HYDRAULIC FLUID SAMPLING PROCEDURE AND PARTICLE COUNTING

Overview

One of the most difficult but important jobs in hydraulic fluid maintenance is taking a proper and representative sample. The best way to do this is to always take the sample at the same place in the hydraulic system.

For properties like acidity, viscosity and moisture it generally doesn't matter where the sample is taken. However, when it comes to determining the cleanliness of a hydraulic fluid, it makes a big difference at what location the sample is taken.

- Fluid being pumped into a system with an auxiliary loop filter will have a different cleanliness compared to fluid at the bottom of the return side of the tank
- Fluid in larger hydraulic systems will have different cleanliness levels at the return and suction side of the tank

Sampling Procedure:

General hygiene and safety guidelines:

- Wear gloves
- Wear glasses
- Be aware of high fluid temperatures
- Be careful for high pressure fluid jets
- Sample should be taken by a technician

1. The preferred sampling point is the "minimess" connection
   - Use a "minimess" connection and "minimess" tube to take the sample

Connection

Tube

2. Mark the sampling point to ensure same conditions
   - Always take samples from this point
   - If possible have the same person take the sample
3. Ensure that the inside of the sample bottle is completely clean **and new**
   - Remove the lid, and leave it in a clean place, with the inner side facing up, to avoid any physical contact with dirt
4. Be sure that the system is working while the sample is taken
5. Tighten the sampling tube until a gentle flow emerges. Once the oil is flowing, do not stop, restart or change the oil flow during the flushing and sampling process
6. Flush the hose and connector, letting oil go through for approximately 10 seconds, before taking the oil sample. Do not change the oil flow during the whole process

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7. After flushing the connector and sampling tube, take an empty and clean new sample bottle to fill with the hydraulic fluid

- Fill the bottle 25-30% and discard content to waste. Repeat this step once
- Then fill the sample bottle
- Do not change the oil flow during the whole process

8. **It's important to avoid the contact among the connector of the sampling tube, the bottle, and the fluid. Avoid oil "splashing" resulting from too strong an oil jet**

9. After sampling:
   - Put the lid on the "minimess" connector

   - Close the "minimess" tube with the plastic caps and store the tube in a clean place

10. Close and properly tighten the bottle cap before sending it to the lab. Include on the sample bottle, the following information
    - Date
    - Company name and affiliate
    - Name/code of system
    - Fluid name
    - Name of sender

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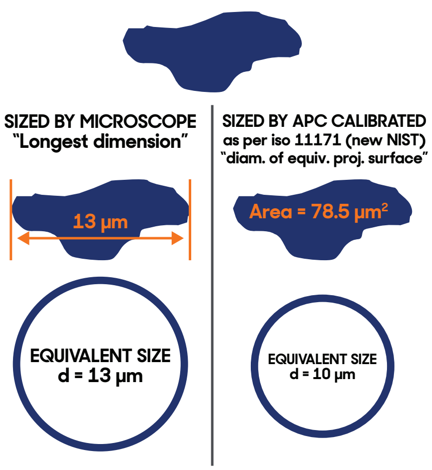
Measuring Fluid Cleanliness

The below overview table shows that cleanliness can be measured using several techniques and reporting methods.

STANDARD	ISO 4405	ISO 4406:1999	SAE AS 4059	NAS 1638
Reporting	Dark Brown Oil	Amount of particles > 4 µm (c) > 6 µm (c) > 14 µm (c)	Amount of particles A: cumulative > 4 µm (c) > 6 µm (c) > 14 µm (c) > 21 µm (c) > 38 µm (c) > 70 µm (c)	Amount of particles 5-15 µm 15-25 µm 25-50 µm 50-100 µm > 100 µm
CALIBRATION METHOD	**BALANCE**	**ISO 11171**	**ISO 11171**	**ISO 4402**
Method and comments	Filter 1 liter through a 1.2 µm filter patch and record weight change of the patch	**By microscope:** Filter 100 ml through a 1.2 µm filter patch 1. Manually count the particles. => Time consuming and requires expertise, but accurate. 2. Compare with reference patches => Time consuming, easy, but not so accurate **Automated particle counter:** => pro : very fast result => con : several techniques available from several suppliers. As the repeatability per unit is limited, the reproducibility between different machine can be very large		

[1]The below figure explains the difference between ISO 4402 and ISO 11171.

PARTICLE TO BE ANALYZED



ISO 4402 Calibration

The longest dimension of a particle is measured and related to the diameter of an area-equivalent circle. This relates directly to standard microscope counting.

ISO 11171 Calibration

The area of every particle is measured and related to the diameter of the area-equivalent circle.

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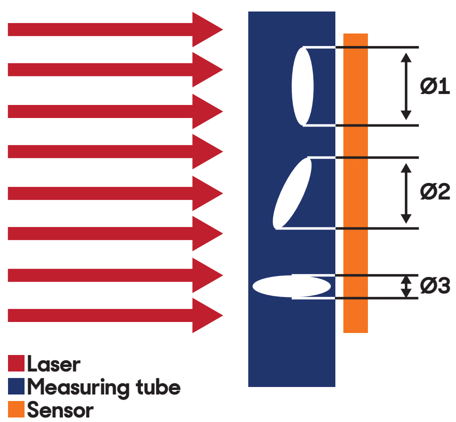
Why a Different Calibration Method?

- [2]Prior to ISO 11171, the previous Automatic Particle Counters (APC) calibration method most widely utilized was ISO 4402, which used Air Cleaner Fine Test Dust (ACFTD) as the reference calibration material
- ACFTD is no longer manufactured making the ISO 4402 method using this dust obsolete
- The industry developed the method ISO 11171, which supersedes ISO 4402, with a calibration standard based on NIST-certified samples of ISO 12103-1 A3 medium test dust suspended in hydraulic oil
- There is a difference between the particle measurements by ISO 4402 and ISO 11171. To retain the same cleanliness measure, calibrations using ISO 11171 are conducted to a corrected particle count scale
    - For example, particles reported as 5 µm with the ISO 4402 method are reported as 6 µm (c) by the ISO 11171 method
    - In fact 5 µm corresponds to 6.4 µm (c), and some round off was conducted for simplification
    - This explains why ISO 4406:1987 reports particles > 5 µm and > 15 µm and ISO 4406:1999 reports particles (> 4µm,) > 6 µm and > 14 µm

Reproducibility of Cleanliness Measurements

- As microscope cleanliness measurements are time consuming and need expertise, automated particle counters are used more and more, and are in fact standard today
- By far the most automated particle counters use laser (most common) or light. The shape on the particle is projected as part of the real length, depending in what position the particle is in front of the sensor as expressed in the illustration to the right



All three particles are identical but obviously the reported dimensions as a function of the projections are different.

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How Cleanliness is Reported

Cleanliness According ISO 4406:1999

NUMBER OF PARTICLES PER ML		SCALE NO.
MORE THAN	UP TO AND INCLUDING	
2.5M	–	> 28
1.3M	2.5M	28
640k	1.3M	27
320k	640k	26
160k	320k	25
80k	160k	24
40k	80k	23
20k	40k	22
10k	20k	21
5000	10k	20
2500	5000	19
1300	2500	18
640	1300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5.0	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
0.0	0.01	0

A readout of:
- > 4 µm = 7500 particles/ml
- > 6 µm = 550 particles/ml
- > 14 µm = 60 particles/ml

Will be reported as:
ISO 4406:1999 = 20/ 16/ 13

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Cleanliness According SAE as 4059
Cumulative counting

Classes

SIZE	>4 µm(c)	>6 µm(c)	>14 µm(c)	>21 µm(c)	>38 µm(c)	>70 µm(c)
SIZE CODE	A	B	C	D	E	F
000	195	76	14	3	1	0
00	390	152	27	5	1	0
0	780	304	54	10	2	0
1	1,560	609	109	20	4	1
2	3,120	1,217	217	39	7	1
3	6,250	2,432	432	76	13	2
4	12,500	4,864	864	152	26	4
5	25,000	9,731	1,731	306	53	8
6	50,000	19,462	3,462	612	106	16
7	100,000	38,924	6,924	1,224	212	32
8	200,000	77,849	13,849	2,449	424	64
9	400,000	155,698	27,698	4,898	848	128
10	800,000	311,396	55,396	9,796	1,696	256
11	1,600,000	622,792	110,792	19,592	3,392	512
12	3,200,000	1,245,584	221,584	39,184	6,784	1,024

** The information reproduced on this and the previous page is a breif extract from SAEAS4059 Rev.E, revised in May 2005. For further details and explanations refer to the full Standard

A readout of:
- > 4 µm = 210 000 particles/100 ml
- > 6 µm = 15 550 particles/100 ml
- > 14 µm = 660 particles/100 ml
- > 21 µm = 80 particles/ 100 ml
- > 38 µm = 2 particles/100 ml
- > 70 µm = 0 particles/100 ml

Will be reported as:
SAE AS 4095, class 9 A

Because 9 is the highest measured class and A indicates which particle size is causing it

Maximum Contamination Limits (per 100 mL)

	00	0	1	2	3	4	5	6	7	8	9	10	11	12
5-15	125	250	500	1000	2000	4000	8000	16000	32000	64000	128000	256000	512000	1024000
12-25	22	44	89	178	356	712	1425	2850	5700	11400	22800	45600	91200	182400
25-50	4	8	16	32	63	126	253	506	1012	2025	4050	8100	16200	32400
50-100	1	2	3	6	11	22	45	90	180	360	720	1440	2880	5760
Over 100	0	0	1	1	2	4	8	16	32	64	128	256	512	1024

A readout of:
- 5-15 µm = 210 000 particles/100 ml
- 15-25 µm = 15 550 particles/100 ml
- 25-50 µm = 660 particles/100 ml
- 50-100 µm = 80 particles/ 100 ml
- > 100 µm = 2 particles/100 ml

Will be reported as:
NAS 1838, class 10
Because 10 is the highest measured class

NAS 1638 is officially inactive, although still widely used.

An alternative NAS 1638 calibrated according ISO 11171 is in a proposal state.

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Troubleshoot guide

QUESTION	POSSIBLE REASONS / ANSWERS
Why is your result different to what we measured?	• Sampling point is different • Sample not taken at the same moment • Used measuring technique is different • Simple reproducibility difference as 1 or maybe 2 class difference is not extreme
What is a good cleanliness for my fluid?	• That depends on the system and components used. For example Servo valves are recommended to run much cleaner than standard valves. Consult manual of the component for requirements
How can the sample have more large dirt particles than small particles?	• Sampling procedure is not good. Large particles are dirt from outside • Sample contains water
How can I have free visible dirt in a sample taken after a filter?	• Sampling procedure not good
Why is my fluid not clean when very fine and high efficiency filters are used?	• Fluid is dirty and filters are on bypass • Sampling procedure is not good • Sample taken at the wrong point

1 and 2: MPFiltri. "Manual of Analysis and Comparison Photographs." Fluid Condition Handbook. MPFiltri, Aug. 2013. Web. July 2016.