HY-PRO
FILTRATION

Selecting Target ISO Cleanliness Codes

When setting target ISO fluid cleanliness codes for hydraulic and lubrication systems it is important keep in mind the objectives to be achieved. Maximizing equipment reliability and safety, minimizing repair and replacement costs, extending useful fluid life, satisfying warranty requirements, and minimizing production down-time are attainable goals. Once a target ISO cleanliness code is set following a progression of steps to achieve that target, monitor it, and maintain it justifiable rewards will be yours.

Set the Target.
The first step in identifying a target ISO code for a system is to identify the most sensitive on an individual system, or the most sensitive component supplied by a central reservoir. If a central reservoir supplies several systems the overall cleanliness must be maintained, or the most sensitive component must be protected by filtration that cleans the fluid to the target before reaching that component.

Other Considerations
Table 1 recommends conservative target ISO cleanliness codes based on a several component manufacturers guidelines and extensive field studies for standard industrial operating conditions in systems using petroleum based fluids. If a non-petroleum based fluid is used (i.e. water glycol) the target ISO code should be set one value lower for each size (4μ[c]/6μ[c]/14μ[c]). If a combination of the following conditions exists in the system the target ISO code should also be set one value lower:

- Component is critical to safety or overall system reliability.
- Frequent cold start.
- Excessive shock or vibration.
- Other Severe operation conditions.

Recommended* Target ISO Cleanliness Codes and media selection for systems using petroleum based fluids per ISO4406:1999 for particle sizes 4μ[c] / 6μ[c] / 14μ[c]

	Pressure < 140 bar < 2000 psi	Media βx[c] = 1000 (βx = 200)	Pressure 212 bar 3000 psi	Media βx[c] = 1000 (βx = 200)	Pressure > 212 bar > 3000 psi	Media βx[c] = 1000 (βx = 200)
Pumps						
Fixed Gear	20/18/15	22μ[c] (25μ)	19/17/15	12μ[c] (12μ)	-	-
Fixed Piston	19/17/14	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)	17/15/12	7μ[c] (6μ)
Fixed Vane	20/18/15	22μ[c] (25μ)	19/17/14	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)
Variable Piston	18/16/13	7μ[c] (6μ)	17/15/13	5μ[c] (3μ)	16/14/12	7μ[c] (6μ)
Variable Vane	18/16/13	7μ[c] (6μ)	17/15/12	5μ[c] (3μ)	-	-
Valves						
Cartridge	18/16/13	12μ[c] (12μ)	17/15/12	7μ[c] (6μ)	17/15/12	7μ[c] (6μ)
Check Valve	20/18/15	22μ[c] (25μ)	20/18/15	22μ[c] (25μ)	19/17/14	12μ[c] (12μ)
Directional (solenoid)	20/18/15	22μ[c] (25μ)	19/17/14	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)
Flow Control	19/17/14	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)
Pressure Control (modulating)	19/17/14	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)	17/15/12	7μ[c] (6μ)
Proportional Cartridge Valve	17/15/12	7μ[c] (6μ)	17/15/12	7μ[c] (6μ)	16/14/11	5μ[c] (3μ)
Proportional Directional	17/15/12	7μ[c] (6μ)	17/15/12	7μ[c] (6μ)	16/14/11	5μ[c] (3μ)
Proportional Flow Control	17/15/12	7μ[c] (6μ)	17/15/12	7μ[c] (6μ)	16/14/11	5μ[c] (3μ)
Proportional Pressure Control	17/15/12	7μ[c] (6μ)	17/15/12	7μ[c] (6μ)	16/14/11	5μ[c] (3μ)
Servo Valve	16/14/11	7μ[c] (6μ)	16/14/11	5μ[c] (3μ)	15/13/10	5μ[c] (3μ)
Bearings						
Ball Bearing	15/13/10	5μ[c] (3μ)	-	-	-	-
Gearbox (industrial)	17/16/13	12μ[c] (12μ)	-	-	-	-
Journal Bearing (high speed)	17/15/12	7μ[c] (6μ)	-	-	-	-
Journal Bearing (low speed)	17/15/12	7μ[c] (6μ)	-	-	-	-
Roller Bearing	16/14/11	7μ[c] (6μ)	-	-	-	-
Actuators						
Cylinders	17/15/12	7μ[c] (6μ)	16/14/11	5μ[c] (3μ)	15/13/10	5μ[c] (3μ)
Vane Motors	20/18/15	22μ[c] (25μ)	19/17/14	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)
Axial Piston Motors	19/17/14	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)	17/15/12	7μ[c] (6μ)
Gear Motors	20/18/14	22μ[c] (25μ)	19/17/13	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)
Radial Piston Motors	20/18/15	22μ[c] (25μ)	19/17/14	12μ[c] (12μ)	18/16/13	12μ[c] (12μ)
Test Stands, Hydrostatic						
Test Stands	15/13/10	5μ[c] (3μ)	15/13/10	5μ[c] (3μ)	15/13/10	5μ[c] (3μ)
Hydrostatic Transmissions	17/15/13	7μ[c] (6μ)	16/14/11	5μ[c] (3μ)	16/14/11	5μ[c] (3μ)

*Depending upon system volume and severity of operating conditions a combination of filters with varying degrees of filtration efficiency might be required (I.e. pressure, return, and off-line filters) to achieve and maintain the desired fluid cleanliness.

Example		ISO Code	Comments
Operating Pressure	156 bar, 2200 psi		
Most Sensitive Component	Directional Solenoid	19/17/14	recommended baseline ISO Code
Fluid Type	Water Glycol	18/16/13	Adjust down one class
Operating Conditions	Remote location, repair difficult High ingression rate	17/15/12	Adjust down one class, combination of critical nature, severe conditions

Extending Roller Bearing Life.
Improving fluid cleanliness in lubrication systems for roller bearings can exponentially increase component life. Figure B describes attainable increases in life expectancy of roller bearings as improvements in ISO fluid cleanliness codes are made. Life extension for hydraulic components can be achieved by improving fluid cleanliness.

Current ISO Code	Target ISO Code	Target ISO Code	Target ISO Code	Target ISO Code
	2 x Life	3 x Life	4 x Life	5 x Life
28/26/23	25/22/19	22/20/17	20/18/15	19/17/14
27/25/22	23/21/18	21/19/16	19/17/14	18/16/13
26/24/21	22/20/17	20/18/15	19/17/14	17/15/12
25/23/20	21/19/16	19/17/14	17/15/12	16/14/11
25/22/19	20/18/15	18/16/13	16/14/11	15/13/10
23/21/18	19/17/14	17/15/12	15/13/10	14/12/9

Accurate oil analysis - Once the target ISO fluid cleanliness code is established it is critical to properly measure the actual cleanliness of the system. A well designed plan to achieve cleanliness can be undermined if steps are not taken to ensure accurate and repeatable oil analysis. When sampling the oil a wide range of variables can affect the outcome yielding inaccurate results. For more information see Accurate oil sampling and analysis article.

Oil sampling methods and practices - Bottle samples analyzed by independent laboratories is common and widely accepted as a method of quantifying fluid cleanliness. However, there are many variables associated with bottle sampling that can cause inaccurate readings.

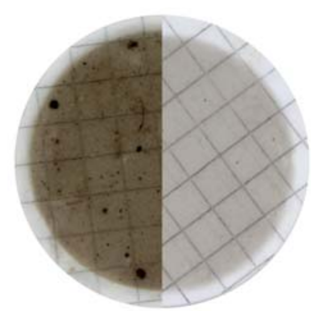
- Background contamination in “clean” sample bottles or vacuum tubes can increase ISO codes by 1~4 classes per size measured, 4μ[c]/6μ[c]/14μ[c].
- Inconsistent in-plant sampling practices (i.e. sample port flush time, bottle rinsed or not).
- Exposure of sample to airborne contaminate during sampling and analysis
- Analysis lab procedure repeatability by operator (i.e. agitation~count interval affect on suspension).
- Analysis lab calibration drift.
- Variability between oil analysis lab particle

On-line particle counting - Connecting an on-line particle counter directly to the hydraulic or lube system through sampling ports provides the most accurate snapshot of fluid cleanliness and eliminates many of the inherent variables associated with bottle sampling. Some particle counters can function with system pressure as low as 20 psi (1.42 bar) at certain viscosities for sampling pressure line, return line, or lubrication system. There are also particle counter options available to draw (Sip) the fluid from a reservoir, tote, or other container directly into the particle counter when system pressure is not available. Monitor sample port cleanliness in real time to know when the sample is truly representative of the system and not tainted with sample port contaminate buildup.

Maintaining control of the sampling and analysis procedures increases the accuracy of your results, eliminates the waiting game to get samples back from a lab, allows quicker response to contamination related issues, and even save money on oil sample kits. No one knows your system better than you and once armed with the right oil analysis approach and diagnostic equipment you can make improvements in reliability.

Oil sampling port types and locations - Just as sampling technique and method can compromise results, sampling port and location can also be a challenge. Sampling ports are often contamination collection points and must be flushed for up to 6 minutes before a truly representative sample is captured. Without a proper port flush the results can be affected. Port location is also critical to obtaining a good sample. Locating a sampling where there is turbulent flow will provide more realistic results than a laminar area. For more information see Accurate oil sampling and analysis article.

PTK-1 Oil analysis kit - Patch test kits are a good complement to on-line particle counters as they provide the capability to visually analyze contamination levels and types in the system. The kit includes a microscope, vacuum pump, test patches, and solvent dispenser integrated into a carrying case. The kit also features a reference manual to correlate visual patch appearance to approximate ISO code.



Machine Tool Contamination Field Study

Focus: Solving contamination issues resulting from insufficient filtration on power units and machine tools.

APPLICATIONS

- Pressure filters are ideal for protecting control valves and other sensitive components from internally generated contaminate and ingression.
- Machine tools without a pressure filter protecting valve manifolds after the pump.
- Power units on CNC lathes and milling equipment, Plastics injection molding, mobile equipment, and other small industrial machines with sensitive control valves.

The Problem - Insufficient filtration

Machine tools and power units are frequently designed without the filtration necessary to maintain recommended fluid cleanliness levels for the system. A fluid cleanliness case study of three CNC lathes (A, B, C) raised some concern. The only filtration present was either a coarse suction strainer or coarse return-line screen. Baseline oil analysis (see fig 1) revealed that the fluid cleanliness levels of the hydraulic fluids (per ISO 4406 code chart) were higher than recommended levels for the system components (see fig 2).

fig. 1

Machine	ISO code*
A	22 / 20 / 14
B	23 / 20 / 14
C	23 / 21 / 16

fig 2.

Pumps	**<2000 psi**	**2000~3000**	**>3000 psi**
Fixed gear	20/18/15	19/17/15	
Fixed vane	20/18/15	19/17/14	18/16/13
Fixed piston	19/17/14	18/16/13	17/15/12
Variable vane	18/16/13	17/15/12	
Variable piston	18/16/13	17/15/13	16/14/12
Valves		**2000~3000**	**>3000 psi**
Directional	(solenoid)	20/18/15	19/17/14
Proportional		17/15/12	16/14/11
Servo Valve		16/14/11	15/13/10

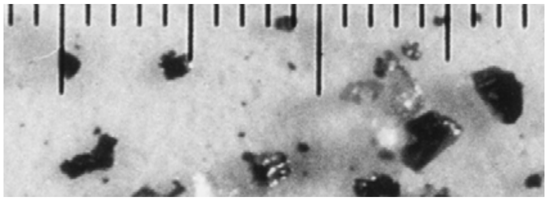
Contamination Basics & Sources

Particulate contamination is the number one cause of hydraulic component failure, and 70~75% of failures are related to surface degradation caused by mechanical wear.

Sources of particulate contamination

- Built-In contamination (assembly environment, dirty new components and hoses, metal fabrication)
- Ingested contamination (leaky reservoirs, no reservoir breather, worn rod wipers and bearing seals, dirty replacement components, system exposure during maintenance, new oil—see fig 3.)
- Internally generated contamination (abrasive wear, adhesive wear, stress related wear, corrosion, fluid breakdown)

Fig 3 (new oil typical ISO code 24/21/18).



HY-PRO FILTRATION

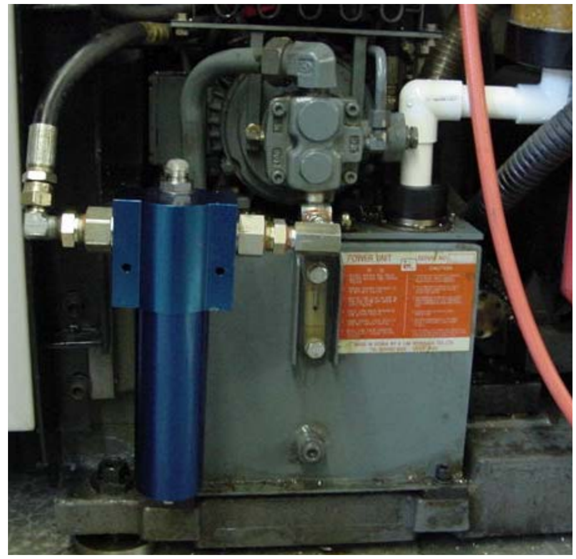
Solution Part I - System Clean-up

The pressure filter assembly, including β12[c] = 1000 filter element and element condition indicator, was added to each of the three machines (see fig 4) after the pressure pump (piston type). After nine days of operation the indicators on machines A and C were signaling terminal pressure drop. At that time all three elements were serviced and the oil was analyzed (see fig 5). The ISO codes improved, but not to the level recommended for servo valves. The next step was to set target cleanliness codes and enhance the filtration efficiency to reach the target. The spent elements that were removed contained large particles including piping putty (from installation of new hoses) and other large debris that was not being removed by the suction strainer.

fig. 5

Mach.	ISO code before Pressure filter	ISO code after 9 days (β12[c] = 1000)
A	22 / 20 / 14	19 / 18 / 12
B	23 / 20 / 14	21 /18 / 12
C	23 / 21 / 16	20 / 18 / 13

Fig 4.



Solution Part II - Enhanced Filtration and Target Cleanliness Codes

A target ISO Cleanliness Code of 16 / 14 / 11 (measured at filter effluent) was established for all three machines to protect and maximize piston pump and solenoid valve life. New filter elements were installed with a more efficient rating of β5[c] = 1000 (β3 = 200 according to old standards) to achieve the target. After 60 days of service the oil from all three machines was analyzed (see fig 7), even though none of the assemblies were indicating terminal pressure drop. Machines B and C were able to attain the target while A did not, although adding of the pressure filter made considerable improvement in cleanliness. The oil was sampled after 180 days using an on-line particle counter connected to the drain plug of the filter bowl. This location represents one of the dirtiest points on the system since the oil has been through the system and in the reservoir. Sampling with an on-line particle counter and proper flushing techniques eliminates variables associated with bottle sampling. Figure 8 illustrates increased life expectancy for hydraulic components that can be realized by reducing fluid cleanliness codes. The benefits of clean fluid justify the cost of filtration.

fig. 7

Mach.	ISO code before filter	ISO code after 60 days (β5[c] = 1000)	ISO code after 180 days (β5[c] = 1000)
A	22 / 20 / 14	17 / 15 / 11	11 / 9 / 7
B	23 / 20 / 14	15 / 13 / 8	13 / 11 / 9
C	23 / 21 / 16	16 / 12 / 10	14 / 11 / 9

Benefits of clean fluid

- Minimize unplanned equipment downtime.
- Reduce maintenance costs and labor.
- Reduce expensive component repair or replacement costs.
- Improve operating efficiency of equipment with sensitive components.
- Extend service life of fluids.

fig. 8 Hydraulic Component

Current ISO Code	Target ISO Code	Target ISO Code	Target ISO Code	Target ISO Code
	2 x Life	**3 x Life**	**4 x Life**	**5 x Life**
28/26/23	25/22/19	22/20/17	20/18/15	19/17/14
27/25/22	23/21/18	21/19/16	19/17/14	18/16/13
26/24/21	22/20/17	20/18/15	19/17/14	17/15/12
25/23/20	21/19/16	19/17/14	17/15/12	16/14/11
25/22/19	20/18/15	18/16/13	16/14/11	15/13/10
23/21/18	19/17/14	17/15/12	15/13/10	14/12/9
22/20/17	18/16/13	16/14/11	15/13/10	13/11/8
21/19/16	17/15/12	15/13/10	13/11/8	-
20/18/15	16/14/11	14/12/9	-	-
19/17/14	15/13/10	13/11/8	-	-
18/16/13	14/12/9	-	-	-
17/15/12	13/11/8	-	-	-

Adding a desiccant breather to the reservoir assures that the air ingested is dry and clean. Reducing water content reduces chemical compound formation, biological growth, oxidation and extends fluid life. Desiccant breathers also control particulate contaminate ingression down to 4μ[c] or 2μ with absolute efficiency. Filler-breather caps commonly found on reservoirs don't properly control particulate contamination. Specific desiccant breathers also adsorb water and oil mist as the reservoir exhales. A full range of adapters is commonly available to retro-fit any reservoir.