Donaldson HY-PRO™

CONTAMINATION GUIDES

Understanding ISO Codes

ISO 4406:2021 Code Chart

ISO Code	Particles per Milliliter (PPM)	
	Lower Limit	Upper Limit
24	**80,000**	**160,000**
23	40,000	80,000
22	**20,000**	**40,000**
21	10,000	20,000
20	5,000	10,000
19	**2,500**	**5,000**
18	1,300	2,500
17	640	1,300
16	320	640
15	160	320
14	80	160
13	**40**	**80**
12	20	40
11	10	20
10	**5**	**10**
9	2.5	5
8	1.3	2.5
7	0.64	1.3
6	**0.32**	**0.64**

Sample Values Before Filtration

Particle Size	PPM	ISO 4406 Code Range	ISO Code
4$\mu_{(C)}$	**151773**	**80,000-160,000**	**24**
4.6$\mu_{(C)}$	87210		
6$\mu_{(C)}$	**38363**	**20,000-40,000**	**22**
10$\mu_{(C)}$	8229		
14$\mu_{(C)}$	**3339**	**2,500-5,000**	**19**
21$\mu_{(C)}$	1048		
38$\mu_{(C)}$	112		
68$\mu_{(C)}$	2		

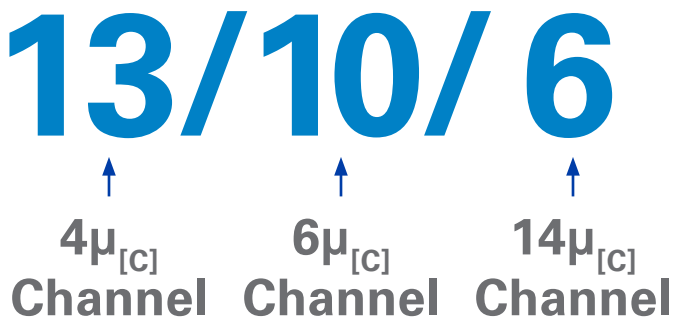
Sample Values After Filtration

Particle Size	PPM	ISO 4406 Code Range	ISO Code
4$\mu_{(C)}$	**69**	**40-80**	**13**
4.6$\mu_{(C)}$	35		
6$\mu_{(C)}$	**7**	**5-10**	**10**
10$\mu_{(C)}$	5		
14$\mu_{(C)}$	**0.4**	**0.32-0.64**	**6**
21$\mu_{(C)}$	0.1		
38$\mu_{(C)}$	0.0		
68$\mu_{(C)}$	0.0		

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:



Fluid Cleanliness Code Comparisons

ISO/DIS 4406 BS 5540/4 Codes	NAS 1638	SAE 749	Defence Standard 05/42 Table A	Defence Standard 05/42 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. Donaldson 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 Donaldson 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 Donaldson 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	Donaldson Hy-Pro Recommended	Industry Standard	Donaldson Hy-Pro Recommended	Industry Standard	Donaldson 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.