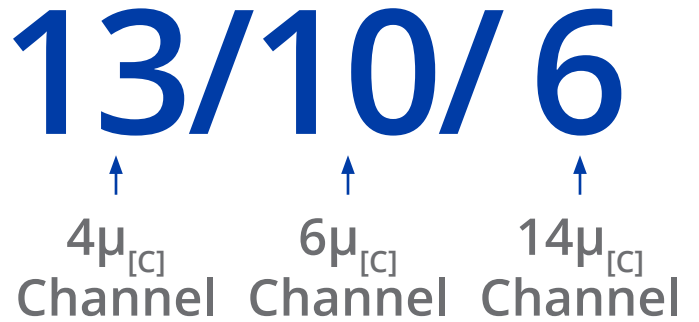


Understanding ISO Codes

The ISO Cleanliness Code (per ISO4406-1999) is used to quantify particulate contamination levels per milliliter of fluid at 3 sizes - $4\mu_{[C]}$, $6\mu_{[C]}$, and $14\mu_{[C]}$. It is expressed in 3 numbers (example 19/17/14) where each number represents a contaminant level code for the correlating particle size. The code includes all particles of the specified size and larger.

It is important to note that each time a code increases, the quantity range of particles is doubling. Inversely, as a code decreases by one the contaminant level is cut in half.

ISO Code Example:



ISO 4406:1999 Code Chart

ISO Code	Particles per Milliliter (PPM)		Sample Values Before Filtration			
	Lower Limit	Upper Limit	Particle Size	PPM	ISO 4406 Code Range	ISO Code
24	80,000	160,000	$4\mu_{[C]}$	151773	80,000-160,000	24
23	40,000	80,000	$4.6\mu_{[C]}$	87210		
22	20,000	40,000	$6\mu_{[C]}$	38363	20,000-40,000	22
21	10,000	20,000	$10\mu_{[C]}$	8229		
20	5,000	10,000	$14\mu_{[C]}$	3339	2,500-5,000	19
19	2,500	5,000	$21\mu_{[C]}$	1048		
18	1,300	2,500	$38\mu_{[C]}$	112		
17	640	1,300	$68\mu_{[C]}$	2		
16	320	640				
15	160	320				
14	80	160				
13	40	80	$4\mu_{[C]}$	69	40-80	13
12	20	40	$4.6\mu_{[C]}$	35		
11	10	20	$6\mu_{[C]}$	7	5-10	10
10	5	10	$10\mu_{[C]}$	5		
9	2.5	5	$14\mu_{[C]}$	0.4	0.32-0.64	6
8	1.3	2.5	$21\mu_{[C]}$	0.1		
7	0.64	1.3	$38\mu_{[C]}$	0.0		
6	0.32	0.64	$68\mu_{[C]}$	0.0		



Fluid Cleanliness Code Comparisons

ISO/DIS 4406 BS 5540/4 Codes	NAS 1638	SAE 749	Defence Standard 05/42	
			Table A	Table B
25/23/17			100,000	
24/22/15			21,000	
23/21/18	12			
23/21/14			15,000	
22/20/17	11			
22/20/13			6,300	
21/19/16	10			
21/19/13			4,400	6,300F
20/18/15	9	6		
20/18/13				4400F
20/18/12			2,000	
19/17/14	8	5		
19/17/11			1,300	2,000F
18/16/13	7			
18/16/11				1,300F
18/16/10			800	
17/15/12	6	3		
17/15/10				800F
17/15/09			400	
16/14/11	5	2		
16/14/09				400F
15/13/10	4	1		
14/12/09	3	0		
13/11/08	2			

ISO Code Limits

Hydraulic component and bearing manufacturers set ISO fluid cleanliness code limits that are the maximum tolerance for fluid contamination under which predictable performance and life can be maintained. These limits often become fluid cleanliness targets at the mill or plant level. Using the upper limit as a target means that you are operating on the absolute edge with no room for error. But there is a better way.

Our mission is to make our customers as efficient as possible. To do this we recommend and help implement operating ISO Codes that are well below OEM upper limits. Our focus is not to hit a valve manufacturer's ISO Code limit but to help our customer reduce servo valve replacements from 220 in one year to 6 in the next by implementing lower operating ISO Codes and drastically reducing component wear/failure. And since that customer could prove that their oil was cleaner than required by spec, those 6 servos in year 2 were replaced under warranty by the manufacturer. Lower operating ISO Codes can extend component life by triple, quadruple and beyond, resulting in huge reliability, profitability and efficiency gains.

How clean is my fluid?

Identifying proper sampling ports and locations, taking accurate samples and correctly interpreting results are critical to success. That's why our training and support are based on knowing and understanding the importance of fluid cleanliness and sampling. Hy-Pro is on the front line with on-line particle counters, expertise and strategies to achieve lower operating ISO Codes.

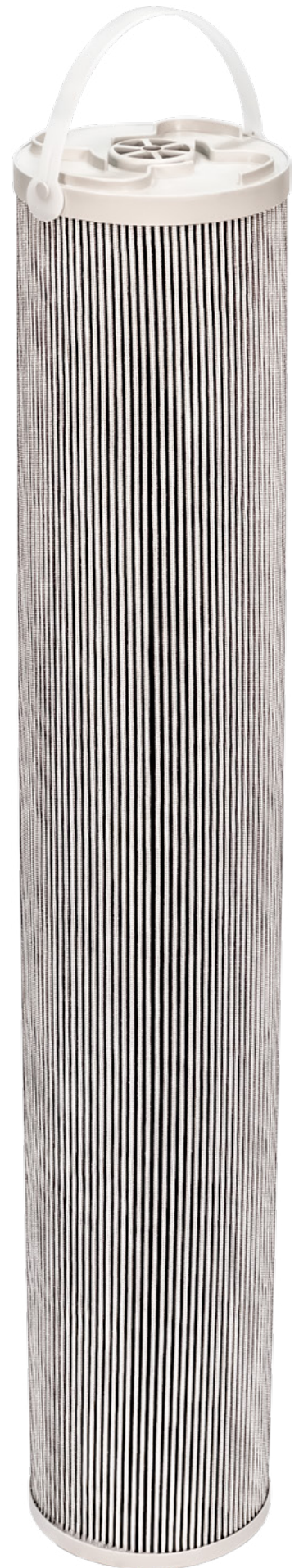
Setting operating ISO Codes.

The table on the following page represents Hy-Pro's recommendations for operating ISO Code by component and pressure. These are lower than typical industry standard target ISO Codes and are based on our experience of extending component life and reliability. Other considerations in setting a lower operating ISO Codes include:

- Component criticality (turbine hydraulic controls)
- Safety (amusement park hydraulics)
- Excessive shock or vibration (mining excavator)
- High frequency duty cycle (high speed stamping press)

Total System Cleanliness

Upgrading to Hy-Pro DFE rated filter elements, Hy-Dry breathers and adding off-line contamination solutions where needed are a small expense compared to the cost of contamination related component repair and replacement, premature fluid replacement, increased maintenance demands and, worst of all, downtime. By taking these small steps and becoming proactive in preventing contamination, you're setting yourself and your plant up with the best possible chance for success.



Recommended* Upper Limit ISO Cleanliness Codes per Component by Pressure Rating

	Pressure <2000 psi (138 bar)		Pressure 2000-3000 psi (138-207 bar)		Pressure >3000 psi (207 bar)	
	Industry Standard	Hy-Pro Recommended	Industry Standard	Hy-Pro Recommended	Industry Standard	Hy-Pro Recommended
Pumps						
Fixed gear	20/18/15	≤ 17/15/12	19/17/15	≤ 16/14/11	-	-
Fixed piston	19/17/14	≤ 16/14/11	18/16/13	≤ 15/13/10	17/15/12	≤ 15/13/10
Fixed vane	20/18/15	≤ 17/15/12	19/17/14	≤ 16/14/11	18/16/13	≤ 15/13/10
Variable piston	18/16/13	≤ 16/14/11	17/15/13	≤ 15/13/10	16/14/12	≤ 15/13/10
Variable vane	18/16/13	≤ 16/14/11	17/15/12	≤ 15/13/10	-	-
Valves						
Cartridge	18/16/13	≤ 16/14/11	17/15/12	≤ 15/13/10	17/15/12	≤ 15/13/10
Check valve	20/18/15	≤ 17/15/12	20/18/15	≤ 17/15/12	19/17/14	≤ 16/14/11
Directional (solenoid)	20/18/15	≤ 17/15/12	19/17/14	≤ 16/14/11	18/16/13	≤ 15/13/10
Flow control	19/17/14	≤ 17/15/12	18/16/13	≤ 16/14/11	18/16/13	≤ 16/14/11
Pressure control (modulating)	19/17/14	≤ 17/15/12	18/16/13	≤ 16/14/11	17/15/12	≤ 15/13/10
Proportional cartridge valve	17/15/12	≤ 15/13/10	17/15/12	≤ 15/13/10	16/14/11	≤ 14/12/9
Proportional directional	17/15/12	≤ 15/13/10	17/15/12	≤ 15/13/10	16/14/11	≤ 14/12/9
Proportional flow control	17/15/12	≤ 15/13/10	17/15/12	≤ 15/13/10	16/14/11	≤ 14/12/9
Proportional pressure control	17/15/12	≤ 15/13/10	17/15/12	≤ 15/13/10	16/14/11	≤ 14/12/9
Servo valve	16/14/11	≤ 14/12/9	16/14/11	≤ 14/12/9	15/13/10	≤ 13/11/8
Bearings						
Ball bearing	15/13/10	≤ 15/13/10	-	-	-	-
Gearbox (industrial)	17/16/13	≤ 15/13/10	-	-	-	-
Journal bearing (high speed)	17/15/12	≤ 15/13/10	-	-	-	-
Journal bearing (low speed)	17/15/12	≤ 15/13/10	-	-	-	-
Roller bearing	16/14/11	≤ 15/13/10	-	-	-	-
Actuators						
Cylinders	17/15/12	≤ 16/14/11	16/14/11	≤ 15/13/10	15/13/10	≤ 15/13/10
Vane motors	20/18/15	≤ 17/15/12	19/17/14	≤ 16/14/11	18/16/13	≤ 15/13/10
Axial piston motors	19/17/14	≤ 16/14/11	18/16/13	≤ 15/13/10	17/15/12	≤ 15/13/10
Gear motors	20/18/14	≤ 17/15/12	19/17/13	≤ 16/14/11	18/16/13	≤ 15/13/10
Radial piston motors	20/18/15	≤ 17/15/12	19/17/14	≤ 16/14/11	18/16/13	≤ 15/13/10
Other						
Test stands	15/13/10	≤ 15/13/10	15/13/10	≤ 15/13/10	15/13/10	≤ 15/13/10
Hydrostatic transmissions	17/15/13	≤ 16/14/11	16/14/11	≤ 15/13/10	16/14/11	≤ 15/13/10
High pressure fuel injector or common fuel rail	18/16/13	≤ 16/14/11	18/16/13	≤ 15/13/10	18/16/13	≤ 15/13/10

*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.

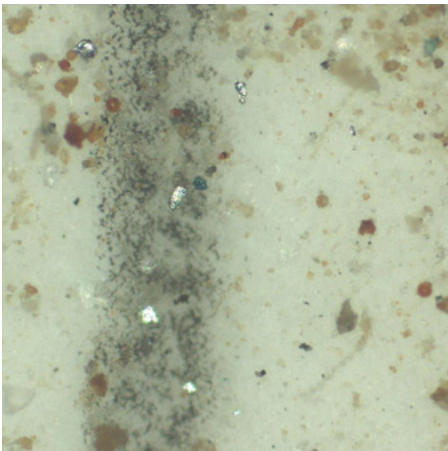
Bearing & Component Life Extension

Improving fluid cleanliness means reduced downtime, more reliable equipment, longer fluid life, and fewer maintenance hours. In addition, it also means reduced component replacement and repair expenses.

By improving the cleanliness of your fluid by only a few ISO Codes, you can directly increase the lifespan of your components and equipment. The tables on the following page demonstrate the life extension for both roller contact bearings and hydraulic components given a reduction in ISO Codes.

How clean is your *new* oil?

As it turns out, new oil can be one of the worst sources of particulate and water contamination.



The picture above was taken from a patch test at 10x magnification on a new oil sample direct from the manufacturer and shows the level of contamination present in seemingly clean oil.

A good upper limit for new oil cleanliness is 16/14/11. However, a commonly seen ISO Code for new oil reaches an ISO Code of 25/22/19, which is not only not suitable for hydraulic or lubrication systems but can actually be a major cause of degradation and premature component failure.

Hy-Pro will help you develop a plan to achieve and maintain target fluid cleanliness. Arm yourself with the support, training, tools and practices to operate more efficiently, maximize uptime and save money.



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Hydraulic Component Life Extension

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

Roller Contact Bearing Life Extension

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