HY-PRO

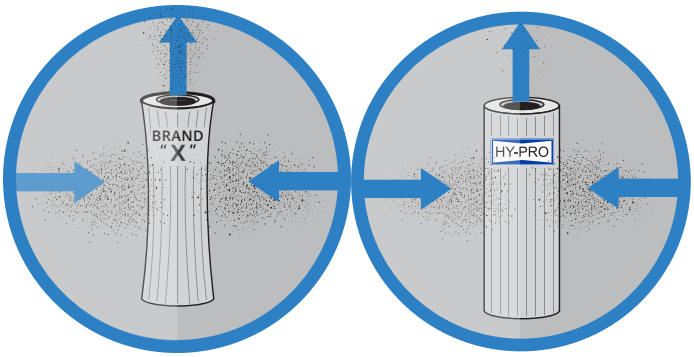
Filter Element Upgrades
PRODUCT GUIDE

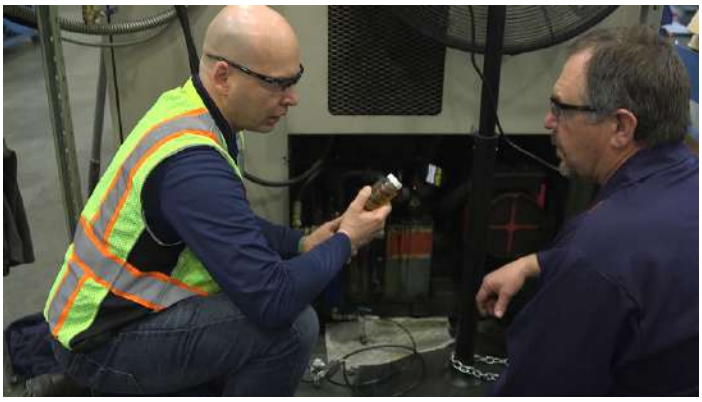
Cut your filter usage and increase your uptime. (Yes, you read that correctly.)

Drive uptime and lower total cost of ownership.

Hy-Pro filter element upgrades deliver the highest capture and retention efficiencies ($\beta x_{[c]} \geq 4000$) through advanced DFE rated element media and the removal of particles, water and oxidation byproducts, making Hy-Pro elements the one component in your critical systems that **saves** you money.

Hy-Pro's advanced media technology is at the heart of our performance. DFE filter element construction goes beyond the lab and is field tested and proven to deliver cleaner oil in industry's toughest applications, all the time.





We'll prove it on your system

Together we help you achieve and maintain world class fluid cleanliness with solutions and strategies, sampling best practices, connected fluid monitoring, results interpretation, and condition based solutions all combined to give you cleaner oil and longer element life.

Improved Sustainability

Implement Hy-Pro contamination solutions, strategies and best practices to dramatically improve your sustainability efforts. Hydraulic and lubricating oils are too often prematurely condemned because of contamination. Hy-Pro filter element upgrades have been proven to extend in-service oil life by 3-4 times by removing water, high particle load and oxidation by-products. Eliminate waste from premature oil and filter changes, and get the most out of your oil; restore demulsibility, protect sacrificial additives, eliminate varnish and acid, improve your sustainability and your bottom line at the same time.

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Complete Element Upgrade Range

The world's largest selection of critical filter elements.

With over 500,000 filter element crosses, Hy-Pro's Interchange offers the most extensive and comprehensive selection of critical hydraulic and lube oil filter elements anywhere. And it's only growing larger. Each year, we catalog thousands of filter elements in our efforts to provide our customers with the best contamination solutions, service and support possible.

Element Upgrades for:

Pall
Schroeder
Donaldson
General Electric
Indufil
Stauff
CC Jensen

Cuno
MP Filtri
Hydac
Argo Hytos
Des Case
Hilco
PTI

Eaton
Rexroth
Filtroil
RRR
Parker
Internormen
Eppensteiner

Kaydon
Taisei Kogyo
Harvard
Mahle
Isopur
Yamashin
And More...

Industrial Grade - Outperform the original.

DFE Rated Glass Media

$\beta X_{[C]} \geq 4000$ rated, high efficiency capture and retention synthetic media.

Water Removal

Glass media with special layers to adsorb and retain water.

Wire Mesh

Coarse media for high viscosity fluids.

NSD Non-Spark Discharge

Glass media optimized to prevent element sparking.

Coalesce

Used to separate water from turbine oils and diesel fuels.

VTM

High efficiency particulate, insoluble oxidation by-product and water removal media

ICB Resin

Specialty media for removing oxidation by-products from certain fluids.

Dynafuzz

Stainless fiber media for fire resistant and highly corrosive fluids.

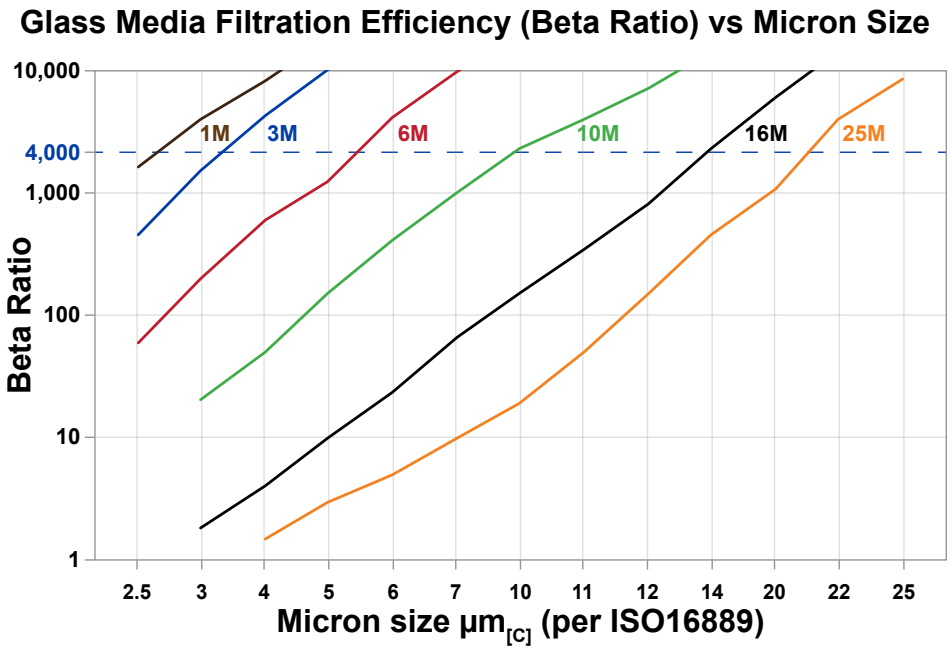
How clean is my oil?

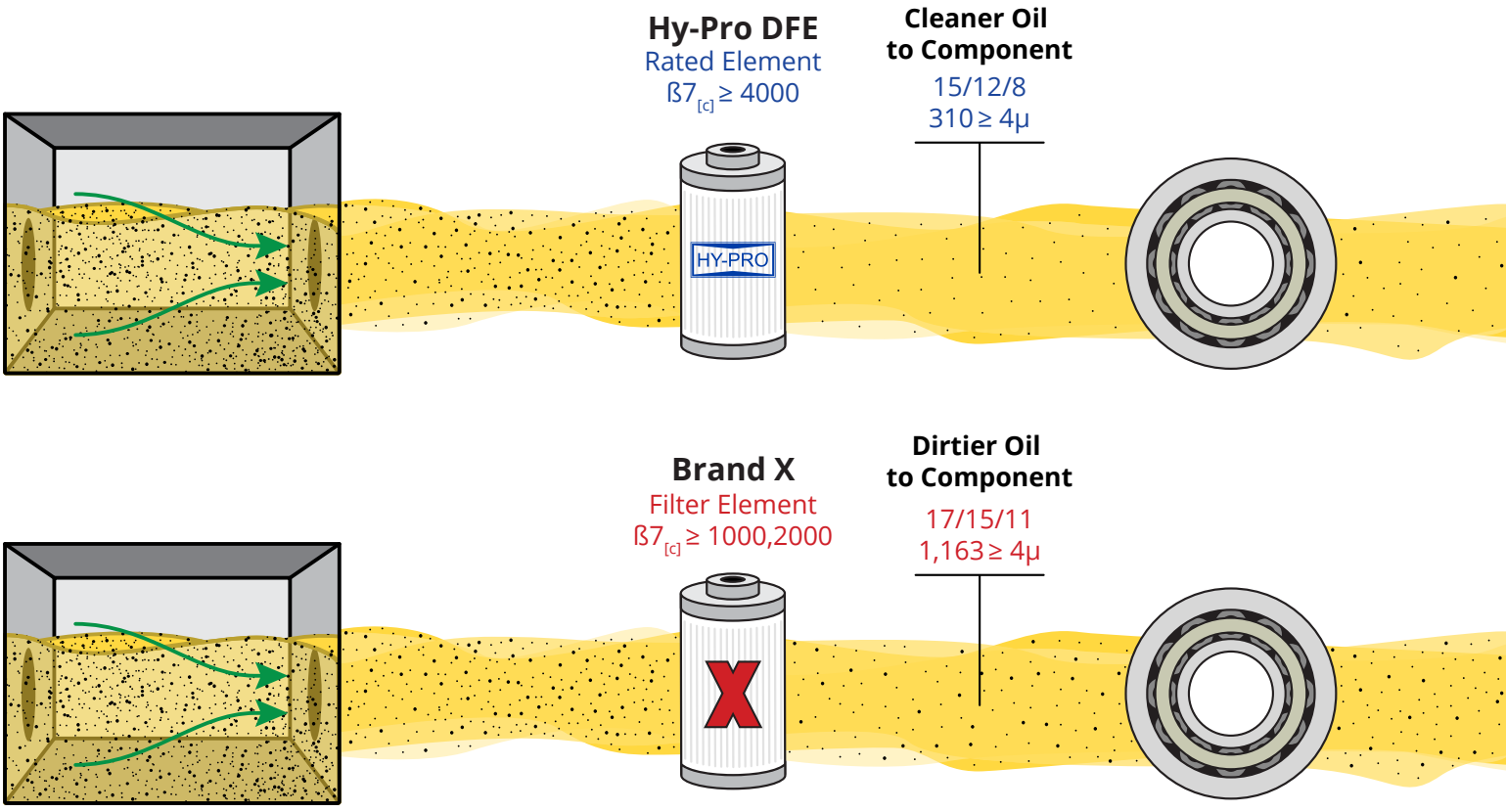
Highest single pass capture and retention efficiency.

Hy-Pro DFE rated filter element upgrades deliver industry's lowest in-service ISO codes before and after the filter. Rated to $\beta X_{[C]} \geq 4000$, Hy-Pro elements ensure your fluids are always clean and always in spec.

It's all about ISO Codes.

What really matters in critical hydraulic, lube and fuel applications is actual in-service oil cleanliness (ISO codes). Proven in both the lab and real world applications, Hy-Pro filter elements deliver the highest single pass efficiency, translating to remarkably lower in-service ISO Codes than competitors.





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How long will my filters last?

Dirt makes dirt.

The worst contamination source in properly maintained hydraulic and lube systems is internally generated wear. Small, clearance sized particles including $4\mu_{[c]}$, $6\mu_{[c]}$, and smaller are the most destructive. As these particles pass through your system, they wreak havoc on your sensitive components, generating more dirt along the way. By removing these particles, you ensure your equipment and your filters last up to and even beyond their expected lifespans.

Hy-Pro Element Upgrades last longer once a new fluid cleanliness equilibrium is achieved.

Hy-Pro elements achieve and maintain lower actual in-service fluid cleanliness (ISO) codes utilizing DFE media technology to capture and retain more contaminants. By maintaining a cleaner system and greatly reducing the rate of internally generated wear, Hy-Pro elements provide incredible efficiency over consistently long lifespans.

Figure 1
Clearance sized particle gets trapped between adjacent surfaces.

Figure 2
Particle under load damages the outer surface, creating a crack.

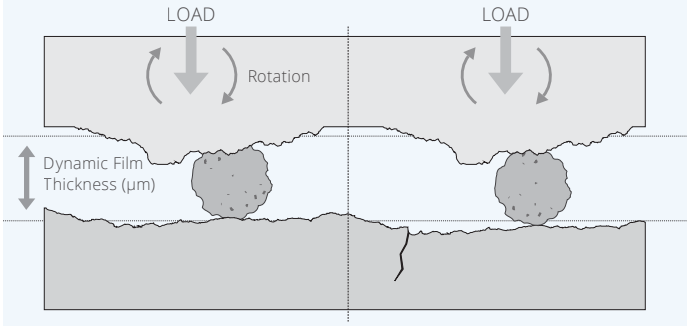
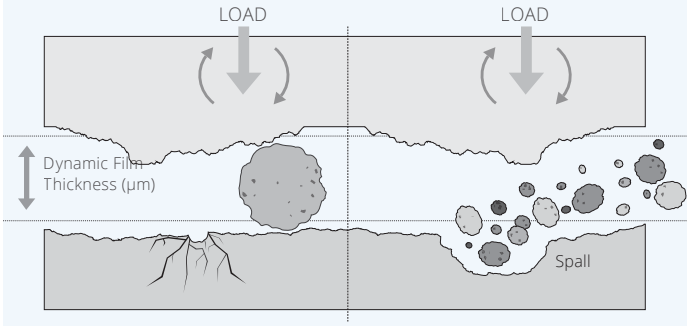
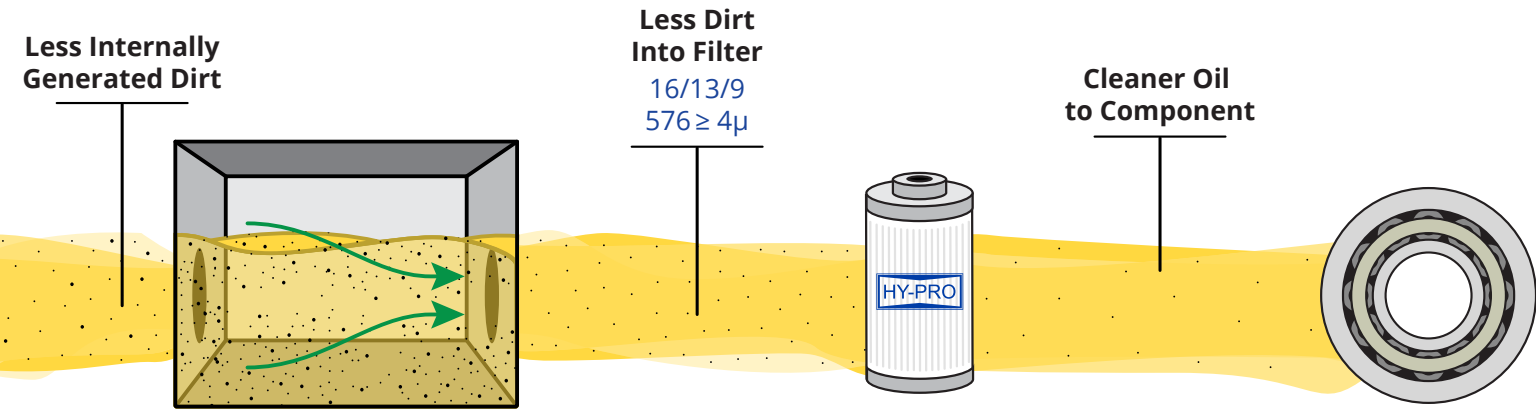
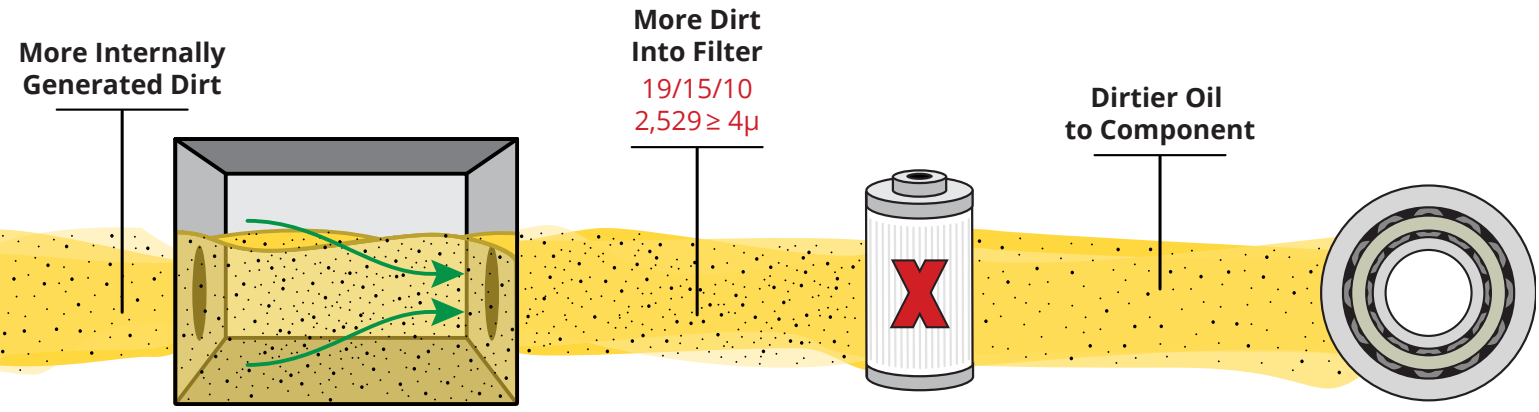


Figure 3
Damage to the outer surface spreads, causing more stress to the crack.

Figure 4
Small contamination breaks away leaving a pit, releasing more abrasive wear.







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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:

13/10/6

$4\mu_{[C]}$ Channel	$6\mu_{[C]}$ Channel	$14\mu_{[C]}$ Channel

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		

Bearing & Component Life Extension

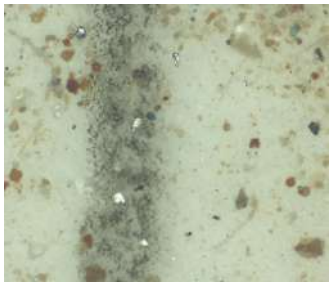
Improving fluid cleanliness means reduced downtime, more reliable equipment, longer fluid life, and fewer maintenance hours. In addition, it also means reduced component replacement and repair expenses.

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.

This picture (right) was taken from a patch test at 100x 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.

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	–	–	–

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	–	–	–

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.

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DFE Filter Element Technology

Quantifying Contaminant Capture and Retention

Filters for critical hydraulic, lube and fuel systems are specifically designed for high efficiency particle capture. However, a filter is not a black hole, capturing and retaining particles in a real-world dynamic environment is far more challenging. Hy-Pro pioneered the DFE (Dynamic Filter Efficiency) multipass test to optimize performance under real-world conditions. This methodology drives the development of proprietary media layers, media support structure, and filter construction. The results are higher efficiency particle capture and retention and cleaner fluids when Hy-Pro upgrade elements are in service.

Hy-Pro uses DFE and the ISO/CD23369 Cyclic Flow Multi-Pass Test to benchmark performance between its filters and those of its competitors. The Cyclic Flow Multi-Pass protocol ISO/CD23369 moves the industry standard one step closer to real-world conditions by incorporating cyclic flow with rapid flow transitions (between 100-200 msec) as shown in Figure 5.

Figure 5: ISO23369 Flow Cycle

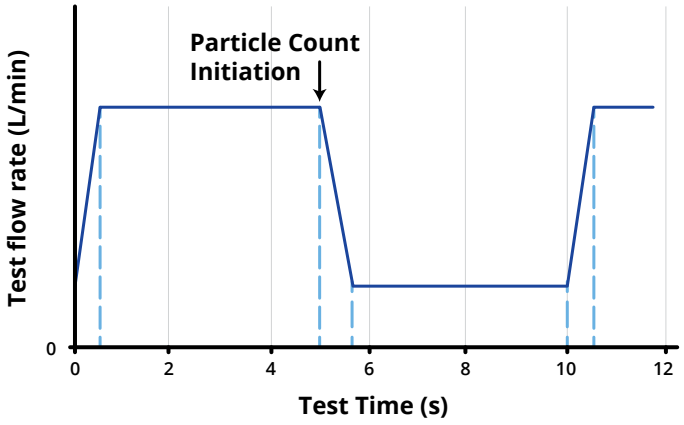


Table 1 illustrates this differentiation during dynamic conditions. Hy-Pro filters and a competitor's filters (Filter X) of similar rating were tested using ISO16889 and ISO23369. The average Beta ratios are listed and plotted vs particle size in Figure 6. Under static ISO16889 (dashed lines) both filters easily exceeded a Beta ratio of $B7_{[c]}$ > 2000 (Hy-Pro filter averaged β 6.2µm=2000, Filter X averaged a higher level of performance, β 6.0µm=2000). In beta ratios the lower the BX number the better the efficiency.

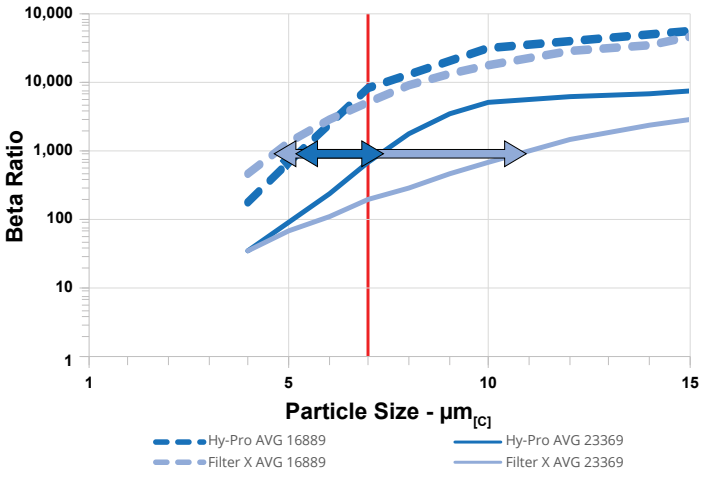
Table 1: Test Conditions and Results

ISO/CD23369 Test Conditions		
Flow Rates	114 lpm:28.5 lpm (30 gpm:7.5 gpm)	
ISO16889 Test Results		
	Hy-Pro	Filter X
β≥1000	6.2 µm	6.0 µm
ISO/CD23369 Test Results		
	Hy-Pro	Filter X
β≥1000	7.2 µm	10.6 µm
β≥2000	8.1 µm	12.9 µm
β≥4000	9.2 µm	17.7 µm

But that is where the similarity ends. The Hy-Pro DFE rated filter element shifted from 6.2µm during static testing to 8.1µm during dynamic conditions – a shift of only 1.9µm. Filter X shifted from 6.0µm to 12.9µm, from static to dynamic conditions – a 6.9µm drop, 6 times greater efficiency loss at Bx≥2000 than Hy-Pro . And these differences dramatically increased at higher Beta ratios with Filter X falling to 17.7 µm at β≥4000.

Hy-Pro DFE rated filter elements are optimized to deliver and maintain the lowest real world, in-service ISO fluid cleanliness codes even in industry's toughest systems. This is what separates Hy-Pro from the rest and how we improve your reliability, efficiency and keep your fluids cleaner and always in spec.

Figure 6: ISO16889 & ISO23369 Avg Beta vs Particle Size

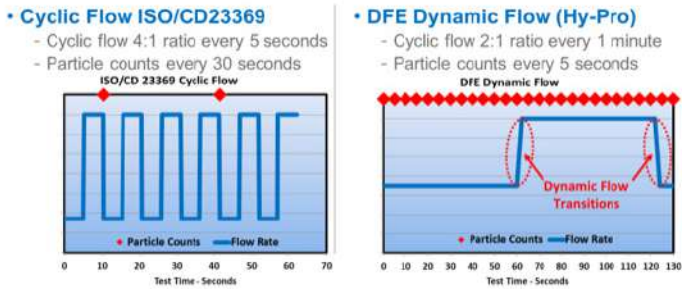


Hy-Pro's Competitive Advantage

DFE Multi-Pass: Cold Start Contamination Retention

Hy-Pro utilizes DFE to bridge the gap between lab and real world filter performance for hydraulic, lube and fuel systems. The DFE restart test challenges a filter's ability to retain the contaminants it has captured in a worst-case scenario, once the filter is near the end of its life. Once the filter is heavily loaded the DFE test main flow and particle injection systems are stopped for a short dwell time, then full flow is restarted without injection to measure what comes out of the filter. After restart the DFE cycle is repeated several times all while the downstream particle counts are monitored in real time. The developmental value of the DFE test is the continuous, real time particle counts that occur concurrently every 5 seconds measuring actual retention efficiency during flow changes and restart (Figure 7). This is the advantage of DFE over ISO/CD23369 Cyclic Flow Multi-Pass test, where several high frequency flow changes are normalized over 30-60 second particle counts. ISO/CD23369 would miss the short-term particle events captured by the DFE test.

Figure 7: ISO/CD23369 vs DFE Multi-Pass



Restarts in hydraulic, lubrication and fuel systems are one of the toughest conditions for a filter and for this reason Hy-Pro includes it in the DFE test. A filter that doesn't properly retain is a dangerous source of concentrated contamination in front of critical components and bearings. Figures 8 and 9 depict the particles released during restart for Filter X and Hy-Pro. The DFE rated Hy-Pro element has much higher retention efficiency than filters designed and validated only to ISO16889 multi-pass or ISO23369. In the real world this means that Hy-Pro DFE rated elements provide lower ISO codes (consistently cleaner oil) and better protection of your critical equipment and uptime.

Figure 8: Filter X DFE Restart Test

Released 1810 particles/ml ≥4µm$_{[c]}$

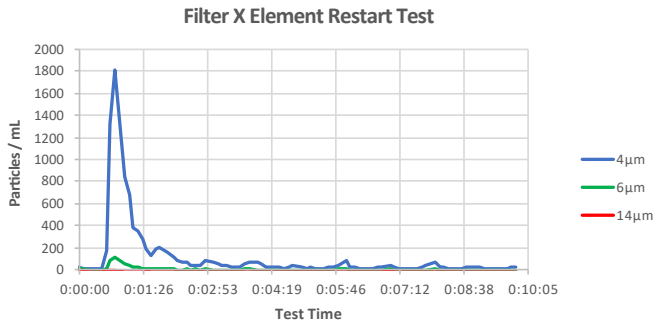
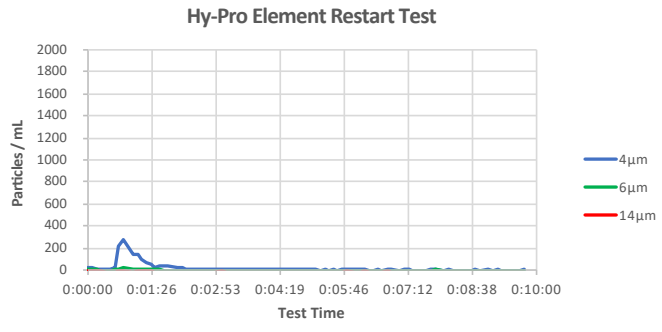


Figure 9: Hy-Pro DFE Restart Test

Released 283 particles/ml ≥ 4µm$_{[c]}$



Downstream Particle Counts / mL During Restart Test

	≥4µm$_{[c]}$	≥6µm$_{[c]}$	≥14µm$_{[c]}$	ISO Code per ISO: 4406:1999	ADHC
Hy-Pro Element	283	29	1.8	15/12/8	54.17g
Element X	1,810	117	1.2	18/14/7	53.27g

Hy-Pro Interchange

The world's largest selection of critical filter elements.

With over 500,000 filter element crosses, Hy-Pro's Interchange offers the most extensive and comprehensive selection of critical hydraulic and lube oil filter elements anywhere. And it's only growing larger. Each year, we catalog thousands of filter elements in our efforts to provide our customers with the best contamination solutions, service and support possible.

Lower ISO Codes: Lower Total Cost of Ownership Hy-Pro filter elements deliver lower operating ISO Codes so you know your fluids are always clean, meaning lower total cost of ownership and reducing element consumption, downtime, repairs, and efficiency losses.

DFE Rated Filter Elements DFE is Hy-Pro's proprietary testing process which extends ISO 16889 Multi Pass testing to include real world, dynamic conditions ensures that our filter elements excel in your most demanding hydraulic and lube applications.

Upgrade Your Filtration Keeping fluids clean results in big reliability gains and upgrading to Hy-Pro filter elements is the first step to clean oil and improved efficiency.

Advanced Media Options DFE glass media maintaining efficiency to $\beta 1_{(c)} > 4000$, Dualglass + water removal media to remove free and emulsified water, stainless wire mesh for coarse filtration applications, and Dynafuzz stainless fiber media for EHC and aerospace applications.

Delivery in days, not weeks From a massive inventory of ready-to-ship filter elements to flexible manufacturing processes, Hy-Pro is equipped for incredibly fast response time to ensure you get your filter elements and protect your uptime.

More than just filtration Purchasing Hy-Pro filter elements means you not only get the best filters, you also get the unrivaled support, training, knowledge and expertise of the Hy-Pro team working shoulder-to-shoulder with you to eliminate fluid contamination.

Want to find out more? Get in touch.

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HY-PRO

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