We produce fluid power **solutions**

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Fluid Management & Oil Condition Monitoring

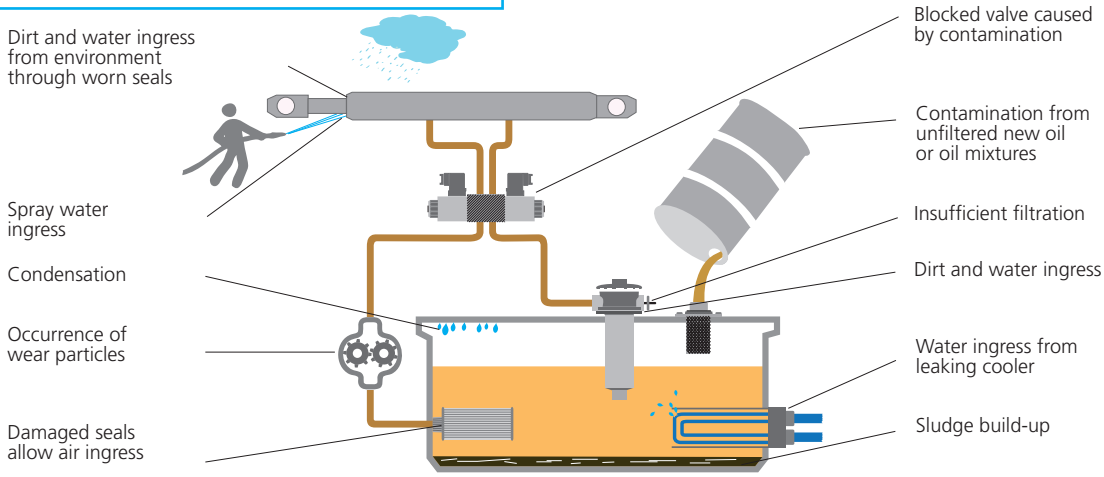
Technical Handbook

Solutions for clean oil

Index

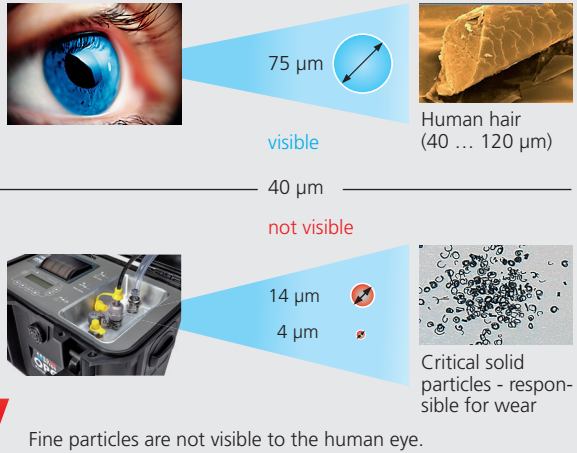
Damaging factors

Sources of pollution

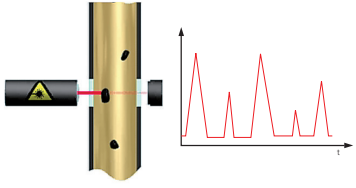


Contaminant	Cause	Effect on systems	Detected by	Solution
Dirt	Start-up contamination, oil contamination from environment, dirt ingress during maintenance / repair, component breakdown, wear	Early breakdown, increased wear, reduced system performance / lifetime	Particle counter	Filter oil to correct target cleanliness level (TCL)
Water	Leaking cooler, damaged seals, no / insufficient filler cap, condensation	Loss of oil performance, oil life shortened, corrosion	Humidity sensor	Water removal element, vacuum unit, oil change
Air	Product design, leaks, damaged seals, low oil level	Cavitation, oxidation, oil life shortened	Dielectricity / conductivity / viscosity sensor	Seal system, add / change oil
Heat	Blocked valve, damaged cooler	Loss of oil performance, oil life shortened, component damage	Temperature sensor	Check / repair system, change oil
Mixture	Wrong fluid added to system	Damaged fluid, loss of system performance	Dielectricity / conductivity / viscosity sensor	Drain system, flush, refill with filtered oil
Shear	Overstressed fluid	Oil life shortened, damaged fluid	Dielectricity / conductivity / viscosity sensor	Check system, change oil

Make pollution visible



Fine particles are not visible to the human eye.



Light blocking sensor

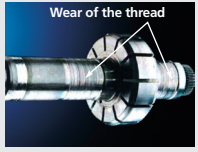
Oil passing the measuring cell is irradiated by a laser beam and the light intensity is measured by a detector. Particles contained in the oil block the light and the signal at the detector reduces proportionally to the particle size. Thereby particles may be detected and their size can be determined. Electronics interpret the signal.

Visually the oil samples look the same. One is however considerably more contaminated than the other.

Automatic particle counters give a fast, accurate and repeatable contamination picture of your oil.

Photos showing damages

Bearing damaged by pitting



Shaft damaged by erosion

Incrustation caused by oil aging

Clutch case damaged by oil aging

Damage by oil mixture leads to flocculation

Bearing seal damaged by microdiesel effect

Source: KraussMaffei

Water content

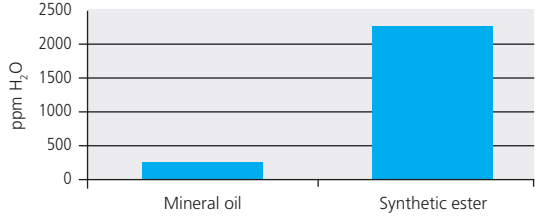
Water absorbing capacities of different fluid types

Mineral oil containing 500 ppm H_2O

Synthetic ester containing 500 ppm H_2O

ppm = parts per million, 500 ppm ≙ 0,5 l water in 1000 l oil

10.000 ppm	1 %
1.000 ppm	0.1 %
100 ppm	0.01 %



The water absorbing capacity varies from oil to oil. At saturation point (>100 % relative humidity), free water results in clouding.

Consequences of water contamination

Accelerated oil oxidation

Negative influence on:

- Capacity of air separation
- Antifoams
- Lubrication performance

Degeneration of additives

Accelerates:

- Corrosion
- Wear

Shortened oil lifetime
System failure

An installed humidity sensor gives early warning, permitting fast action to extend the oil lifetime and machine availability.

Solutions for clean oil

		Process	Reason	Product
Oil Transfer with / without particle monitoring	 	Single pass filtration with / without particle monitoring during filling of new hydraulic equipment / systems	Remove contamination from new oil – reduce start-up failures, reduce warranty claims	Mobile filter systems
Mobile off-line filtration with / without particle monitoring	 	Multipass filtration with or without particle monitoring during oil flushing	Remove wear debris, contamination and / or water to extend oil life, reduce breakdowns and measure the oil cleanliness	Mobile filter systems
Permanent off-line filtration with / without particle monitoring	 	Permanent multipass filtration with or without particle monitoring	Remove wear debris, contamination and / or water to extend oil life, reduce breakdowns and measure the oil cleanliness	Stationary off-line filter systems Particle monitors
Periodic Oil Condition Monitoring	 	Periodic oil condition monitoring, either online, on-machine or in laboratory	Regular monitoring of the oil condition. Troubleshooting tool, measurement of the oil cleanliness after completion and analysis of the oil condition during operation. Reduction of external lab costs by up to 90 %.	Portable particle counters
Permanent Oil Condition Monitoring	 	Permanent on-line oil condition monitoring	Follow proactive / predictive maintenance regimes. Reduce breakdowns. Reduce lab costs. Roll-off cleanliness verification / certification. System control.	Particle monitors Oil condition sensors Stationary off-line filter systems

Products at a glance

Stationary off-line filter systems

Simply and rapidly fit to your existing systems. Get maximum fluid performance and lifetime with permanent off-line cleaning. Flow rates from 4 to 650 l/min, filter finenesses from 3 µm upwards. Water removal elements available.

FN series FNA series

Mobile filter systems

Easy to use systems for through filter filling and cyclic cleaning with or without particle monitoring.
Flow rates from 3 to 45 l/min, filter finesseses from 3 µm upwards.
Water removal elements available.

FA series UMPC series OPS series

Online oil condition monitors

Prevent damage with early stage diagnosis by using the OPCom Particle Monitor for continuous real time online particle monitoring and LubCos Level for combined measurement of filling level and oil condition as well as LubCos H_2O+II for moisture content and oil aging measurement.

OPCom Particle Monitor Sensors LubMon Visu

Portable particle counters

Our wide range of particle counters and monitors meet all your requirements. Use OPCount for bottle and online particle counting with viscosity and temperature measurement, in your lab or in field. Use OPCom Portable Oil Lab for plug and play online sampling, with built-in battery and memory, for day to day monitoring and as a troubleshooting tool.

OPCom Portable Oil Lab OPCount

Cleanliness standards

ISO 4406:1999
Counts / ml, cumulative

ISO Class	Particles / ml	
0	0	0.01
1	0.01	0.02
2	0.02	0.04
3	0.04	0.08
4	0.08	0.16
5	0.16	0.32
6	0.32	0.64
7	0.64	1.3
8	1.3	2.5
9	2.5	5
10	5	10
11	10	20
12	20	40
13	40	80
14	80	160
15	160	320
16	320	640
17	640	1,300
18	1,300	2,500
19	2,500	5,000
20	5,000	10,000
21	10,000	20,000
22	20,000	40,000
23	40,000	80,000

ISO Class	Particles / ml	
24	80,000	160,000
25	160,000	320,000
26	320,000	640,000
27	640,000	1,300,000
28	1,300,000	2,500,000
x28	2,500,000	

Although there is no direct relationship between ISO 4406:1999 and NAS 1638, a rough guide can be found below.

NAS	ISO
3	-/12/9
4	-/13/10
5	-/14/11
6	-/15/12
7	-/16/13
8	-/17/14
9	-/18/15
10	-/19/16
11	-/20/17

Note: NAS 1638 has been replaced by SAE AS 4059 in 2001

ISO 4406:1999 is a 3 digit code, representing the cumulative counts per ml at 4, 6 and 14 µm(c). The counts at each size are compared with the table to find the contamination code. The code is written as 3 numbers separated by a ‚/'. For example: 19/17/14. The first number represents the count at 4 µm(c), the second at 6 µm(c) and the third at 14 µm(c). More details can be found in ISO Standard 4406:1999.

Target cleanliness levels

SAE AS 4059 E
Counts / 100 ml, cumulative
NAS 1638 has been replaced by SAE AS 40 59 in 2001.

SAE AS 4059	Max. contamination limits - Particles / 100 ml					
Size, ISO 4402 calibration or optical microscope	> 1 µm	> 5 µm	> 15 µm	> 25 µm	> 50 µm	> 100 µm
Size, ISO 11171 calibration or electron micro-scope	> 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	360	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

Data is sorted into cumulative particle counts per 100 ml and is expressed either as the total number of particles for a given size (for example AS 4059 Class 6) or by designating a class for each size range (for example 6B/5C/4D/3E/3F).

Counts / 100 ml, differential*

Classes	5 to 15 µm	15 to 25 µm	25 to 50 µm	50 to 100 µm	over 100 µm
00	125	22	4	1	0
0	250	44	8	2	0
1	500	89	16	3	1
2	1,000	178	32	6	1
3	2,000	356	63	11	2
4	4,000	712	126	22	4
5	8,000	1,425	253	45	8
6	16,000	2,850	506	90	16
7	32,000	5,700	1,012	180	32
8	64,000	11,400	2,025	360	64
9	128,000	22,800	4,050	720	128
10	256,000	45,600	8,100	1,440	256
11	512,000	91,200	16,200	2,880	512
12	1,024,000	182,400	32,400	5,760	1,024

Differential particle counts per 100 ml at various size ranges.
For example, for a classification of NAS 6, the particle counts in each particle size range must be below the counts / 100 ml shown in the table for NAS class 6.

*Classes and contamination limits identical to NAS 1638.

Target cleanliness levels

Recommended Target Cleanliness Levels (TCL)
according to ISO 4406:1999
for different system components.

Pumps	
Axial piston pumps	21/18/15
Radial piston pumps	21/18/15
Gear pumps	21/18/15
Vane pumps	20/17/14
Motors	
Axial piston pumps	21/18/15
Radial piston pumps	21/18/15
Gear pumps	21/18/15
Vane pumps	20/17/14
Valves	
Directional proportional valves (solenoid valves)	21/18/15
Pressure valves (controlling)	21/18/15
Flow control valves	21/18/15
Check valves	21/18/15
Proportional valves	20/17/14
Servo valves	17/14/11
Cylinders	21/18/15

If the operating pressure is increased in a system, it is necessary to improve the oil cleanliness in order to achieve the same wear lifetime for the components.

Operating pressure	Changes in oil cleanliness
0 - 100 bar	3 classes worse
100 - 160 bar	1 class worse
160 - 210 bar	none
210 - 250 bar	1 class better
250 - 315 bar	2 classes better
315 - 420 bar	3 classes better
420 - 500 bar	4 classes better
500 - 630 bar	5 classes better

By improving the system cleanliness, the lifetime of the hydraulic or lubrication system can be extended:

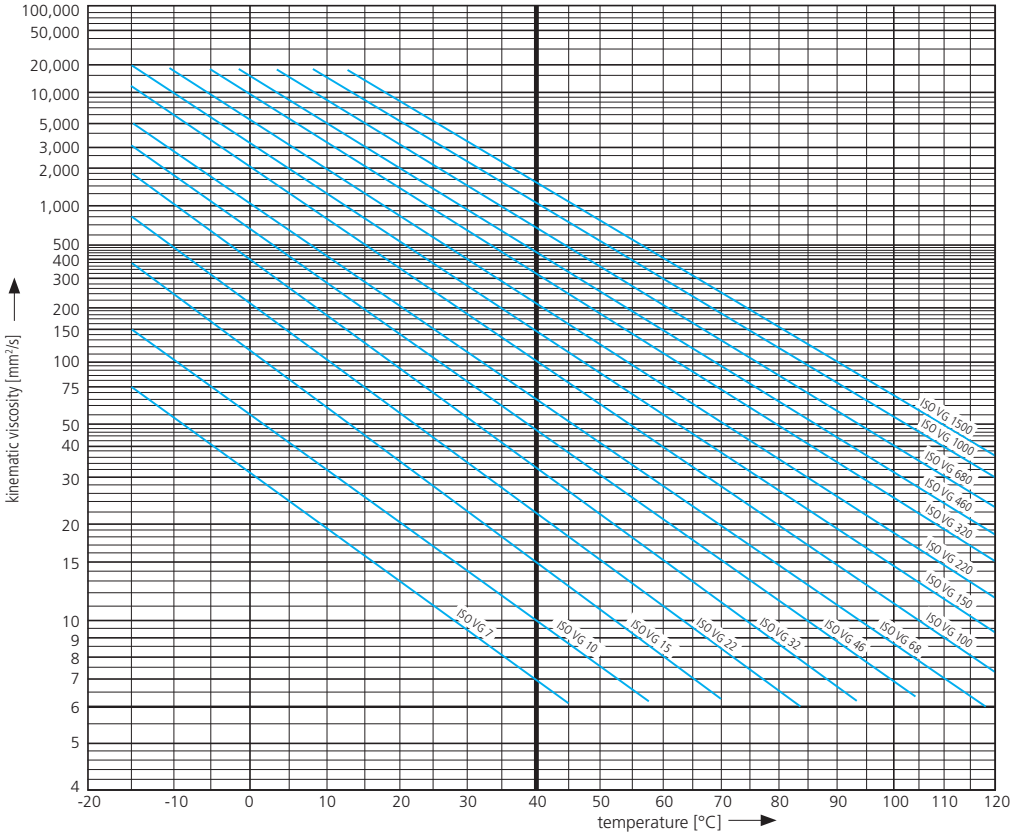
Type of system	Initial ISO Code	Target ISO Code	Lifetime extended by:
Hydraulic	-/19/17	-/14/11	x 4
Lube	-21/19	-/15/12	x 3

Return on investment calculation

Calculate your return on investment		Example	Formula	Your figures
No. of machines	(a)	3		
Annual operating hours	(b)	4000		
Hourly machine costs	(c)	45		
Hourly labor cost	(d)	45		
Current machine uptime %	(e)	95		
Current machine downtime %	(f)	5		
Downtime hours total	(g)	4000 x 3 x 0.05=600	(b x a) / 100 x f	
mechanical / electrical failure	(h)	500		
hydraulic failure	(j)	100		
caused by the fluid	(k)	80	j x 0.8	
Fluid related downtime costs	(l)	3600	k x c	
Labor costs for repair	(m)	3600	k x d	
Total maintenance cost	**(n)**	**7200**	l + m	
Fluid service will prevent up to 80 % of fluid related failures; leaving 20 %				
Remaining downtime hours		16	k x 0.2	
Reduction in downtime costs		720	l x 0.2	
Reduced labor costs		720	m x 0.2	
Total new maintenance cost	**(o)**	**1440**	**n x 0.2**	
Total savings for your facility, simply by caring for your oil:		**5760**	**n - o**	

Space for notes / your calculations

Viscosity / temperature diagram



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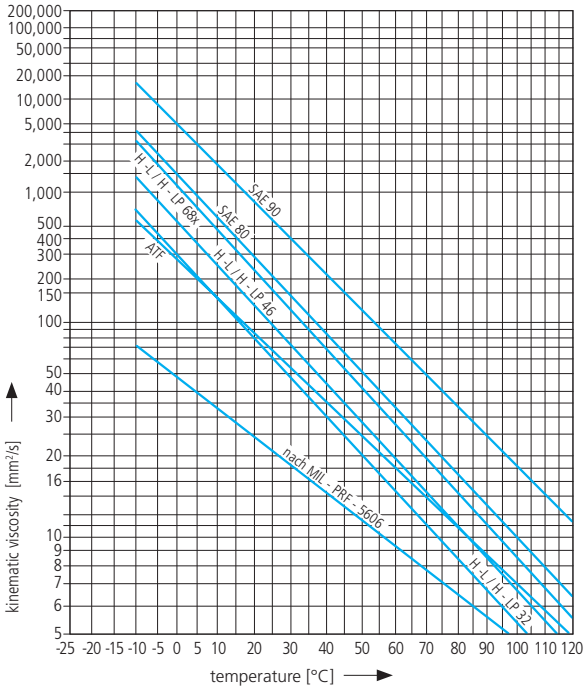
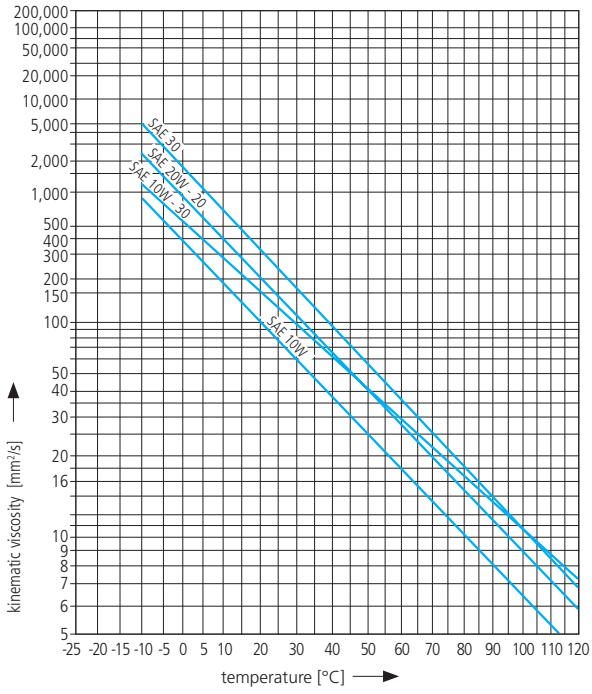
Viscosity / temperature diagram

Hydraulic oils, motor vehicle transmission oils, automatic transmission fluid oils and oils according to MIL - PRF - 5606



Motor oils



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