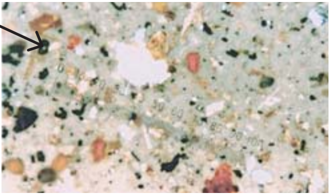
Types of inspection for oil cleanliness

- Offline examination of oil samples in the laboratory
- Microscopic particle count in accordance with ISO 4407
- Gravimetric test in accordance with ISO 4405
- Microscopic determination of the type of contamination





▲ **Test membrane, 1,2 µm**



▲ **Microscopic image, 100 x**

Mobile Particle Counter for Conducting Online Measurements of the Oil Cleanliness Class

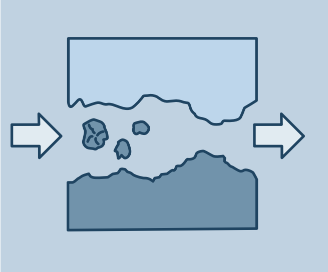
- Light extinction principle
- Laser sensor
- Robust and reliable device with all basic functions
- Integrated battery pack and memory
- Oil cleanliness classes in accordance with ISO 4406 4 µm(c), 6 µm(c), 14 µm(c)
- Comprehensive range of accessories, e.g. printer, tank pump, external memory card
- Very easy to use

▲ **MPC 4614**

▲ **Tank pump**

▲ **Printer**

Types of Contamination



1. Solid particles (abrasion and dirt)

Consequences:
- Initial damage through "scoring"
- Impact on control and regulation properties
- Component wear
- Component failure
- Reduction in machine availability

Measures: Filtration

2. Liquid contamination (usually water, free and in solution)

Consequences:
- Corrosion, wear
- Impairment of viscosity
- Chem. reaction with the fluid
- Impact on lubricating properties
- Ageing (oxidation) of oil
- Poor filterability
- Reduction in filter service intervals
- Reduction in machine availability

Measures:
- Breather filters with AS filter material
- Water absorbing filter elements (free)
- Vacuum dehydrator (water in solution)

3. Gaseous contamination (air)

Consequences:
- Foam formation in the oil
- Inaccurate valve response
- Loss of energy
- Pump damage
- Chem. reaction with the fluid
- Oxidation
- Reduction in machine availability

Measures:
- Bleed system
- Seal pumps
- Use a vacuum dehydrator

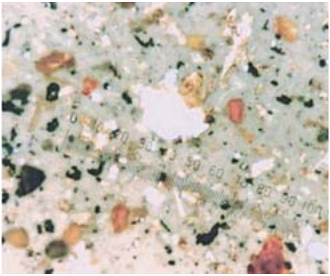
Sources of Contamination

1. Built-in contamination

- Foundry sand, dust
- Manufacturing residue:
  - Welding residue
  - Metal swarf
  - Blasting material, lacquer/paint particles
  - Preservation material
- Residue from cleaning agents (textile fibers)

2. External contamination

- Dirt from the ambient air, introduced via
  - Plunger rods
  - Labyrinth seals
  - Aeration
- Contamination caused by adding oil

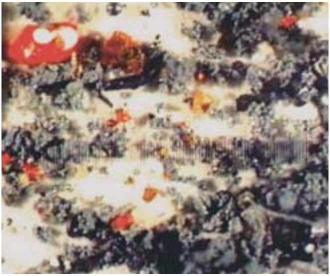


3. Self-generated contamination

- Metallic wear caused by abrasion and erosion
- Seal abrasion
- Chemical corrosion
- Oil ageing products
- Oxidation residue
- Oil-insoluble substances caused by mixing oil

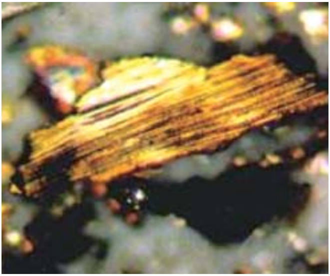
Examples of residual dirt

Built-in contamination
Residue from a return line filter (mobile hydraulic systems)



- Welding residue
- Metal swarf
- Paint residue
- Resin

Self-generated contamination (wear)
Residue from a high-pressure filter in a hydraulic system within a stainless steel forging press

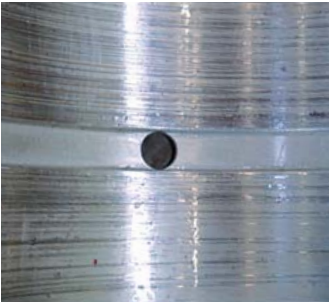


- Coarse brass and steel abrasion particles
- Severe sliding wear (grooves and stress marks)

Damage Caused By Contamination

Material removal (erosion)
caused by a high flow rate along edges combined with a high number of ingressed dirt particles with high speed in the flow.

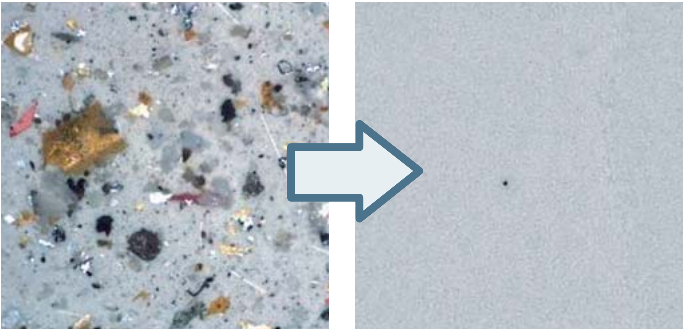
Grooving (abrasion)
caused by hard, abrasive particles that are roughly the same size as the clearance of the components.
Consequence: Reduction in performance due to leaking oil.



The Approach

Prevent with Rexroth filter technology.

- Optimum oil cleanliness
- Reliable component protection
- Major contribution towards machine availability
- High degree of customer satisfaction

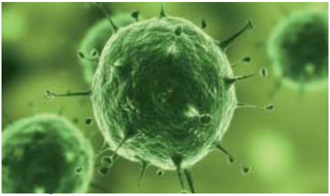


- High degree of oil contamination
- ISO 22/20/18

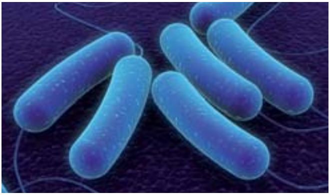
- Achievable oil cleanliness using fine filter elements
- ISO 12/10/8

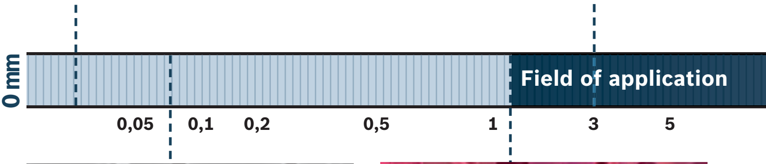
Filtration Grade – Particle Sizes

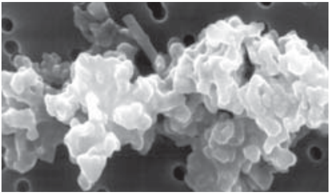
▼ **Viruses 0,003 – 0,05 µm**



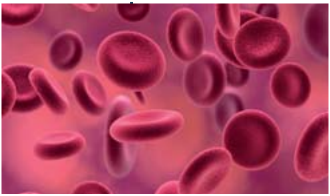
▼ **Bacteria 0,3 – 20 µm**





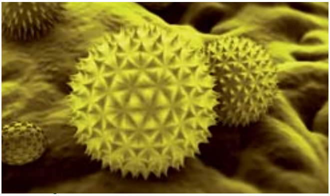


▲ **Tobacco smoke 0,01 – 1 µm**

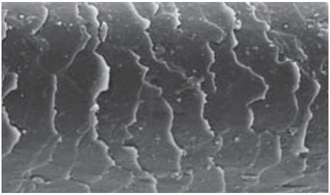


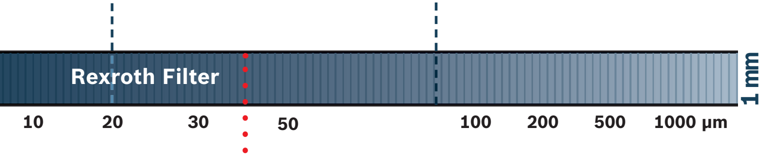
▲ **Blood cells 0,5 – 1,5 µm**

▼ **Pollen ~ 20 µm**



▼ **Human hair ~ 70 µm**





▲ **Visibility limit = 40 µm**

Particle sizes are measured in units called “micrometers”.
A micrometer is one millionth of a meter.
The visibility limit of the human eye is approx. 40 µm. This means that particles that are the most hazardous to a hydraulic system cannot be detected with the naked eye.

Achievable Oil Cleanliness in Accordance with ISO 4406

HydroClean XL filter material	
H20XL	19/16/12 - 22/17/14
H10XL	17/14/10 - 21/16/13
H6XL	15/12/10 - 19/14/11
H3XL	13/10/8 - 17/13/10
H1XL	10/6/4 - 14/8/6

Overview of the most important filter characteristics

ßx
α
Δp

Filtration grade

- Nominal (from manufacturer)
- “Absolute” in accordance with ISO 16889
- Mesh width for wire fabric

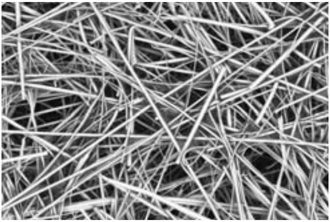
Dirt absorption capacity

- In accordance with ISO 16889
- ISOMTD test dust

Differential pressure

- In accordance with ISO 3968
- In relation to 30 cSt/25 μm

All three properties are mutually interdependent. Rexroth filter elements are characterized by an optimum ratio for these properties, ensuring the best possible filtering action with maximum dirt absorption and minimum Δp.



Fitting Tolerance of Hydraulic Components

Gear pump Gear pump, Side plate Gear housing	0,5 - 5 µm 0,5 - 5 µm
Vane pump Vane tip Vane surfaces	0,5 - 5 µm 5 - 13 µm
Piston pump Piston bore Valve plate cylinder	5 - 40 µm 1,5 - 10 µm
Servo valve Control piston Baffle plate	18 - 63 µm 2,5 - 8 µm
Control valve Control piston Cone valve	2,5 - 23 µm 13 - 40 µm

◀ **Extract from CETOP RP 92H**

Examinations show that even particles with sizes that are $^1/_3$ x the clearance width can lead to the clearance becoming blocked. The filtration grade of the system filters should therefore be selected in such a way as to ensure the absolute filtration grade is smaller than or equal to $^1/_3$ of the smallest clearance width in the system.

Filtration grade ≤ $^1/_3$ x smallest clearance

Recommended Oil cleanliness level

Application	**Oil cleanliness required in accordance with ISO 4406**	**Recommended filter material/ filtration grade**
Systems with extremely high dirt sensitivity and very high availability requirements	≤ 16/12/9	H1XL / 1 µm
Systems with high dirt sensitivity and high availability requirements, such as servo valve technology	≤ 18/13/10	H3XL / 3 µm
Systems with proportional valves and pressures > 160 bar	≤ 19/14/11	H6XL / 6 µm
Vane pumps, piston pumps, piston engines	≤ 18/16/13	H10XL / 10 µm
Modern industrial hydraulic systems, directional valves, pressure valves	≤ 20/16/13	H10XL / 10 µm
Industrial hydraulic systems with large tolerances and low dirt sensitivity	≤ 21/17/14	H20XL / 20 µm

Oil Cleanliness Codes in Accordance with ISO 4406 and Examples of Contamination

Number of particles (per 100 ml)		ISO-Code
from	to	
1.000.000	2.000.000	21
500.000	1.000.000	20
250.000	500.000	19
130.000	250.000	18
64.000	130.000	17
32.000	64.000	16
16.000	32.000	15
8.000	16.000	14
4.000	8.000	13
2.000	4.000	12
1.000	2.000	11
500	1.000	10
250	500	9
130	250	8
64	130	7
32	64	6
16	32	5

Classification of all particles

≥ 4 µm(c), ≥ 6 µm(c) and
≥ 14 µm(c)

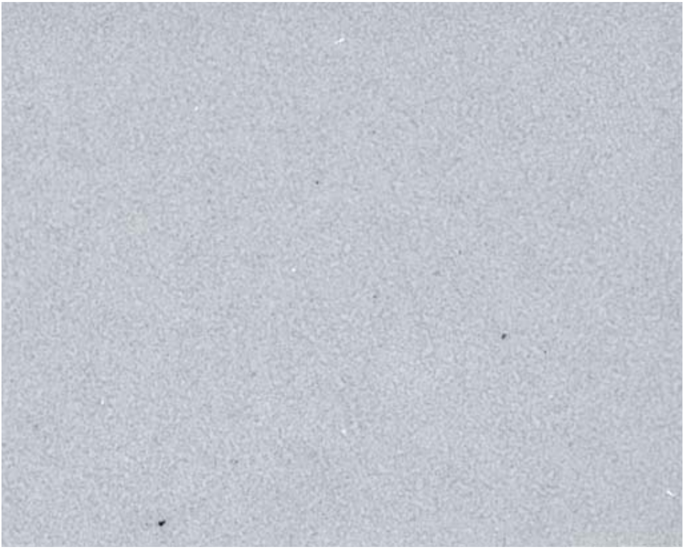
Example from ISO 18/16/11:

190.000 particles ≥ 4 µm(c)/100 ml
58.600 particles ≥ 6 µm(c)/100 ml
1.525 particles ≥ 14 µm(c)/100 ml

ISO 4406 counts particles accumulatively, i.e. all particles that are larger than or equal to 4 µm. In contradiction to this, NAS 1638 counts the particles in differential size classes, i.e. all particles within the range of 5 – 15 µm, 15 – 25 µm, etc.
NAS 1638 became INVALID on 05/30/2001! The replacement standard SAE AS 4059 is a national standard intended for the US aviation industry only. It is therefore no longer permitted to specify contamination classes in accordance with NAS. Specifying contamination in accordance with ISO 4406 on the other hand is considered to be state-of-the-art.

ISO 10/7/5

(NAS 1638: class 1)



Particle size		
≥ 4 µm(c)	≥ 6 µm(c)	≥ 14 µm(c)
Particle count		
500 to 1.000	64 to 130	16 to 32

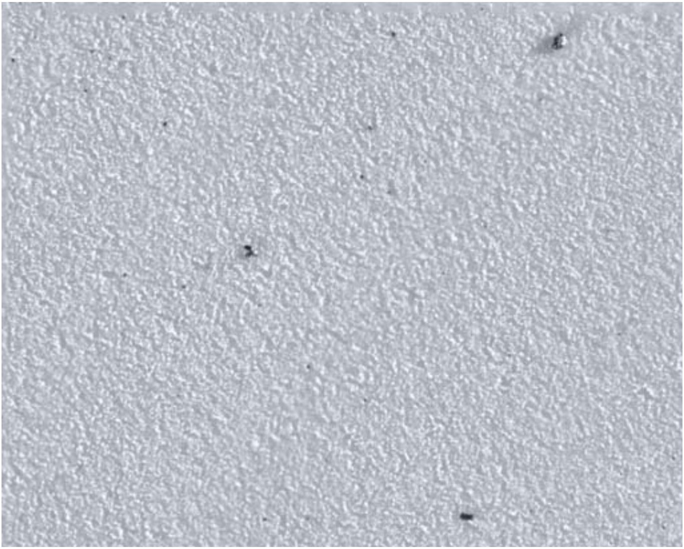
ISO 12/11/6

(NAS 1638: class 2)

Particle size		
≥ 4 µm(c)	≥ 6 µm(c)	≥ 14 µm(c)
Particle count		
2.000 to 4.000	1.000 to 2.000	32 to 64

ISO 14/13/9

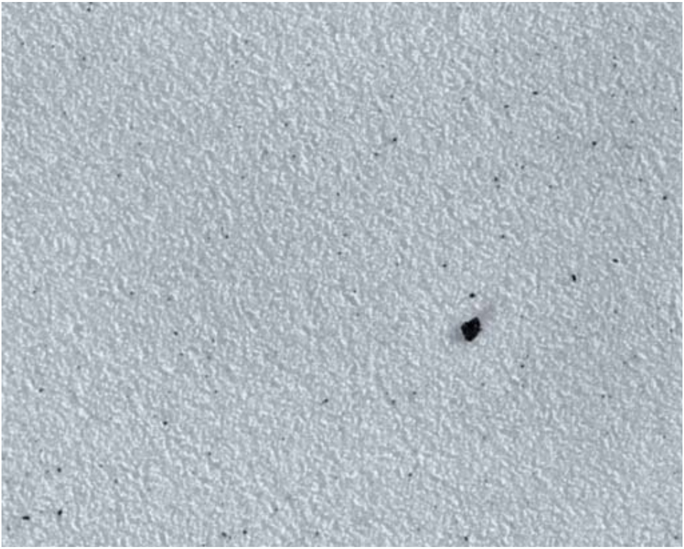
(NAS 1638: class 3)



Particle size		
≥ 4 µm(c)	≥ 6 µm(c)	≥ 14 µm(c)
Particle count		
8.000 to 16.000	4.000 to 8.000	250 to 500

ISO 16/14/10

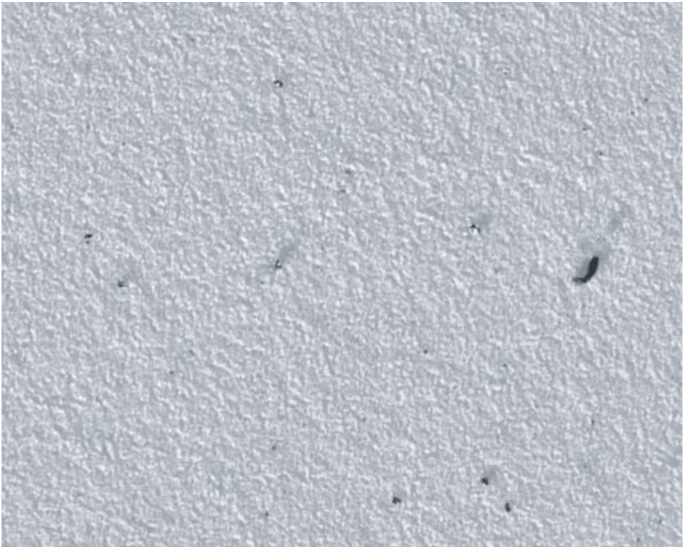
(NAS 1638: class 5)



Particle size		
≥ 4 µm(c)	≥ 6 µm(c)	≥ 14 µm(c)
Particle count		
32.000 to 64.000	8.000 to 16.000	500 to 1.000

ISO 17/15/13

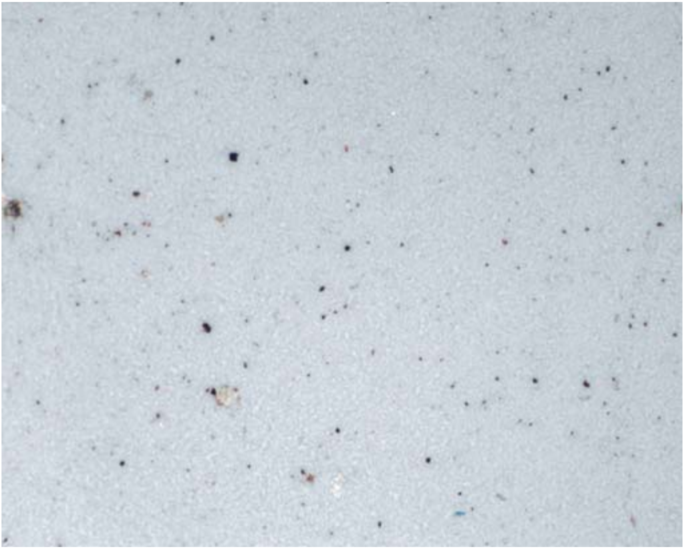
(NAS 1638: class 6)



Particle size		
≥ 4 µm(c)	≥ 6 µm(c)	≥ 14 µm(c)
Particle count		
64.000 to 130.000	16.000 to 32.000	4.000 to 8.000

ISO 18/16/13

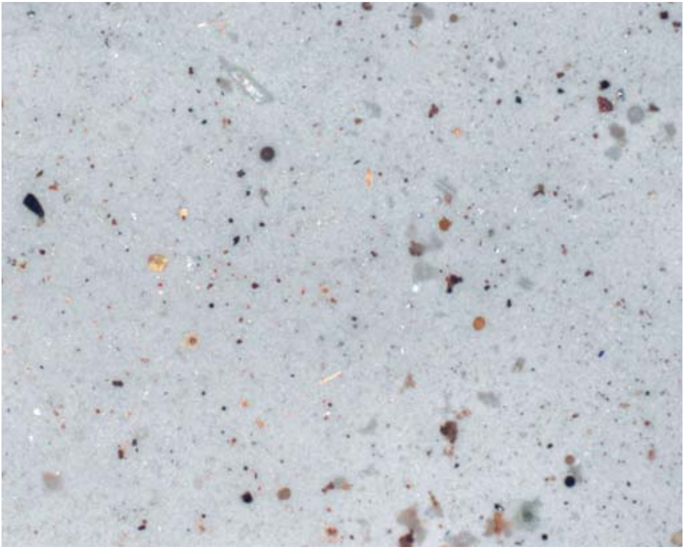
(NAS 1638: class 7)



Particle size		
≥ 4 µm(c)	≥ 6 µm(c)	≥ 14 µm(c)
Particle count		
130.000 to 250.000	32.000 to 64.000	4.000 to 8.000

ISO 19/17/14

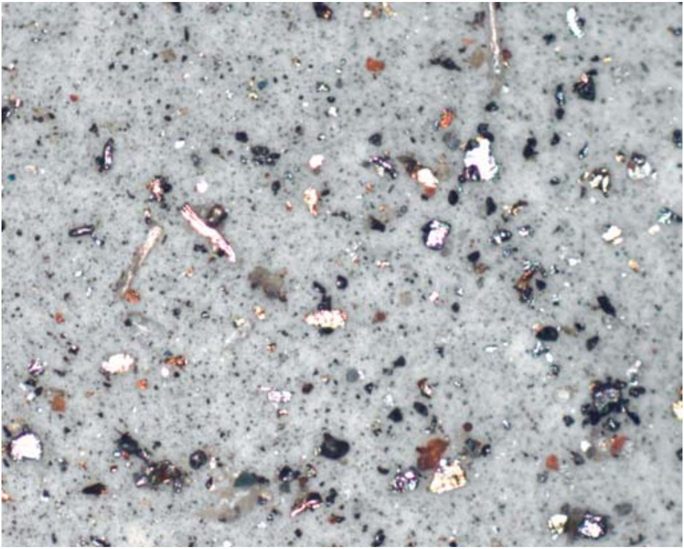
(NAS 1638: class 8)



Particle size		
≥ 4 µm(c)	≥ 6 µm(c)	≥ 14 µm(c)
Particle count		
250.000 to 500.000	64.000 to 130.000	8.000 to 16.000

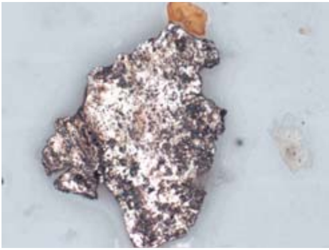
ISO 22/19/17

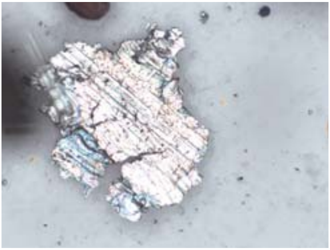
(NAS 1638: class 10)



Particle size		
≥ 4 µm(c)	≥ 6 µm(c)	≥ 14 µm(c)
Particle count		
2.000.000 to 4.000.000	250.000 to 500.000	64.000 to 130.000

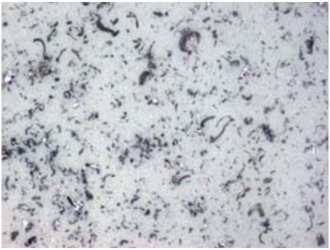
Fatigue wear, 500 x ▶





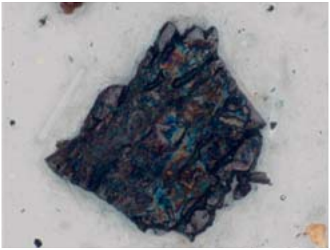
◀ **Sliding wear, 500 x**

Cutting wear, 100 x ▶



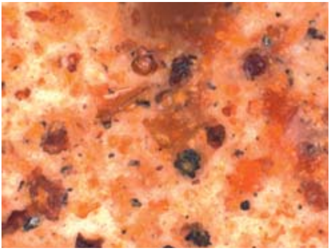
◀ **Cutting wear, 500 x**

Dark, shiny metal, 500 x ▶



◀ **Copper particles, 500 x**

Red iron oxide, 500 x ▶

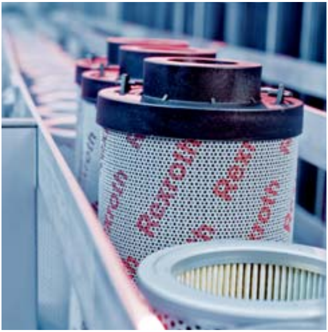


◀ **Greasy/resinous residue, 500 x**

Seal abrasion, 500 x ▶

Fluid and Product Service

- Oil analysis – particles, water content, residual additives
- Filter element analysis
- System flushing and decontamination
- Advice on oil cleanliness and oil maintenance



Extract from the product range

Oil Analysis Case

- Contamination control for hydraulic fluids and lubricants
- With sampling equipment

Sampling Equipment

- Safe and simple oil sampling from pressure lines and oil containers

Laser Particle Counter

- Measurement category: ISO 4406 oil cleanliness code
- SAE AS 4059 oil cleanliness code
- Measurement range: 4 – 21 µm(c) with optional printer and pump

Datasheet: 51430

Online Particle Monitor

- Measurement category: ISO 4406 oil cleanliness code
- 4, 6, 14 and 21 µm(c)

Online Water-Content Measuring Device

- Application: Online determination of water activity in hydraulic systems and lubricating oil
- Measurement range: 0 – 100 % of the saturation of water in oil
- With optional data memory, network or alarm module

VacuClean® Oil Purification

- Operating data: End vacuum up to 50 mbar
- Oil flow rate: 20 l/min, 5 – 50 l/min, 5 – 80 l/min

Offline Filter Units (portable, 2- and 4-wheel design)

- Volume flow: 10, 15, 30, 35, 50, 80 l/min.
- Filter type: 40 LE 0018, 7 SL 45, 7 SL 130, 40 FLE 0045, 40 FLE 0095, 40 FLE 0120
- Adjustable volume flow: 40 – 150 l/min.
- Filter type: 40 FLE 0270C

Wide Product Range of Filterelements made of paper, metal and fiberglass

- Filtration grade: 1 – 1500 µm
- Filter area: 10 cm^2 – 4,8 m^2

Datasheet: 51420

Inline Filter

Datasheet:

51400 Type 40/100 LEN 0040 to 0400
51401 Type 40 FLEN 0160 to 1000
51402 Type 100 FLEN 0160 to 0630
51403 Type 16 FE 2500 to 7500
51421 Type 245 LEN 0040 to 0400
51422 Type 350 LEN 0040 to 0400
51423 Type 445 LEN 0040 to 1000

Tank Mounted Filter

Datasheet:

51424 Type 10 TEN 004
51425 Type 10 TEN 0160, 0250, 0400, 0630, 1000

Duplex Filter/ Change-Over Inline Filter

Datasheet:

51406 Type 50/150 LDN 0040 to 0400
51407 Type 40 FLDKN 0063 to 0630
51408 Type 40 FLDN 0160 to 1001
51409 Type 100 FLDN 0160 to 1000
51410 Type 16 FD 2500 to 7500

Manifold Mounted Filter

Datasheet:

51417 Type 450 PBFN 0040 to 1000
51418 Type 245 PSFN 0040 to 0400
51419 Type 350 PSFN 0040 to 1000
51427 Type 320 PZR 025, 075, 125

Filter for Mobile Hydraulics

Datasheet:
51426 Type 7SL 30 to 260

Filter for Process Engineering

Type 16 FKE 25/400 to 150/2500
Type 40 FKE 25/400 to 150/2500
Type 16 FKD 25/400 to 150/2500
Type 40 FKD 25/400 to 150/2500

Design coated in Steel
and Stainless Steel

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