Hydraulic & Lube Oil Contamination Reference Chart

Filter Element Upgrades
Deliver lower ISO Codes, longer element life, and lower total cost of ownership

FC Off-line Filter Carts
Heavy duty off-line Filter Carts for reservoir and gearbox conditioning

SVR Soluble Varnish Removal Systems
Complete recovery and maintenance solution for mineral oil based turbine oil lubricants

NSD Non-Spark Discharge Filter Elements
Elements designed to prevent spark discharge in bearing lube and hydraulic control systems

VUD Vacuum Dehydration Systems
Complete oil conditioning systems for removal of particulate and all forms of water

FSL High Viscosity Filtration Systems
Oversized filter systems for off-line gearbox and reservoir conditioning

FCLCOD Diesel Conditioning Filter Carts
Heavy duty water and particulate removal filter carts for diesel fuels

FSAPE Phosphate Ester Conditioning Systems
Complete conditioning systems to remove acid, increase resistivity and lower ISO Codes

HY-PRO

CUT DIRT, CUT COSTS

hyprofiltration.com/

Appearance of Water in Oil

Dissolved Water:
Oil appears bright and clear. Water can only be removed by vacuum dehydration.

500 ppm 1000 ppm 2500 ppm 5000 ppm 10000 ppm

Emulsified Water:
Very small droplets dispersed in oil. Oil viscosity may go up and appear cloudy and milky. Tiny amounts of detergent engine oil can contaminate industrial oils.

Harmful Effects of Water in Oil

Water is one of the most common and most damaging contaminants found in a lube or hydraulic system. Continuous or periodic high water levels can result in damage such as:

- Metal Etching (Corrosion)
- Abrasive Wear in Hydraulic Components
- Dielectric Strength Loss
- Fluid Breakdown
- Additive Precipitation and Oil Oxidation
- Reduction in Lubricating Properties

Contamination Related Failure

Component Life Extension by Removing Water*

Current Moisture Level PPM

	New Moisture Level PPM (%)									
	1000 (0.1%)		500 (0.05%)		250 (0.025%)		100 (0.01%)		50 (0.005%)	
	Rolling Element	Journal Bearing	Rolling Element	Journal Bearing	Rolling Element	Journal Bearing	Rolling Element	Journal Bearing	Rolling Element	Journal Bearing
5000	**2.3**	1.6	**3.3**	1.9	**4.8**	2.3	**7.8**	2.9	**11.2**	3.5
2500	**1.6**	1.3	**2.3**	1.6	**3.3**	1.9	**5.4**	2.4	**7.8**	2.9
1000	**-**	-	**1.4**	1.2	**2**	1.5	**3.3**	1.9	**4.8**	2.3
500	**-**	-	**-**	-	**1.4**	1.2	**2.3**	1.6	**3.3**	1.9
250	**-**	-	**-**	-	**-**	-	**1.5**	1.3	**2.3**	1.6
100	**-**	-	**-**	-	**-**	-	**-**	-	**1.4**	1.2

*Courtesy of Noria

Before After

Fluid Analysis Reference Guide

Below are contaminants found on fluid analysis test reports listed according to their chemical symbol (often how they'll be listed on the reports) and the various sources from which they are known to occur.

Oil Analysis Test Categories

Xx Name **Wear Metals** Xx Name **Additives** Xx Name **Contaminants**

Al Aluminum
- Wear Metals: Bearings, Blocks, Blowers, Bushings, Clutches, Cylinders, Housings, Pistons, Pump Bearings, Motor Housings, Rotors, Thrust Bearings, Thrust Washers
- Contaminants: Alumina, Bauxite, Catalyst, Coal, Fly Ash, Foundry Dust, Granite, Grease Thickener, Paint, Road Dust

Sb Antimony
- Wear Metals: Alloy Steel
- Contaminants: Ceramic Products, Paint

Ba Barium
- Additives: Fuel Additive, Grease Thickener, Oil Additive: Detergent

Be Beryllium
- Wear Metals: Alloy Steel

B Boron
- Additives: Coolant Inhibitor, Oil Additive: Anti Wear
- Contaminants: Oil Additive: Ext Pressure, Oil Additive: Detergent

Cd Cadmium
- Wear Metals: Journal Bearings, Plating

Ca Calcium
- Wear Metals: Cement Dust, Fuller's Earth, Grease Thickener, Gypsum, Hard Water, Lignite
- Contaminants: Hard Rock Dust, Oil Additive: Detergent, Oil Additive: Rust Inhibitor, Road Dust, Rubber, Salt Water, Slag

Cr Chromium
- Wear Metals: Exhaust Valves, Sleeve Liners, Low Alloy Steel, Oil Coolers, Rings, Rods
- Contaminants: Roller Bearings, Stainless Steel, Taper Bearings, Water Treatment, Paint

Cu Copper
- Wear Metals: Babbitt Bearings (Underlay), Bearing Cage, Brass, Bronze, Cam Bushings, Clutches, Governors, Guides, Oil Coolers
- Contaminants: Oil Pumps, Pump Piston & Thrust Plate, Steering Disc, Valve Train Bushings, Wear Plates, Wrist Pin Bushings, Oil Additive: Anti Wear, Paint

Fe Iron
- Wear Metals: Bearings, Blocks, Brake Pads, Cam Shaft, Cast Iron, Crankshafts, Cylinders, Discs, Gears, Housings
- Contaminants: Hydraulic Pump, Vanes, Gears, Pistons, Liners, Oil Pump, Power Take Off (PTO), Rings, Screws, Shafts

Predictor Source of Spectrometry Metals

Wear Metals | Contaminants & Abrasives

Pb Lead
- Wear Metals: Babbitt, Journal Bearing (Overlay), Bronze Alloy, Solder, Balancing Weights
- Contaminants: Gasoline Additives, Paint, Road Dust

Mg Magnesium
- Wear Metals: Turbine Metallurgy
- Contaminants: Hard Water, Oil Additive: Detergent, Road Dust, Sea Water, Fuller's Earth

Mo Molybdenum
- Wear Metals: Alloy Steel, Ring
- Contaminants: Oil Additive: Ext Pressure, Grease

Ni Nickel
- Wear Metals: Hardened Steels, Stainless Steel, Plating

P Phosphorous
- Contaminants: Oil Additive: Anti Wear, Oil Additive: Ext Pressure

K Potassium
- Wear Metals: Coolant Inhibitor, Fly Ash, Fuel Element
- Contaminants: Granite, Paper Dust, Road Dust

Si Silicon
- Wear Metals: Alloy Steel, Asbestos, Cement Dust, Fly Ash, Road Dust, Glass
- Contaminants: Granite, Grease, Limestone, Oil Additive: Antifoam, Synthetic Lubricant, Sealant

Ag Silver
- Wear Metals: Bearing (Overlay), Needle Bearings
- Contaminants: Oil Cooler (Solder), Wrist Pin Bushings

Na Sodium
- Wear Metals: Activated Alumina, Coolant Inhibitor, Dirt, Fly Ash
- Contaminants: Grease, Oil Additives, Paper Mill Dust, Road Salt

Sn Tin
- Wear Metals: Bearing Cage, Babbitt, Bearing Flashing
- Contaminants: Piston Overlay, Solder

Ti Titanium
- Wear Metals: Gas Turbine Bearings, Turbine Blades
- Contaminants: Paint

V Vanadium
- Wear Metals: Turbine Blades, Valves
- Contaminants: Bunker Oil

Zn Zinc
- Wear Metals: Brass, Plating
- Contaminants: Cathodic Protection, Galvanizing, Grease, Oil Additive: Anti Wear

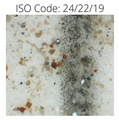
Oil Analysis Patch Test Kits

Lowering Your ISO Codes: Oil Analyses Filter Patches

Understanding the condition of your fluid is the first step toward improving your system cleanliness. Establish your current ISO code, set a target and a plan of action, and finally trend your progress to your goal.

PTK1 Patch Test Kit

ISO Code: 24/22/19



ISO Code: 20/17/13

ISO Code: 16/14/11

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 4406:1999 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		

Component Life Extension Tables

Develop a Fluid Cleanliness Target

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.

Laboratory and field tests prove time and again that Hy-Pro filters consistently deliver lower ISO fluid cleanliness codes.

Improving fluid cleanliness means reduced downtime, more reliable equipment, longer fluid life, fewer maintenance hours, and reduces costly component replacement or repair expenses.

DFE Rated Filter Elements Lower ISO Codes and Improve Reliability

Hydraulic Component Life Extension

Current ISO Code	New ISO Code 2 x Life	New ISO Code 3 x Life	New ISO Code 4 x Life	New ISO Code 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	–	–	–

ISO Code Limits

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.

Roller Contact Bearing Life Extension

Current ISO Code	New ISO Code 2 x Life	New ISO Code 3 x Life	New ISO Code 4 x Life	New ISO Code 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	–	–	–