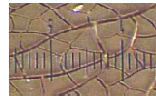




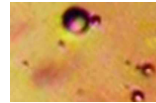
HYDAC INTERNATIONAL Fluid Problems.

- ...can and will cost you and your company a fortune!

Oil



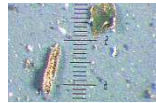
Oil aging



Water in oil



Rust



Particle Contamination



Bearing wear



Zinc soap

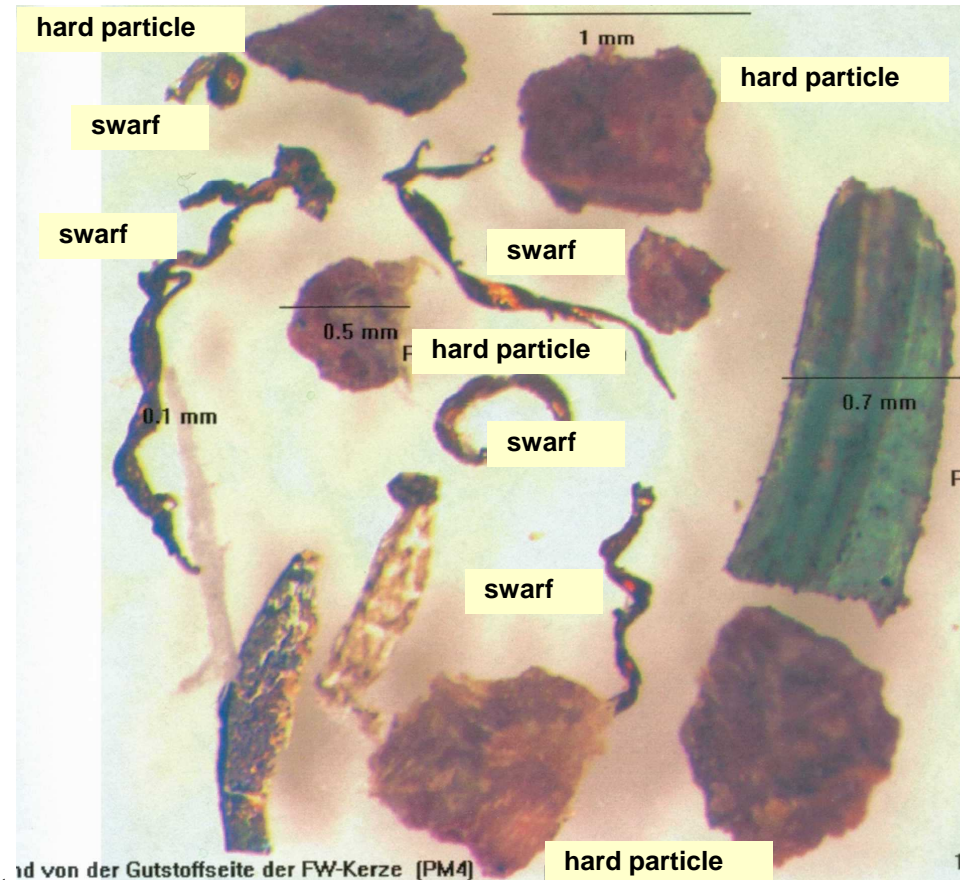


Corrosion in reservoir floor



Damaged components

Water





HYDAC INTERNATIONAL

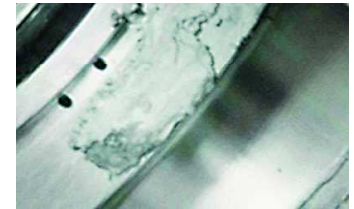
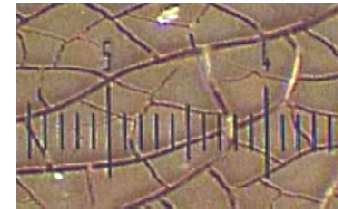
Fluid Problems.

Fact is, that

70-80% of all failures of hydraulic systems

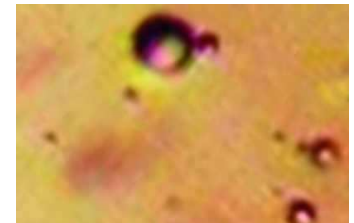
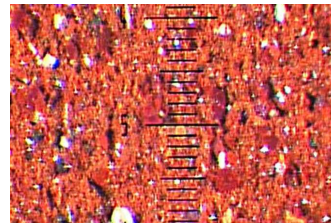
and

up to 45% of all bearing failures



are caused by

contamination of the hydraulic fluid or lubricant





HYDAC INTERNATIONAL

Types of Contamination

SOLID



LIQUID



GAS





HYDAC

INTERNATIONAL

Types of Contamination

SOLID



LIQUID



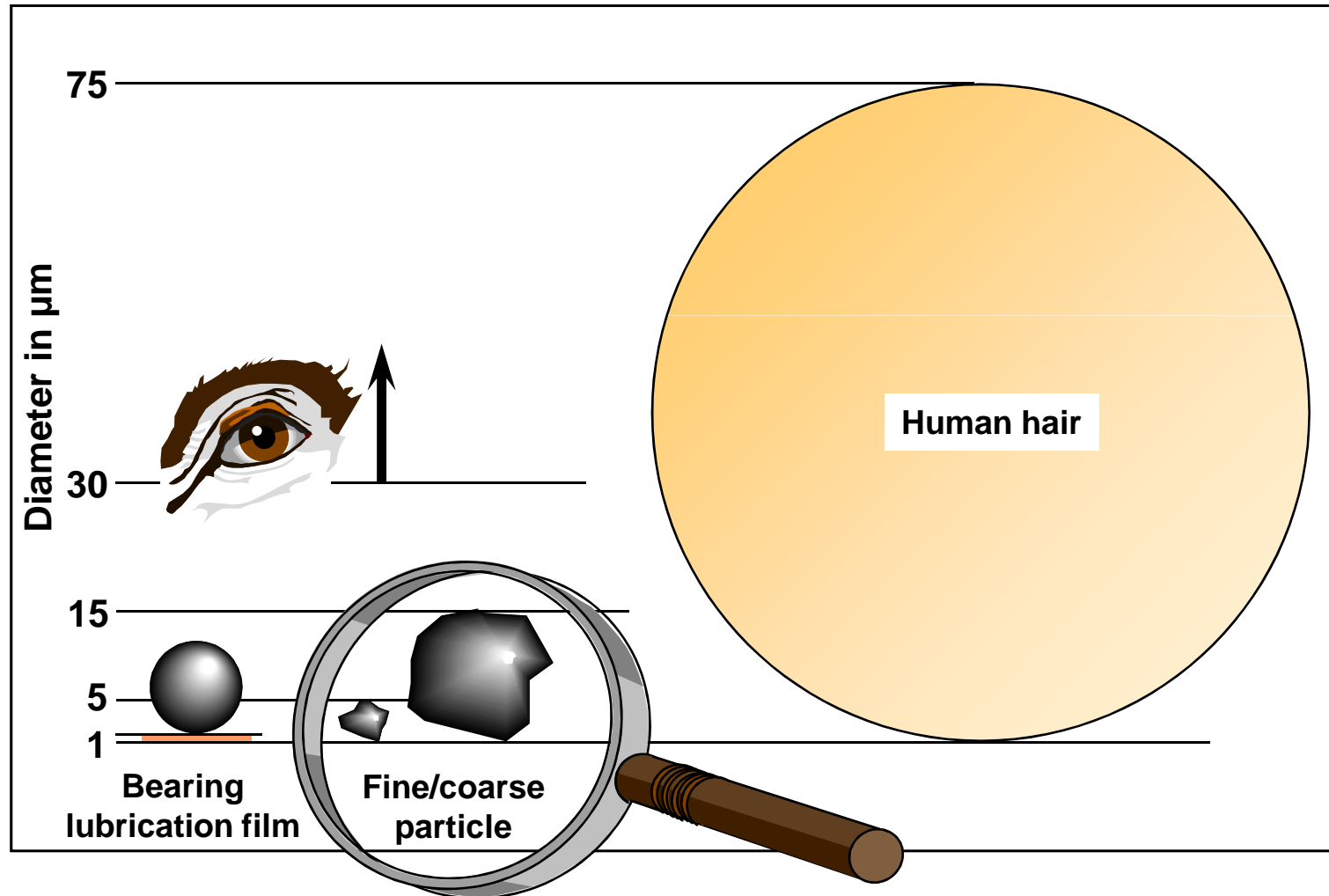
GAS





HYDAC INTERNATIONAL

Particle Proportions





HYDAC INTERNATIONAL

How do we measure fluid contamination?

ISO / NAS codes:
*Are a measure of
particles/particulate per a
specific volume of fluid*





HYDAC INTERNATIONAL

Structure of ISO-Code

max. amount of dirt particles
in 100 ml > given size

ISO 4406: 1999 (E) - ISO Contamination Code

Number of Particles per 100 ml

Scale Number	More Than	Up To and Including
28	130,000,000	250,000,000
27	64,000,000	130,000,000
26	32,000,000	64,000,000
25	16,000,000	32,000,000
24	8,000,000	16,000,000
23	4,000,000	8,000,000
22	2,000,000	4,000,000
21	1,000,000	2,000,000
20	500,000	1,000,000
19	250,000	500,000
18	130,000	250,000
17	64,000	130,000
16	32,000	64,000
15	16,000	32,000

Chart cont...

Scale Number	More Than	Up To and Including
14	8,000	16,000
13	4,000	8,000
12	2,000	4,000
11	1,000	2,000
10	500	1,000
9	250	500
8	130	250
7	64	130
6	32	64
5	16	32
4	8	16
3	4	8
2	2	4
1	1	2
0	0.5	1



HYDAC INTERNATIONAL

How do we measure fluid contamination?

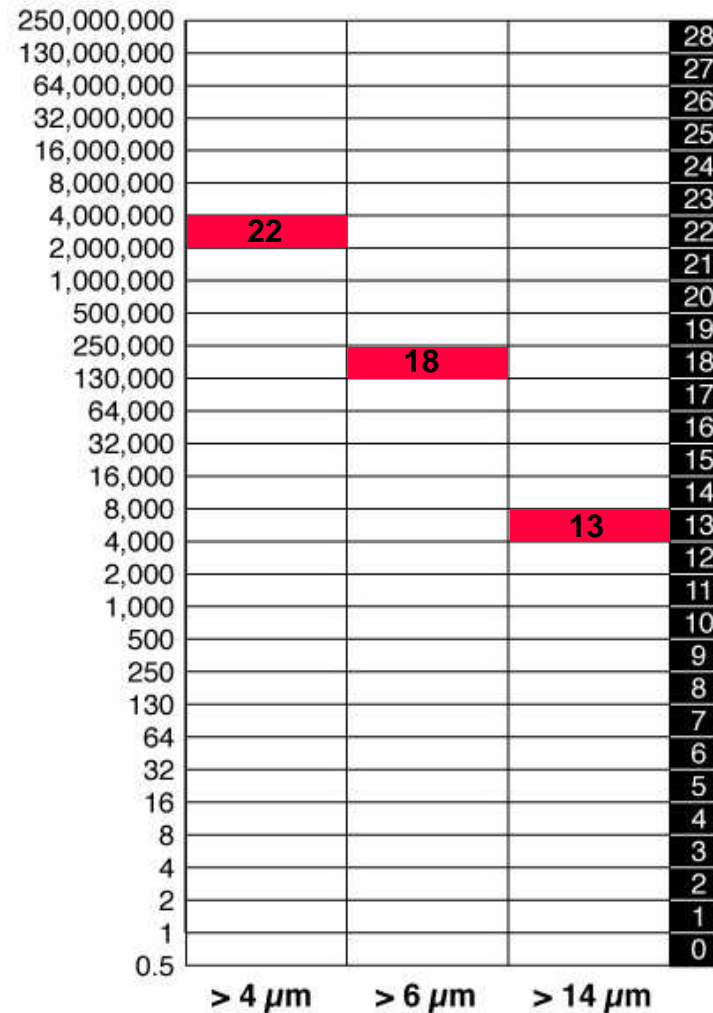
Structure of ISO-Code:

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 = 195,000
larger than 14µm = 4,250

ISO Code = 22 / 18 / 13





HYDAC INTERNATIONAL

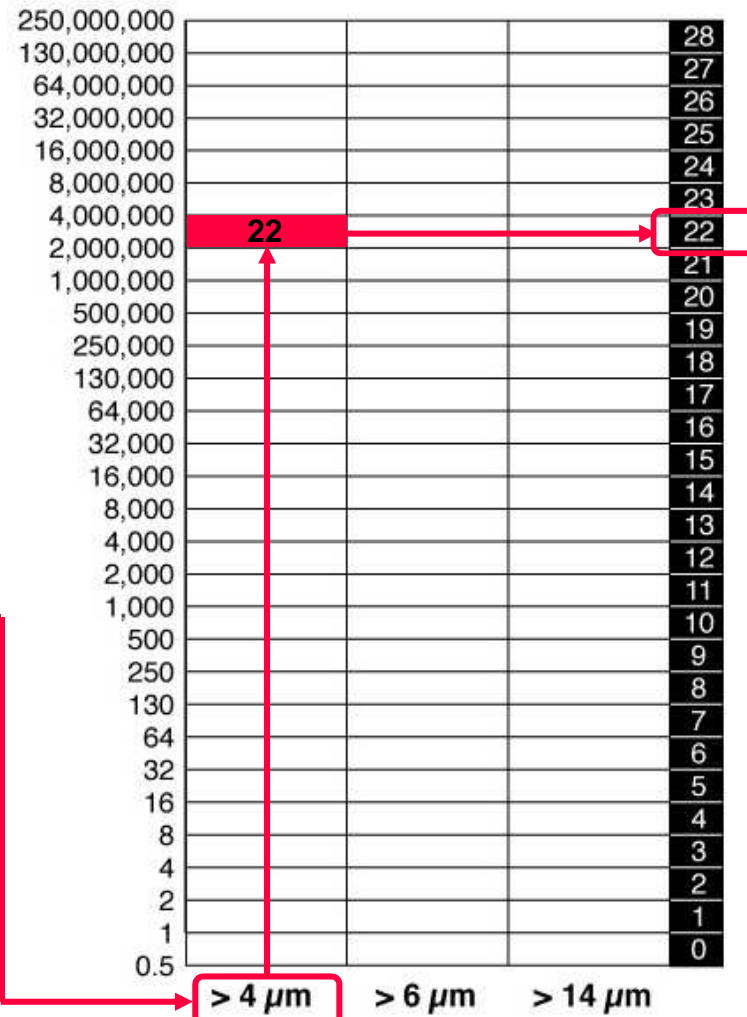
How do we measure fluid contamination?

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



ISO Code = **22** / /



HYDAC INTERNATIONAL

How do we measure fluid contamination?

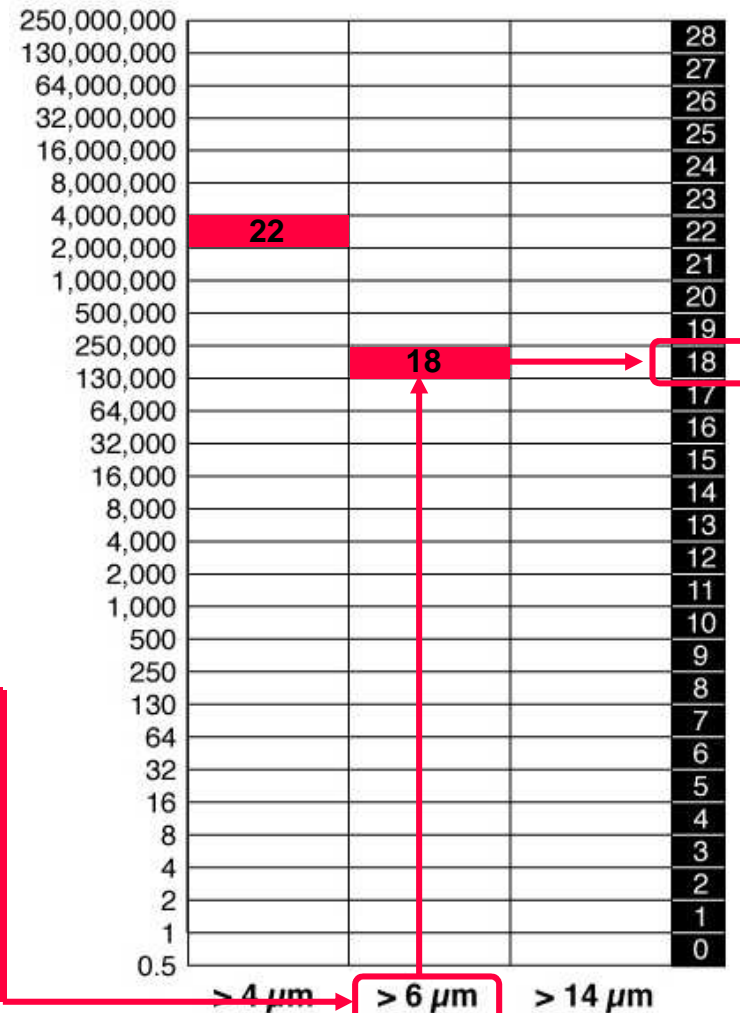
Structure of ISO-Code:

amount of dirt particles
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larger than these specified sizes:
4µm / 6µm / 14µm

Example:

larger than 4µm = 2,234,000
larger than 6µm = 195,000

ISO Code = 22 / 18 /





HYDAC INTERNATIONAL

How do we measure fluid contamination?

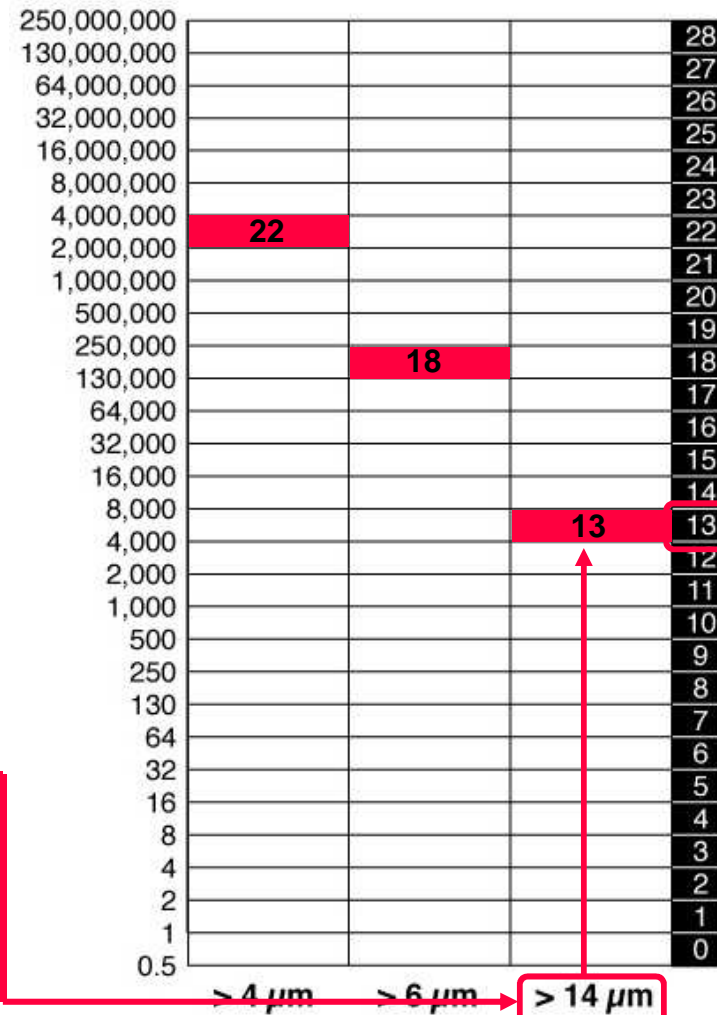
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HYDAC INTERNATIONAL

How do we measure fluid contamination?

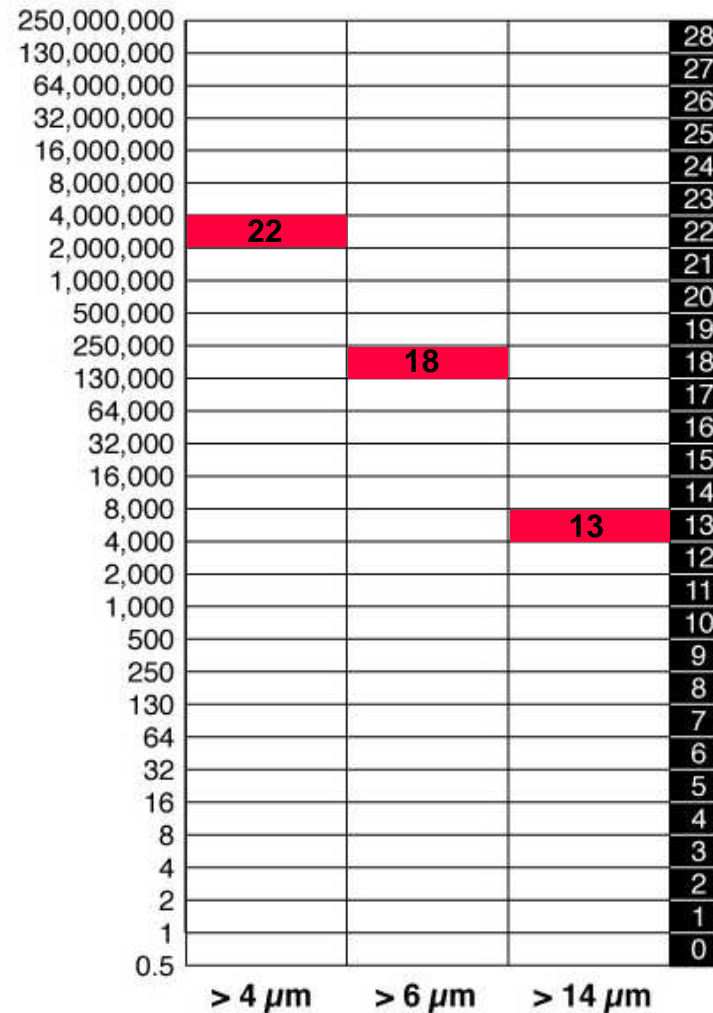
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HYDAC INTERNATIONAL

How do we measure fluid contamination?

Structure of SAE AS 4059 (previously NAS Codes)

Class	4-6 μm	6-14 μm	14-21 μm	>21 μm
00	125	22	4	1
0	250	44	8	2
1	500	89	16	3
2	1000	178	32	6
3	2000	356	63	11
4	4000	712	126	22
5	8000	1425	253	45
6	16000	2850	506	90
7	32000	5700	1012	180
8	64000	11400	2025	360
9	128000	22800	4050	720
10	256000	45600	8100	1440
11	51200	91200	16200	2880
12	1024000	182400	32400	5760

NAS 6

max. amount of dirt particles in 100ml at given size



HYDAC INTERNATIONAL

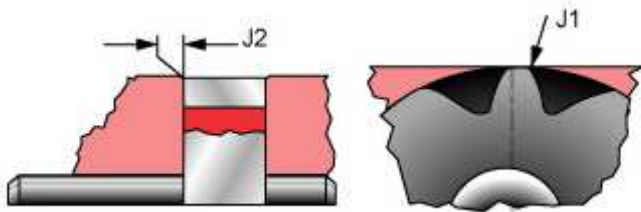
Recommended Cleanliness Classes

Hydraulic- components	Cleanliness class to		recommended absolute filtration rating [μm]
	NAS 1638	ISO DIS 4406	
Gear pumps	9	21/18/15	10
Cylinders	9	21/18/15	10
Directional valves	9	21/18/15	10
Relief valves	9	21/18/15	10
Throttle valves	9	21/18/15	10
Piston pumps	9	21/18/15	10
Vane pumps	9	21/18/15	10
Pressure valves	6-8	19/16/13	5
Proportional valves	6-8	19/16/13	5
Servo valves	4	16/13/10	3
Servo cylinders	4	16/13/10	3

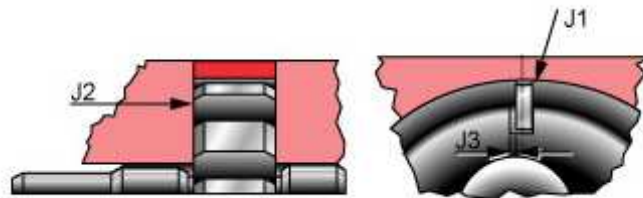


HYDAC INTERNATIONAL

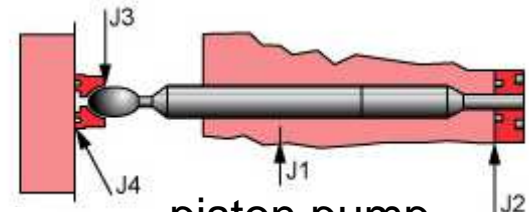
Hydraulic Component Clearances Are Critical and therefore require strategic filtration designs to remove the sized particles that will attack the most critical components of the hydraulic system



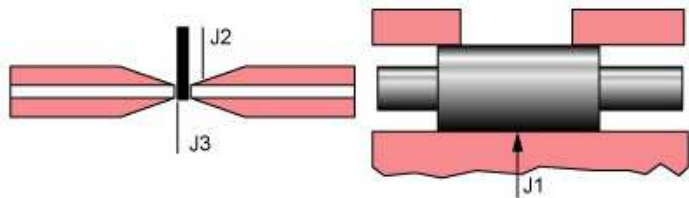
gear pump
J1: 0.5 - 5µm
J2: 0.5 - 5µm



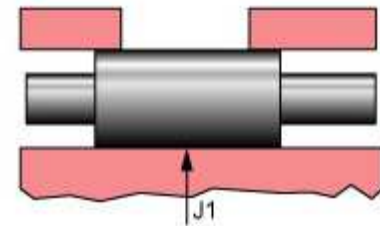
vane pump
J1: 0.5 - 5µm
J2: 5 - 20µm
J3: 30 - 40µm



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

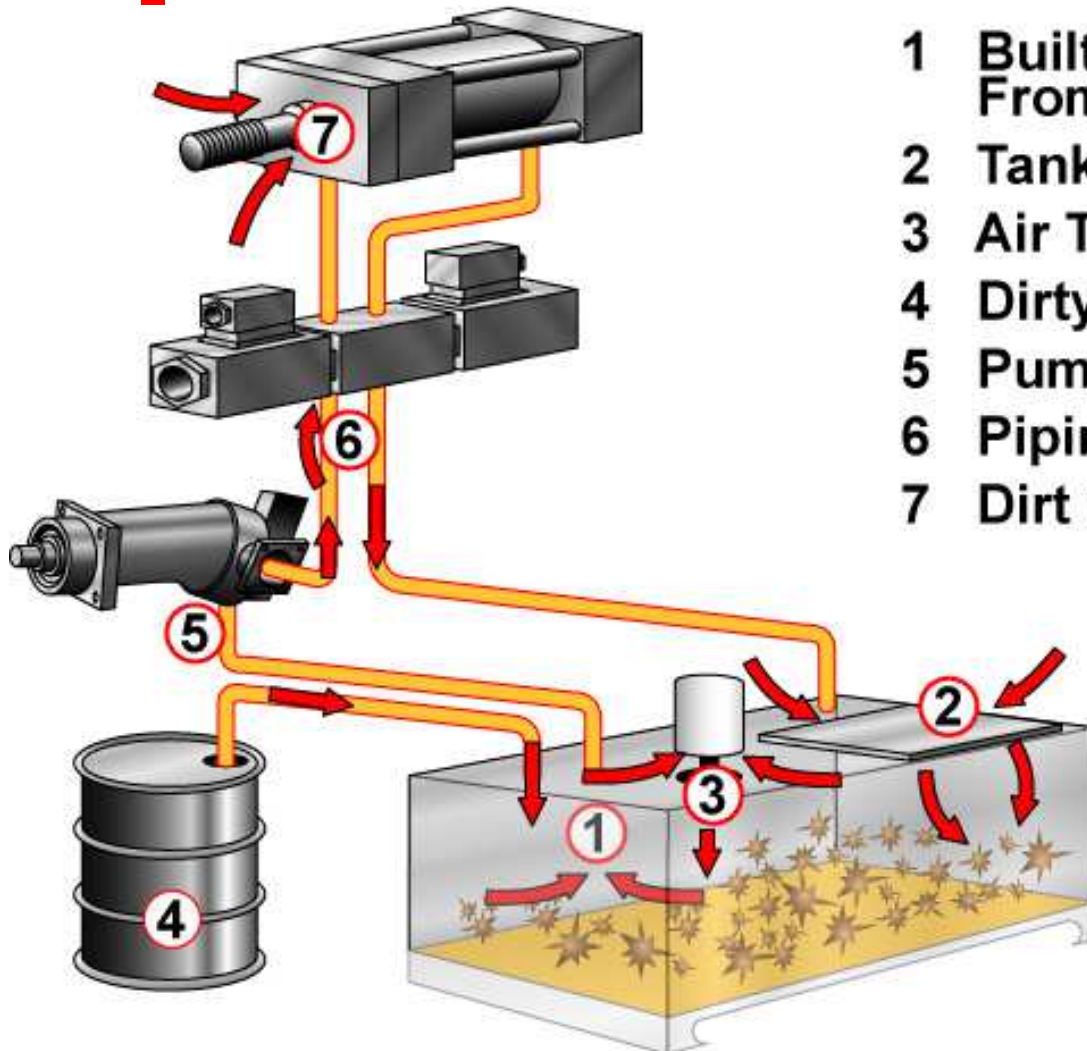


valve
J1: 5 - 25µm



HYDAC INTERNATIONAL

Sources of Contamination

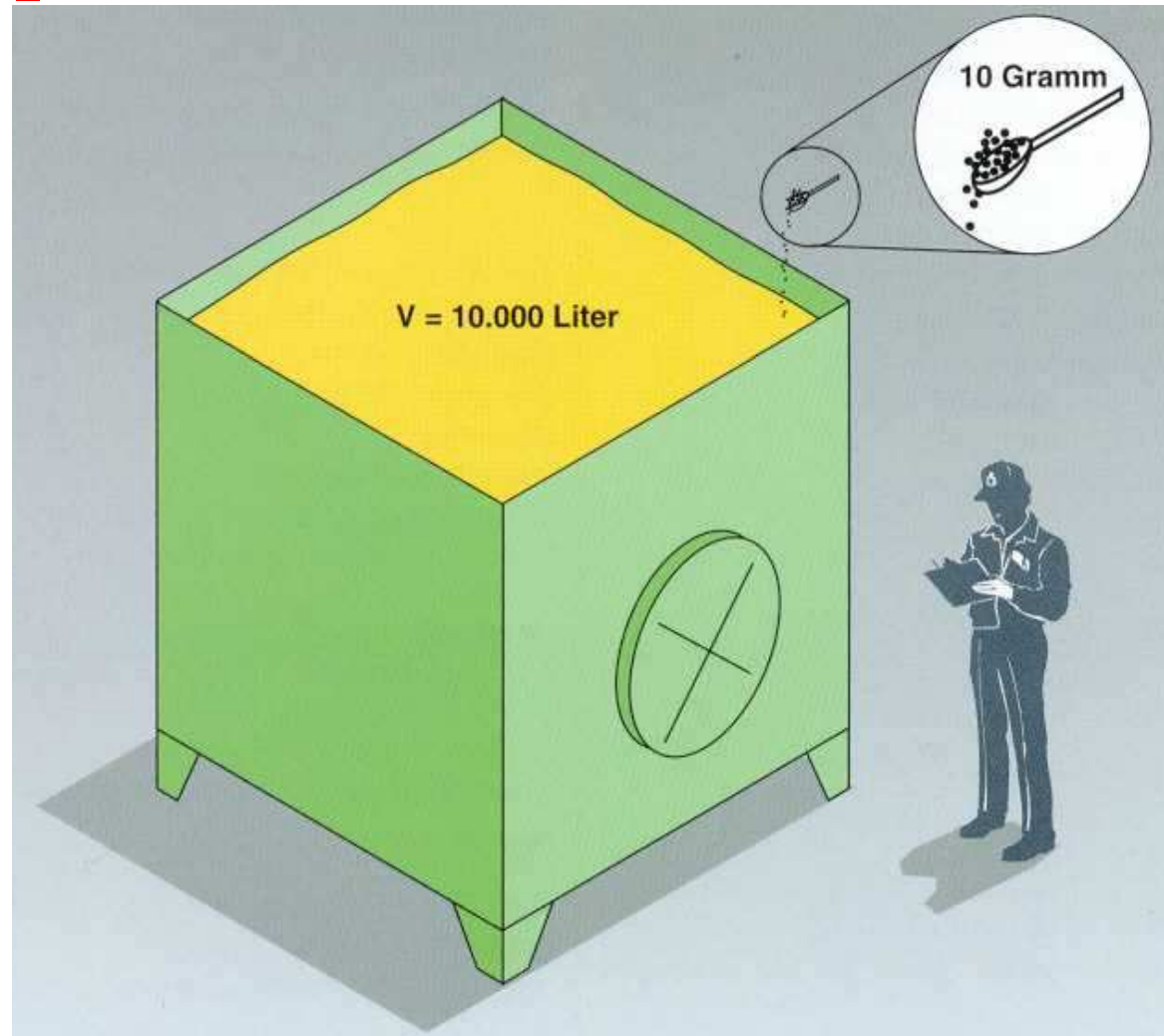


- 1 Built-In or From Maintenance
- 2 Tank Leakage
- 3 Air Through Breather
- 4 Dirty New Oil
- 5 Pump Wear
- 6 Piping Scale
- 7 Dirt On Rods



HYDAC INTERNATIONAL

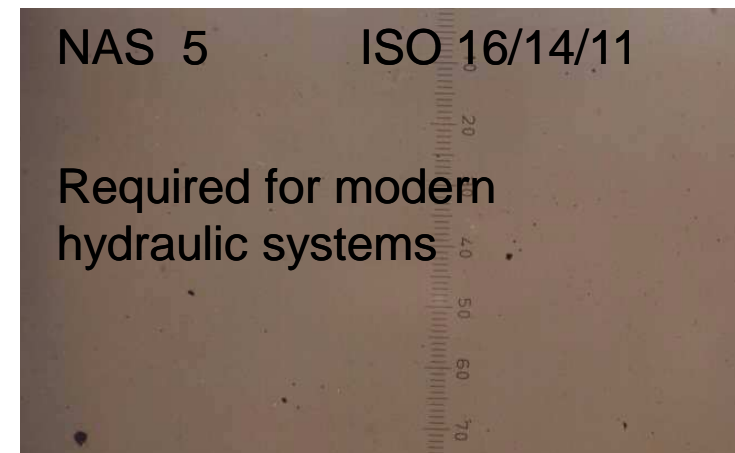
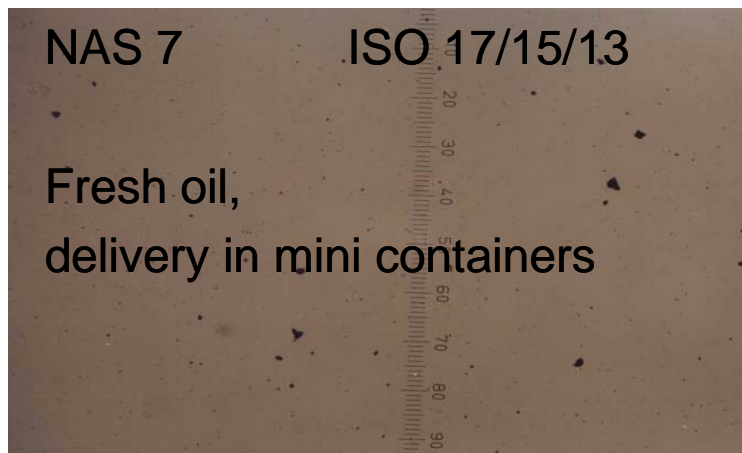
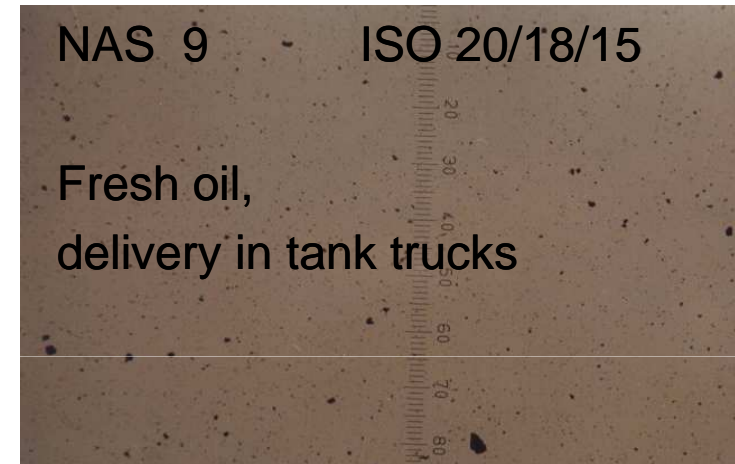
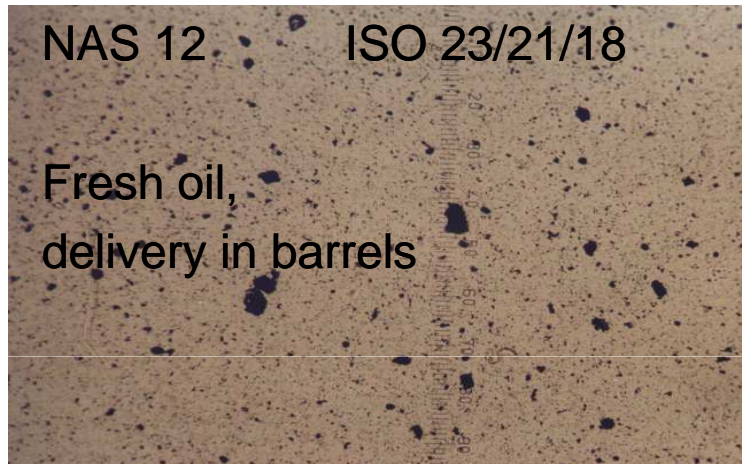
Contamination Class **NAS 7** or **ISO 17/14**





HYDAC INTERNATIONAL

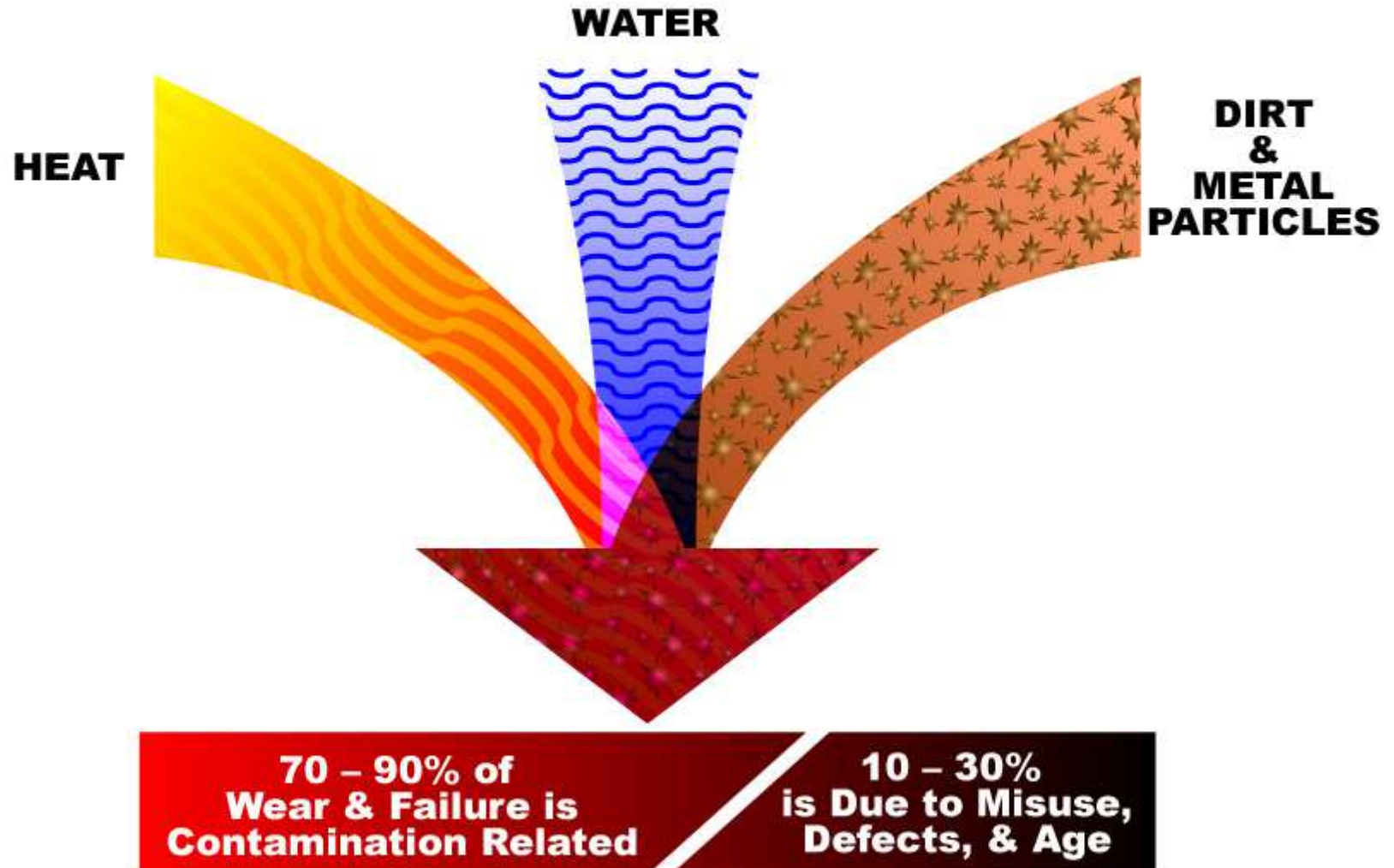
Contamination Classes





HYDAC INTERNATIONAL

Effects of Contamination





HYDAC

INTERNATIONAL

Types of Contamination

SOLID



LIQUID



GAS





HYDAC INTERNATIONAL

Effects of liquid contamination

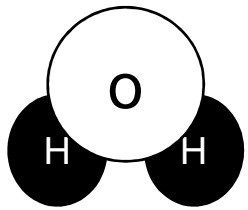
Water ingress sources

- **Fresh oil / storage**
- **Heat exchanger leaks**
- **Process water**
- **Seal leak**
- **Atmospheric condensation**



Effects of liquid contamination

Free and emulsified water causes most of the destruction to lubricants and machines



The water molecule is polar unlike the base oil.

Dissolved water

⇒ like humidity in the air. All water molecules are detached to polar compounds in the oil (e.g. additives, particles).

Emulsified or free water

⇒ like fog. When exceeding the saturation point, water forms either an emulsion, where microscopic globules of water are dispersed in stable suspension. This causes a visible cloud or haze or

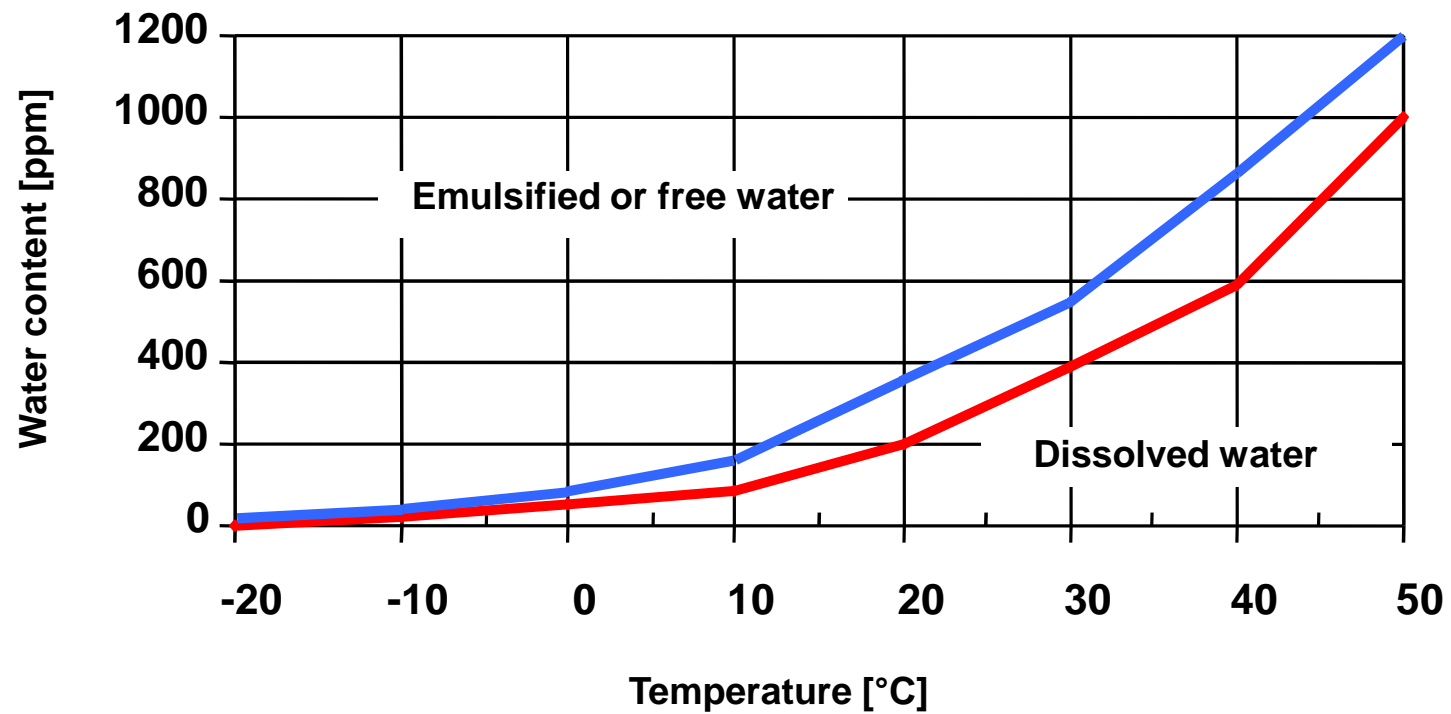
⇒ Water exists as free water like rain that settles to tank/sump bottom





Water in oil - Aqua Sensors (AS)

Saturation curve for different fluids





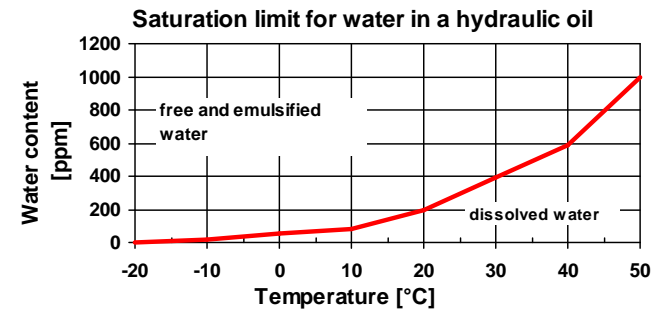
Effects of liquid contamination

How much water an oil can accept

100ppm
=
0,01%

Depends highly upon:

- Type of base oil
- Type and concentration of additives
- Existence of impurities
- Temperature



Oil	Dissolved [ppm]	Emulsified [ppm]	Free [ppm]
New hydraulic fluid	0-400	400-1000	>1000
Aged hydraulic fluid	0-800	800-5000	>5000

Examples with approx. values for a standard hydraulic fluid



Effects of liquid contamination

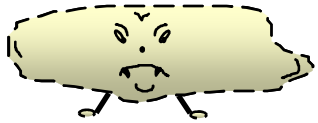
Related problems of oil ageing

- **Short service life of oil**
- **Filter plugging**
- **Corrosion**
- **Higher viscosity**
- **Sludge and sediment formation**
- **Additive mortality**
- **Component stiction (valves, ..)**
- **Detoriation in the lubrication characteristics
(increased wear and tear)**
- **Cavitation (vaporous cavitation, causing erosive wear)**
- **Detoriation in the control characteristics
(inaccuracies)**



HYDAC INTERNATIONAL

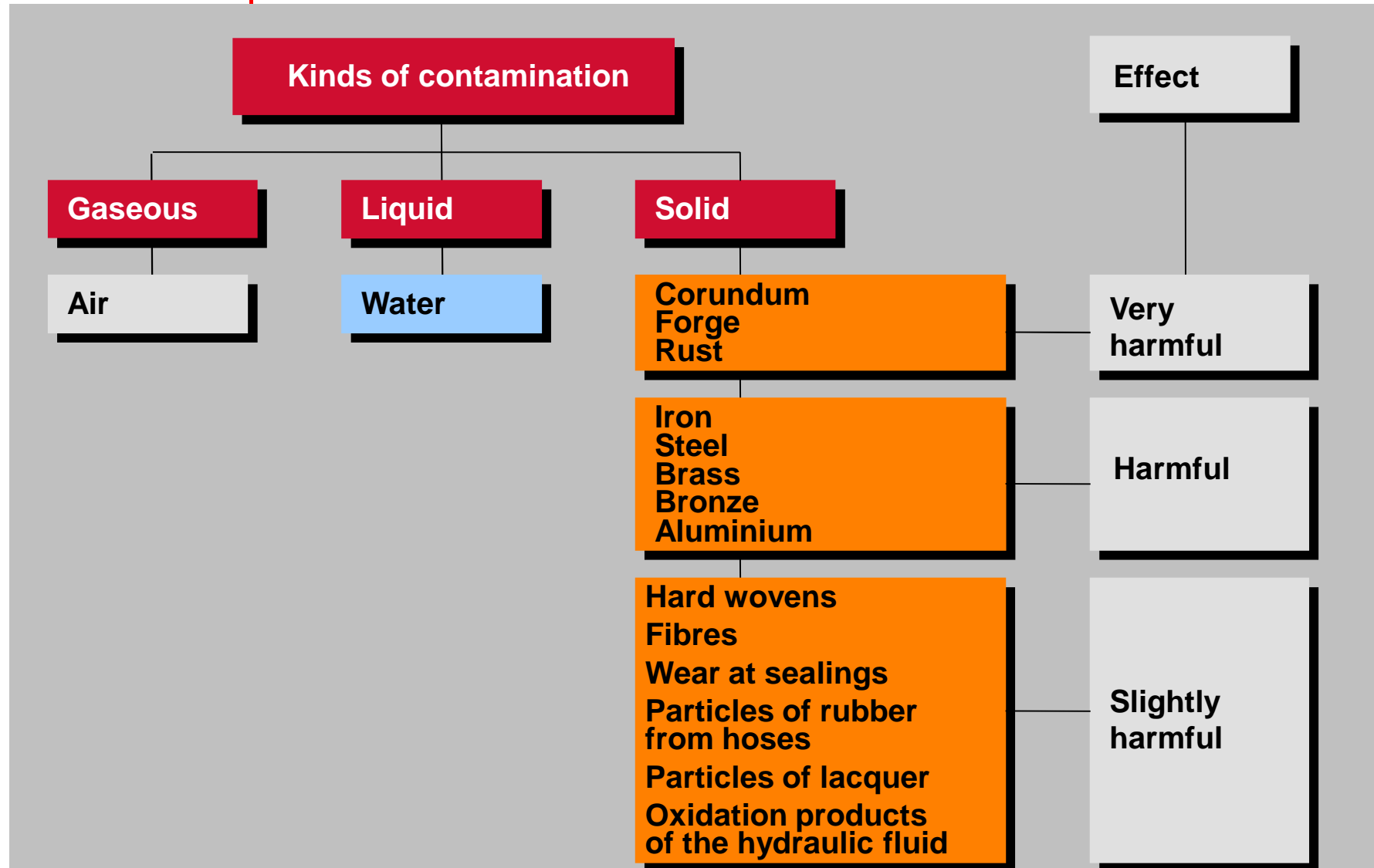
Effects of Gaseous Contamination



- **Cavitation**
- **Local overheating of the oil**
- **Diesel Effect**
- **Oil aging**
- **Leads to unstable control reactions**
- **Reduces the dynamic lubrication film**



Kinds and Effects - Summary

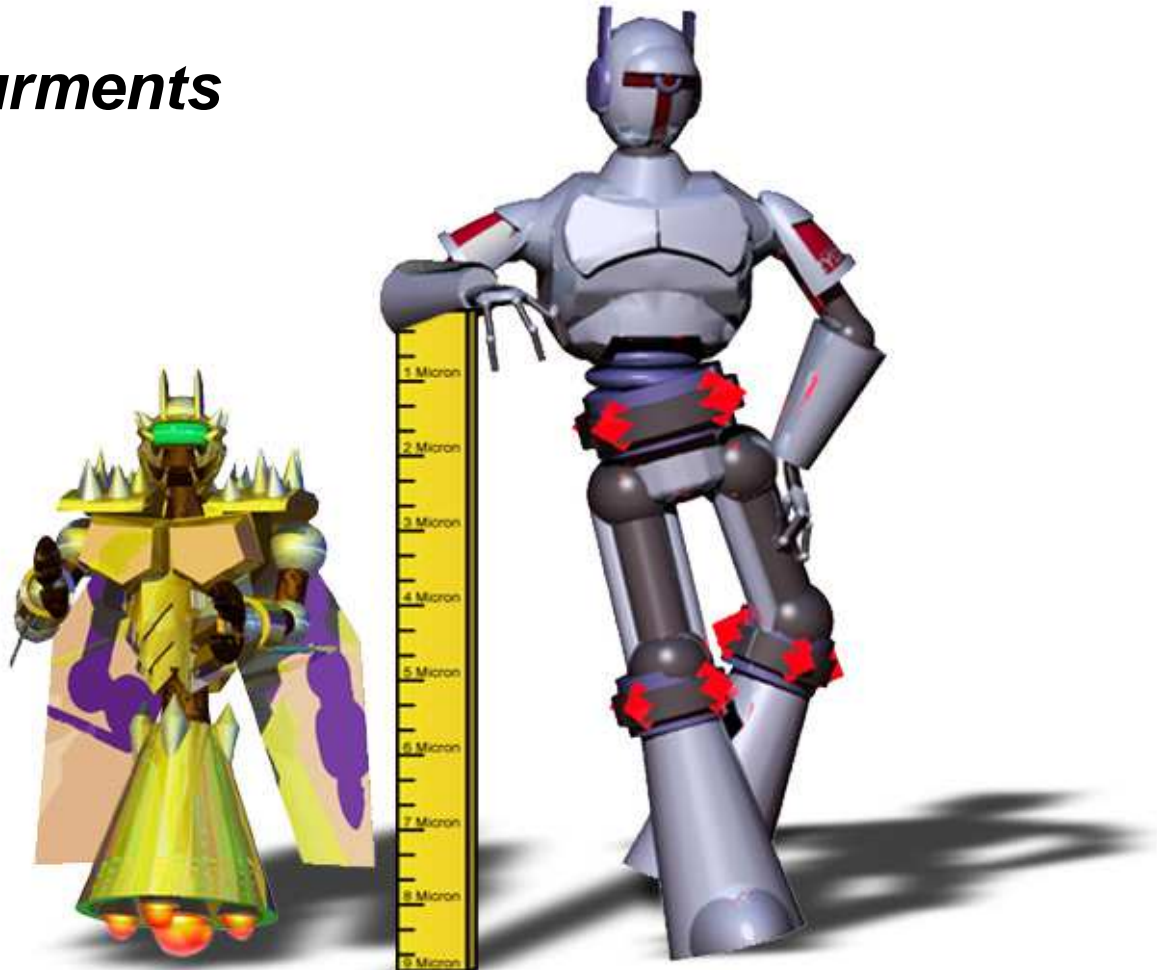




HYDAC INTERNATIONAL

How do we measure fluid contamination?

Methods for measurements





How do we measure fluid contamination?

Measuring procedures for solid particle contamination

Chart Title

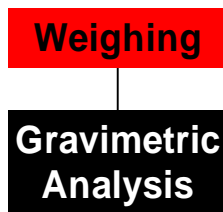
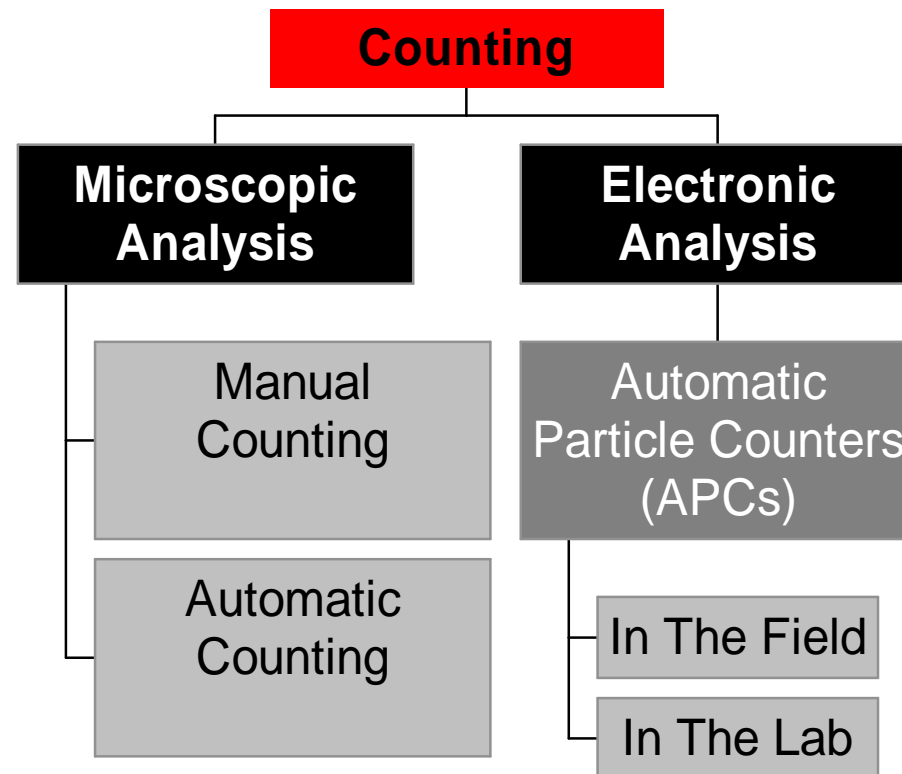


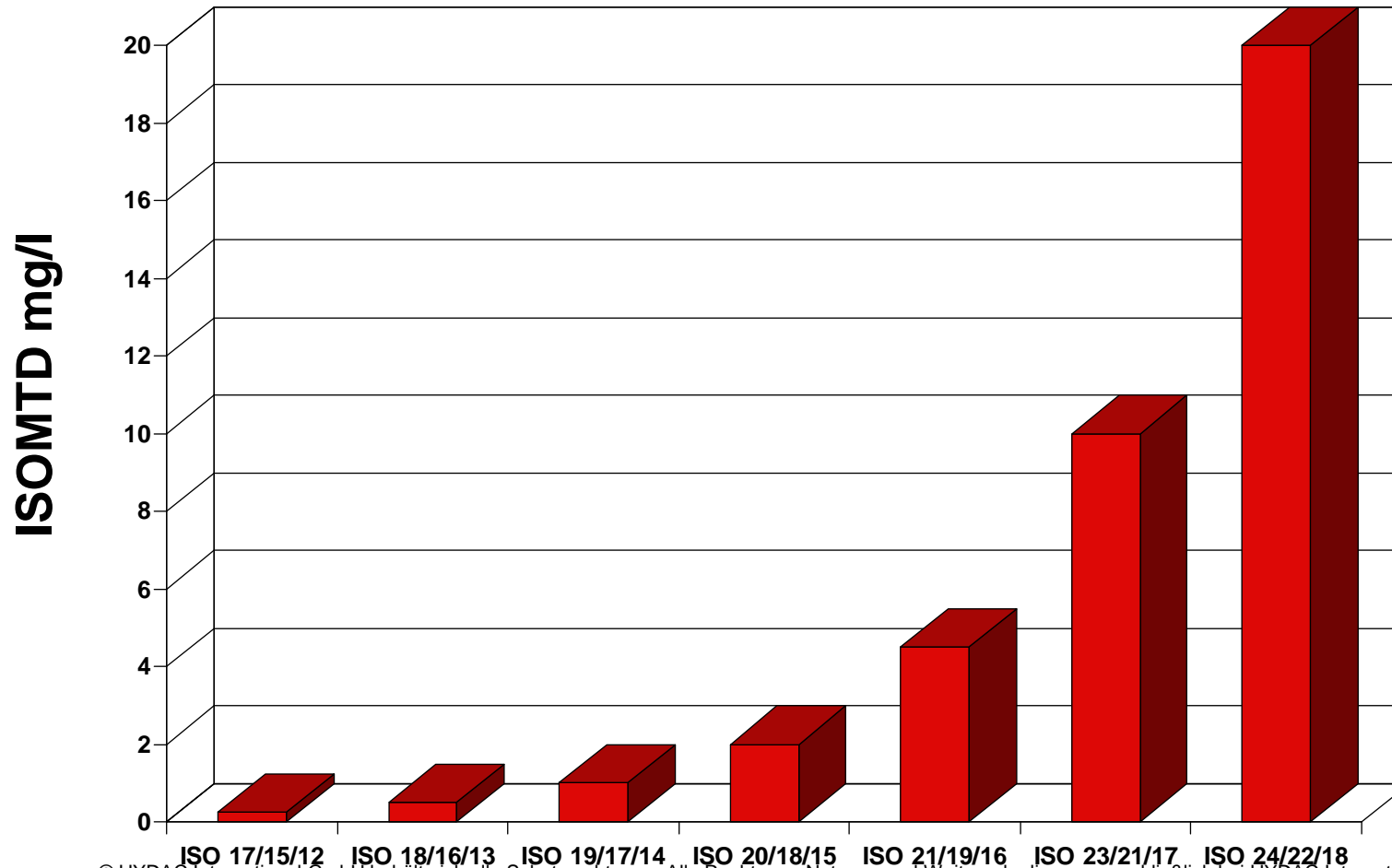
Chart Title





How do we measure fluid contamination?

Weighing: Gravimetric Concentration

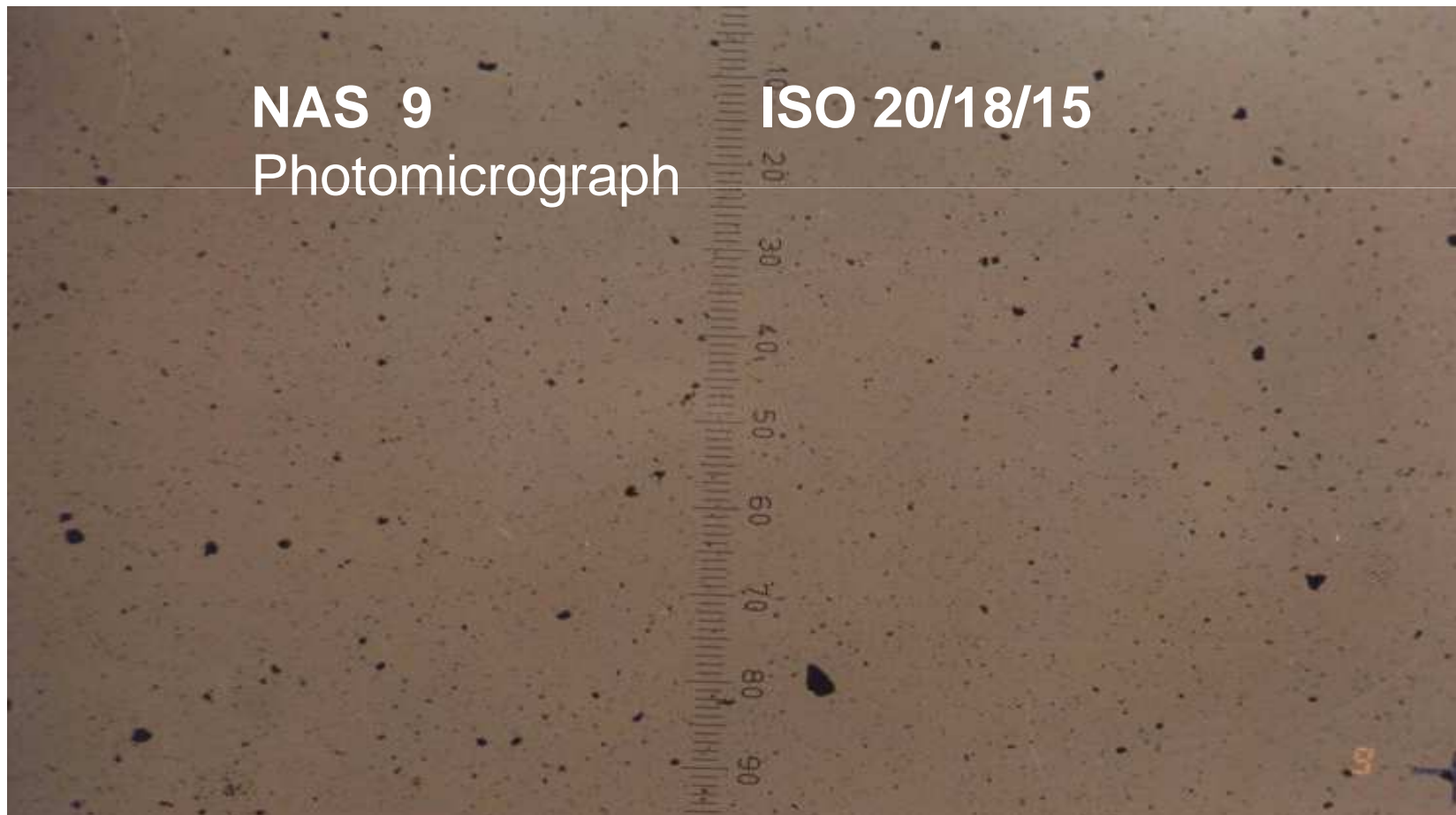




HYDAC INTERNATIONAL

How do we measure fluid contamination?

Microscopic analysis



NAS 9

Photomicrograph

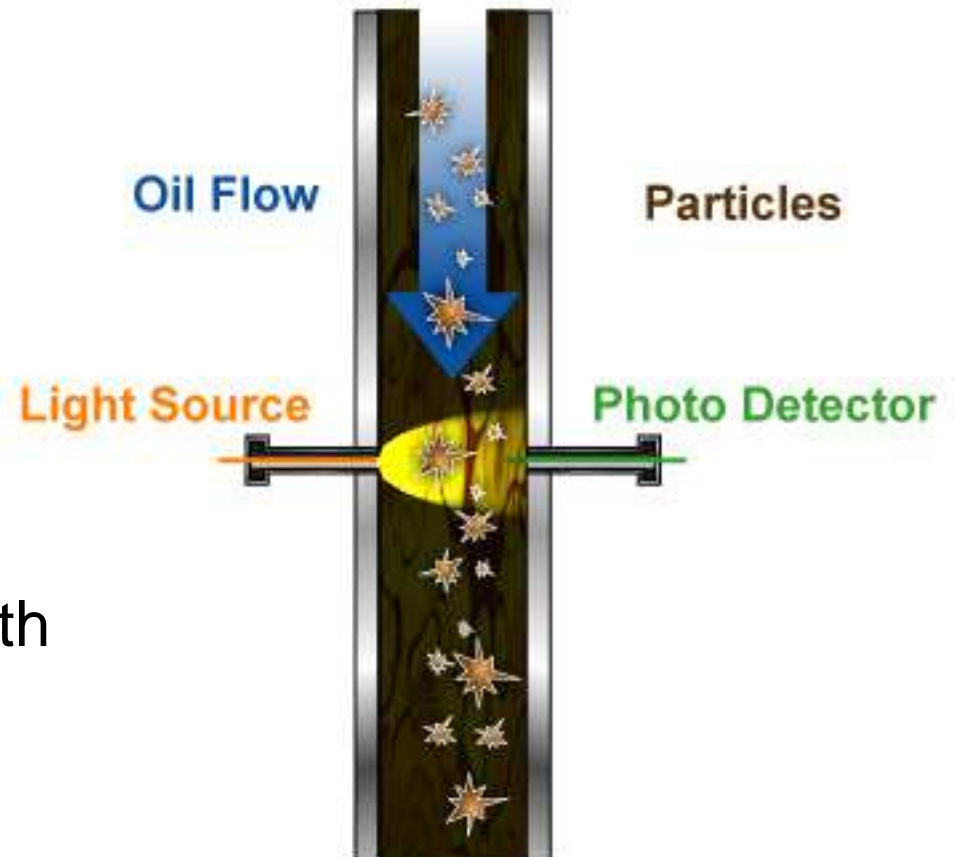
ISO 20/18/15

Basic principle

■ **light obscuration**

Light source is an LED light

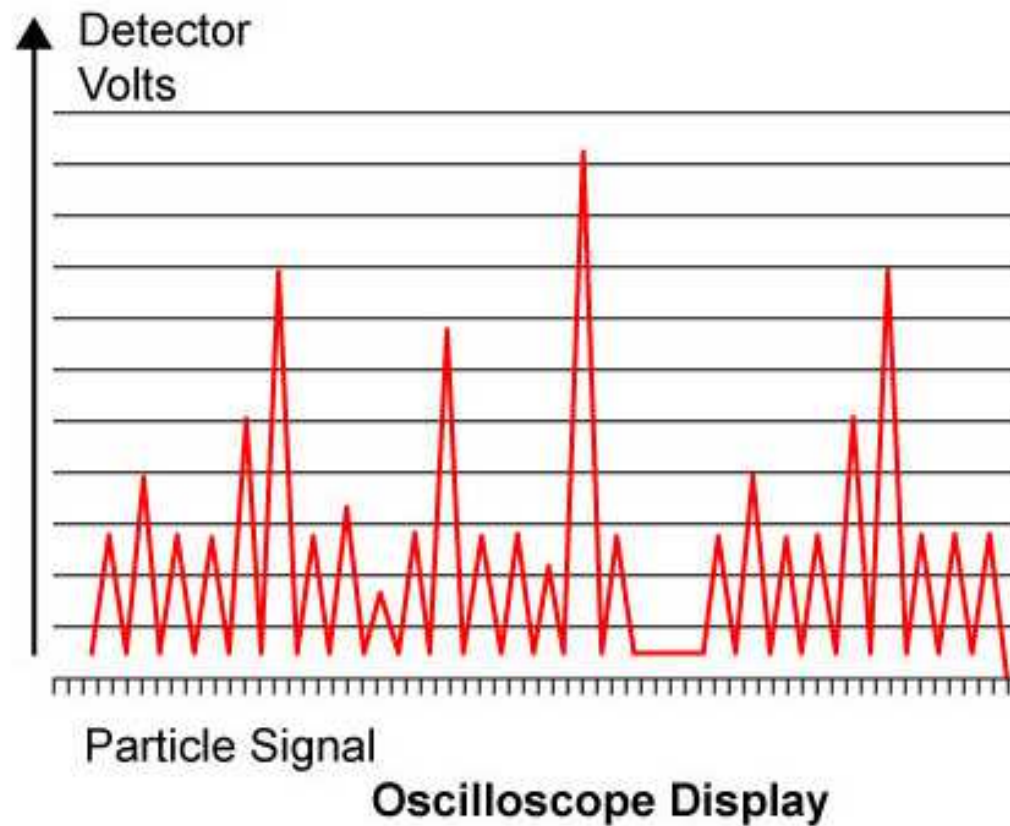
- Durability
- Holds calibration
- Does not saturate quickly with high contamination levels





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How do we measure fluid contamination?

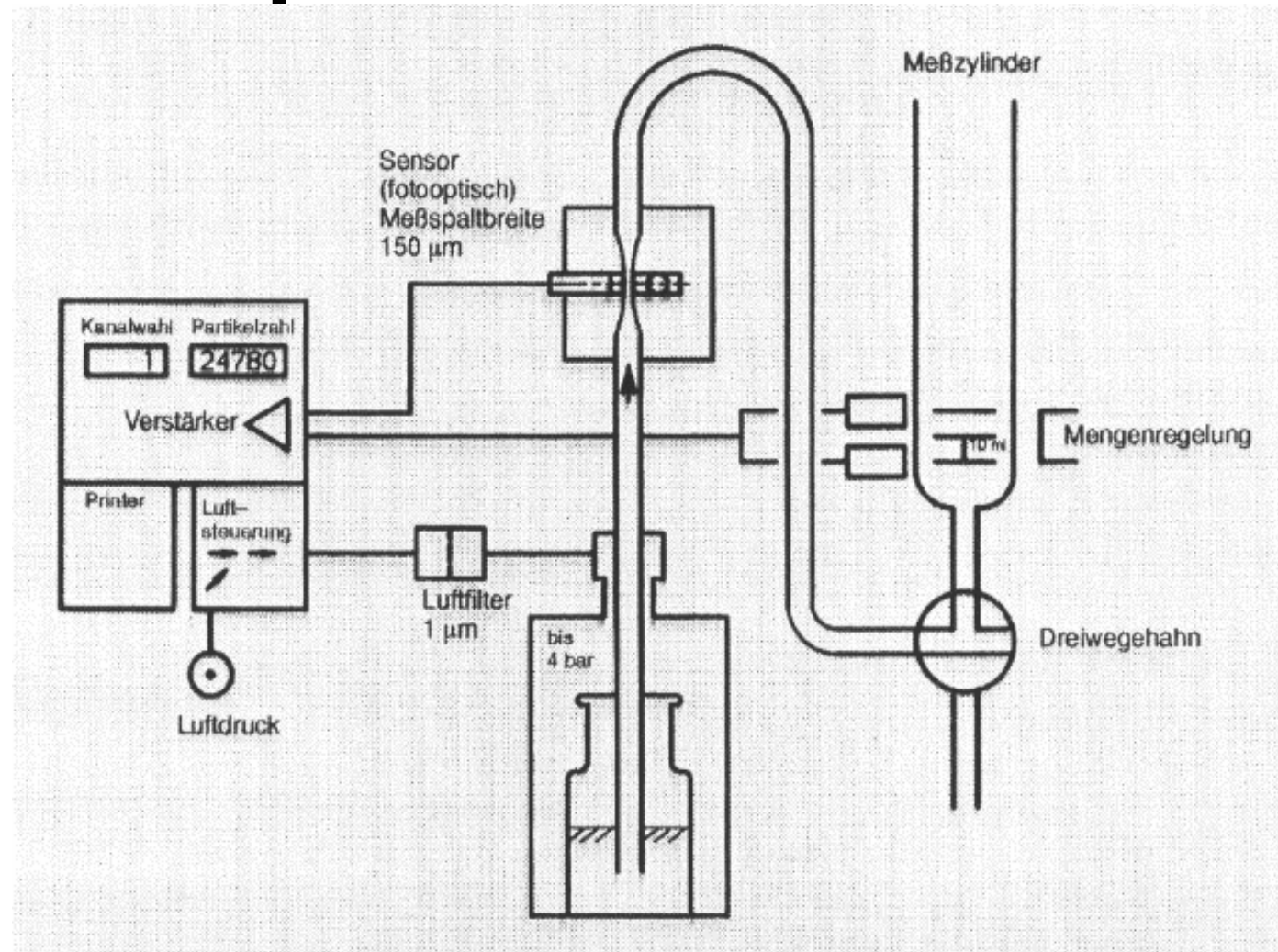


The number of pulses equals the number of particles.



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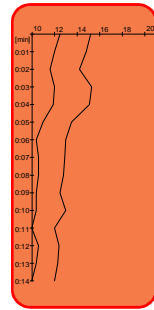
Particle Counter Principle



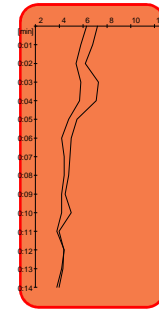


HYDAC INTERNATIONAL

Measuring with Fluid Control Unit (FCU)

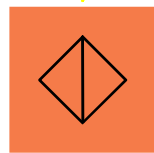


NAS



ISO

Document



Directing



PC



SPS

Controlling

**Measuring
and
Registering**



HYDAC INTERNATIONAL

How do we measure fluid contamination?

Electronic analysis:
In the field

FCU 2000 Series

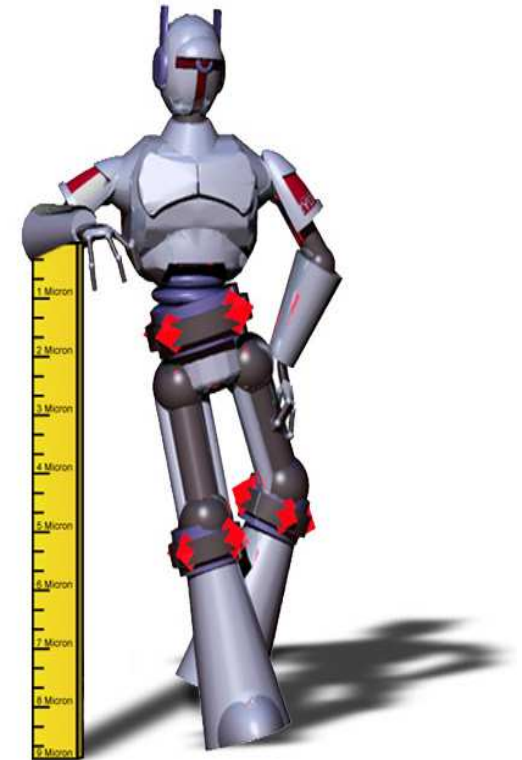




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How do we measure fluid contamination?

- **Karl-Fischer Analysis** (*chemical*) Laboratory
- **Turbidity Measurement** (*optical*) Field
- **Infrared Spectroscopy** (*optical*) Laboratory
- **Crackle Test** (*acoustic*) Field
- **Hydrogen Gas Method** (*chemical*) Field
(*WTK*) Water test kit
- **Aqua Sensor - AS-** (electronic
Field Installation)



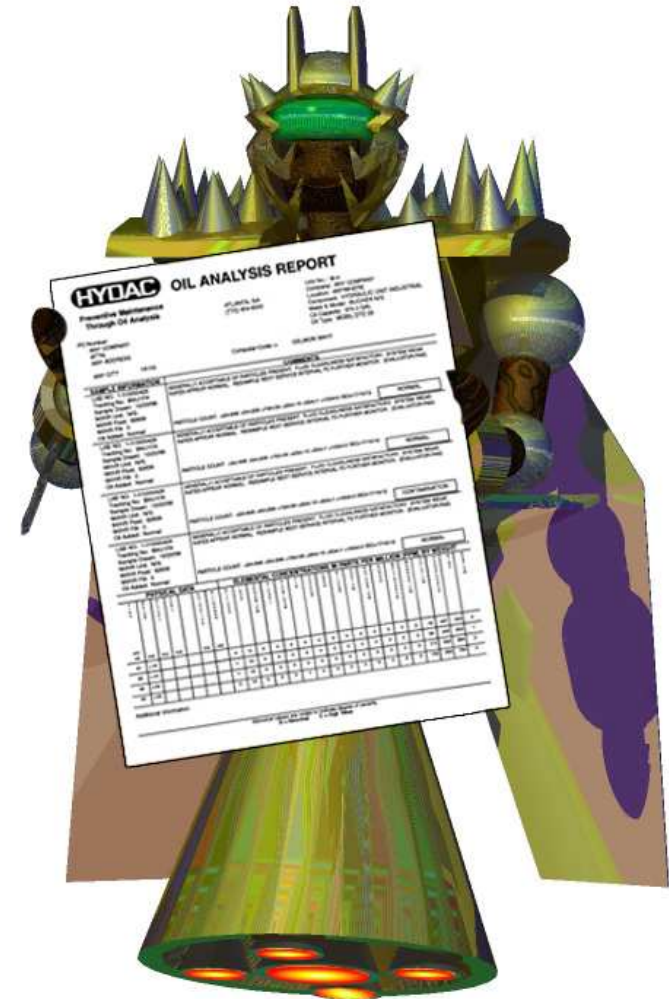


HYDAC INTERNATIONAL

What errors can be made during fluid sampling and analysis



Fluid Analysis Kit





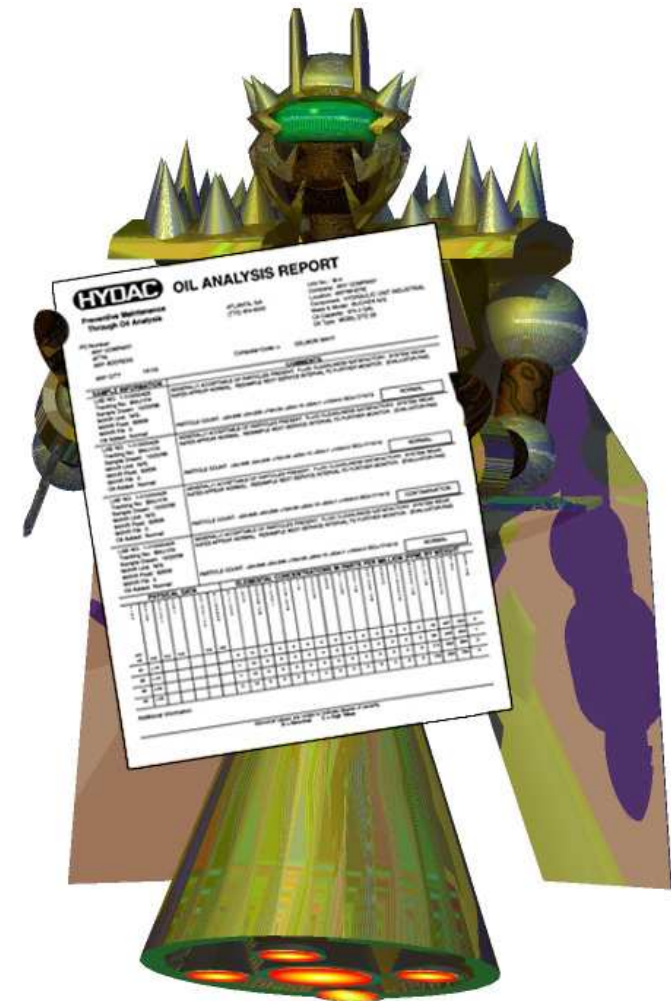
HYDAC

INTERNATIONAL

Sources of Error

**Does the sample represent
the system cleanliness?**

- Foreign media
(*air particulate, O₂, water etc.*)
- Type of extraction
(*static, dynamic*)
- Point of extraction
 - **Where in the system?**
 - Test Connection Penetration
and type of test sample fitting

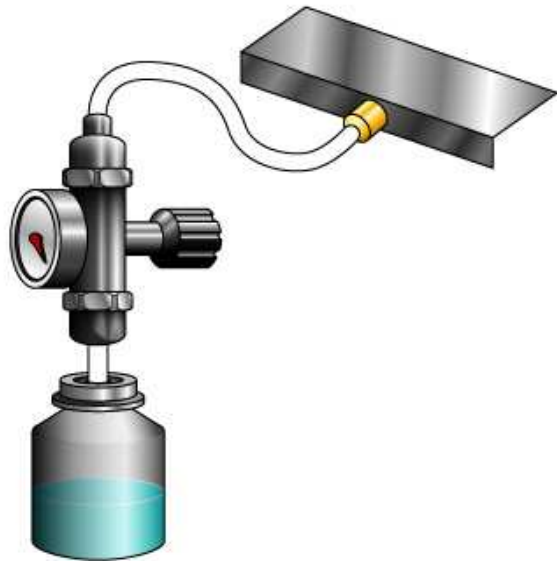




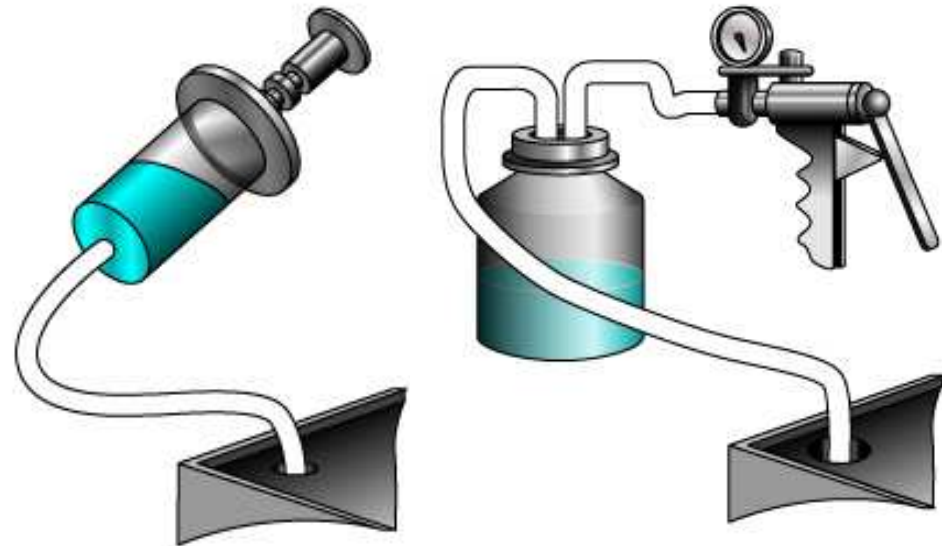
HYDAC INTERNATIONAL

Sources of Error

Possible Sources of Error During Measurement



Taking a sample from pressure header



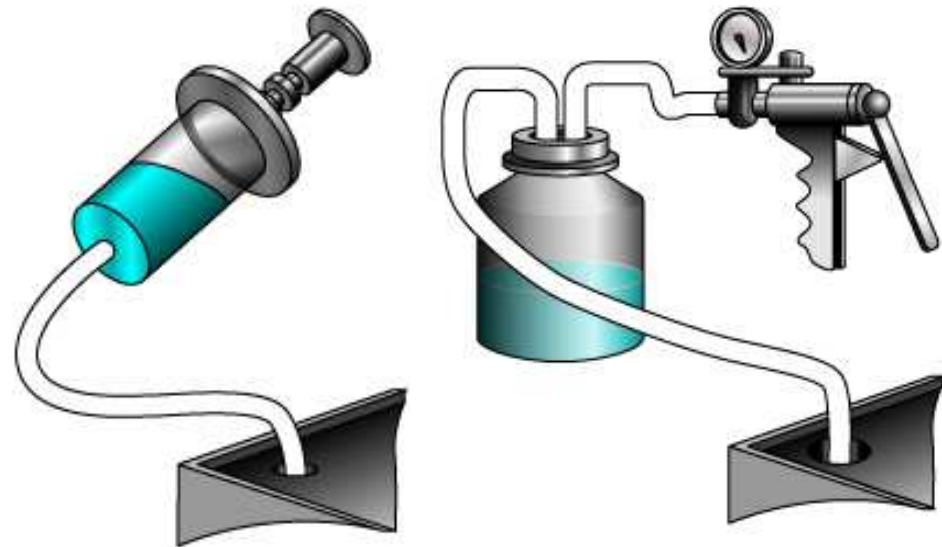
Taking a sample from stagnant fluid



HYDAC INTERNATIONAL

Sources of Error

Possible Sources of Error During Measurement

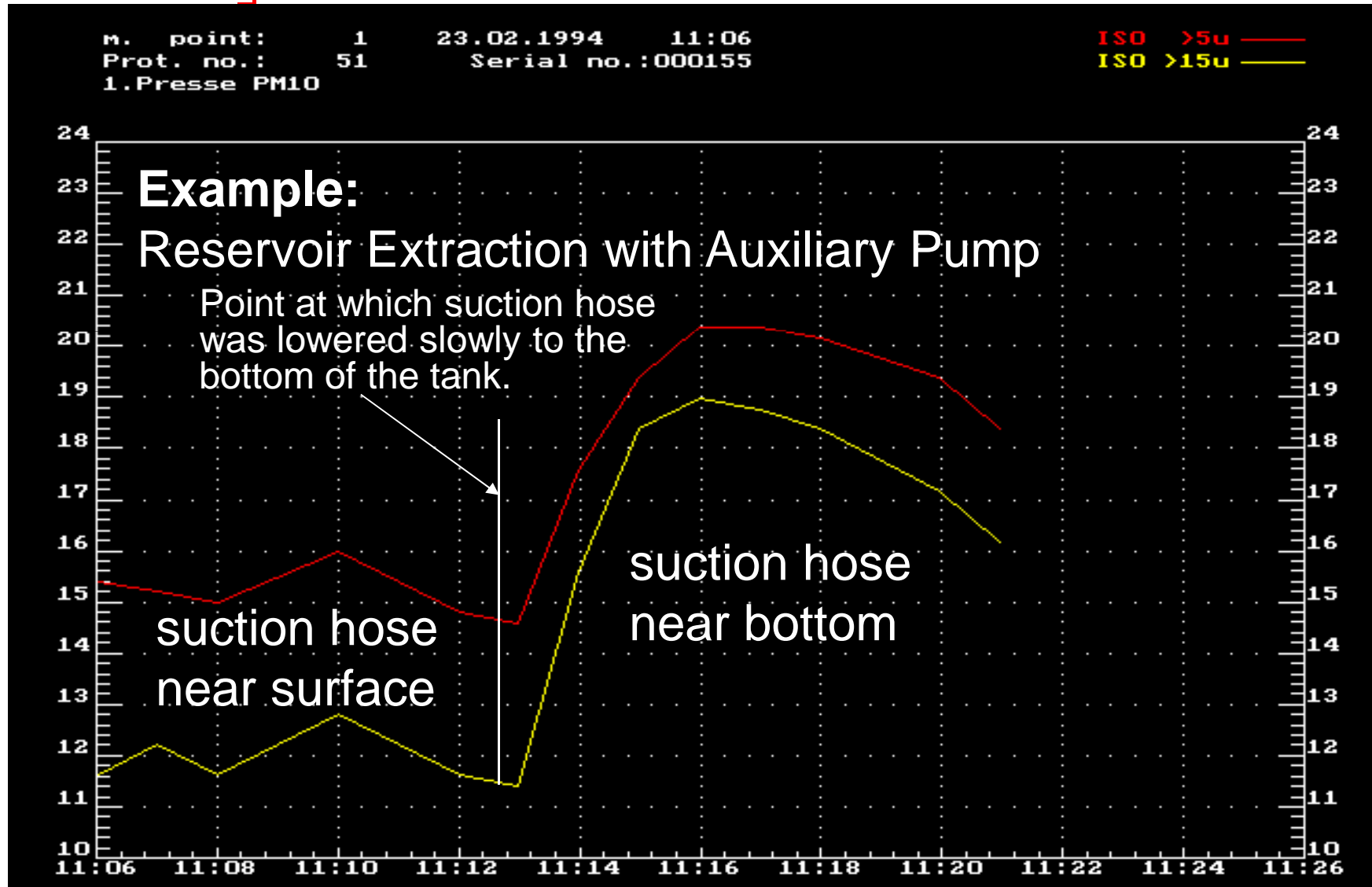


Taking a sample
from stagnant fluid



HYDAC INTERNATIONAL

Sources of Error

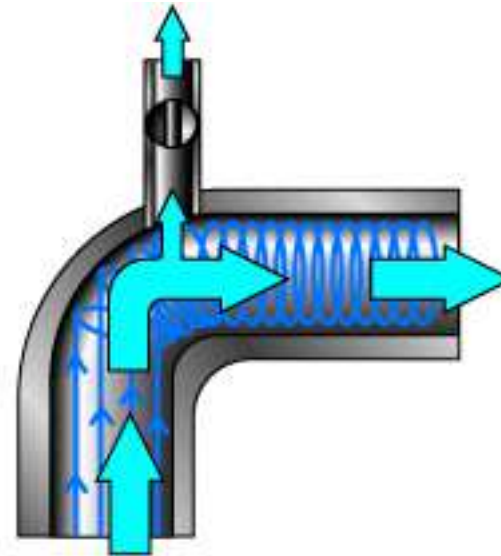
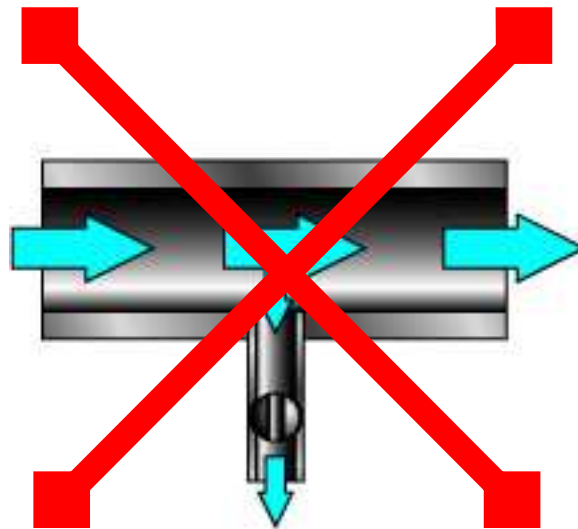




HYDAC INTERNATIONAL

Sources of Error

Point of Extraction - Test Connection Arrangement

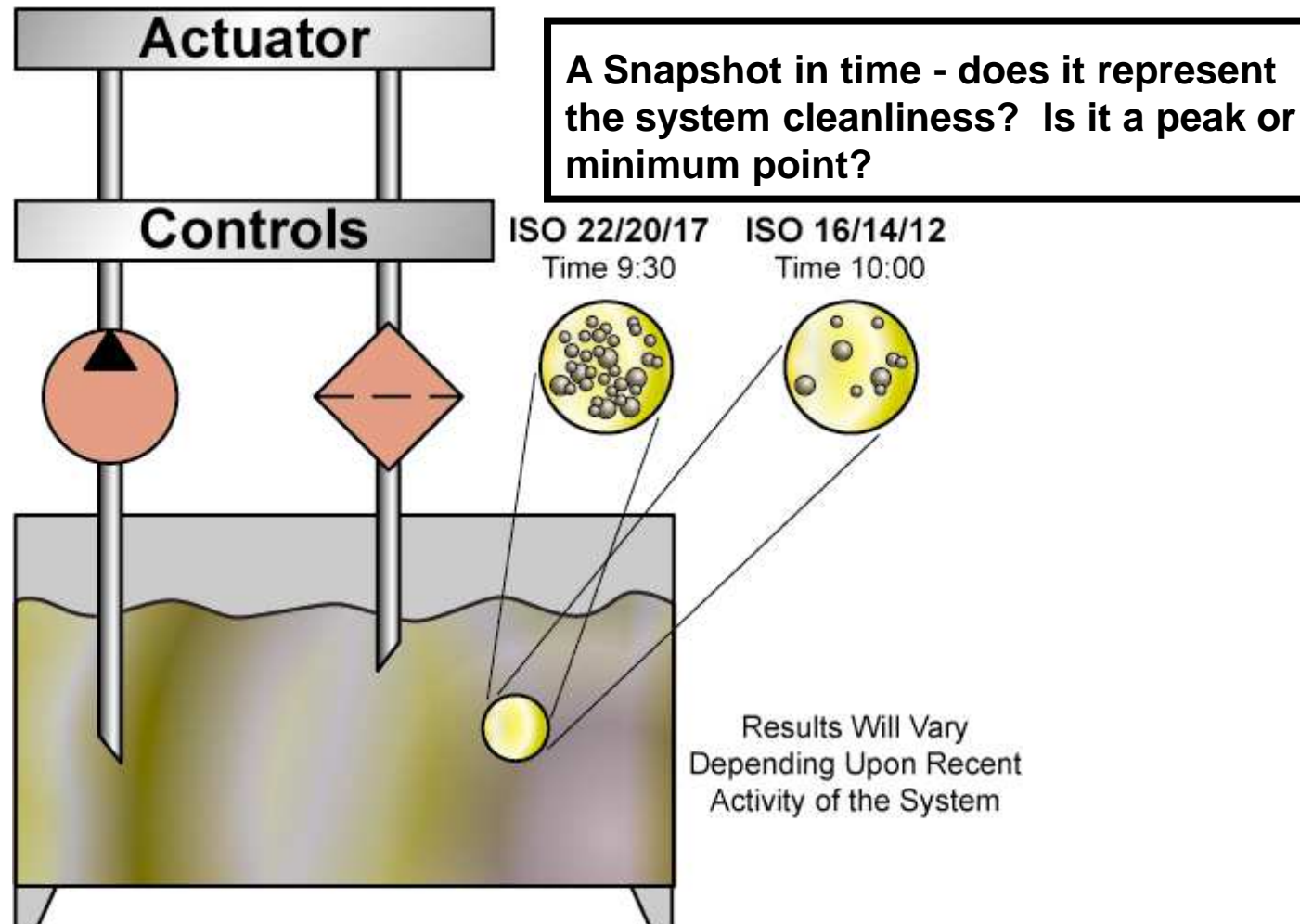




HYDAC INTERNATIONAL

Sources of Error

Disadvantages of Oil Sampling

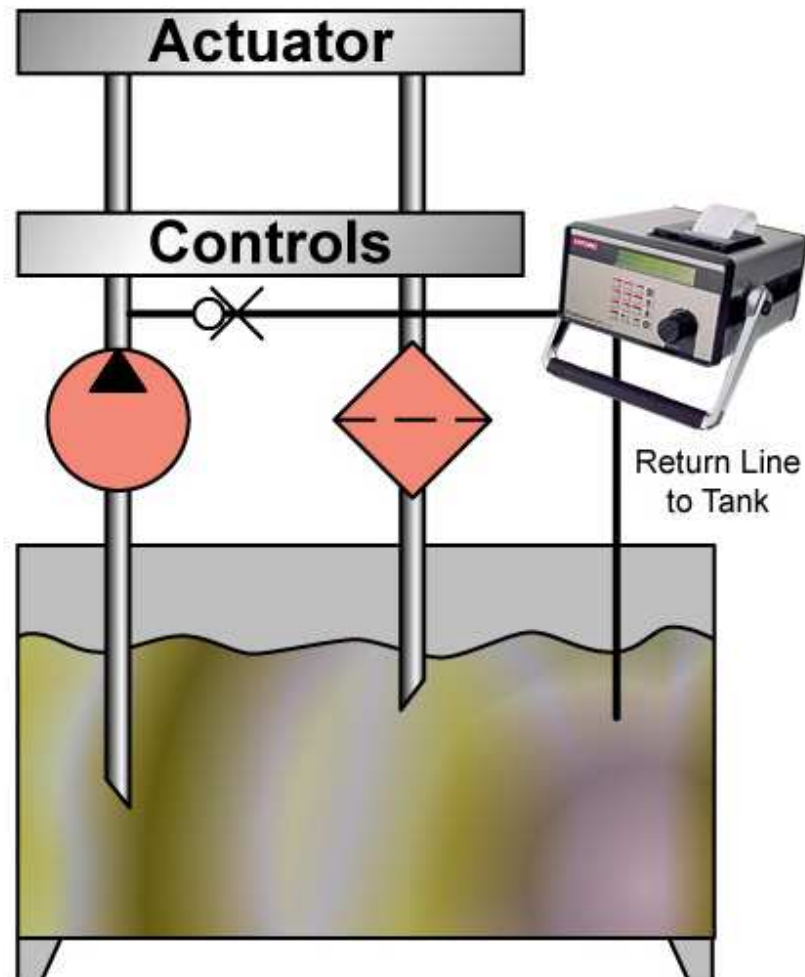




HYDAC INTERNATIONAL

Sources of Error

Point of Extraction - Where in the System?

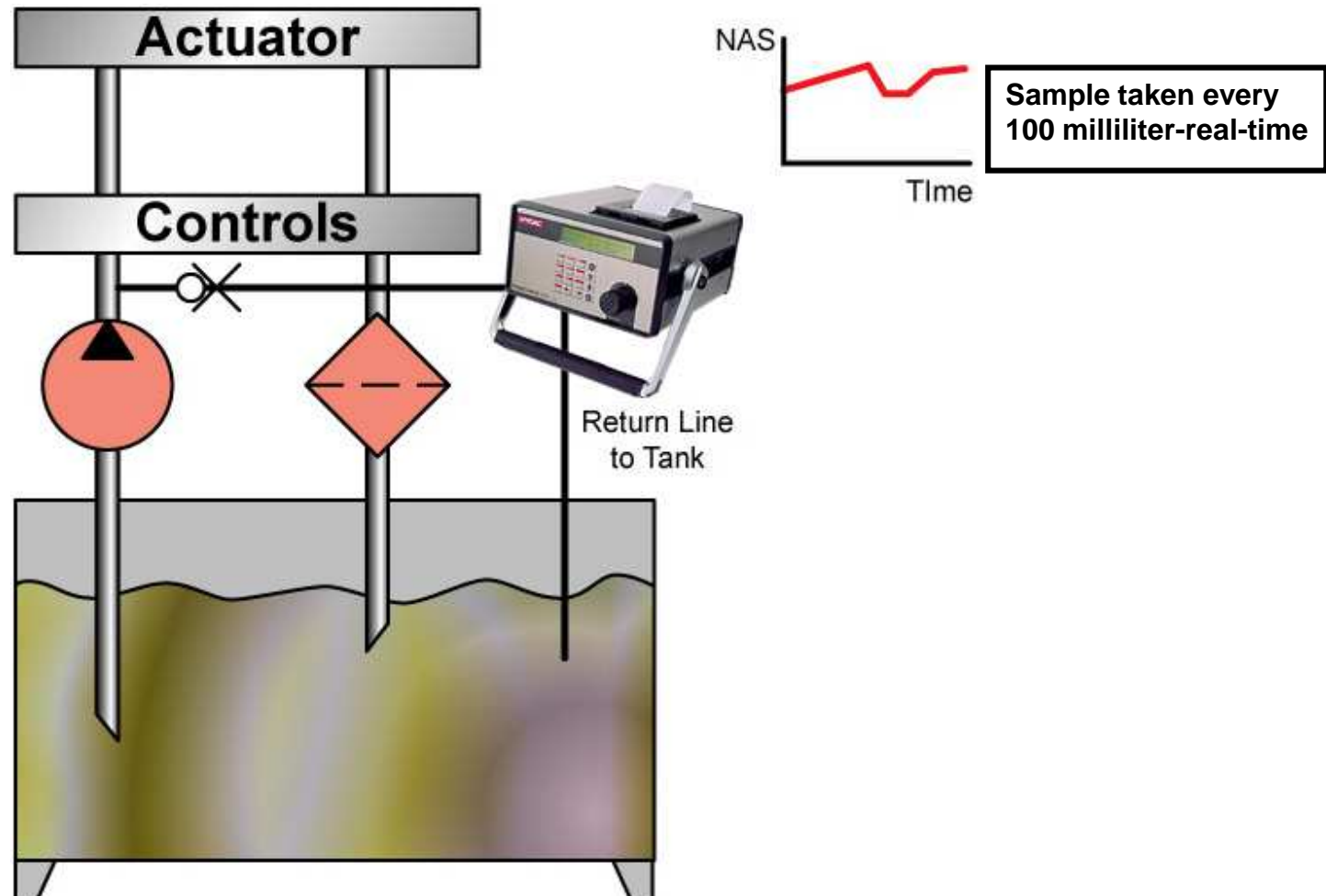




HYDAC INTERNATIONAL

Sources of Error

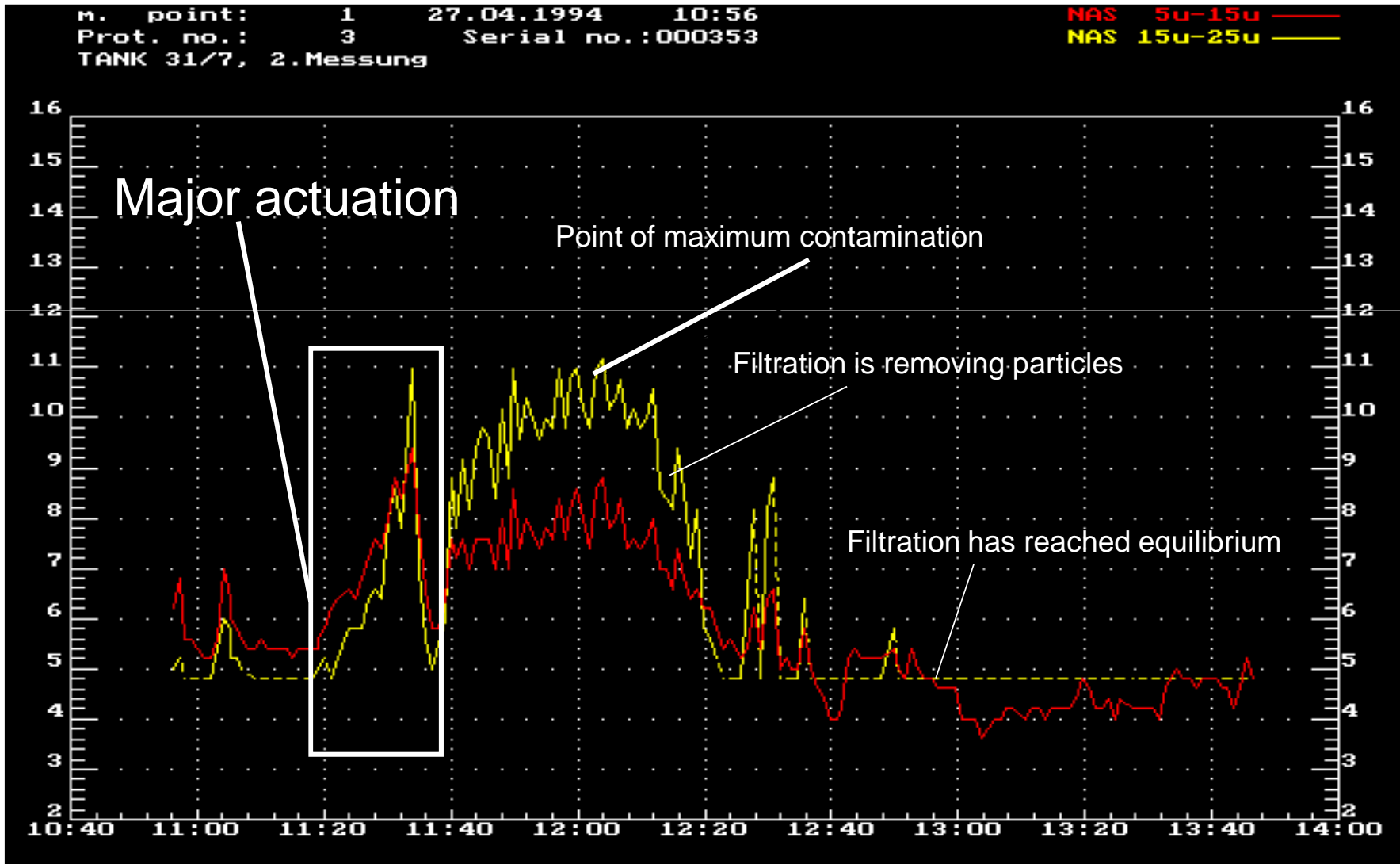
Advantages of Continuous Measurement





HYDAC INTERNATIONAL

Sources of Error





HYDAC INTERNATIONAL

Guidelines Data Sheet

Provides ISO target cleanliness levels for various critical hydraulic/Lube oil components and the filter selection that will achieve that cleanliness level target.

Most Sensitive System Component	Guidelines for Determining, Achieving, and Maintaining Target Cleanliness Levels with High Performance Filtration (Beta Ratio ≥ 200)					
	Low/Medium Pressure Under 2000 psi (moderate conditions)		High Pressure 2000 to 2999 psi (or low/medium pressure plus severe conditions) ¹		Very High Pressure 3000 psi and Over (or high pressure plus severe conditions) ¹	
	ISO Target Levels	HYDAC Filter Micron Ratings	ISO Target Levels	HYDAC Filter Micron Ratings	ISO Target Levels	HYDAC Filter Micron Ratings
Pumps						
Fixed Gear or Fixed Vane	20/18/15	20	19/17/14	10	18/16/13	5
Fixed Piston	19/17/14	10	18/16/13	5	17/15/12	3
Variable Vane	18/16/13	5	17/15/12	3	not applicable	not applicable
Variable Piston	18/16/13	5	17/15/12	3	16/14/11	3 ²
Valves						
Check Valve	20/18/15	20	20/18/15	20	19/17/14	10
Directional (solenoid)	20/18/15	20	19/17/14	10	18/16/13	5
Standard Flow Control	20/18/15	20	19/17/14	10	18/16/13	5
Cartridge Valve	19/17/14	10	18/16/13	5	17/15/12	3
Proportional Valve	17/15/12	3	17/15/12	3	16/14/11	3 ²
Servo Valve	16/14/11	3 ²	16/14/11	3 ²	15/13/10	3 ²
Actuators						
Cylinders, Vane Motors, Gear Motors	20/18/15	20	16/17/14	10	18/16/13	5
Piston Motors, Swash Plate Motors	19/17/14	10	18/16/13	5	17/15/12	3
Hydrostatic Drives	16/15/12	3	16/14/11	3 ²	15/13/10	3 ²
Test Stands	15/13/10	3 ²	15/13/10	3 ²	15/13/10	3 ²
Bearings						
Journal Bearings	17/15/12	3	not applicable	not applicable	not applicable	not applicable
Industrial Gearboxes	17/15/12	3	not applicable	not applicable	not applicable	not applicable
Ball Bearings	15/13/10	3 ²	not applicable	not applicable	not applicable	not applicable
Roller Bearings	16/14/11	3 ²	not applicable	not applicable	not applicable	not applicable

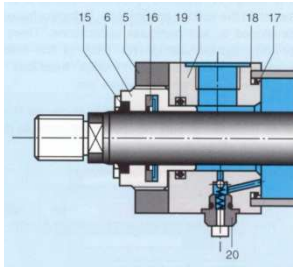
Notes: 1 Severe conditions may include high flow surges, pressure spikes, frequent cold starts, extremely heavy duty use or the presence of water.
2 Two or more system filters of the recommended rating may be required to achieve and maintain the desired Target Cleanliness Level.

HYDAC TECHNOLOGY CORPORATION
2260 City Line Road • Bethlehem, PA 18017
Phone (610) 286-0100 • Fax (610) 264-3540
www.hydacusa.com • powerup@hydacusa.com

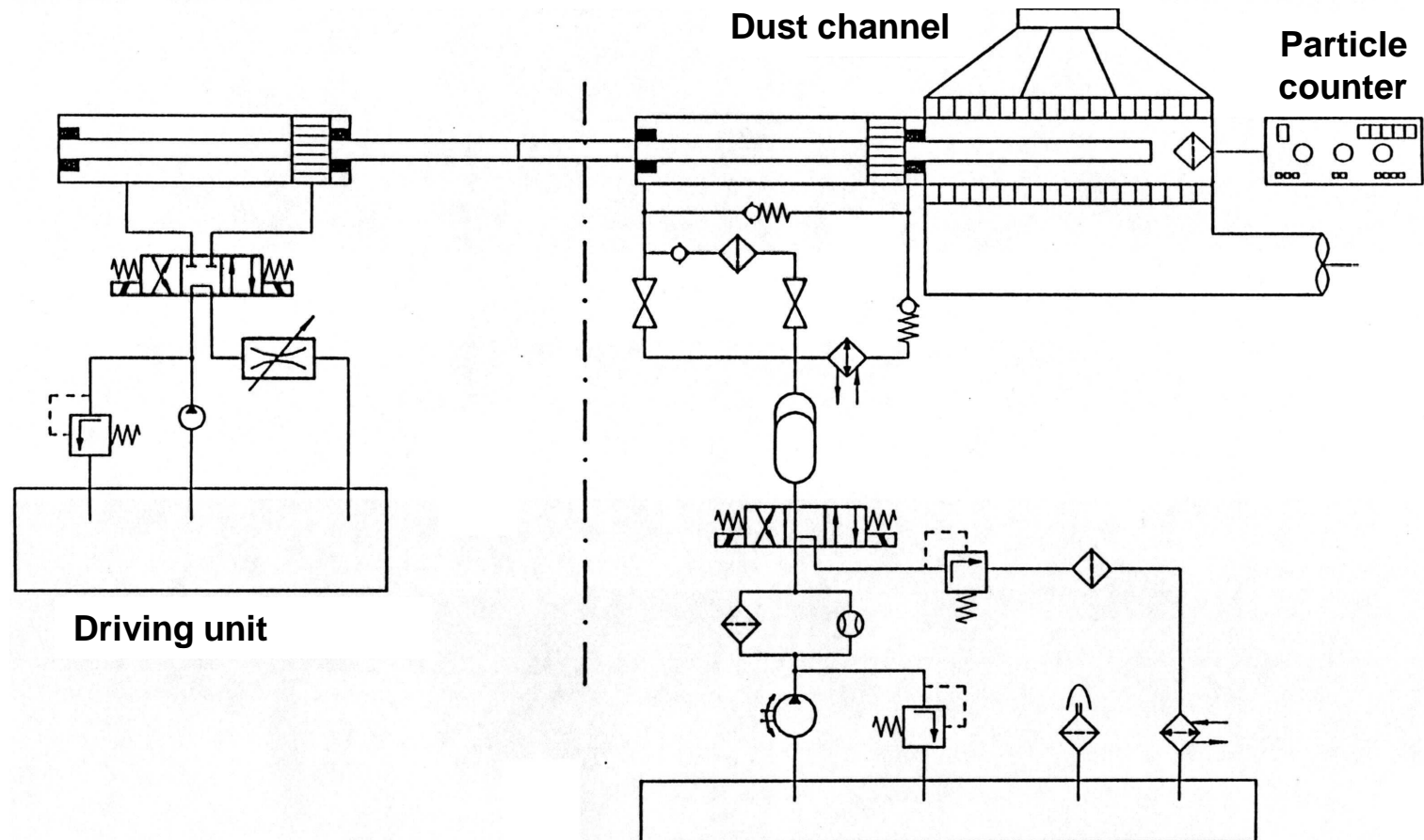


HYDAC INTERNATIONAL

Dirt Penetration e.g. Cylinder



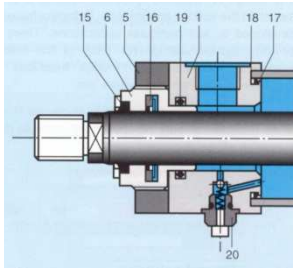
Principle Dirt Penetration Test Bench



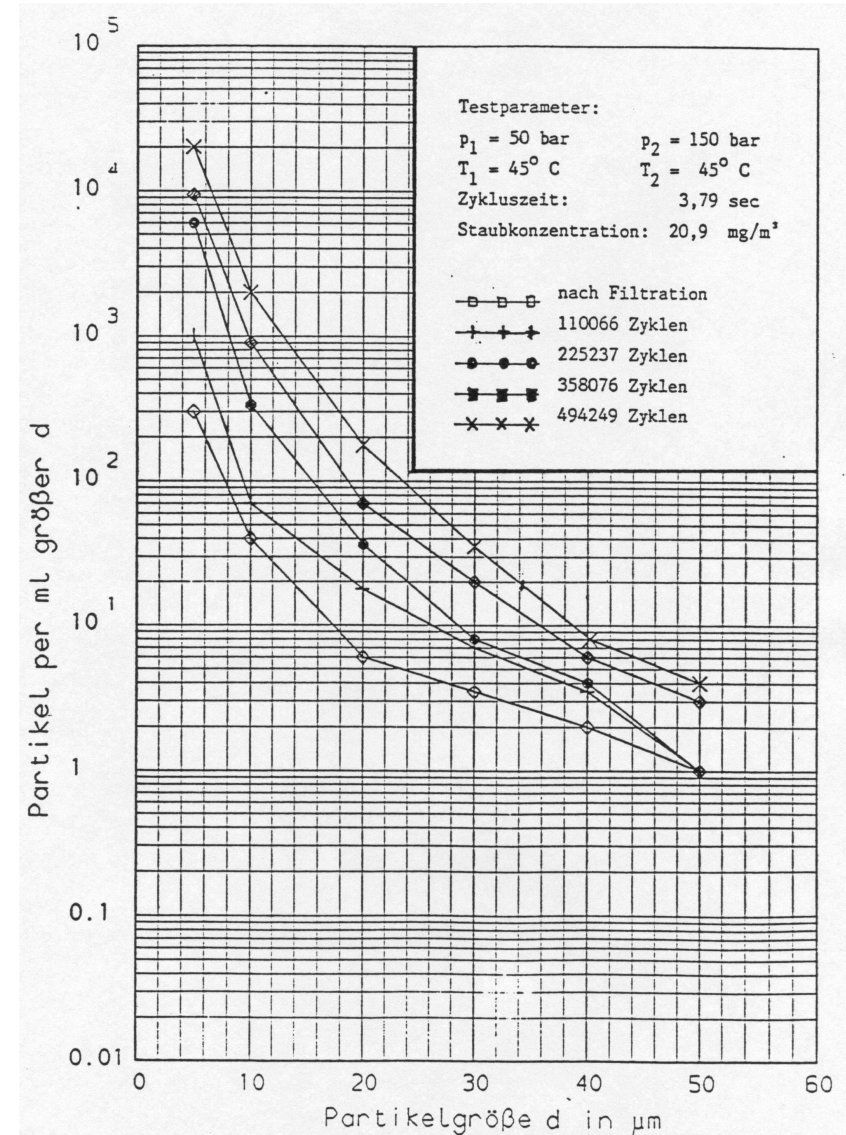


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Dirt Penetration e.g. Cylinder



**Steady
increase of the
particle numbers**





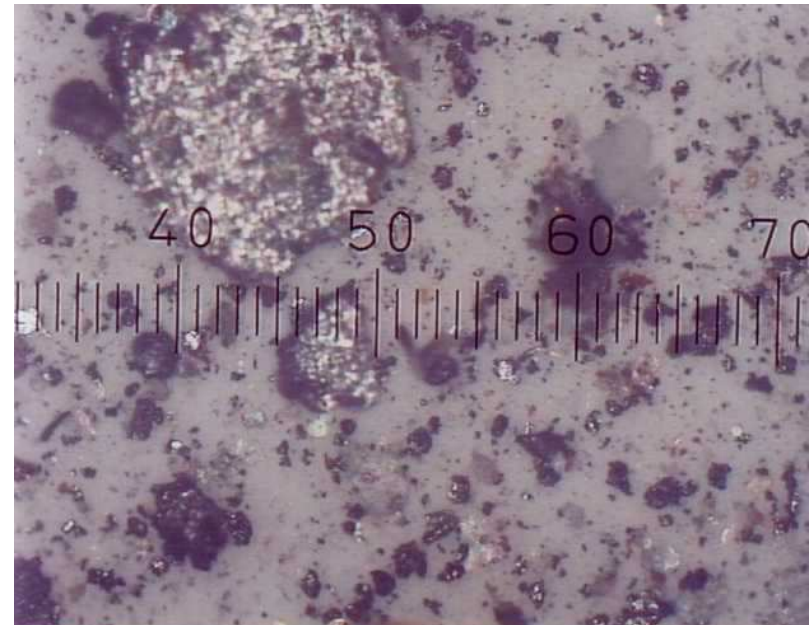
HYDAC INTERNATIONAL

Purity Audit

Fresh Oil, Reservoirs, Pipes, Hoses

A bow of pipework was taken from the assembly line and rinsed.

This piece has been pickled before the assembly.





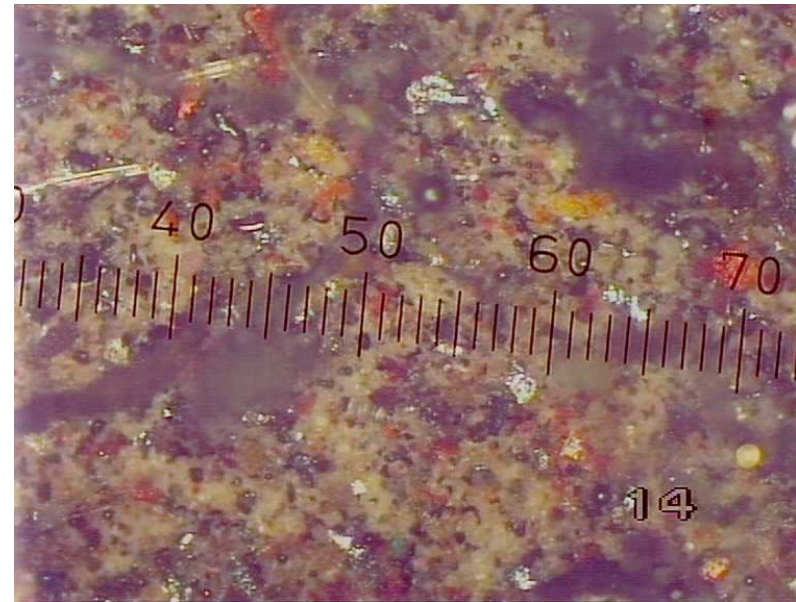
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Purity Audit

Fresh Oil, Reservoirs, Pipes, Hoses

A reservoir sample from the production line was rinsed with a solvent.

The resulting cleanliness was beyond the range of NAS or ISO standards.

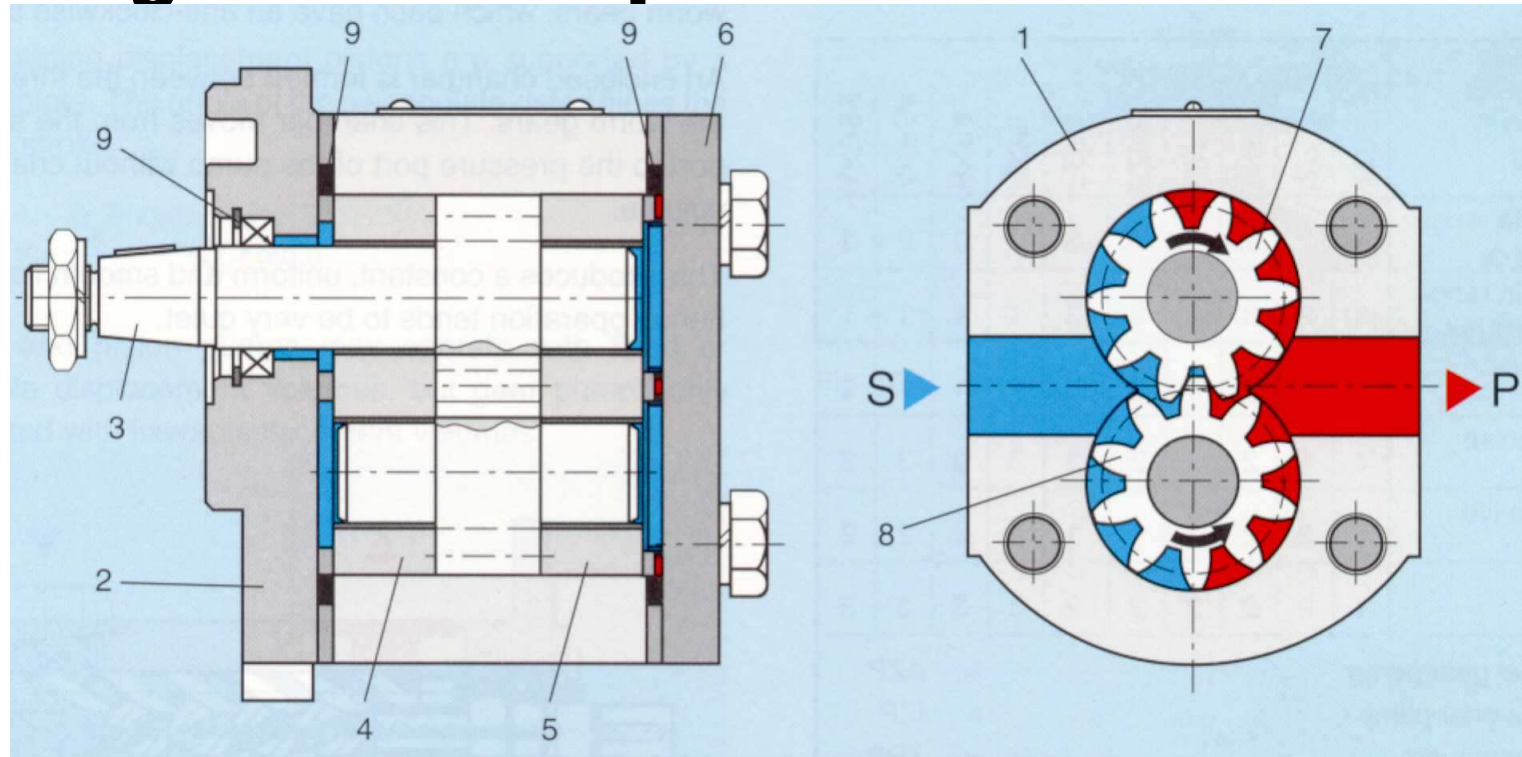


HYDAC-FILTERTECHNIK 160fach 1 Teilstrich =16µm FAUN



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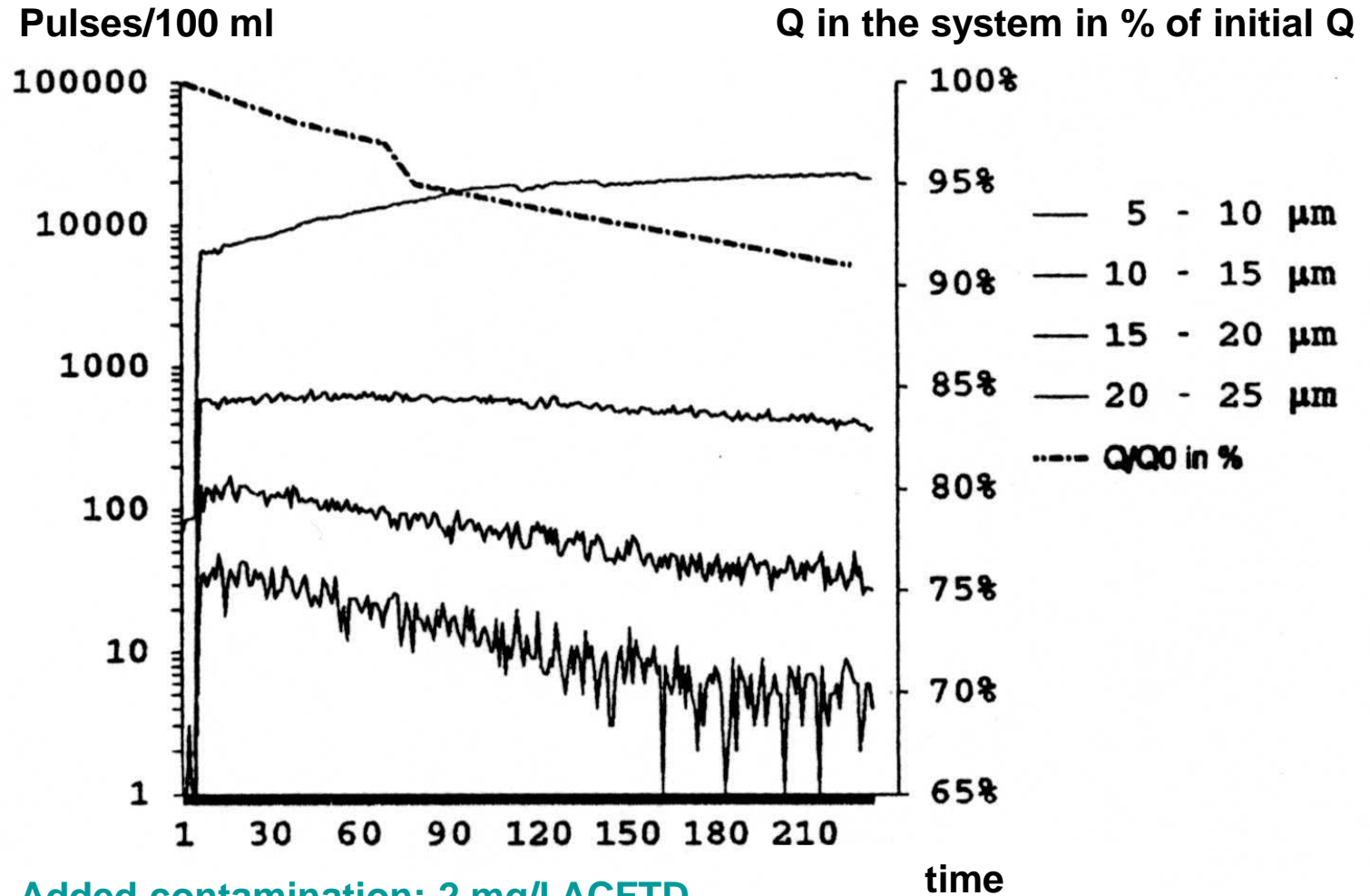
Effects of Solid Contamination e.g. Gear Pump





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Effects of Solid Contamination e.g. Gear Pump

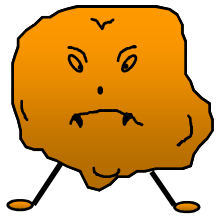


Added contamination: 2 mg/l ACFTD

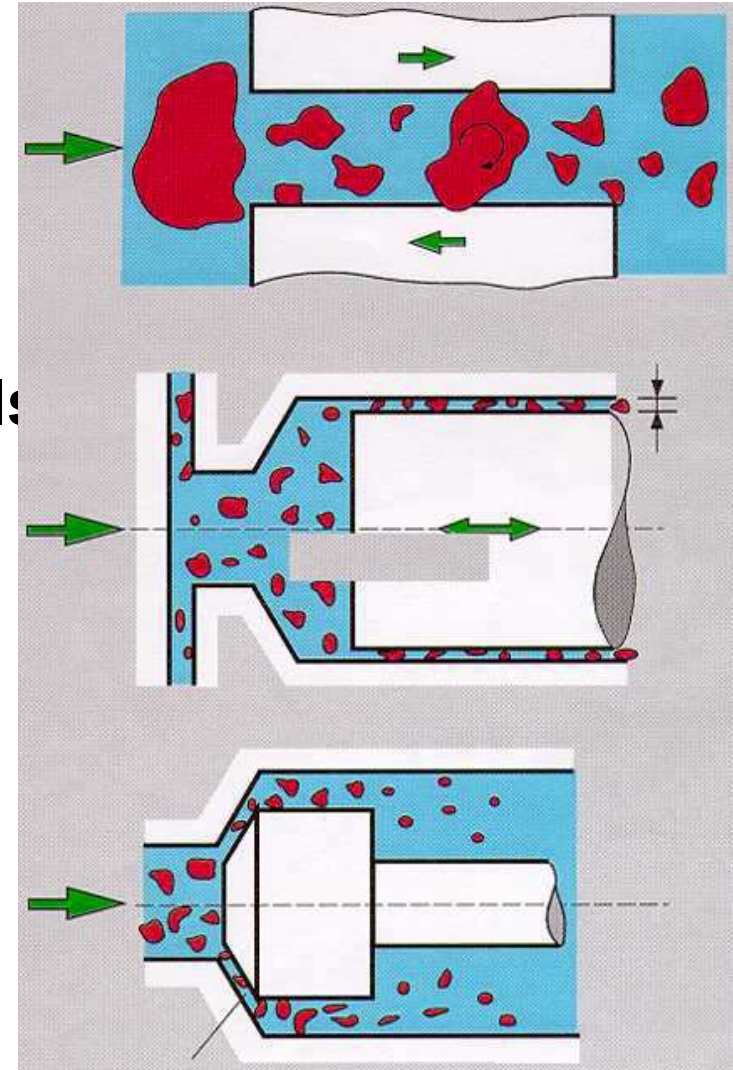


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Effects of Solid Contamination



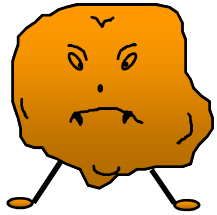
- Increased leakage
- Jamming of pistons and spools
- Component failure
- Changes in control characteristics





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Parameters that determine the Amount of Wear caused by Solid Particles



- **Material of the solid particles**
- **Size and shape of the solid particles**
- **Ratio of particle size / working clearance**
- **Working pressure**
- **Flow rate**
- **Fluid viscosity**



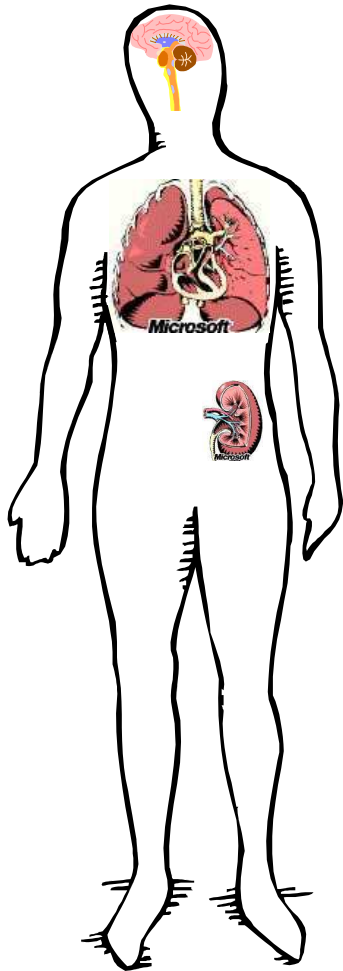
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Tasks of an Hydraulic Filter

- **Prevent functional disturbances**
- **Prevent variations in switching times**
- **Reduce downtime between maintenance shutdowns**
- **Maintain reliability between maintenance shutdowns**
- **Increase component life**
- **Maintain the lubricity of the fluid**
- **Extend the life of the fluid**



Tasks of an Hydraulic Filter



Component		Tasks	
in the human body	in the hydr. system	in the human body	in the hydraulic system
bronchial tubes	air breather filter	cleaning of the in- and outcoming air	
kidney	return line filter	separation of solid particles and water	
liver	pressure filter	protection filter for organs or components	
heart	pump	generation of pressure and volume flow	
brain	control block	responsable for the entire function of the body/system	
dialysis	bypass filter	separation of solid particles and water	
blood	working fluid	supply of the organs and removal of contamination	transport of energy, temperature, reduction of friction
nerve system	control	information system about condition of the organs	inform. system about pressure, temperature and tank level