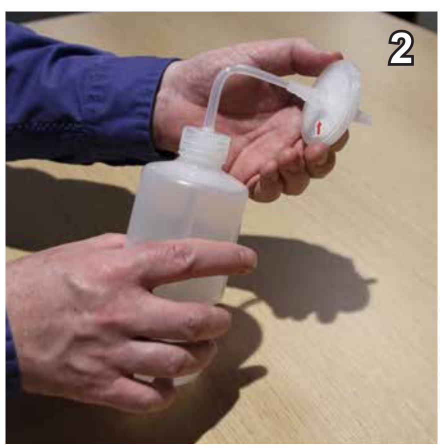
Smart Analysis Kit

Assemble waste bottle, funnel-patch assembly, and vacuum pump to form the sample processing assembly. Tighten the vacuum pump o-ring on the funnel-patch assembly tube by turning the aluminum locking device.



Install solvent* dispensing tube.

*Mineral spirits are the most commonly used solvent

Rinse the funnel-patch assembly with the solvent to remove background contamination. The patch should not be in place for this process.

Separate the funnel from the patch supporter and install a filter patch with ink grid up. (If the patch has an ink grid)

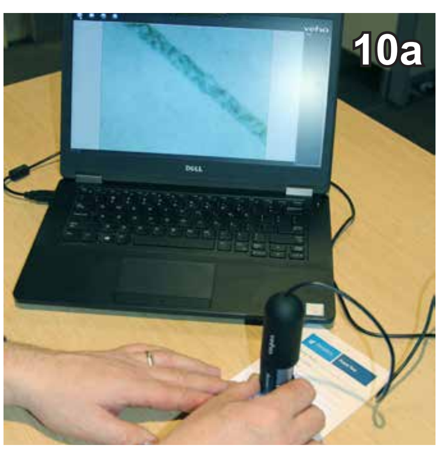
Reattach the funnel to the filter patch base with filter patch. Twist lock the funnel to the base.

Agitate the sample fluid bottle and pour 25ml into the funnel. 25ml is denoted by the first line on the funnel (closest to the patch).

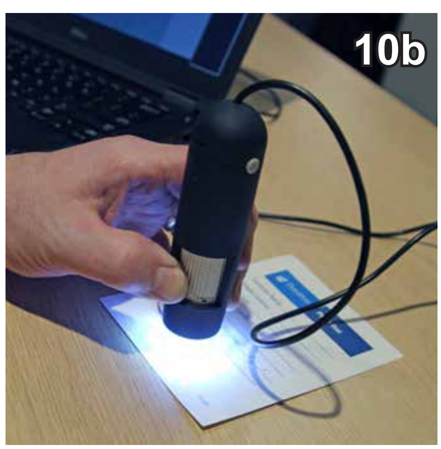
Draw the sample fluid through the patch by pulling on the vacuum pump handle.

Once the entire sample has passed through the patch rinse the funnel with filtered solvent and draw through the patch. Continue to pull air through until the patch starts to dry. Then separate the funnel from the patch supporter and remove the patch with forceps.

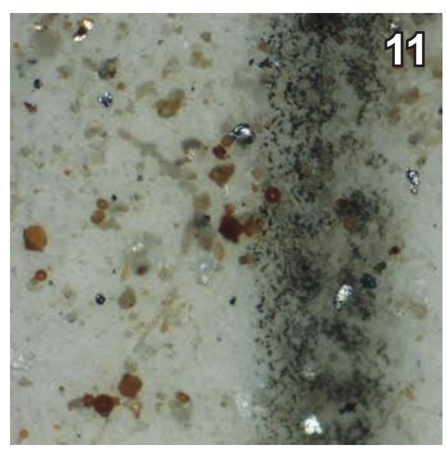
Place the sample (ink/dirty side up) on a clean index card and cover it immediately with a plastic laminate patch cover.



Analyze the sample with the 100x magnification field microscope. (Detailed microscope instructions are provided on the following page.)



For best results, stand the microscope (without the lens cap or base) direcly over the sample.



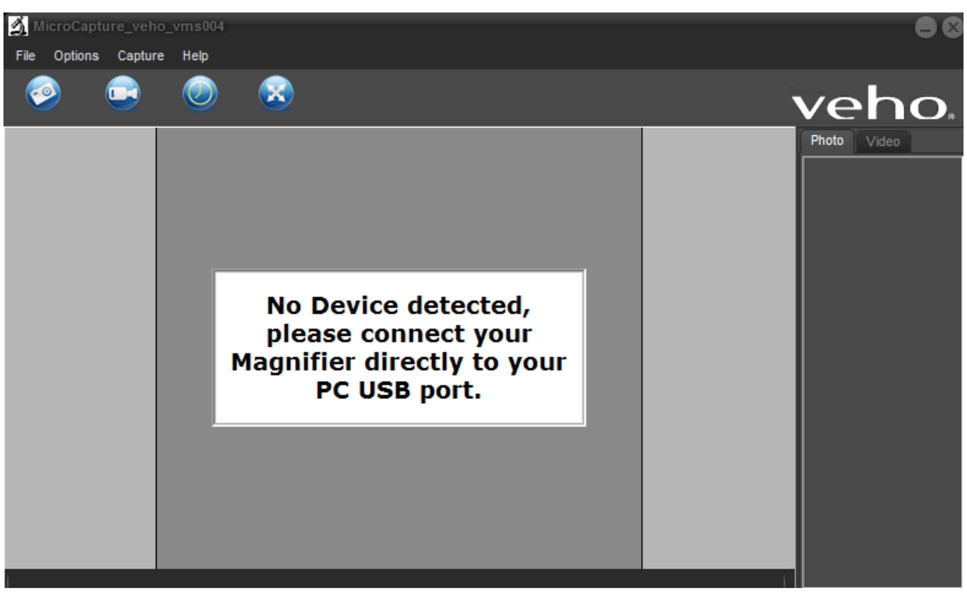
Use the reference photos at the back of the manual to make approximate ISO code correlation and identify contaminant types.

Veho Discovery VMS-006-DX1 Microscope Instructions.

NOTE: The Veho VMS-006-DX1 digital microscope comes in the Patch Kit case when new. It is a sensitive piece of optical electronics and should not be stored in the Kit once the kit is in use. Contamination and damage to the electronics are likely in the portable Patch Kit case containing solvent and fluid samples.

1. Install the MicroCapture software DX1-Windows.zip from the USD provided or the CD that comes with the scope. You will need computer administrator permission for this.

2. Plug the microscope into the USB port of the computer. This powers the light and will be recognized by the software when you run the USB microscope microCapture software. If you do not see a live image from the scope and get the following error, close out of the application and unplug the scope. Plug the scope back in and then re-start the software. You should now have a live image from the scope.

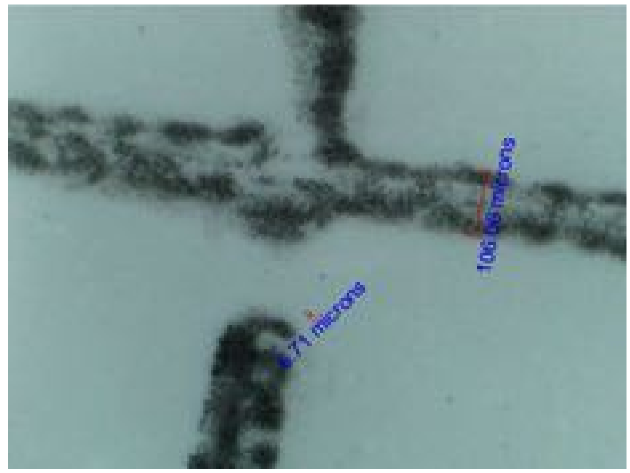


3. Microscope features. There are 3 important features of the Veho VMS-006-DX1 for preparing ISO membrane patch images. The LED light control – should be set on maximum brightness for best resolution. The Focus wheel – should be focused at maximum magnification range for preparing ISO counts. There is a camera icon/button on the computer software for taking still images of the patch area.

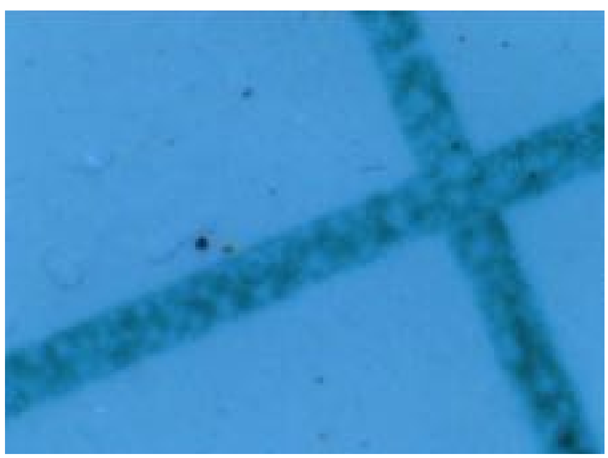
The scope is best used for preparing patch images when it is not in the base. If the scope has a protective cap over the clear base, remove it. The scope's clear plastic lower end must rest directly on the properly prepared and clear slip covered ISO membrane patch to achieve proper focus and magnification.

4. Focusing the microscope to the proper magnification. The microscope can focus at 2 different magnification levels, the lower 10X magnification and higher 200X magnification. ISO particle counting is done only at the higher magnification level. You achieve higher magnification by adjusting the gray focus wheel on the side of the microscope.

   The low-resolution focal range will show a large area of the filter patch. This is NOT high enough magnification to see particles and do an ISO count. The image on the **LEFT is at the INCORRECT-LOW MAGNIFICATION LEVEL, the image on the RIGHT is at the CORRECT-HIGH MAGNIFICATION LEVEL**.



5. The microscope LED light control wheel should be used at maximum brightness for most analysis. In general, shoot images at the highest light level for best results. If you see an image similar to the one below, turn the light control wheel down and back up and it should correct to look similar to above.

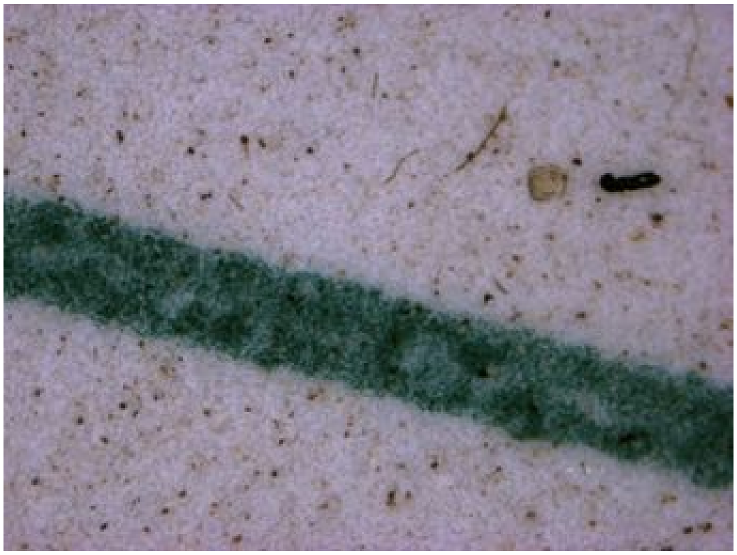


6. **Scanning and photographing ISO patches.** Use the microscope to look around the patch at the high magnification level. You will need to re-focus slightly as you scan around, this is made easier by trying to keep a portion of a grid patch in the view finder as you move and re-focus. You should see debris relatively evenly distributed across the patch. For very low ISO code samples, in the range of ISO 12-16, there will be few particles to see. But in the range of ISO 17 and above there should be quite a few particles visible as you scan around the patch making it a little easier to focus. Shoot 3-4 representative images with the scope and try to include at least a portion of the grid patch. Grid patch lines help you focus on the patch and help provide scale to the viewer. Patch grid lines typically vary in width (roughly 90- 175um) This provides a quick visual reference to recognize the image is at the correct scale for preparing ISO counts.

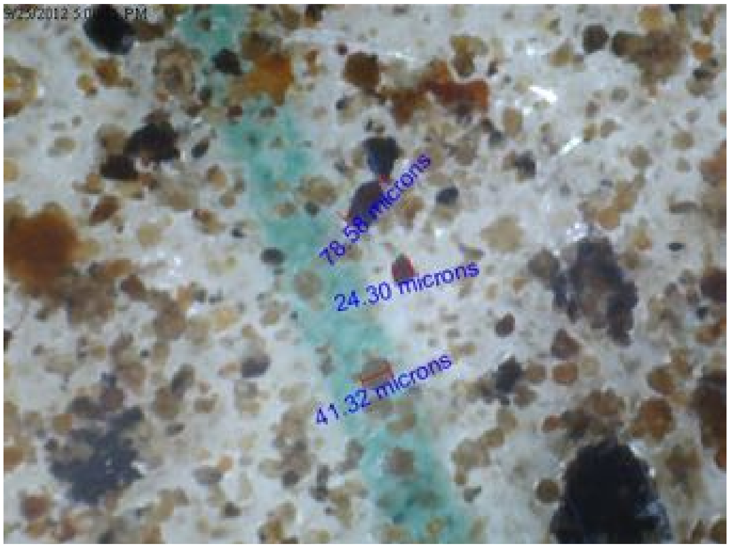
Visual Patch examples for comparison.

Examples of Debris types and various Visual ISO codes.

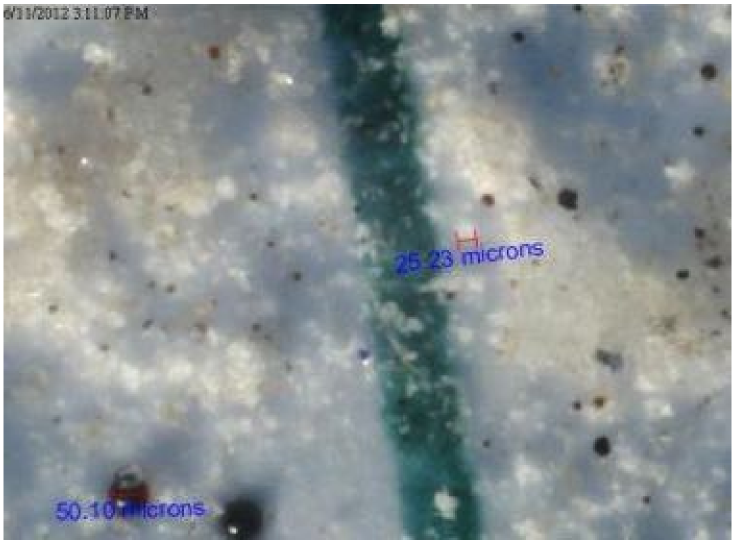
Silica debris in oil and fuel.



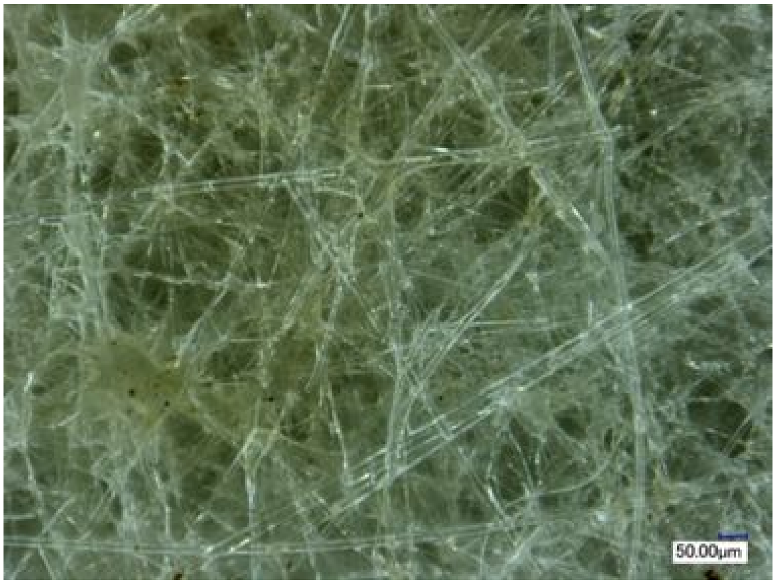
Windblown dust. The fine particles in the image are windblown sand particles and can ingress without proper breathers.



Coarse sand. Large granular sand is from an outside source, dusty conditions, lack of breathers, open caps or access ports, etc.

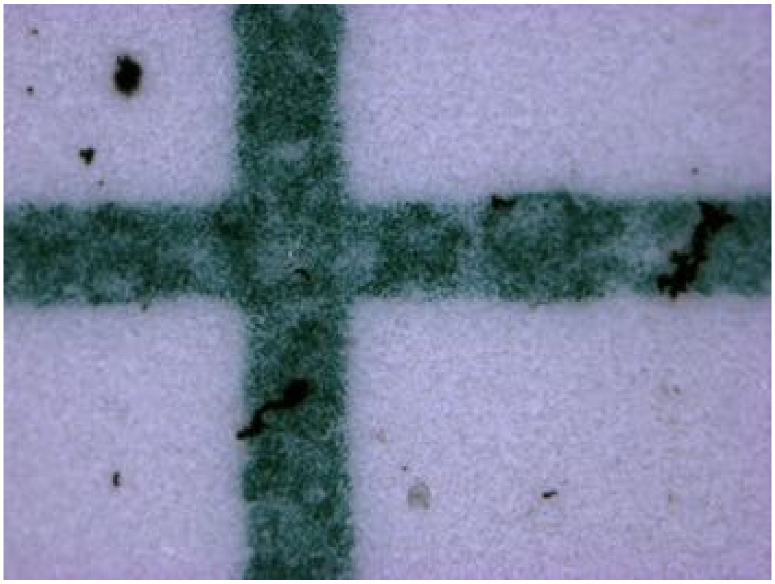


Diatomaceous Earth (silica based granular filtration media), typically from the oil production process at the refinery.



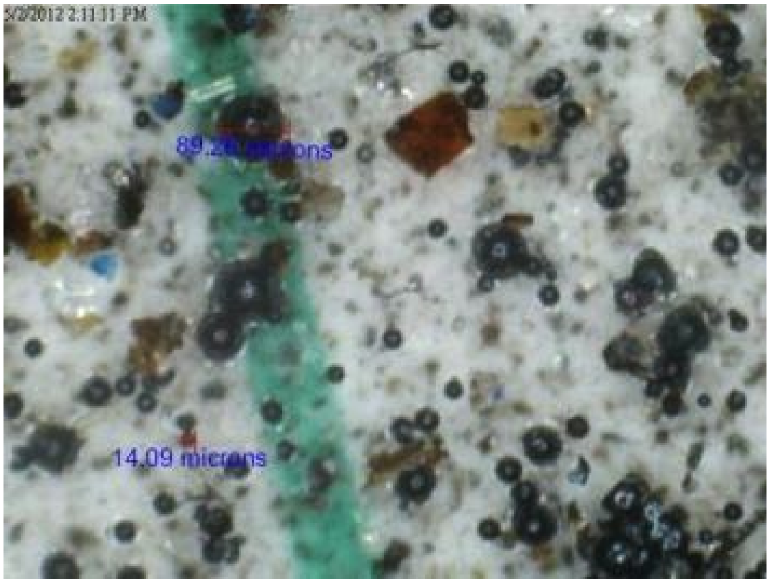
Glass (silica) media fibers or other environmental contamination source, fiberglass insulation, etc.

Metal contaminants



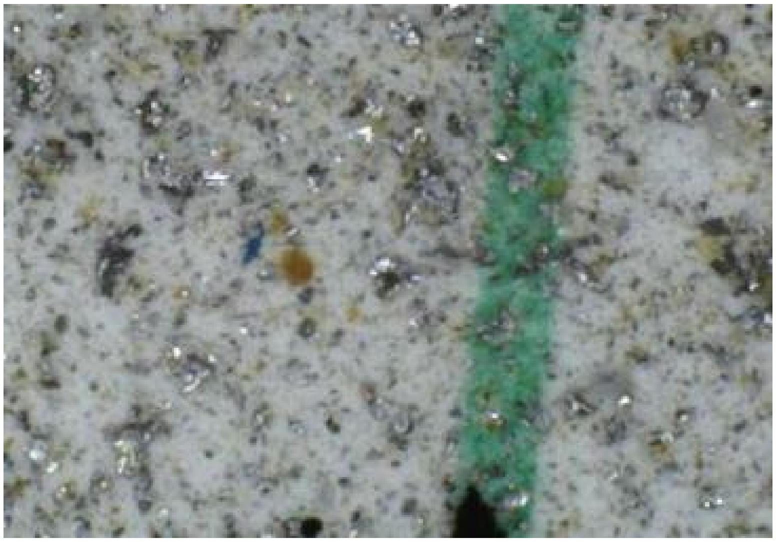
Iron

Rust flakes from corrosion in the system or outside contamination. Note the granular look of the background of this image. It was shot with a very high-resolution microscope. At lower resolution you will not see the patch pore detail and the background will typically look more uniform for clean samples.

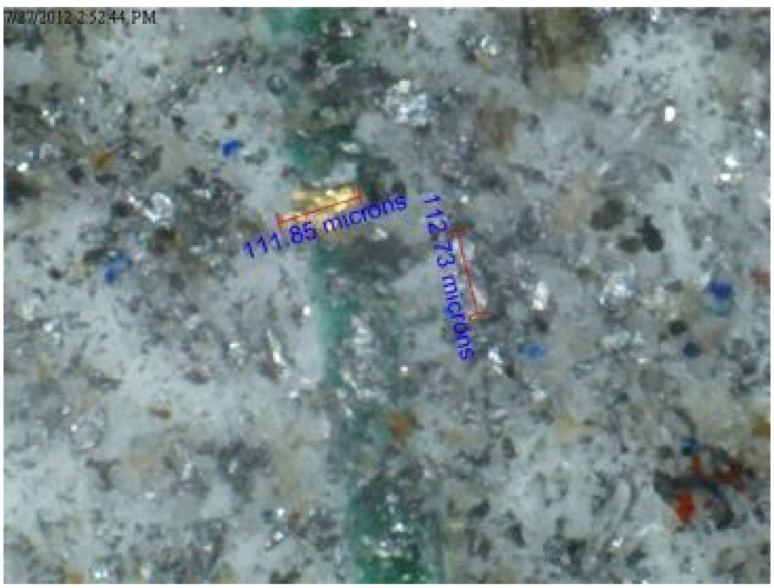


Weld debris from tank building or piping repair etc.

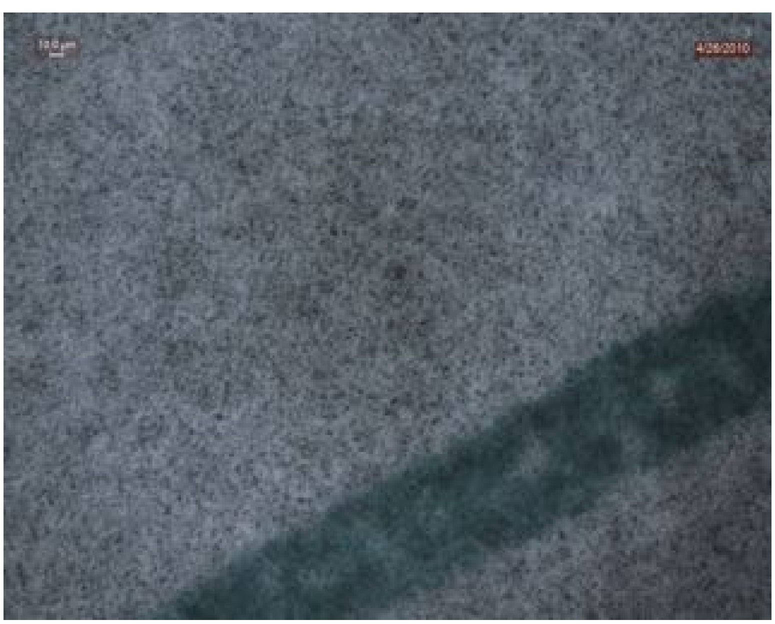
The dark round spheres are hollow iron weld splatter and can shatter into hard, metal debris. This indicates a lack of proper system rinse before start up.



Grinding or wear debris (bright metal). Can be contamination from component manufacture, service or generated in a system that is incurring damage.

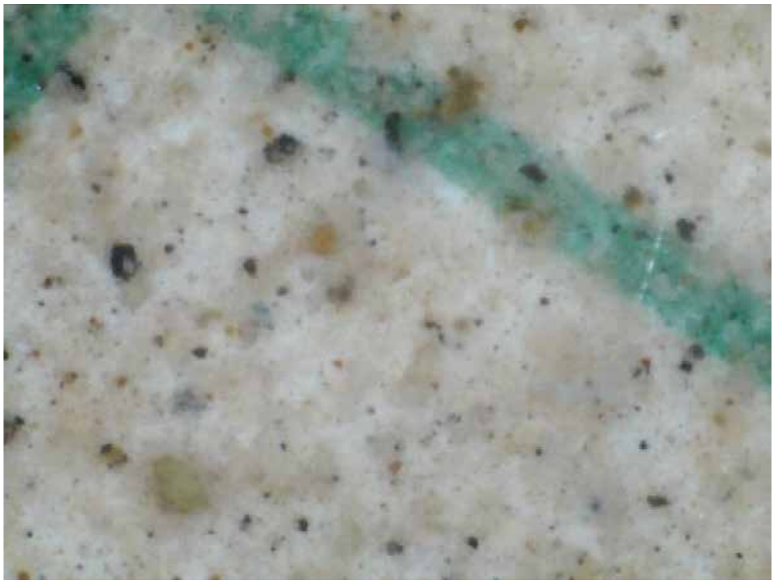


Bright metal with a large 111-micron piece of brass visible.



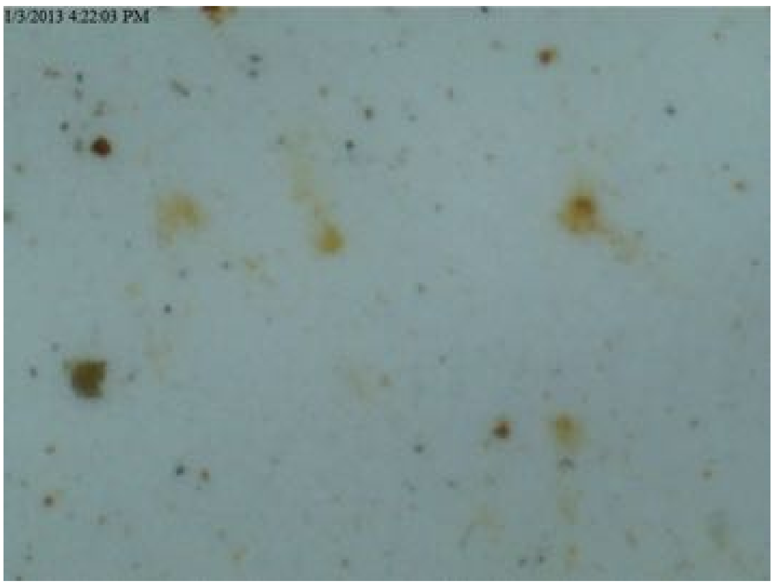
1-2um iron fines can ingress on cylinders etc. or be derived in the system. Note this is a very high-resolution image to show the fine particulate. It is very hard to discern sub 4um particulate as individual particles at lower resolution, with the scope included the kit. It may appear as a gray background but is technically not counted in the ISO count (only 4um and larger).

Soft contaminants



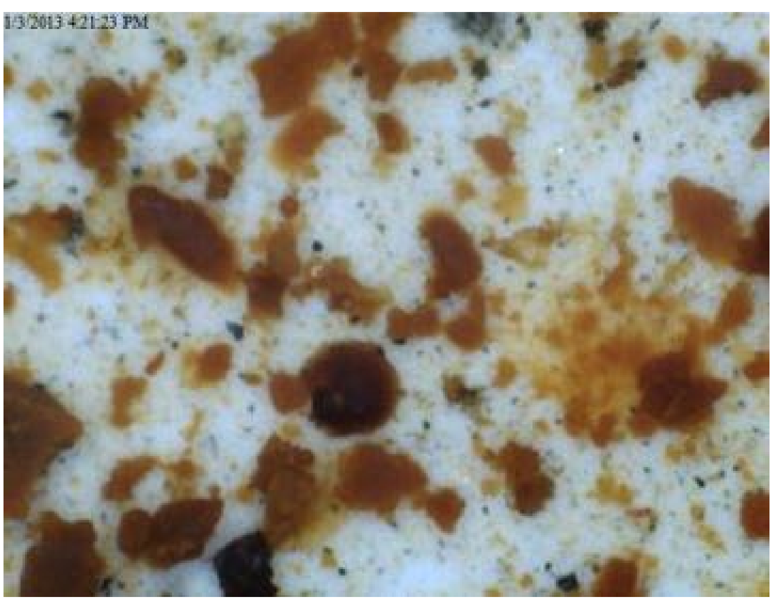
Soft contaminants

Debris rinsed from plugged fuel filter media, it is a mixture of hard particles and overdosed additive and free water reacting to create a large volume of soft/ semi-solid tan colored material.



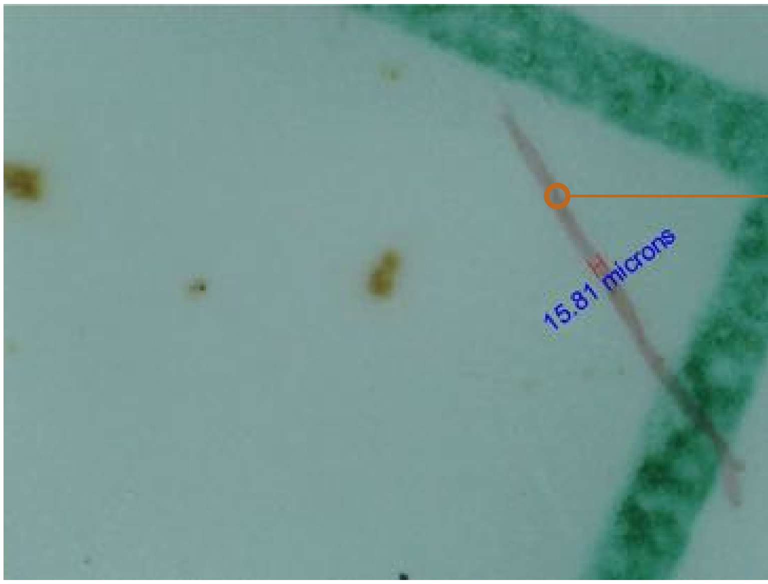
Glycerin solids from biodiesel

Glycerin solids form in bio blended diesel fuel or 100% biodiesel. Other soft contaminants will appear similar with very soft edges.



Glycerin solids from fuel in tank bottoms

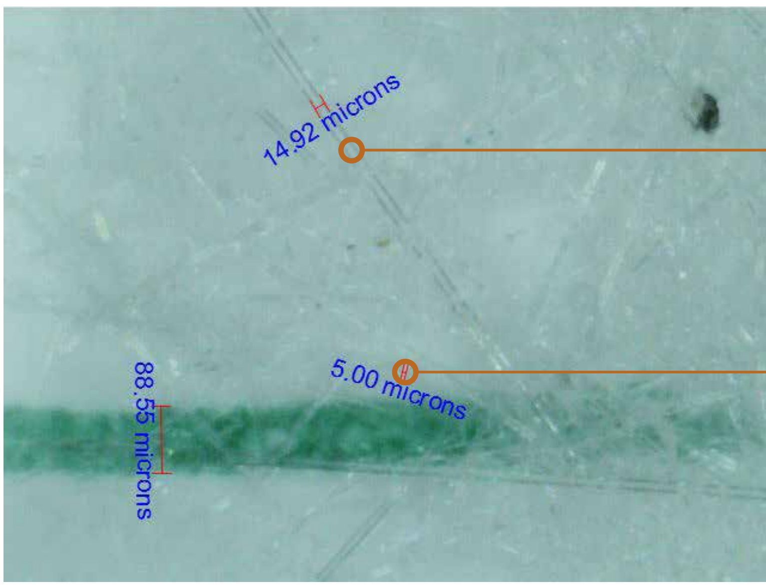
Fiber contaminants



Cellulose fibers can be from media or outside contamination in many applications.

15.81-micron wide cellulose fiber in a sample.

This is a cellulose fiber



Glass fiber

This is a plastic fiber

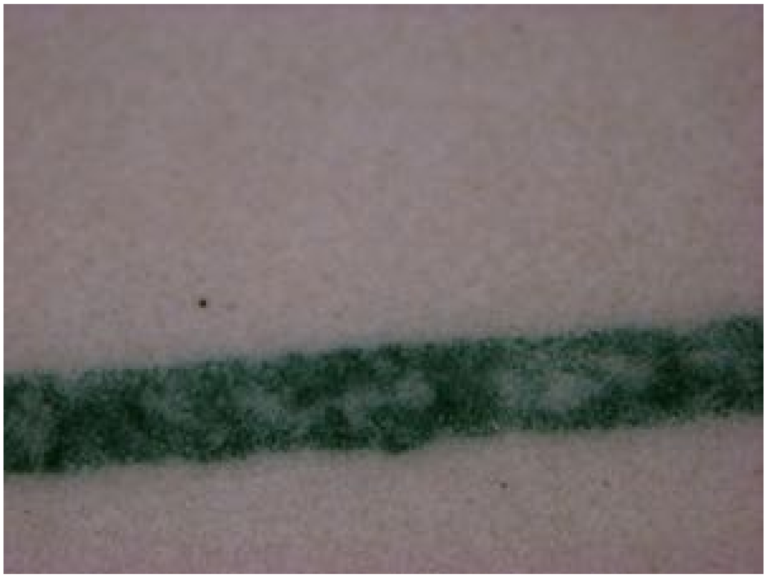
This is a glass fiber, which is very difficult to see

Clear plastic fiber

This is a plastic fiber

Example Field Samples ISO 4406 visual particle count estimates

ISO 14/13/10

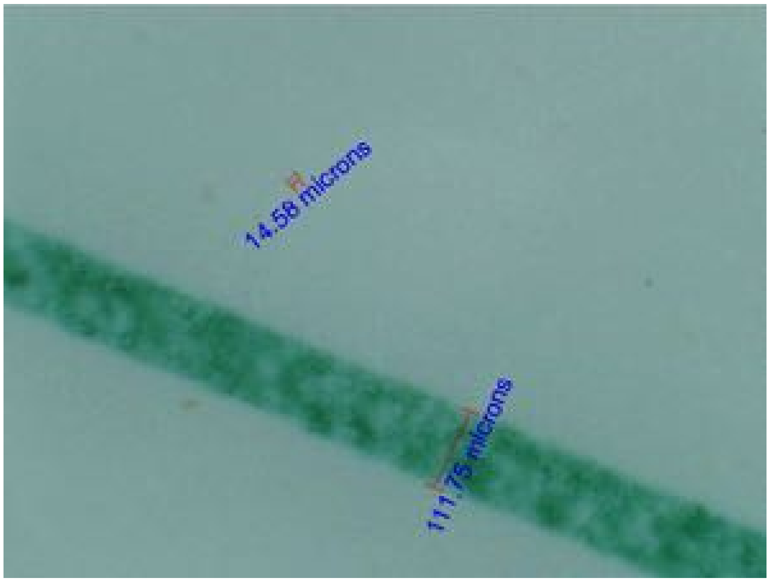


ISO 14/13/10 (4-8 particles in the view finder).
Note:
This is a very high definition image, the granular background is the filter patch media.

ISO 14/13/10

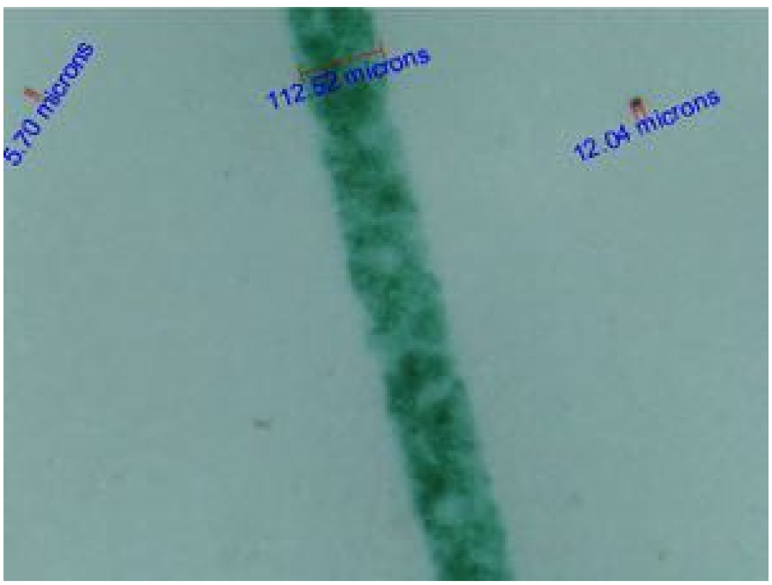
Lower resolution image of a similar cleanliness level (with the scope from the Kit) notice you do not see the patch pores as much and the ink line is not as clear. There are perhaps a couple small particles visible, one has been measured.

ISO 15/13/12

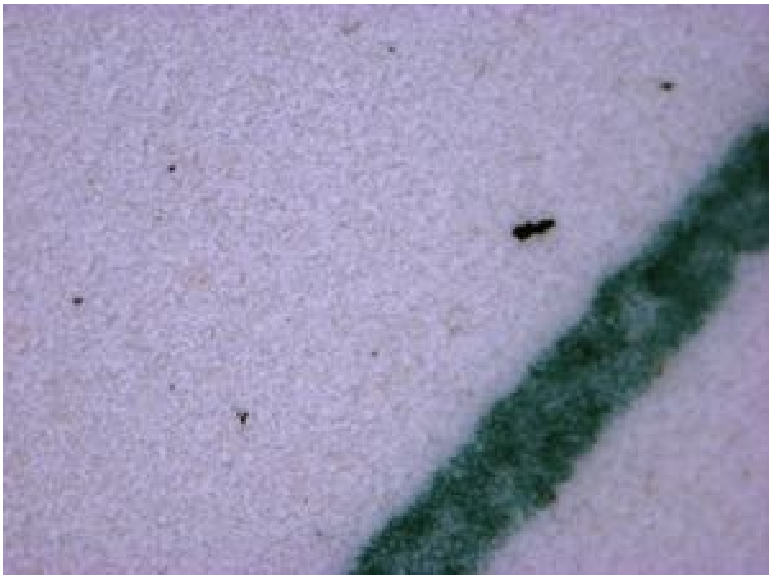


ISO 15/13/12 (8-15 particles in the view finder).
Note:
This is typically the maximum contamination level for high pressure servo valve hydraulic fluid applications.

ISO 15/13/12



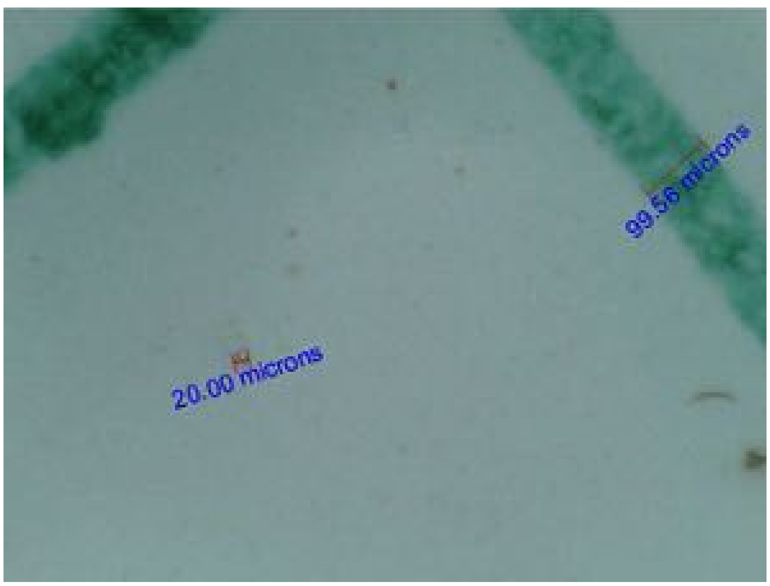
ISO 16/14/13



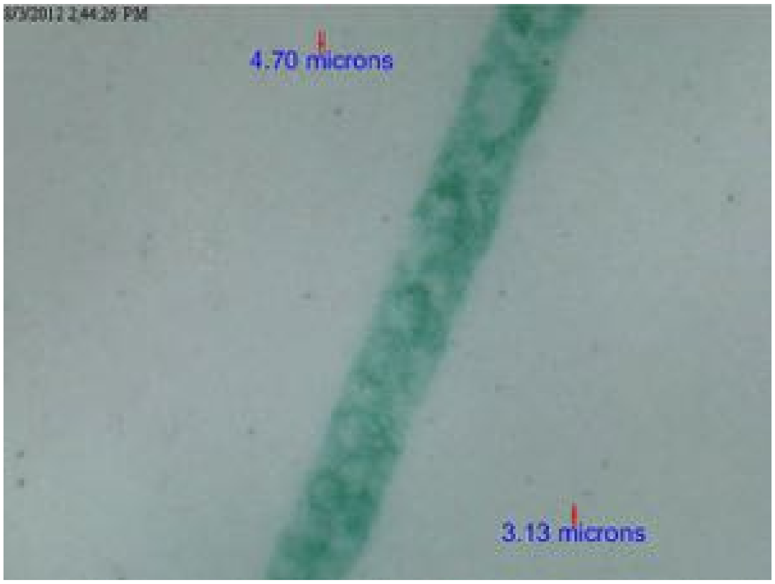
ISO 16/14/13 (15-30 particles in the view finder) Very high-resolution patch image where you can see the patch pores.

Note:
This is typically the maximum contamination level for hydraulic transmission fluid applications.

ISO 16/14/13



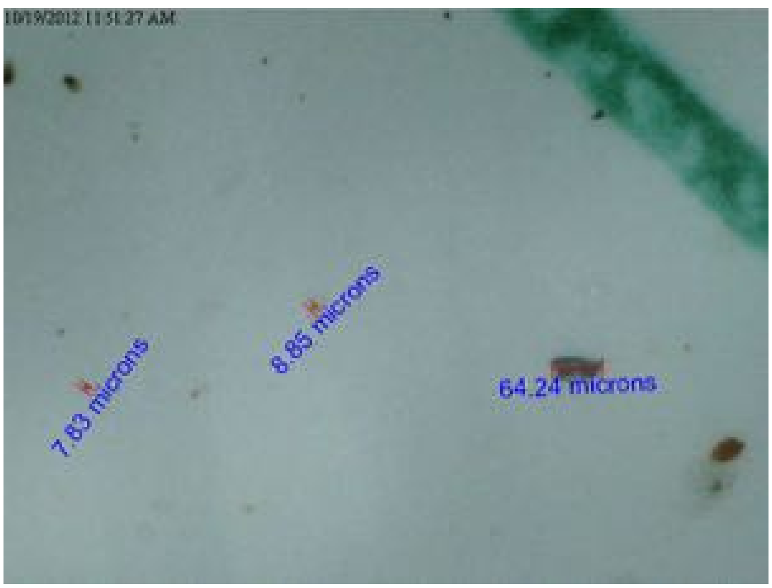
ISO 17/14/11



ISO 17/14/11 (30-61 particles in the view finder)

Note:
This is typical of a filtered fluid that is an ISO 17, there are few if any large particles seen in the sample since they were filtered out.

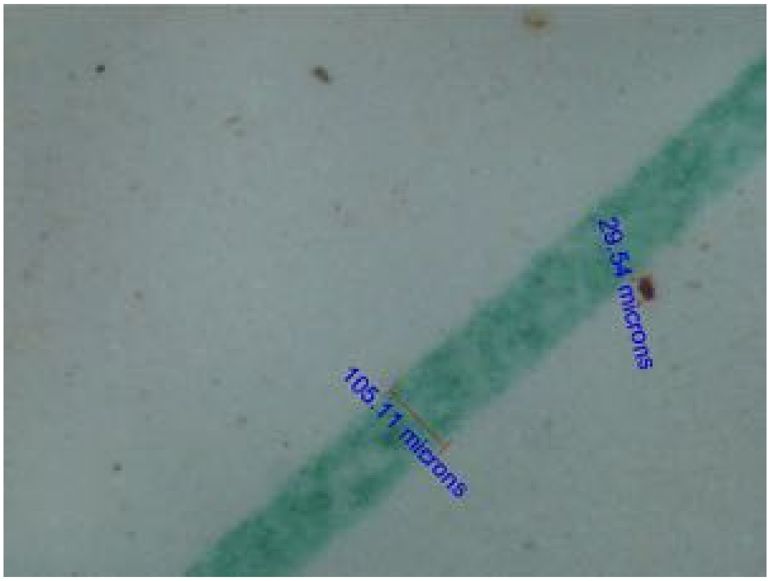
ISO 17/16/15



ISO 17/16/15 (30-61 particles in the view finder)

Note:
This is typical of an unfiltered ISO 17 sample, there are large and small particles and a large 64um piece of bright metal visible.

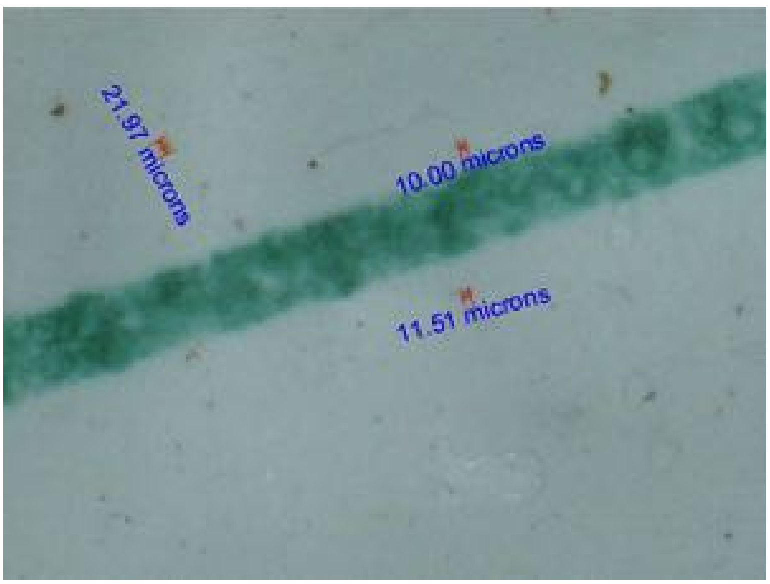
ISO 18/16/14



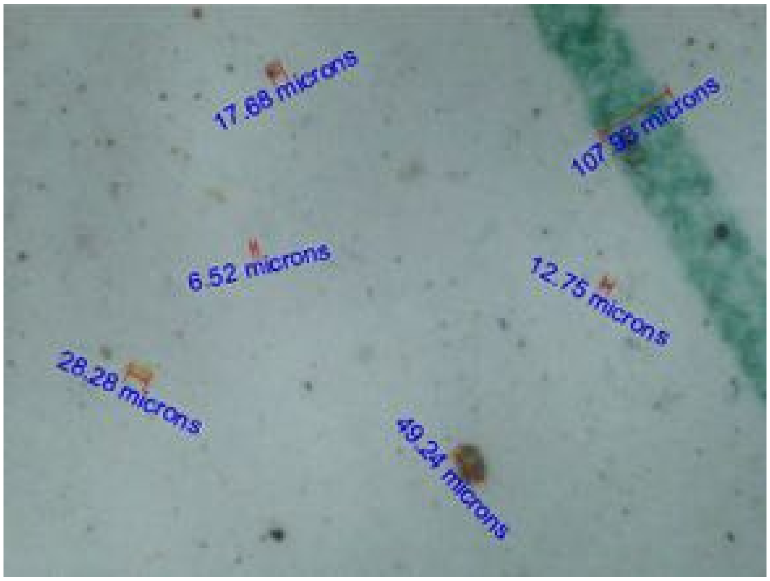
ISO 18/16/14 (61-118 particles in view finder)

Note:
This is typically the maximum contamination level for hydraulic gear oil applications.

ISO 18/16/14

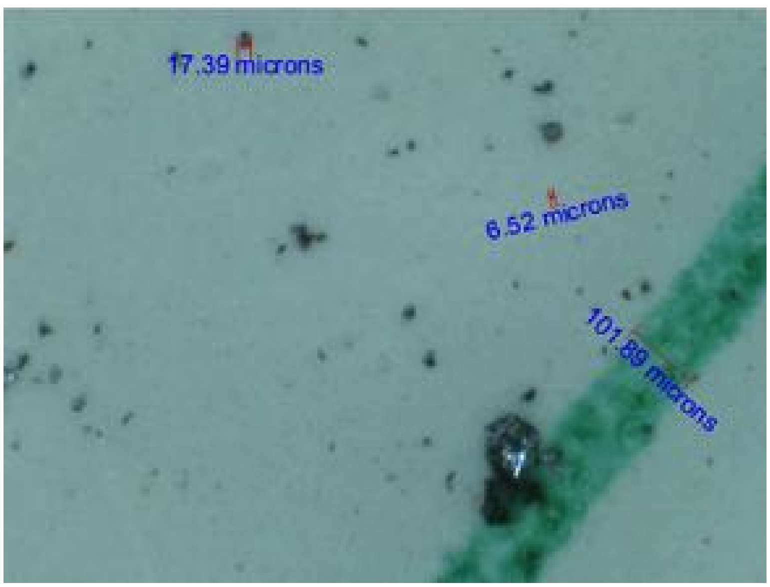


ISO 19/16/15



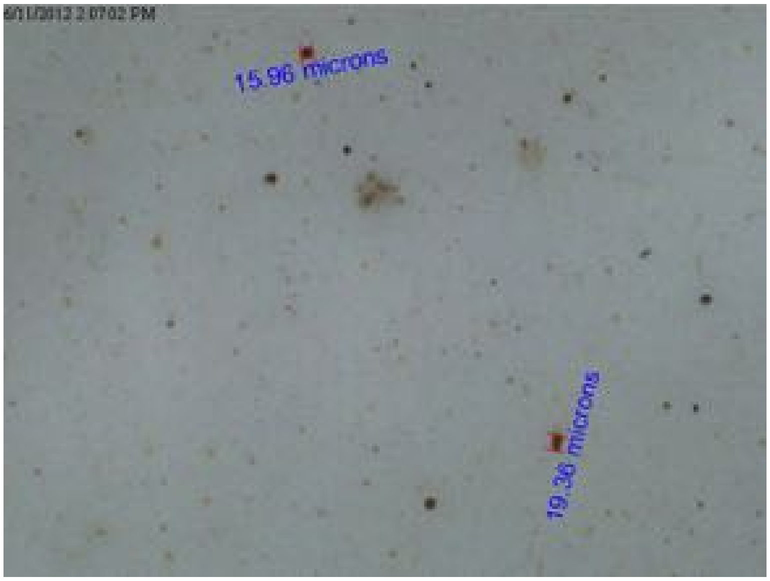
ISO 19/16/15 (118-236 particles in view finder)

IOS 19/17/15



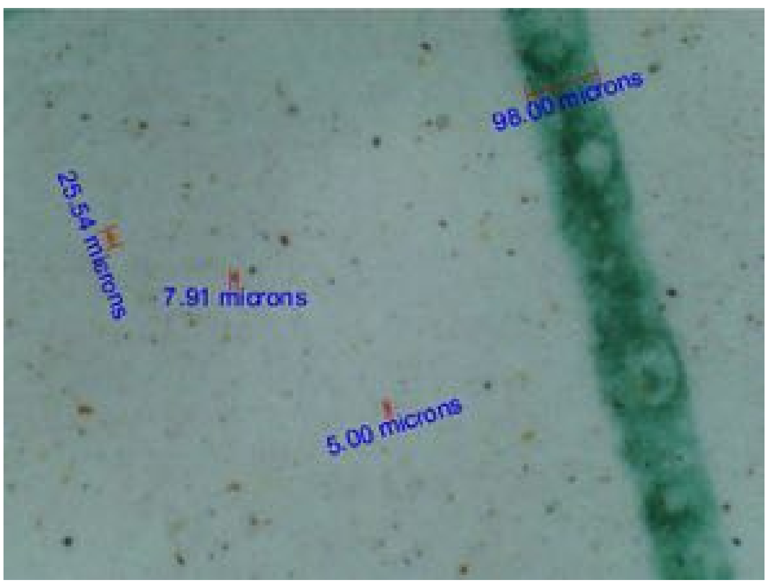
IOS 19/17/15

ISO 20/17/15

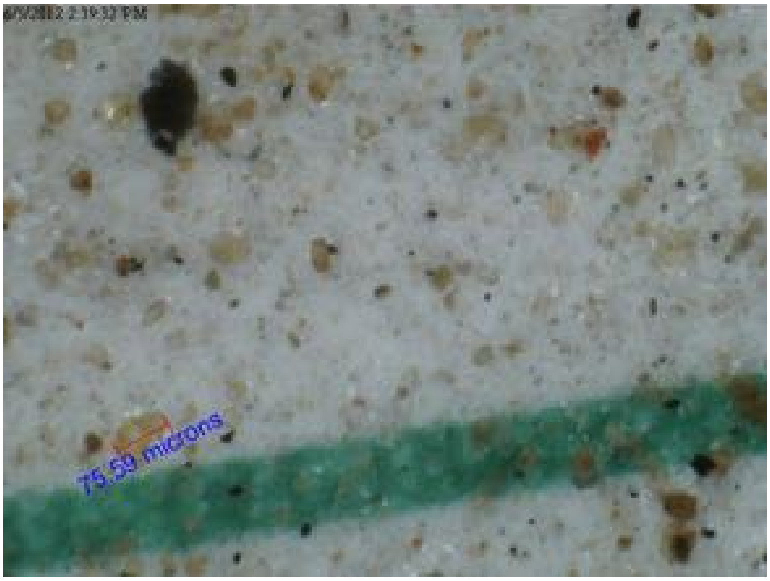


ISO 20/17/15 (236-472 particles in the view finder)

ISO 20/17/15

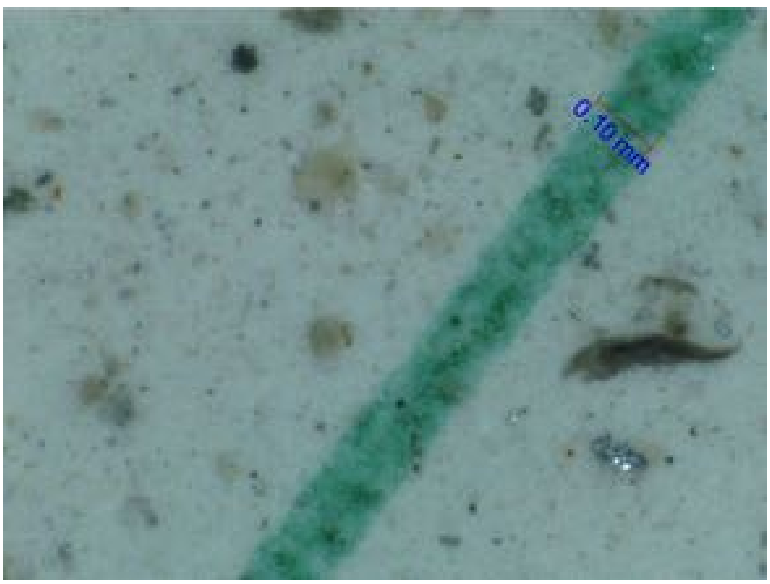


ISO 21/19/17

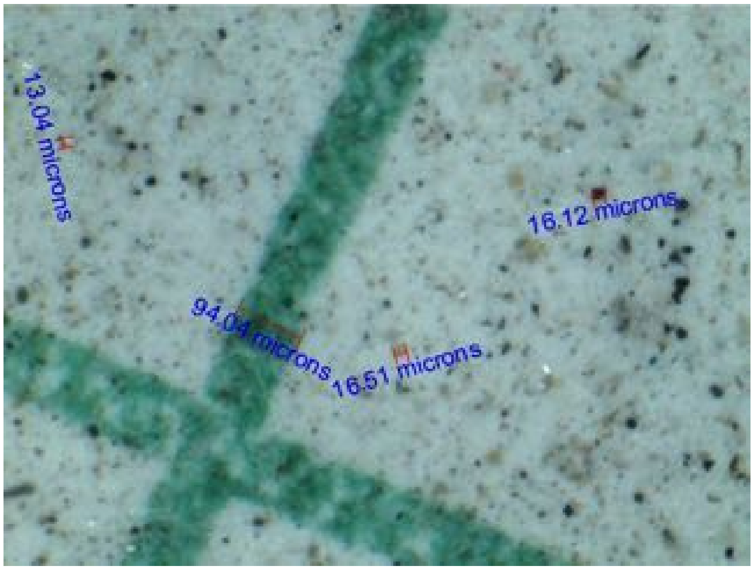


ISO 21/19/17 (472-943 particles in the view finder) Sample is contaminated with large grain sand particles as well as significant small debris visible in the background.

ISO 21/19/17

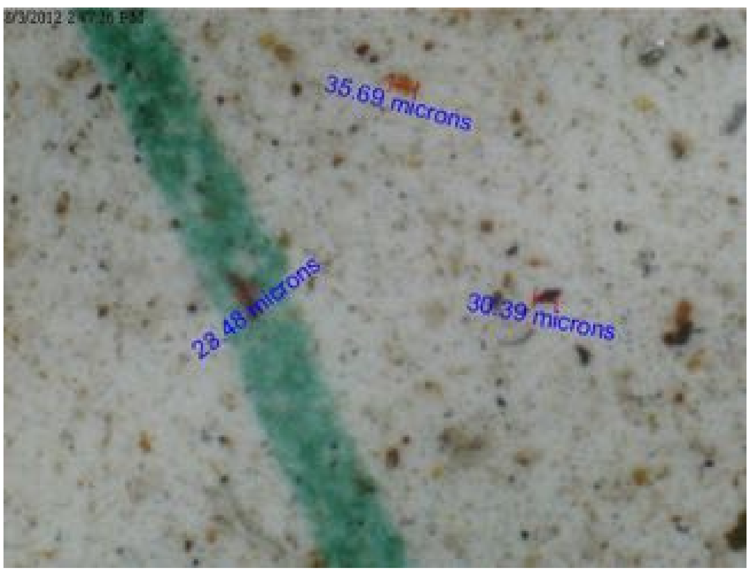


ISO 22/20/18



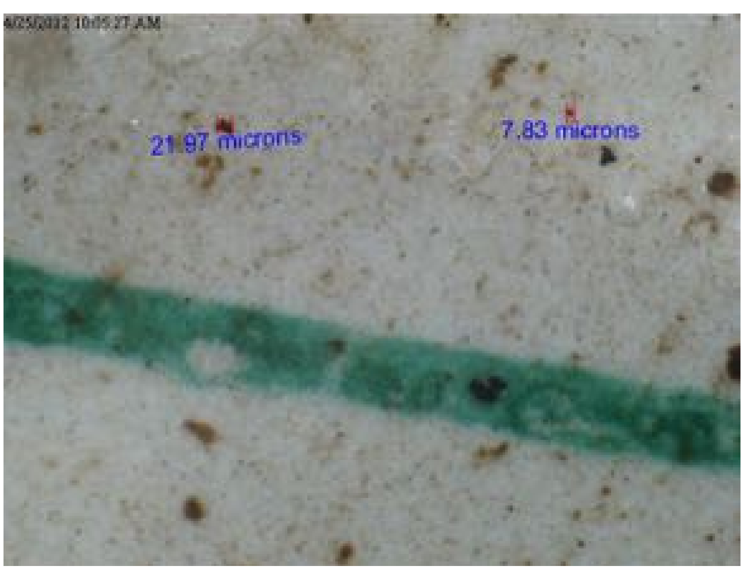
ISO 22/20/18 (943-1,886 particles in the view finder)

ISO 22/20/18



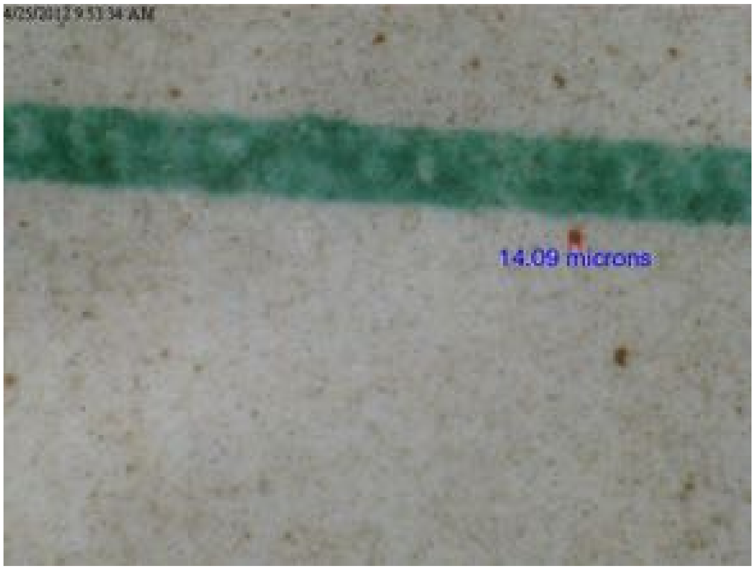
ISO 22/20/18 (943-1,886 particles in the view finder)

ISO 23/22/18



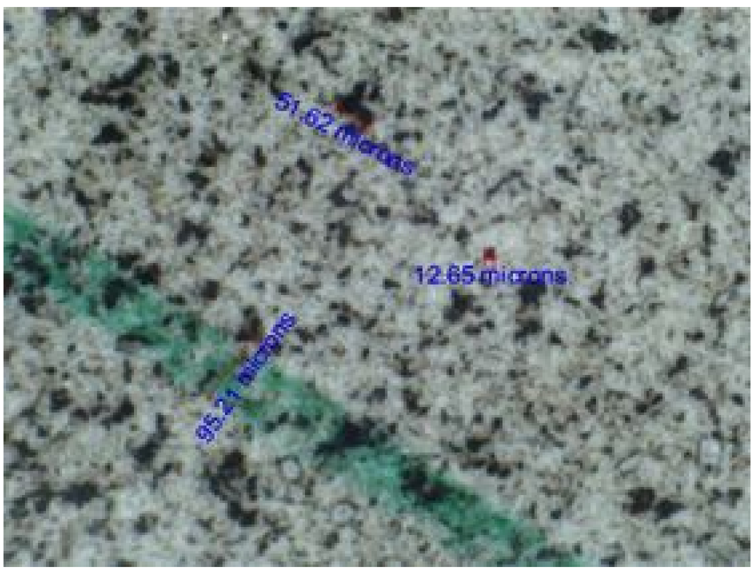
ISO 23/22/18 (1,886-3,773 particles in the view finder)

ISO 23/19/17



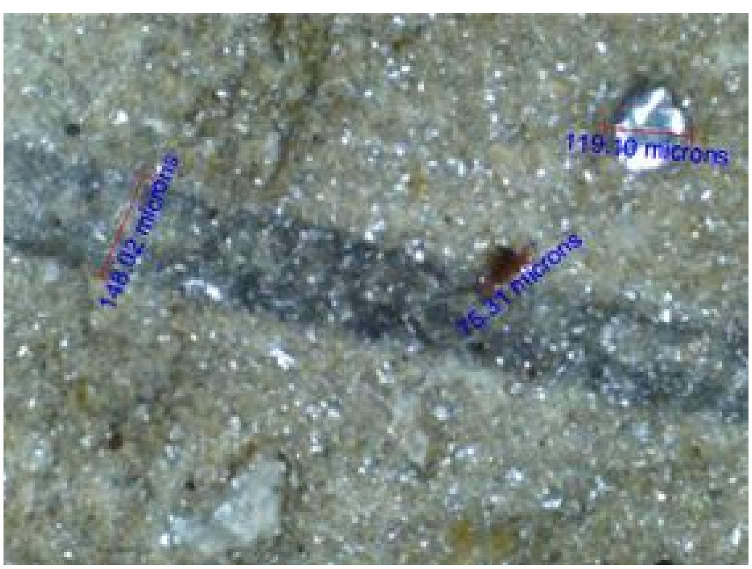
ISO 23/19/17 (1,886-3,773 particles in the view finder)

ISO 24/22/20



ISO 24/22/20 (3,773-7,545 particles in the view finder)

ISO 25/22/20



ISO 25/22/20 (7,545- 15,090 particles in the view finder)

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 $14\mu_{[c]}$. The ISO code is expressed in 3 numbers (example: 19/17/14). 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 and inversely as a code decreases by one the contaminant level is cut in half.

ISO 4406:1999 Code Chart

Range Code	Particles per Milliliter	
	More Than	Up To/Including
24	80000	160000
23	40000	80000
22	20000	40000
21	10000	20000
20	5000	10000
19	2500	5000
18	1300	2500
17	640	1300
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

Particle Size	Particles per Milliliter	ISO 4406 Code Range	ISO Code
$4\mu_{(c)}$	151773	80000~160000	24
$4.6\mu_{(c)}$	87210		
$6\mu_{(c)}$	38363	20000~40000	22
$10\mu_{(c)}$	8229		
$14\mu_{(c)}$	3339	2500~5000	19
$21\mu_{(c)}$	1048		
$38\mu_{(c)}$	112		
$68\mu_{(c)}$	2		

Particle Size	Particles per Milliliter	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		

Succeed with the Total Systems Cleanliness Approach

Implementing the Total System Cleanliness Approach to control contamination and care for fluids from arrival to disposal will ultimately result in more reliable plant operation and save money. Several steps to achieve Total Systems Cleanliness include: evaluate and survey all hydraulic and lubrication systems, establish an oil analysis program and schedule, insist on specific fluid cleanliness levels for all new fluids, establish a baseline and target fluid cleanliness for each system, filter all new fluids upon arrival and during transfer, seal all reservoirs and bulk tanks, install high quality particulate and desiccant breathers, enhance air and liquid filtration on existing systems wherever suitable, use portable or permanent off-line filtration to enhance existing filtration, improve bulk oil storage and handling during transfer, remove water and make a commitment to fluid cleanliness.

The visible cost of proper contamination control and total systems cleanliness is less than 3% of the total cost of contamination when not kept under control. Keep your head above the surface and avoid the resource draining costs associated with fluid contamination issues including:

- Downtime and lost production
- Component repair/replacement
- Reduced useful fluid life
- Wasted materials & supplies ($)
- Root cause analysis meetings
- Maintenance labor costs
- Unreliable machine performance
- Wasted time and energy ($)

When setting target ISO fluid cleanliness codes for hydraulic and lubrication systems it is important to 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 will yield justifiable rewards for your efforts. Make an impact on reliability by controlling contamination.

Set the Target.

The first step in identifying a target ISO code for a system is to identify the most sensitive component 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 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 ($4\mu_{[c]}/6\mu_{[c]}/14\mu_{[c]}$). 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	Media	Pressure	Media	Pressure	Media
	< 138 bar	$\beta x_{[c]} = 1000$	138-207 bar	$\beta x_{[c]} = 1000$	> 207 bar	$\beta x_{[c]} = 1000$
Pumps	< 2000 psi	(βx = 200)	2000 - 3000 psi	(βx = 200)	> 3000 psi	(βx = 200)
Fixed Gear	20/18/15	$22\mu_{(c)}$ (25μ)	19/17/15	$12\mu_{(c)}$ (12μ)	-	-
Fixed Piston	19/17/14	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)	17/15/12	$7\mu_{(c)}$ (6μ)
Fixed Vane	20/18/15	$22\mu_{(c)}$ (25μ)	19/17/14	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)
Variable Piston	18/16/13	$7\mu_{(c)}$ (6μ)	17/15/13	$7\mu_{(c)}$ (6μ)	16/14/12	$5\mu_{(c)}$ (3μ)
Variable Vane	18/16/13	$7\mu_{(c)}$ (6μ)	17/15/12	$5\mu_{(c)}$ (3μ)	-	-
Valves						
Cartridge	18/16/13	$12\mu_{(c)}$ (12μ)	17/15/12	$7\mu_{(c)}$ (6μ)	17/15/12	$7\mu_{(c)}$ (6μ)
Check Valve	20/18/15	$22\mu_{(c)}$ (25μ)	20/18/15	$22\mu_{(c)}$ (25μ)	19/17/14	$12\mu_{(c)}$ (12μ)
Directional (solenoid)	20/18/15	$22\mu_{(c)}$ (25μ)	19/17/14	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)
Flow Control	19/17/14	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)
Pressure Control (modulating)	19/17/14	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)	17/15/12	$7\mu_{(c)}$ (6μ)
Proportional Cartridge Valve	17/15/12	$7\mu_{(c)}$ (6μ)	17/15/12	$7\mu_{(c)}$ (6μ)	16/14/11	$5\mu_{(c)}$ (3μ)
Proportional Directional	17/15/12	$7\mu_{(c)}$ (6μ)	17/15/12	$7\mu_{(c)}$ (6μ)	16/14/11	$5\mu_{(c)}$ (3μ)
Proportional Flow Control	17/15/12	$7\mu_{(c)}$ (6μ)	17/15/12	$7\mu_{(c)}$ (6μ)	16/14/11	$5\mu_{(c)}$ (3μ)
Proportional Pressure Control	17/15/12	$7\mu_{(c)}$ (6μ)	17/15/12	$7\mu_{(c)}$ (6μ)	16/14/11	$5\mu_{(c)}$ (3μ)
Servo Valve	16/14/11	$7\mu_{(c)}$ (6μ)	16/14/11	$5\mu_{(c)}$ (3μ)	15/13/10	$5\mu_{(c)}$ (3μ)
Bearings						
Ball Bearing	15/13/10	$5\mu_{(c)}$ (3μ)	-	-	-	-
Gearbox (industrial)	17/16/13	$12\mu_{(c)}$ (12μ)	-	-	-	-
Journal Bearing (high speed)	17/15/12	$7\mu_{(c)}$ (6μ)	-	-	-	-
Journal Bearing (low speed)	17/15/12	$7\mu_{(c)}$ (6μ)	-	-	-	-
Roller Bearing	16/14/11	$7\mu_{(c)}$ (6μ)	-	-	-	-
Actuators						
Cylinders	17/15/12	$7\mu_{(c)}$ (6μ)	16/14/11	$5\mu_{(c)}$ (3μ)	15/13/10	$5\mu_{(c)}$ (3μ)
Vane Motors	20/18/15	$22\mu_{(c)}$ (25μ)	19/17/14	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)
Axial Piston Motors	19/17/14	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)	17/15/12	$7\mu_{(c)}$ (6μ)
Gear Motors	20/18/14	$22\mu_{(c)}$ (25μ)	19/17/13	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)
Radial Piston Motors	20/18/15	$22\mu_{(c)}$ (25μ)	19/17/14	$12\mu_{(c)}$ (12μ)	18/16/13	$12\mu_{(c)}$ (12μ)
Test Stands, Hydrostatic						
Test Stands	15/13/10	$5\mu_{(c)}$ (3μ)	15/13/10	$5\mu_{(c)}$ (3μ)	15/13/10	$5\mu_{(c)}$ (3μ)
Hydrostatic Transmissions	17/15/13	$7\mu_{(c)}$ (6μ)	16/14/11	$5\mu_{(c)}$ (3μ)	16/14/11	$5\mu_{(c)}$ (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

ISO 4406 Contamination Codes

Valid for 25 mL fluid sample with a 25 mm diameter patch

Must use Veho VMS-006-DX1 USB microscope set directly on patch and focused at 200x

Code	Range of number of particles per 100 mL		Range of number of particles per 25 mL		Range of number of particles per 10 mL		Range of number of particles per 1 mL		Range of particles in microscope view	
	More Than	Up to & Including	More Than	Up to & Including	More Than	Up to & Including	More Than	Up to & Including	More Than	Up to & Including
24	8,000,000	16,000,000	2,000,000	4,000,000	800,000	1,600,000	80,000	160,000	3,773	7,545
23	4,000,000	8,000,000	1,000,000	2,000,000	400,000	800,000	40,000	80,000	1,886	3,773
22	2,000,000	4,000,000	500,000	1,000,000	200,000	400,000	20,000	40,000	943	1,886
21	1,000,000	2,000,000	250,000	500,000	100,000	200,000	10,000	20,000	472	943
20	500,000	1,000,000	125,000	250,000	50,000	100,000	5,000	10,000	236	472
19	250,000	500,000	62,500	125,000	25,000	50,000	2,500	5,000	118	236
18	130,000	250,000	32,500	62,500	13,000	25,000	1,300	2,500	61	118
17	64,000	130,000	16,000	32,500	6,400	13,000	640	1,300	30	61
16	32,000	64,000	8,000	16,000	3,200	6,400	320	640	15	30
15	16,000	32,000	4,000	8,000	1,600	3,200	160	320	8	15
14	8,000	16,000	2,000	4,000	800	1,600	80	160	4	8
13	4,000	8,000	1,000	2,000	400	800	40	80	2	4
12	2,000	4,000	500	1,000	200	400	20	40	1	2
11	1,000	2,000	250	500	100	200	10	20	0	1
10	500	1,000	125	250	50	100	5	10	0	0
9	250	500	63	125	25	50	3	5	0	0
8	130	250	33	63	13	25	1	3	0	0
7	64	130	16	33	6	13	1	1	0	0
6	32	64	8	16	3	6	0	1	0	0
5	16	32	4	8	2	3	0	0	0	0
4	8	16	2	4	1	2	0	0	0	0
3	4	8	1	2	0	1	0	0	0	0
2	2	4	1	1	0	0	0	0	0	0
1	1	2	0	1	0	0	0	0	0	0

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