Donaldson

FILTRATION SOLUTIONS

Portable Fluid Analysis Kit

Patch Test Kit Manual

Kit Part Number X009329

Carrying Case

Membrane Holder & Funnel Assembly P567863

Filter for Solvent Dispensing Bottle P567860 (Qty. 3)

500 ml Solvent Dispensing Bottle

Microscope P567864

Plastic Tubing (5 ft.)

Patch Covers P567912 (Qty. 150)

Zip Drive of Reference Information

Membrane Filter Forceps

Analysis Cards (3"x5") P567865 (Qty. 50)

Sampling Pump P176431

120 ml Sample Bottles (Qty. 6) P567861

1.2 micron Membrane Filters P567869 (Qty. 100)

Sharpie Marker

5 micron Membrane Filters P567868 (Qty. 50)

Case Size: Height: 14.5"/368.3mm | Width: 19.25"/489mm | Depth: 7.75"/197mm | Case Weight: 9.95 lbs./4.51 kg

1

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.

2

Install solvent* dispensing tube and install solvent filter on end of the dispensing tube.

*Mineral spirits are the most commonly used solvent

3

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

4

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

5

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

6

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).

7

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

8

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.

9

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

10a

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

10b

For best results, stand the microscope (without the lens cap or base) direcly over the sample.
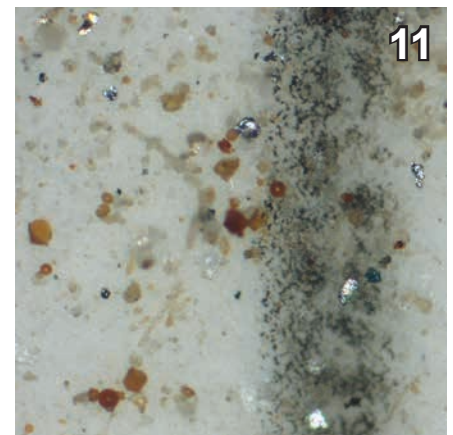
11

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

Celestron Deluxe Handheld Digital Microscope Instructions

NOTE: The Celestron Deluxe handheld 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 Celstron MicroCaprture Pro software from the Celestron site or the CD that comes with the scope. You will need computer administrator permission for your computer to do this.
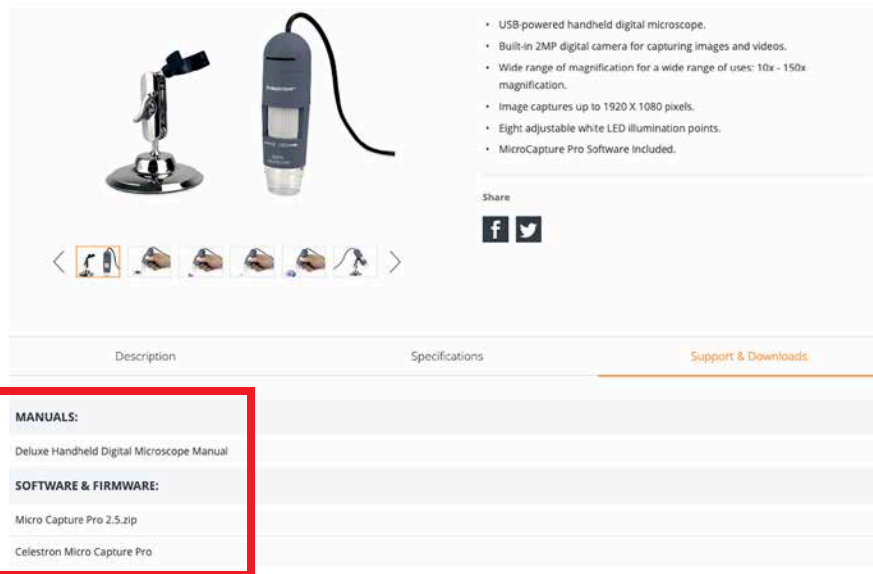
Link to Microscope Manual and software & Firmware:
https://www.celestron.com/products/deluxe-handheld-digital-microscope-44302-c

You can find the manual and software links at the bottom of the Celestron web page.

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 MicroCapture software.
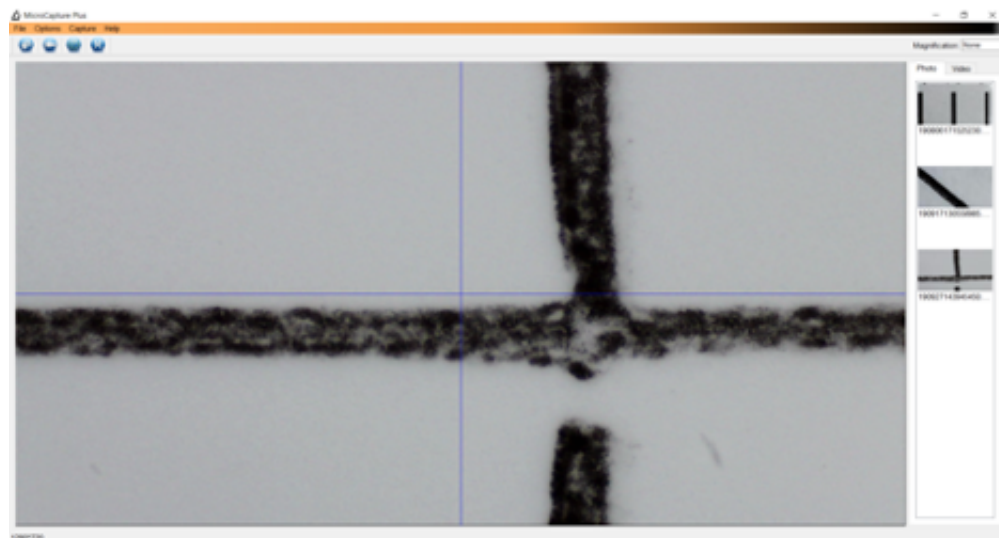
3. Microscope features. There are 2 important features of the Celestron Microscope for preparing ISO membrane patch images. The adjustable LED light control – for best resolution. The Focus wheel – should be focused at maximum magnification range for preparing ISO counts. Photos are taken by clicking on the camera icon/button on the computer software window.

When used to prepare patch images, the scope **must be held in your hand and directly on the patch**. It easily detaches from the base. If the scope has a protective cap over the clear portion, 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.


LED Light Control

Focus Wheel

4. Focusing the microscope to the proper magnification. The microscope can focus at 2 different magnification levels, the lower 20X magnification and higher 100X 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.**
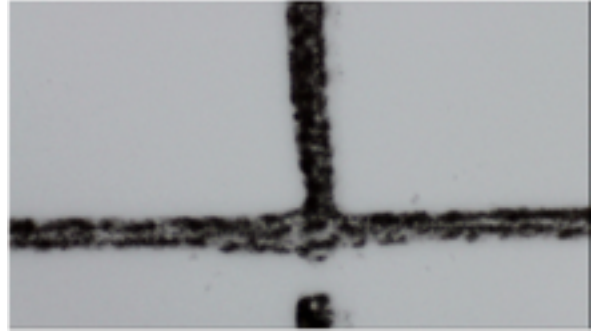
5. The microscope LED light control wheel should be used to adjust brightness for most analysis. In general, shoot images at the highest light level possible for best results. If you see the light flashing or an image like the one below, turn the light level control wheel down and back up and it should correct.
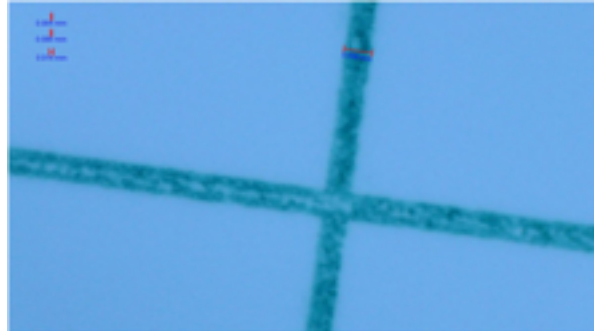
6. Scanning and photographing ISO patches. Use the microscope to look around the patch at the high magnification level. You will need to re-focus slightly as you scan around, this is made easier by trying to keep a portion of a grid patch in the view finder as you move and re-focus. You should see debris 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 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.

7. Processing images and preparing the ISO count. Once you have 2-3 representative images on the screen from the patch, you need to scale them, measure some visible items, and save them before counting an entire patch.


You can see in the column on the right, above, that four images have been shot and are ready for processing. An image is selected for counting by double clicking on the small photo in the right margin. The 3rd image down has been selected by double clicking on it and will appear like the image below. Feel free to zoom in a bit with the blue slide bar at the bottom center of the image. Make the image as large as possible to fill your screen while you can still see the entire image.

Patch Test Kit Manual

To properly scale the image for measuring particle size and counting, you must correct the magnification in the upper right corner for the image. The default is "None" and needs to be changed to "134.00". This magnification correction number was determined by taking a high magnification image of the 0.5mm scale line on the calibration ruler and following the Celestron Microscope instructions for scaling.
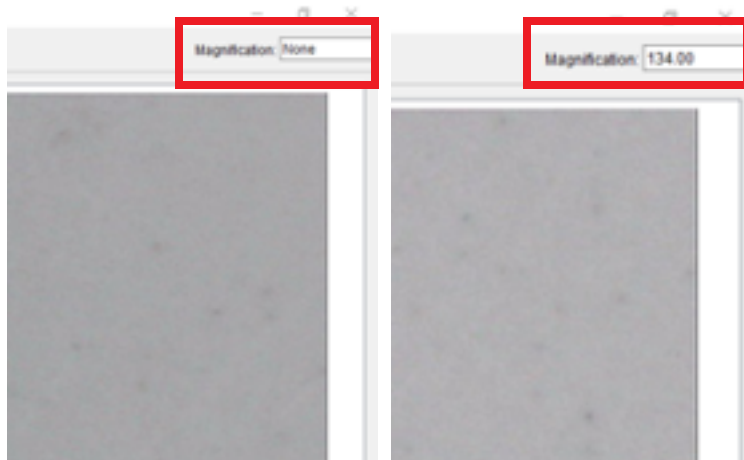

IMPORTANT.

The software measurement tool for the Celestron microscope measures particles in millimeters, it cannot display measurements in microns. The simple conversion for millimeters (mm) to microns(um) is as follows.

0.004 mm = 4 um
0.006 mm = 6 um
0.014 mm = 14um etc.

It is handy to represent these 3 measurements somewhere on the image for reference in counting and discussing the ISO count results (see the zoomed in image below on the left). The image is now prepared for determining the ISO count.

Patch grid lines typically vary in width (90- 225um depending on the patch type) Scaling this provides a quick visual reference to recognize the image is at the correct scale for preparing ISO counts.

To measure particles, you simply drag and drop across things you want to measure. Click and hold the left mouse button, drag across the particle, and release the button when you get to the other side (see the zoomed in image on the right below). The software will automatically display the mm distance across the object. It is not necessary to measure all particles individually.
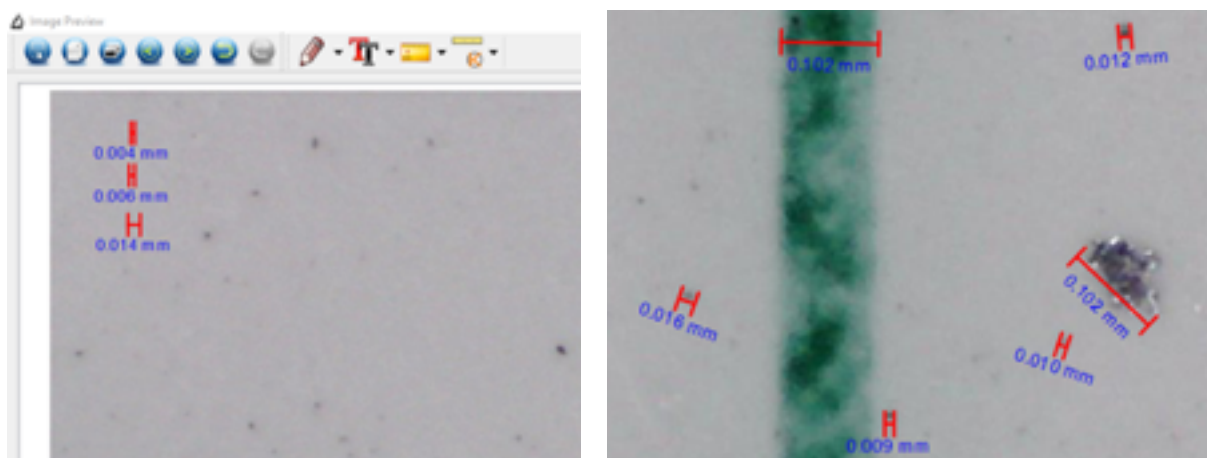
8. Counting and measuring the particles on the prepared patch images. Essentially all the particles visible in the images prepared by the above method are counted as 4 microns and larger and are thus included in the first digit in the ISO 4406 count for the fluid (note how small the 4um scale bar example is on the image).

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	11,543	23,085
23	4,000,000	8,000,000	1,000,000	2,000,000	400,000	800,000	40,000	80,000	5,771	11,543
22	2,000,000	4,000,000	500,000	1,000,000	200,000	400,000	20,000	40,000	2,886	5,771
21	1,000,000	2,000,000	250,000	500,000	100,000	200,000	10,000	20,000	1,443	2,886
20	500,000	1,000,000	125,000	250,000	50,000	100,000	5,000	10,000	721	1,443
19	250,000	500,000	62,500	125,000	25,000	50,000	2,500	5,000	361	721
18	130,000	250,000	32,500	62,500	13,000	25,000	1,300	2,500	188	361
17	64,000	130,000	16,000	32,500	6,400	13,000	640	1,300	92	188
16	32,000	64,000	8,000	16,000	3,200	6,400	320	640	46	92
15	16,000	32,000	4,000	8,000	1,600	3,200	160	320	23	46
14	8,000	16,000	2,000	4,000	800	1,600	80	160	12	23
13	4,000	8,000	1,000	2,000	400	800	40	80	6	12
12	2,000	4,000	500	1,000	200	400	20	40	3	6
11	1,000	2,000	250	500	100	200	10	20	1	3
10	500	1,000	125	250	50	100	5	10	1	1
9	250	500	63	125	25	50	3	5	0	1
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

Looking at the patch image below and counting everything we can see in the image (4um and larger) there are about 170 particles visible. Referencing the ISO code contamination chart, a count of 92-188 (Circled on the chart on the previous page for reference.) on the image indicates and ISO 17/-/-.

Looking at the 6um and larger particles there is a count of roughly 58 particles in the image which correlates to an ISO 16 (46-92 particles), so we have ISO 17/16/-.

Looking at the 14 micron and larger particles there are 4 particles that large or larger. That correlates to an ISO 12 (3-6 particles). Therefore, the complete ISO count is determined to be 17/16/12.
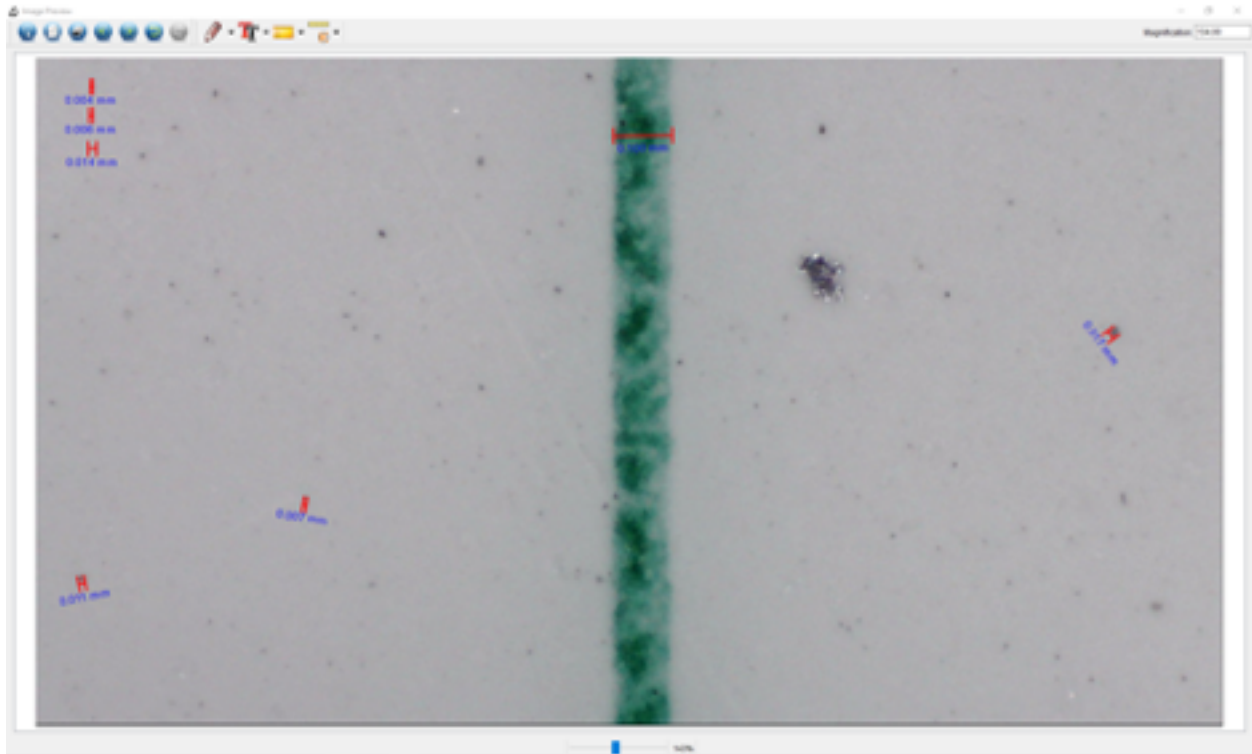
The method above is the full official method of visually determining a particle count. Once you are comfortable with the method and what the image represents, you may be able to determine counts more quickly by comparison to a library of patch images. Following are a range of images from ISO 11/10/09 to ISO 24/23/21 counts for context in interpreting images. We also have included a library of debris types to help interpret the type of contamination you may encounter in real world filtration applications.

ISO 11/10/9
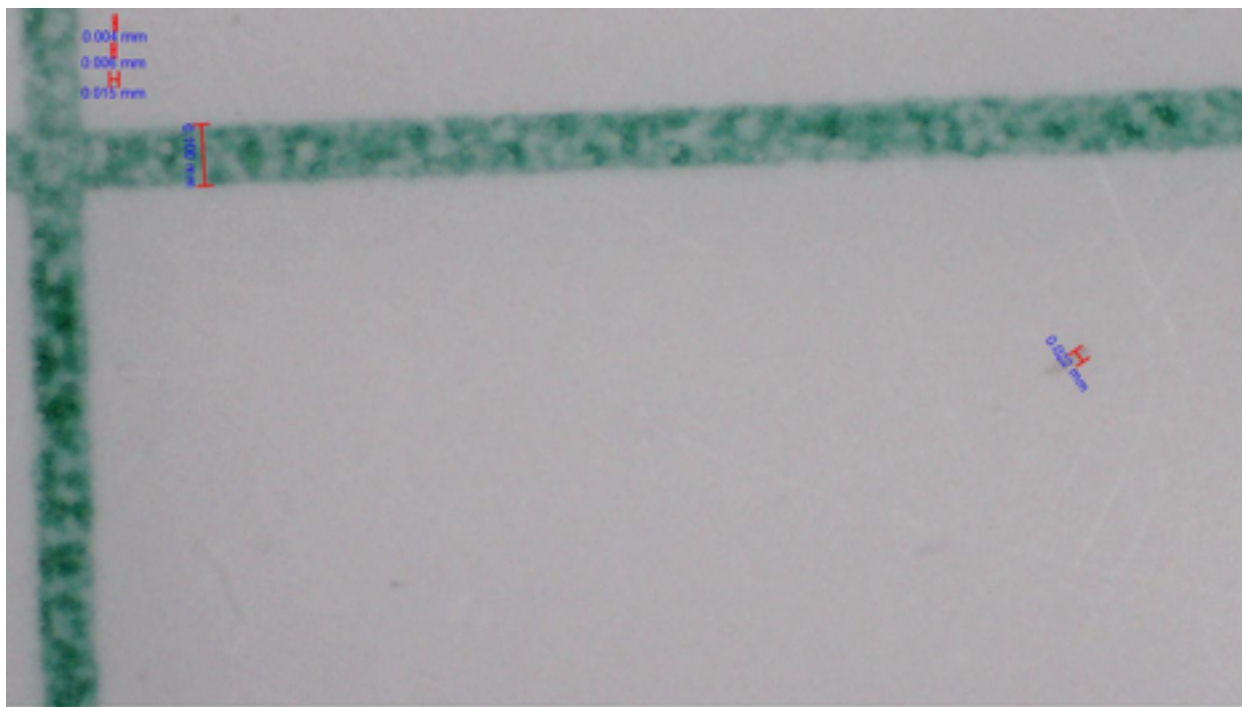
ISO 12/9/6 (Final diesel fuel cleanliness target for modern engines)
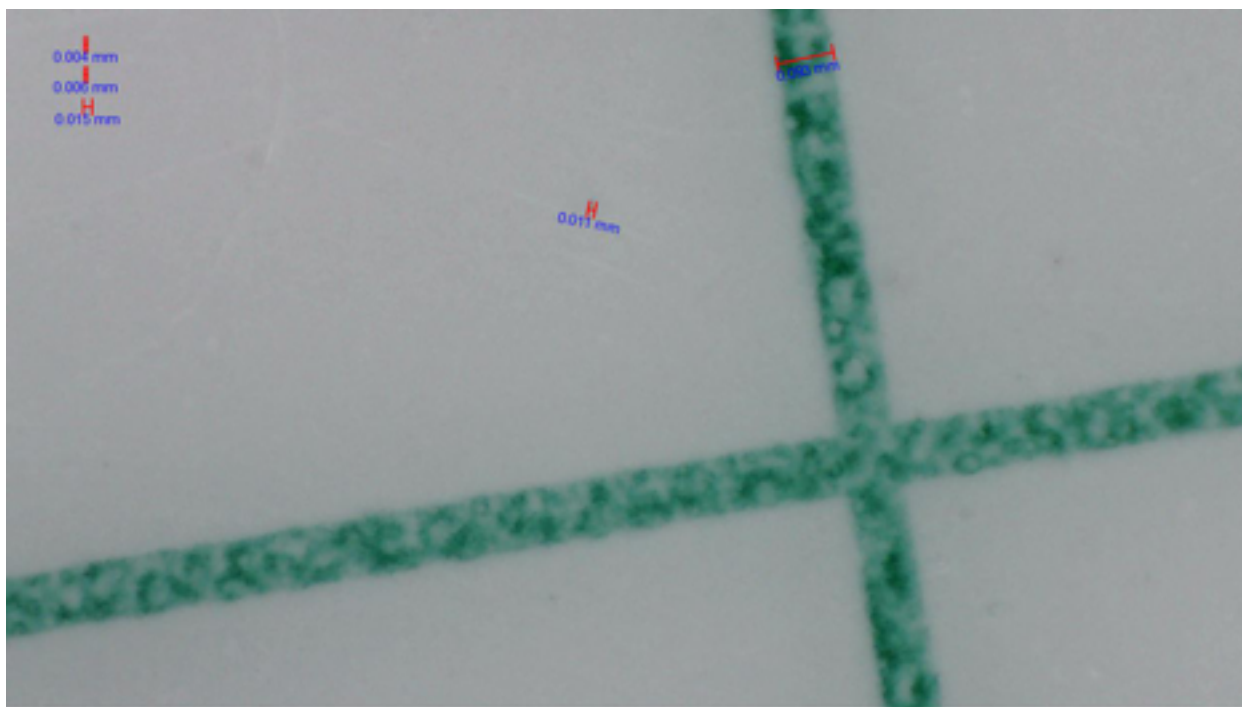
ISO 13/12/9
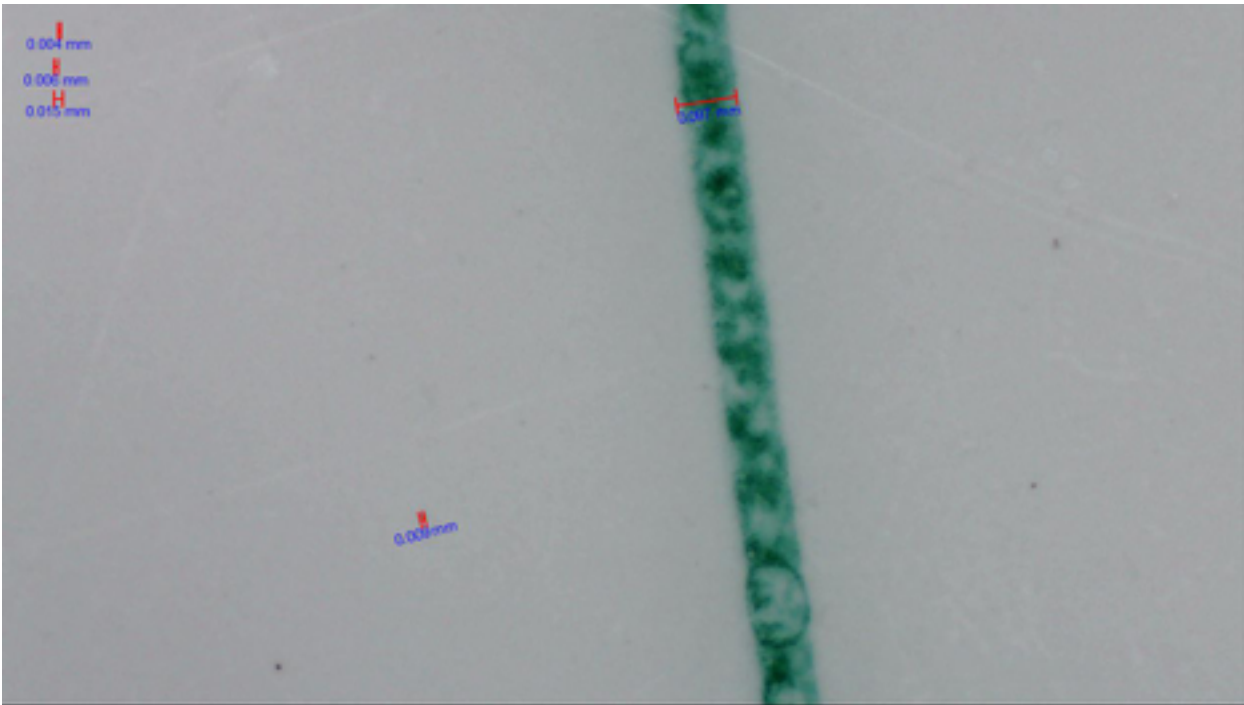
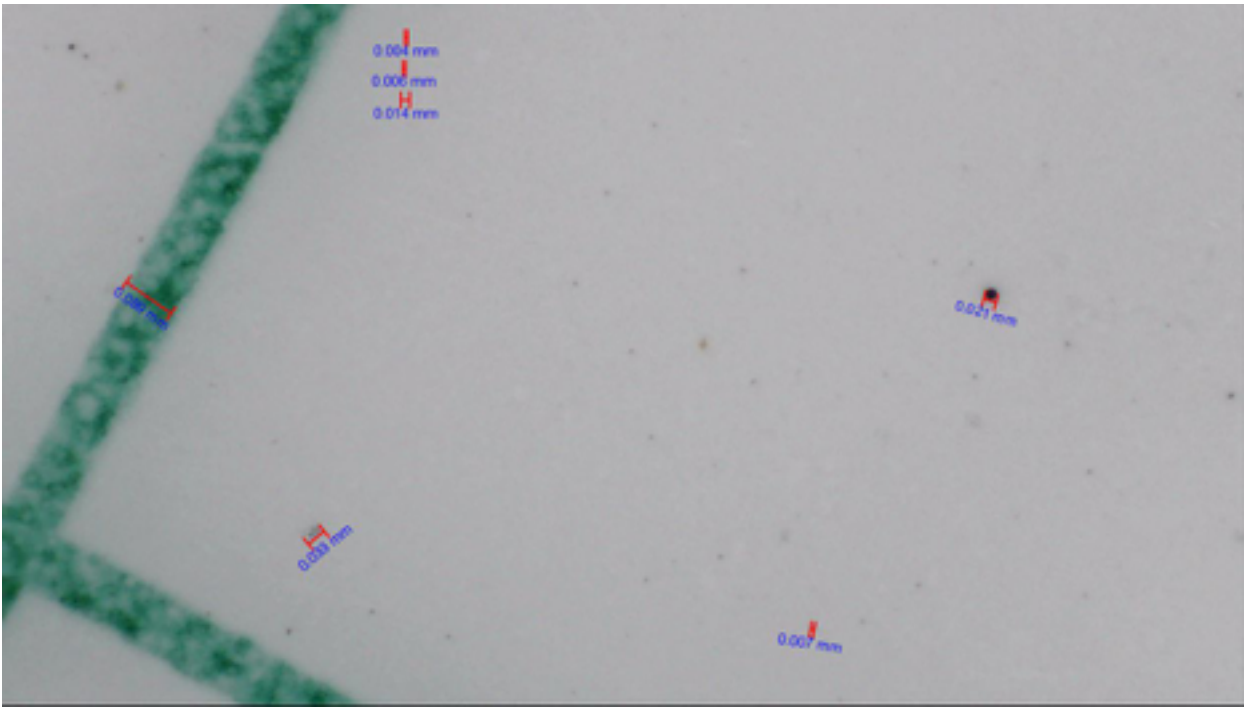## ISO 14/12/10 (Note the air bubbles on the left)
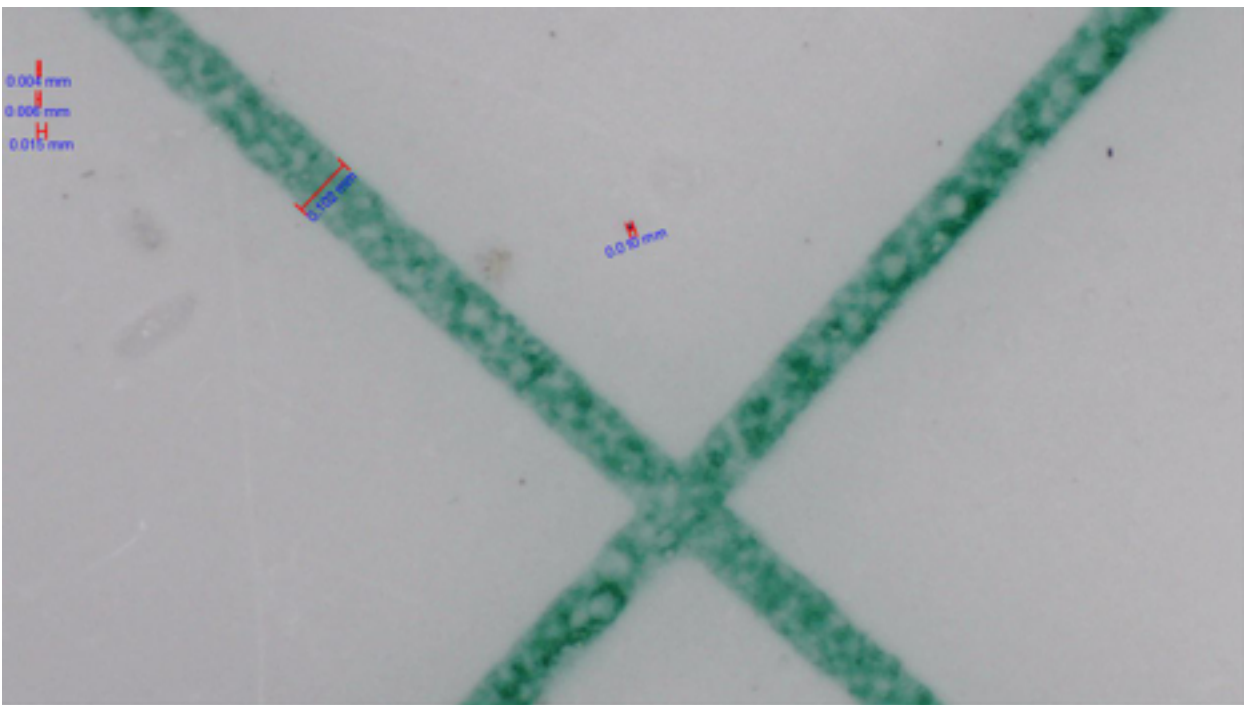
ISO 15/14/11
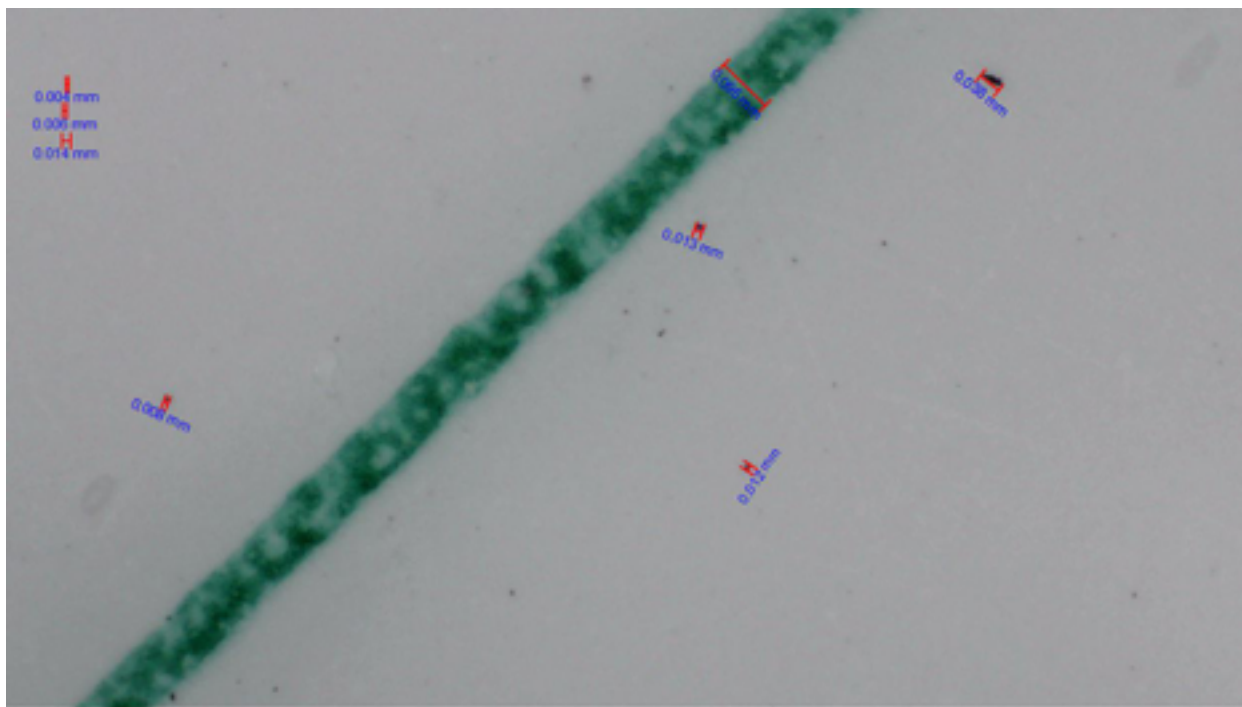
ISO 15/14/12 (Note the obvious blue denim fiber)
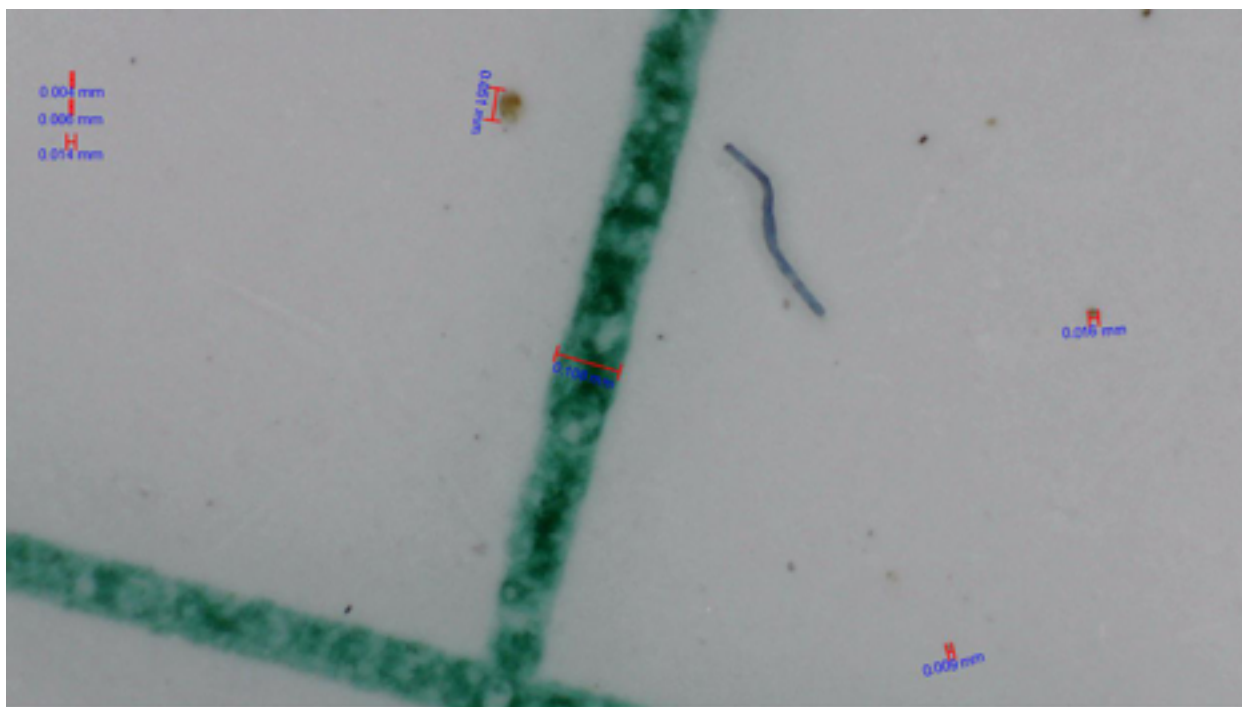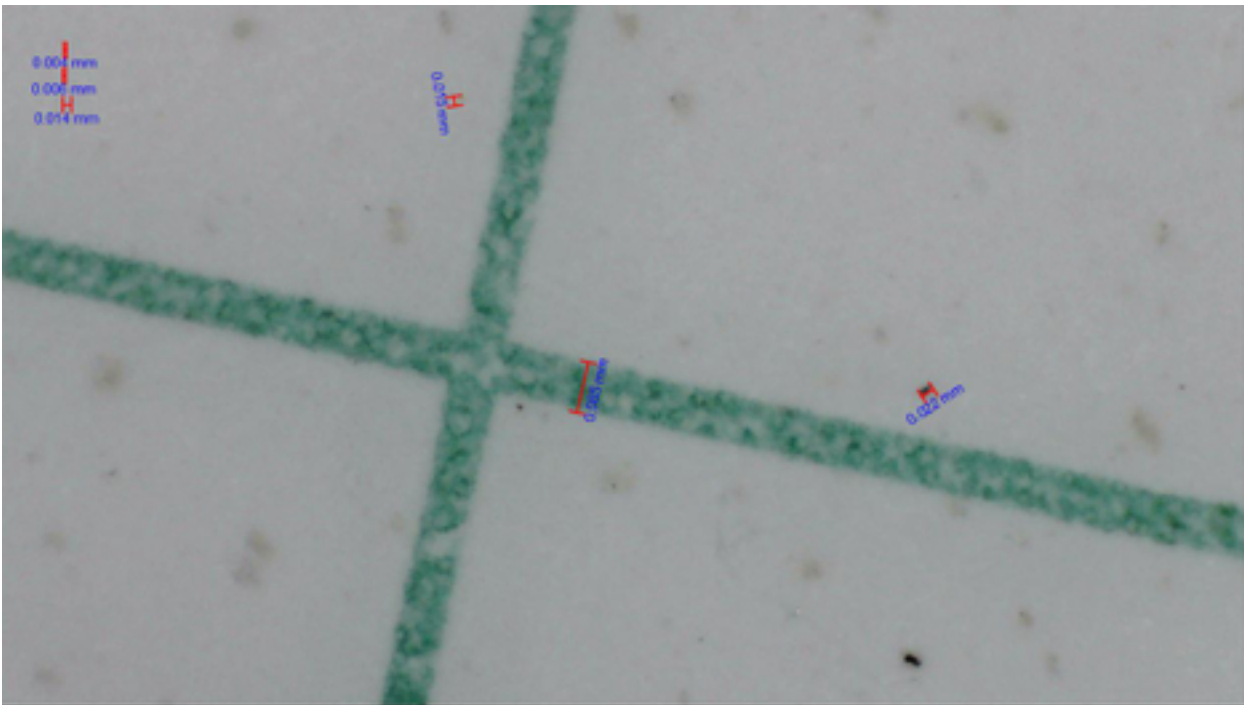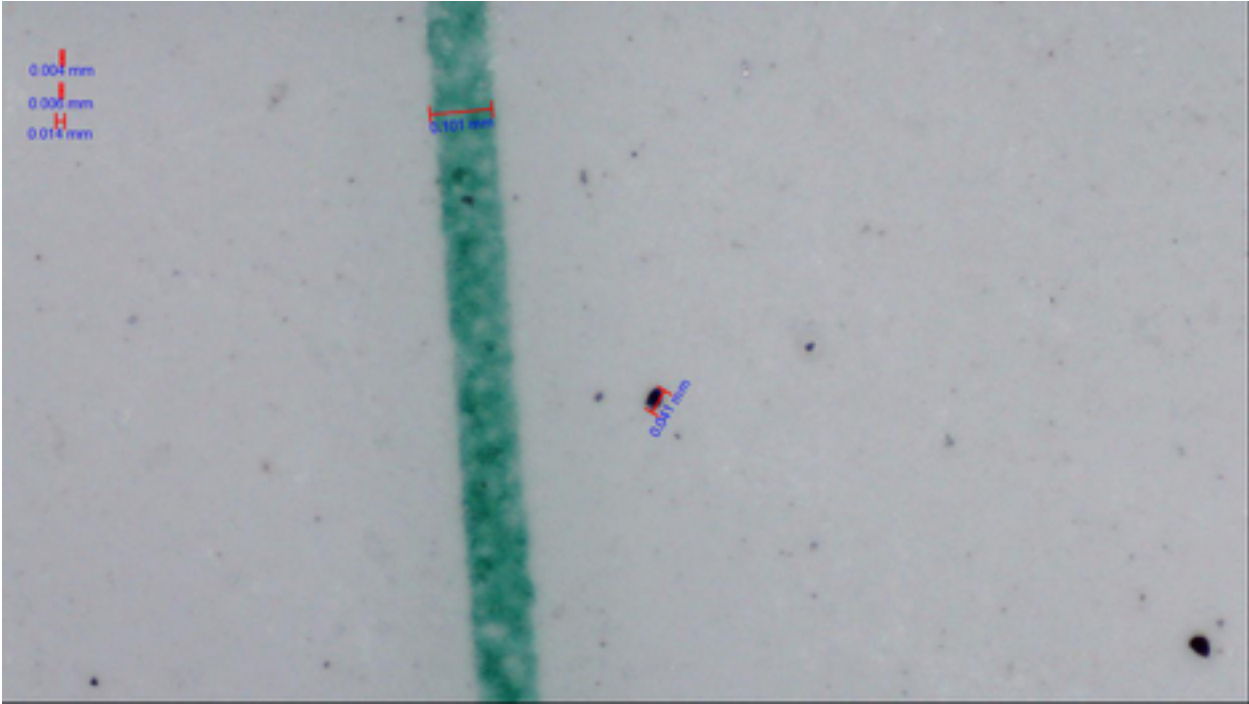
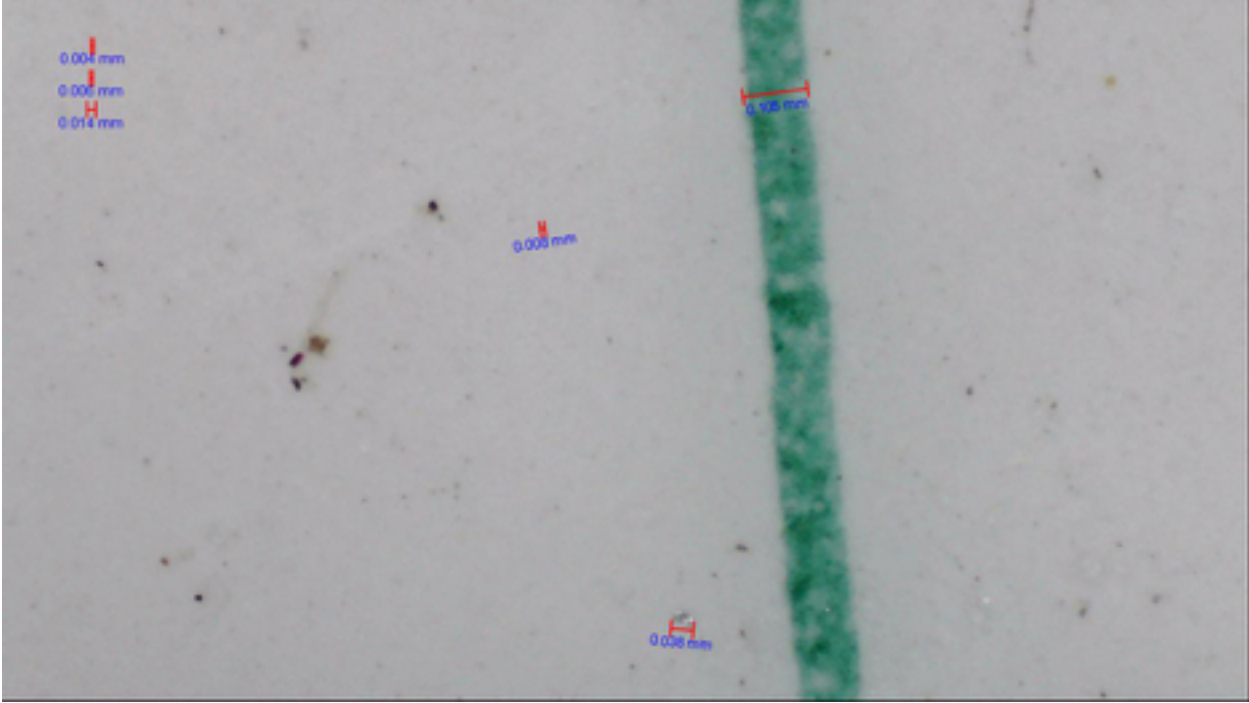ISO 16/13/11 (Typical ISO target level for hydraulic and transmission applications)

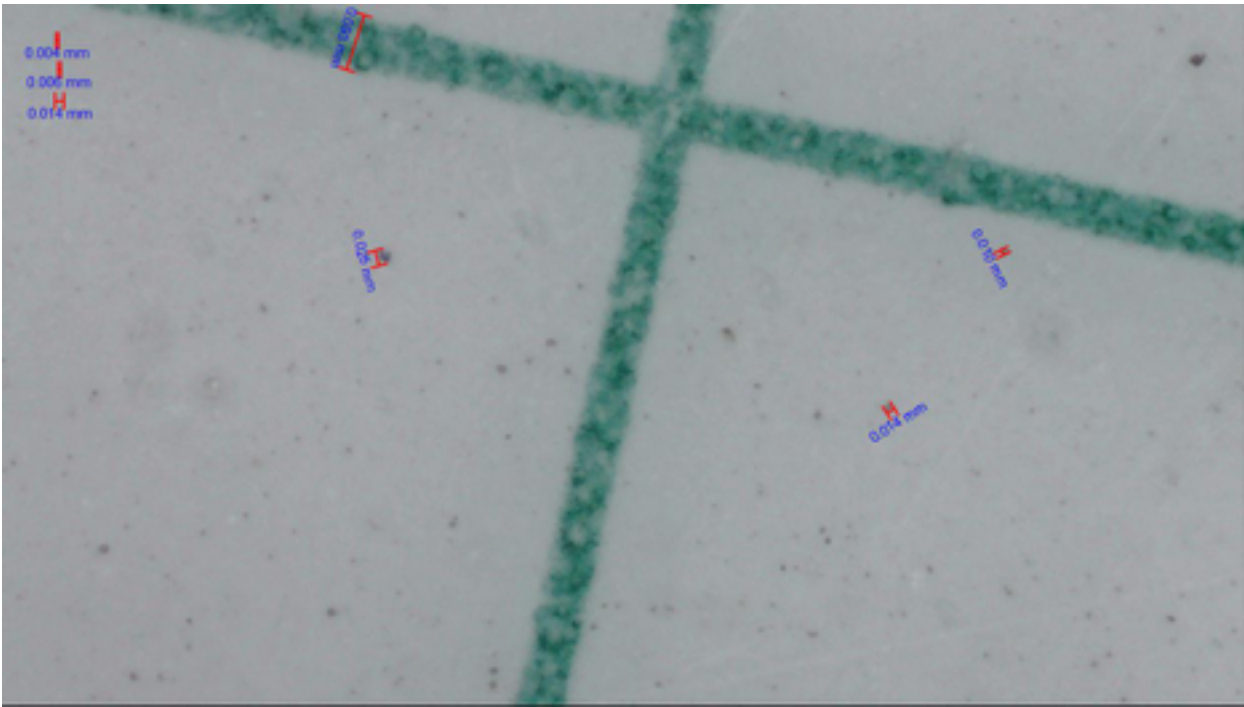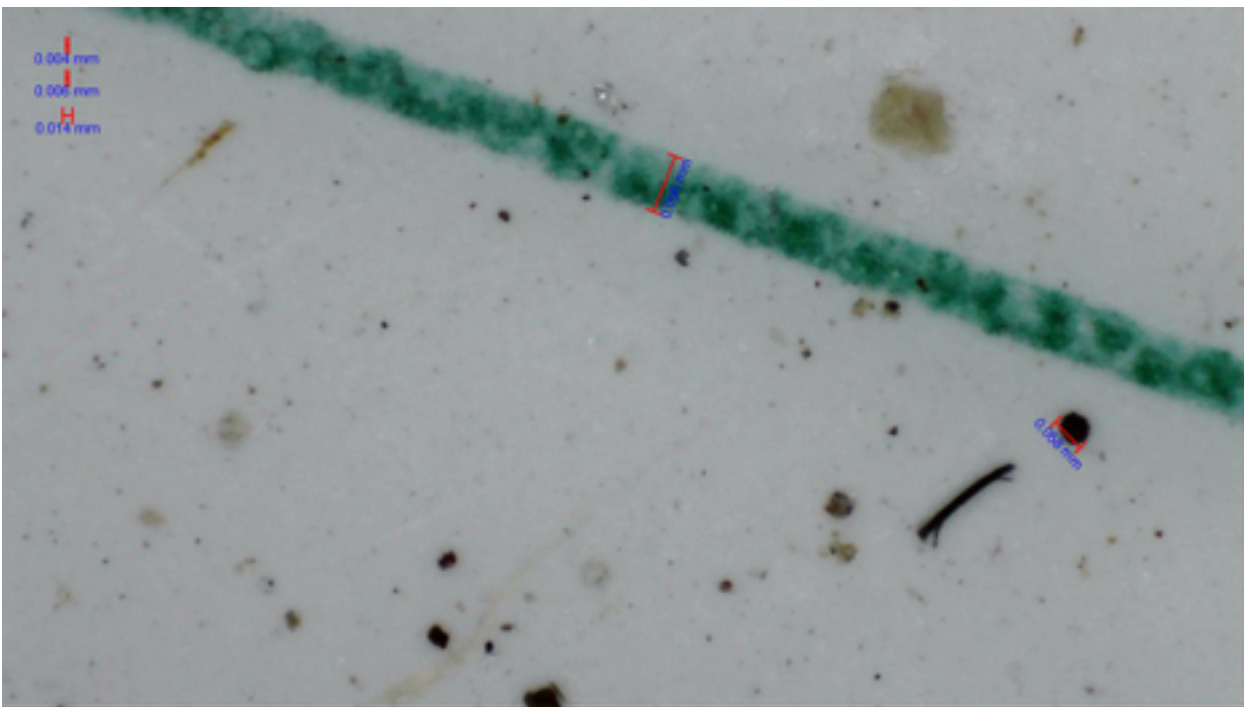ISO 16/15/14 (Note the soft contaminant particles)

ISO 17/15/11

ISO 17/15/13

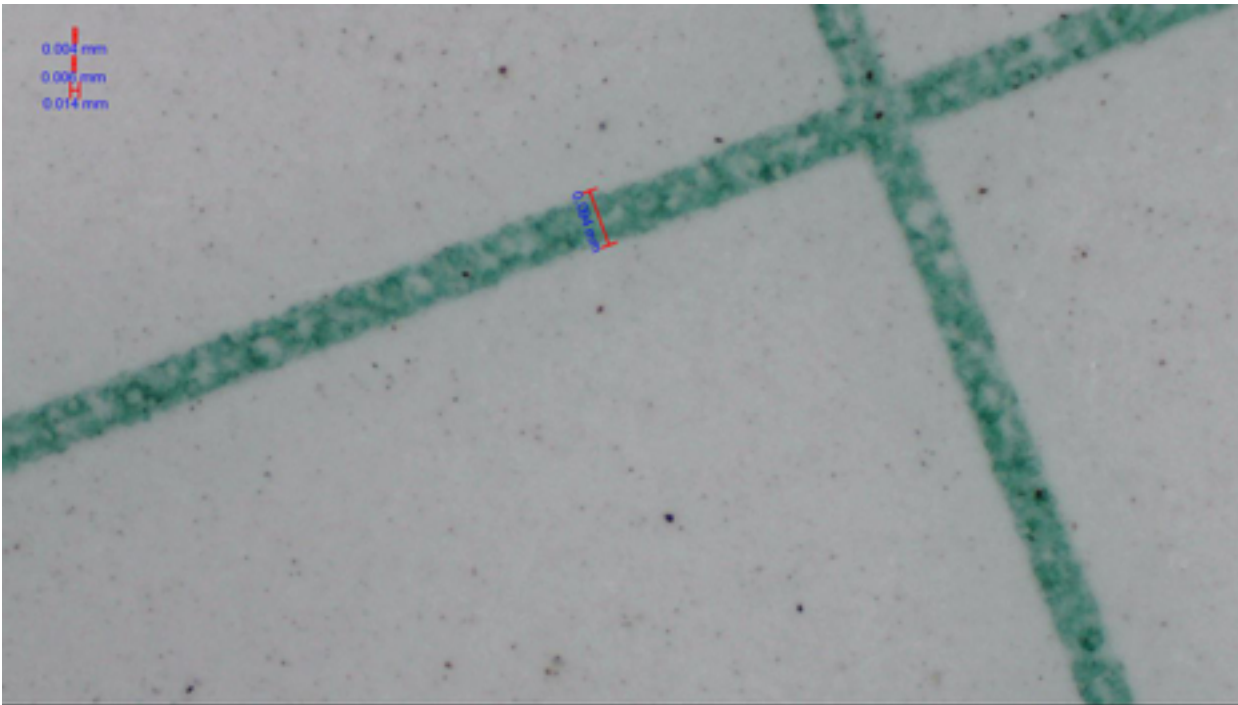ISO 18/16/13 (Typical ISO target level for engine and gear oils) (Likely filtered)

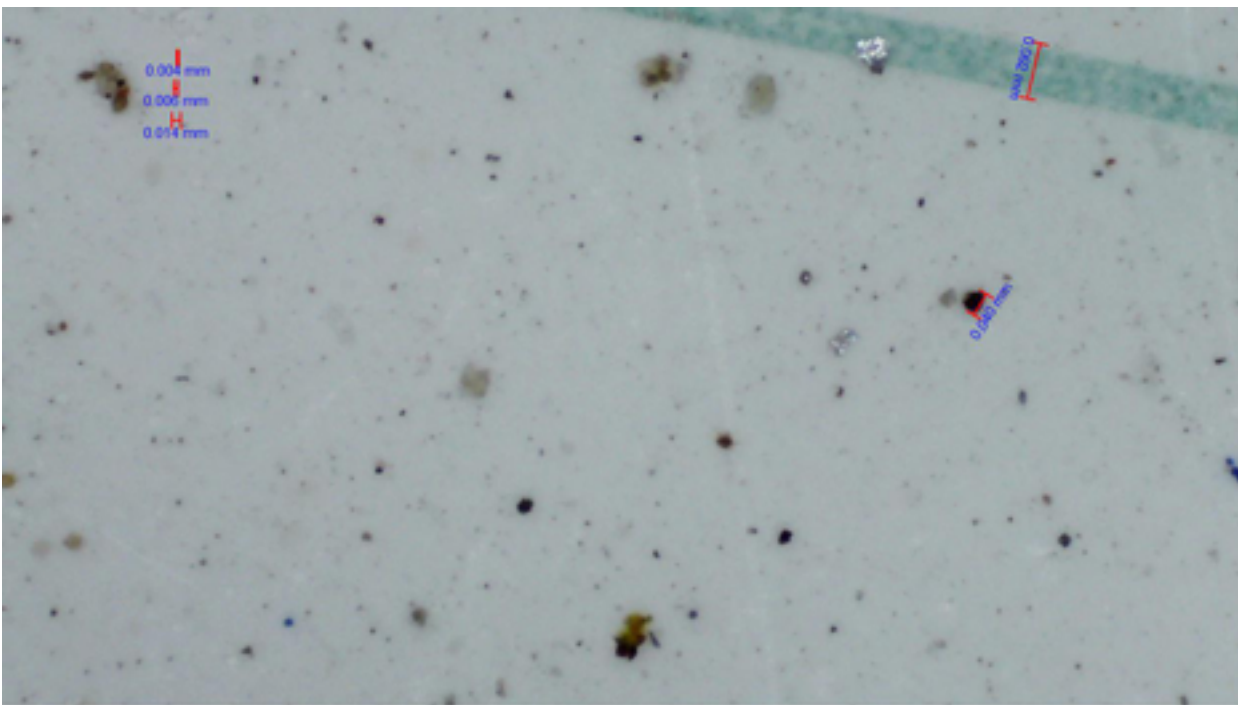ISO 18/16/15 (Note this is a poorly handled or un-filtered sample)
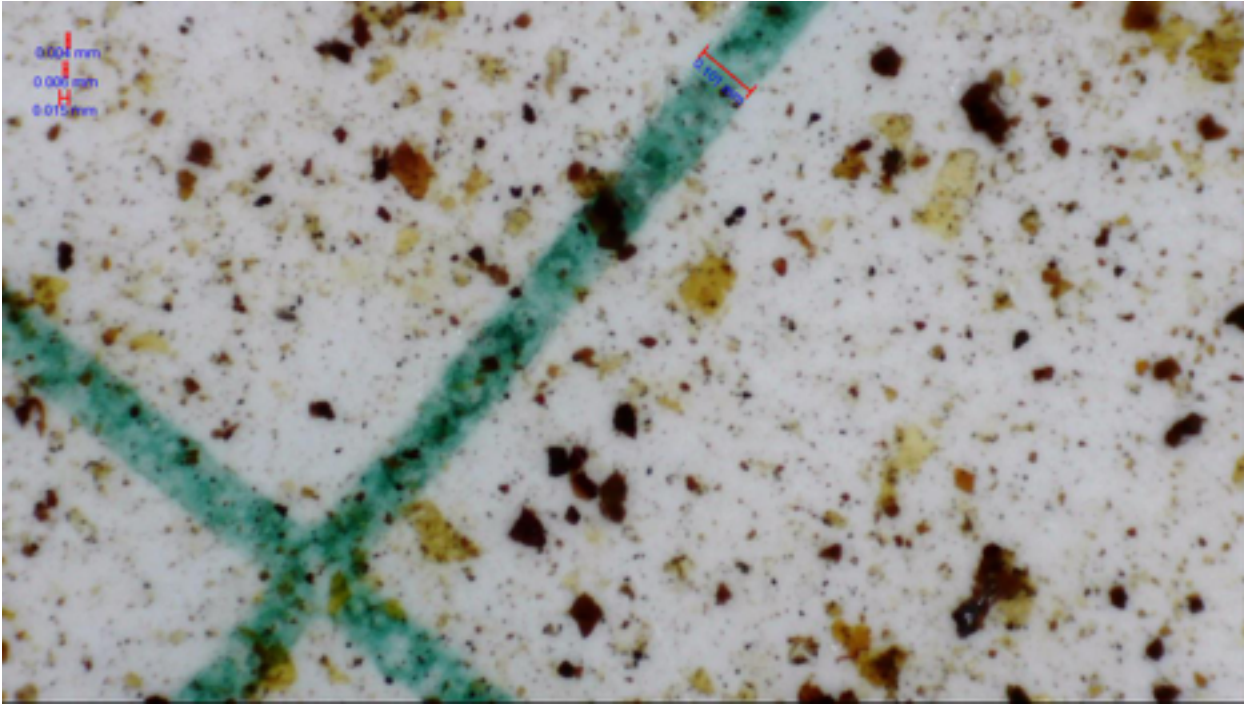
ISO 19/16/10 (Likely filtered)

ISO 19/17/15 (Likely un-filtered, note bright metal particle on green line upper right)
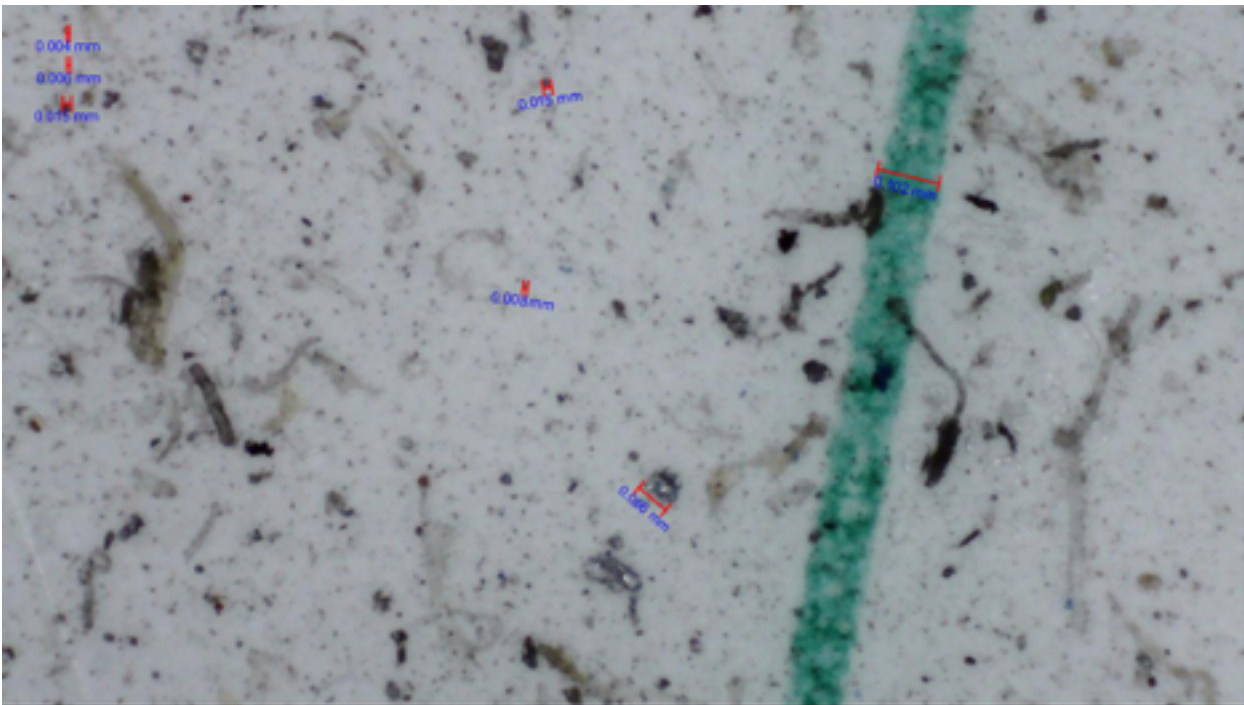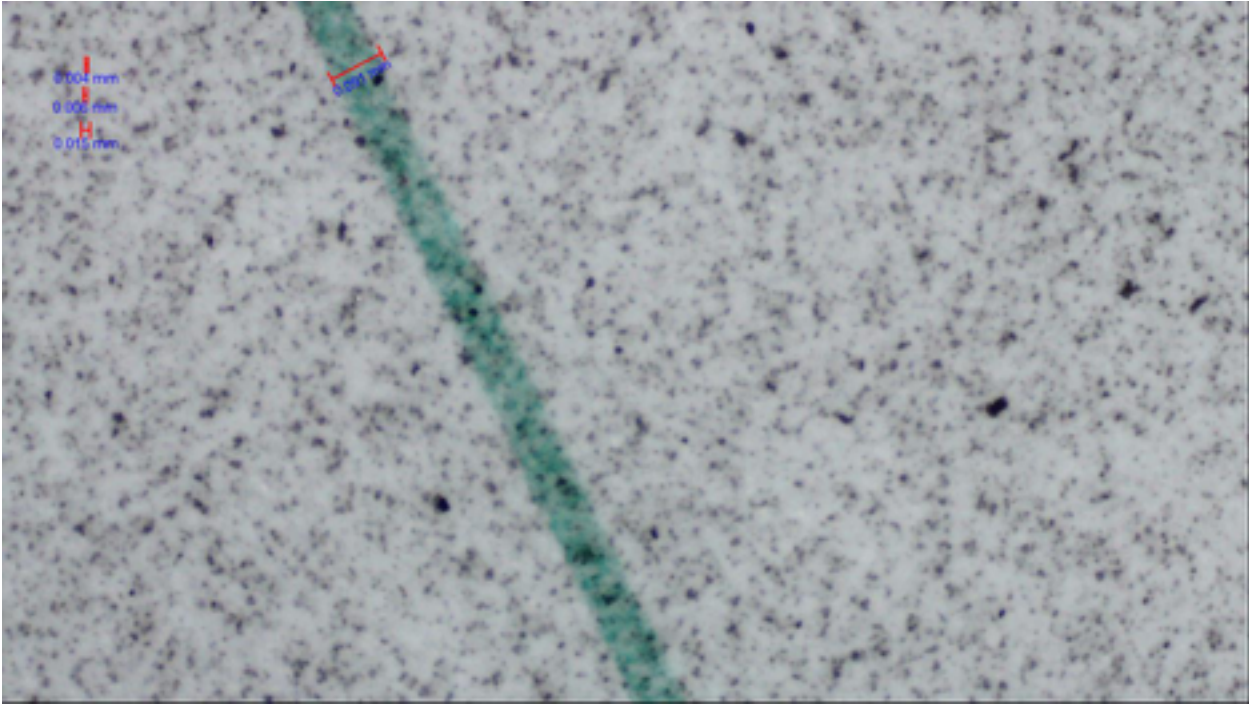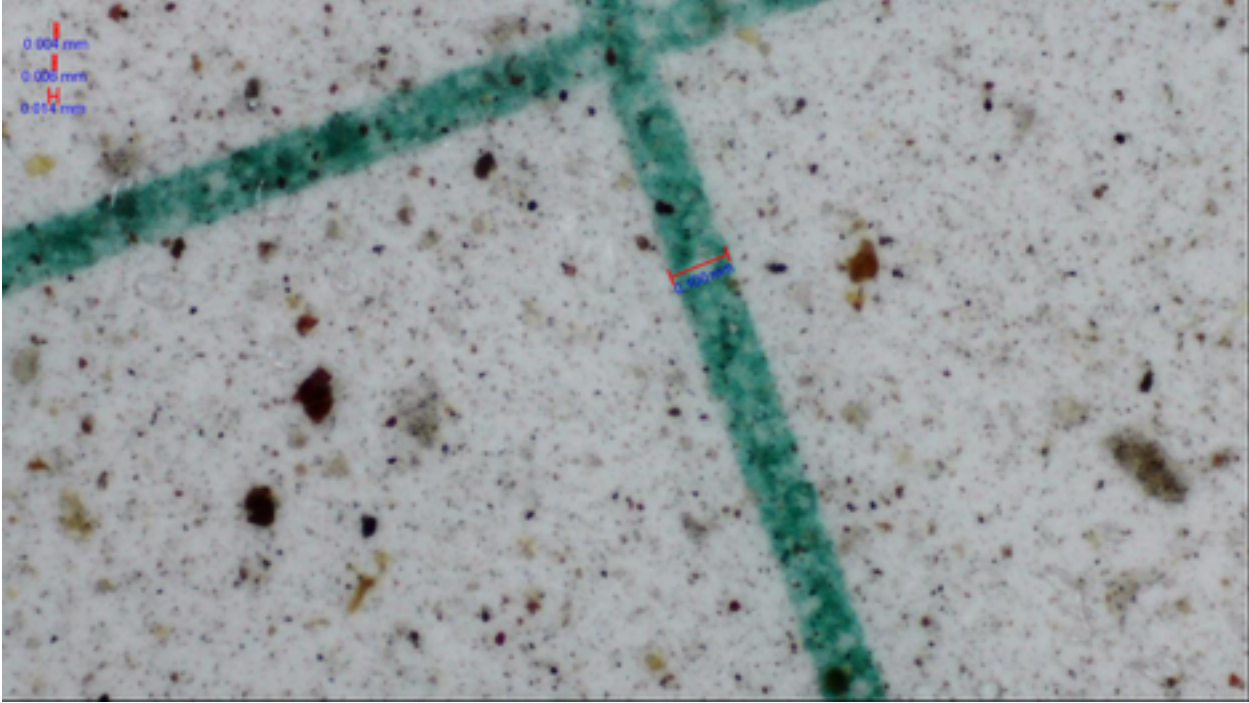
Patch Test Kit Manual

ISO 20/19/18 (Un-filtered)

ISO 20/19/18 (Note extensive fiber contamination)

ISO 21/19/12 (Coarsely filtered)

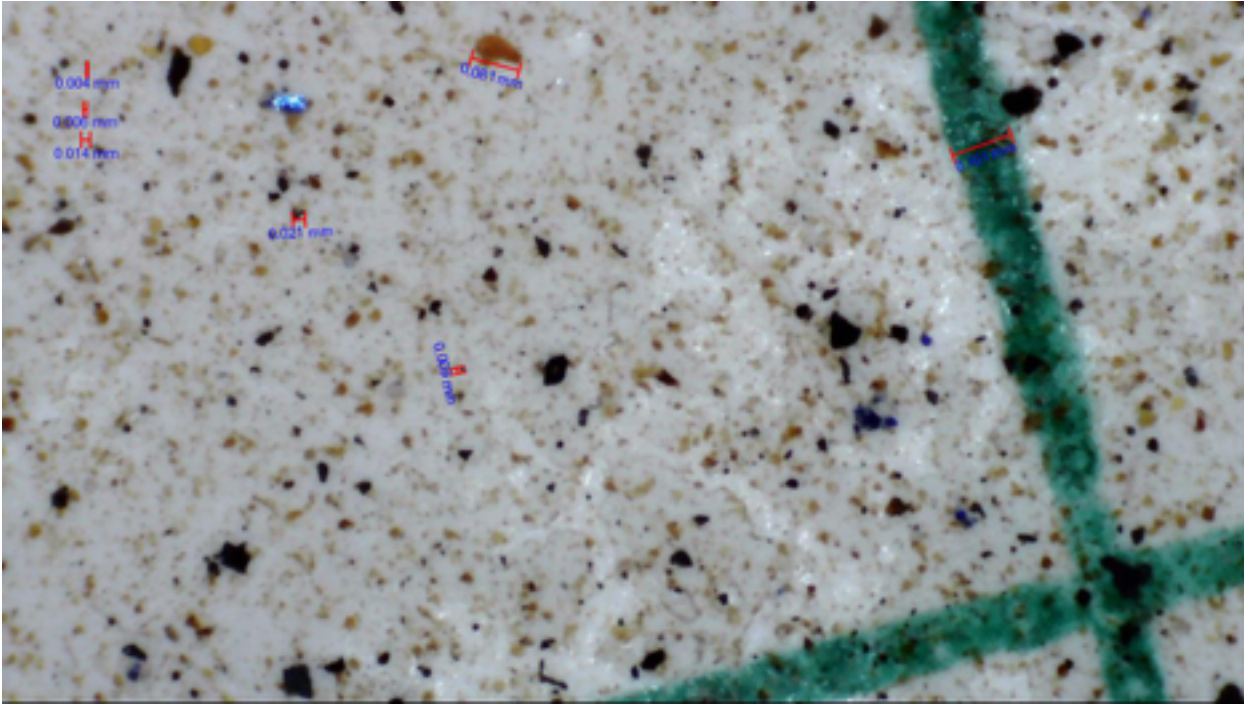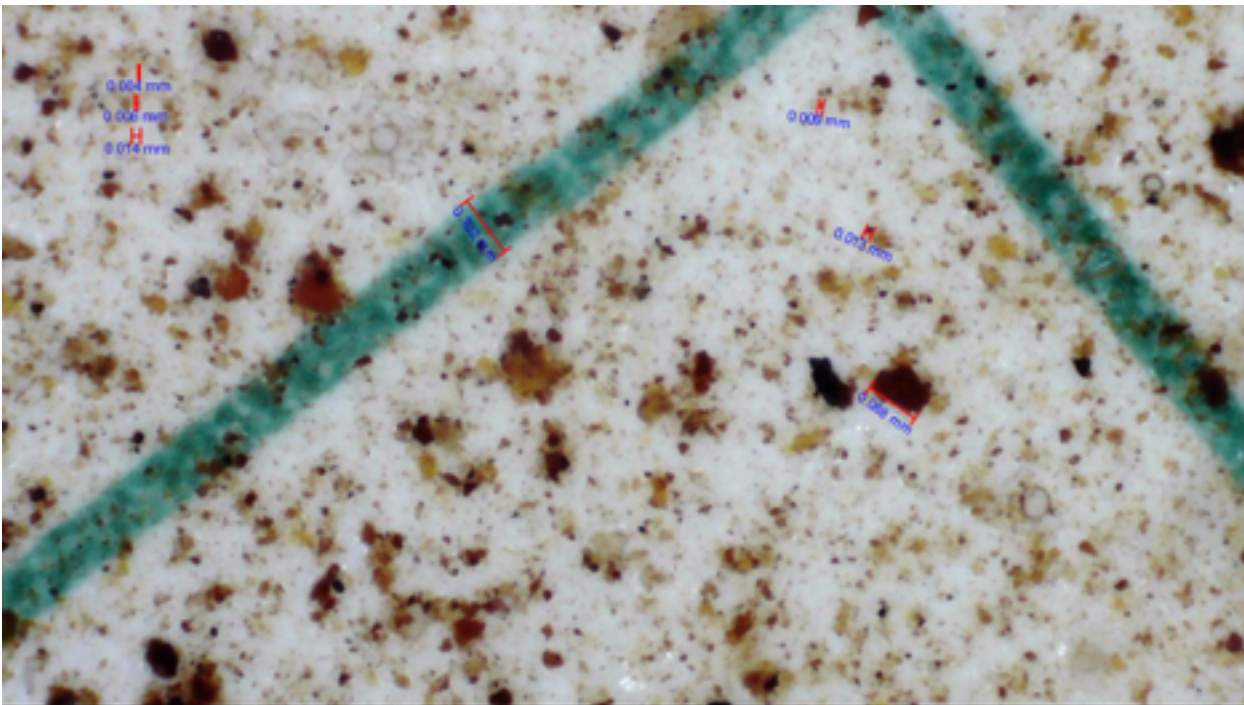## ISO 21/20/16 (Un-filtered)

ISO 22/20/17

ISO 22/20/18

ISO 23/22/20

ISO 23/19/18

Patch Test Kit Manual
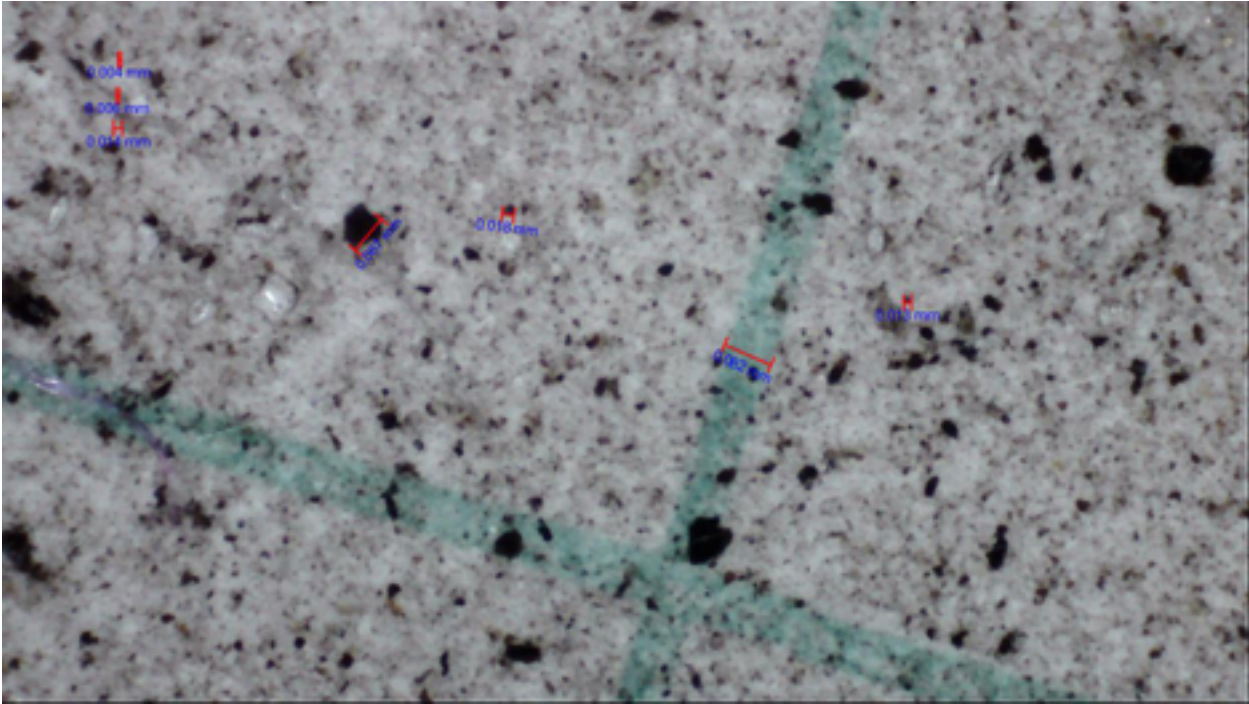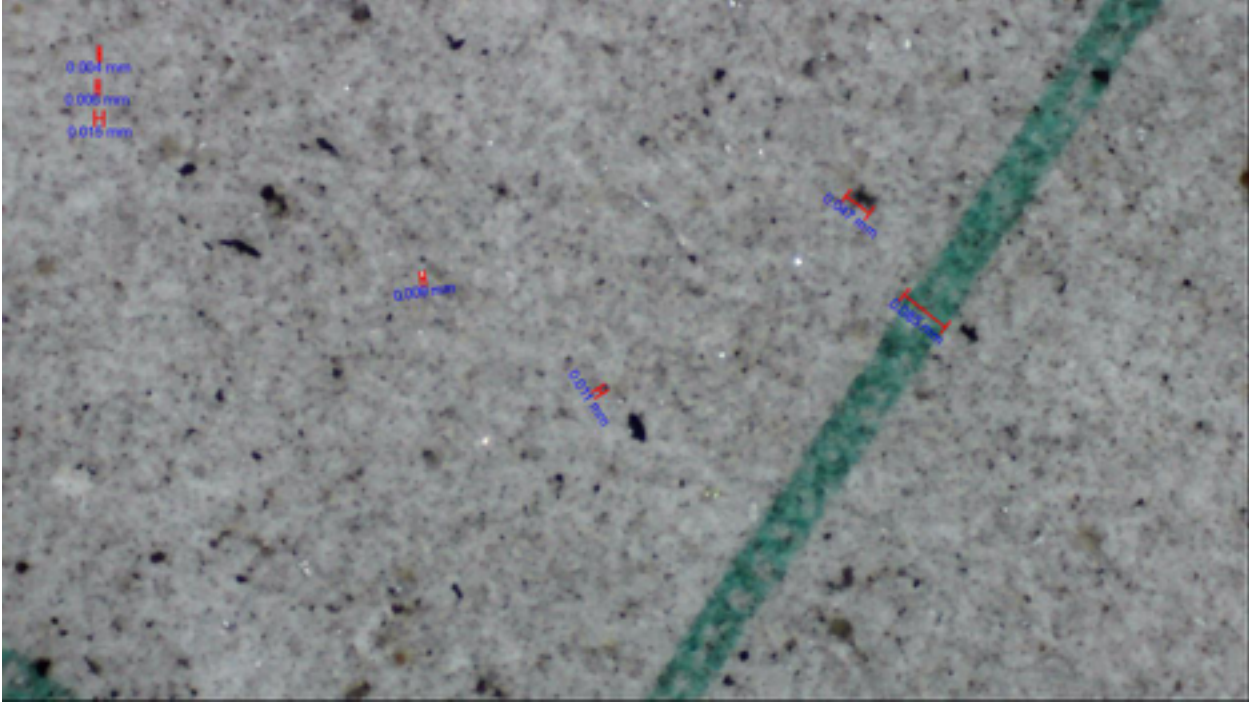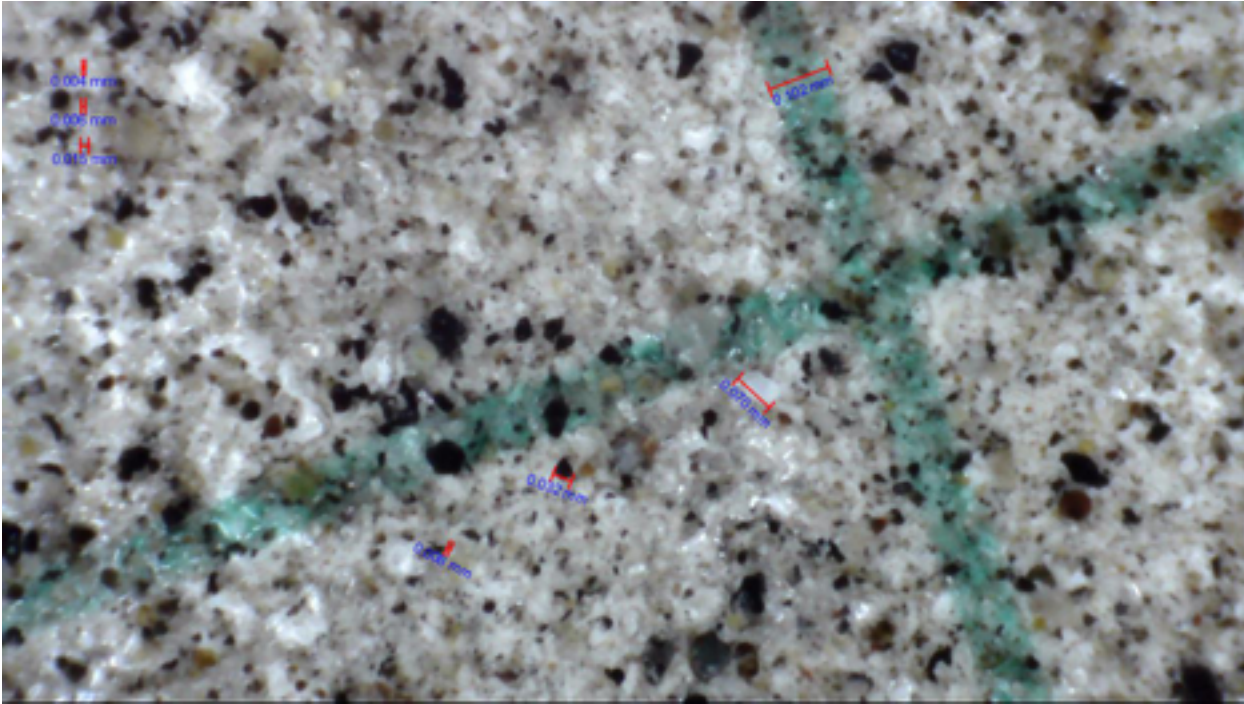
ISO 24/23/20

ISO 24/23/21
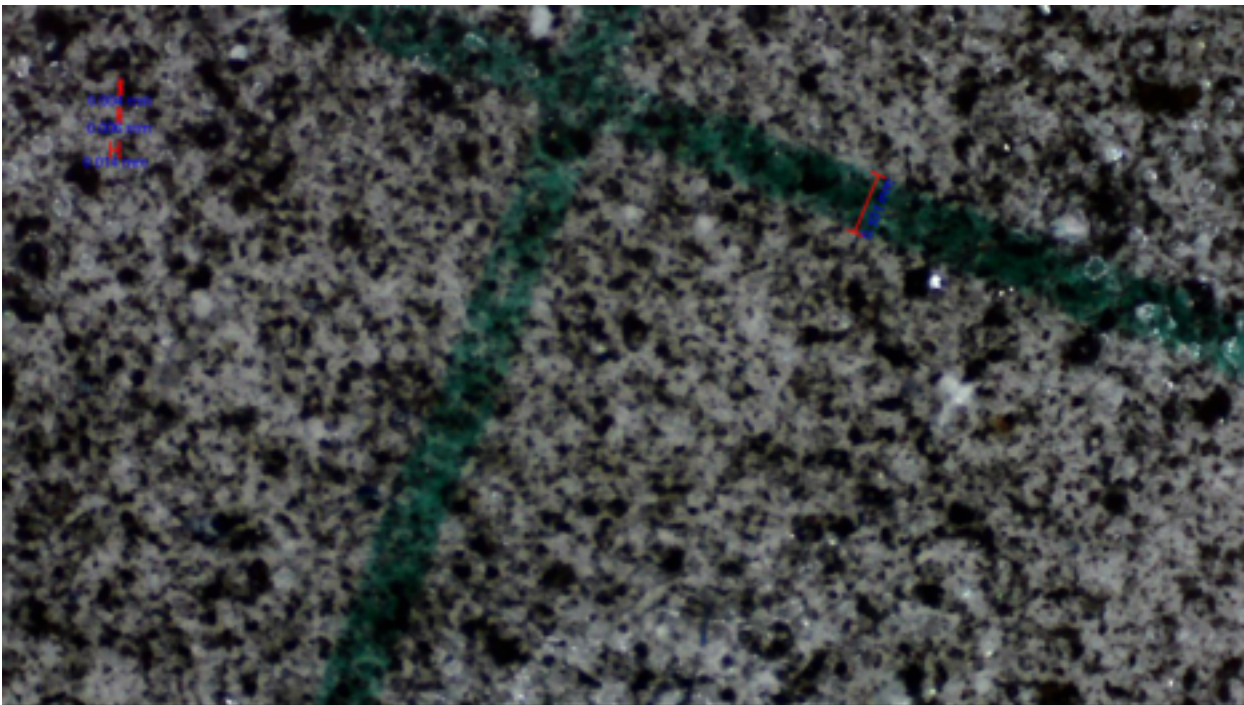
9. Patch debris interpretation. There are many types of debris found in fluids and their appearance can be very informative as to the source of contamination and potential solutions to the problem. A set of manual patch kit code example images and debris types are included with the kit. Compare the results from a field sample to these to determine the concentration and types of debris and compare to your sample the manually ISO counted examples for reference.

Visual Patch examples for comparison.

Examples of Debris types and various Visual ISO codes. Note: Patch images are 1/3 of the image area for cleanliness code images

Silica debris in oil and fuel.
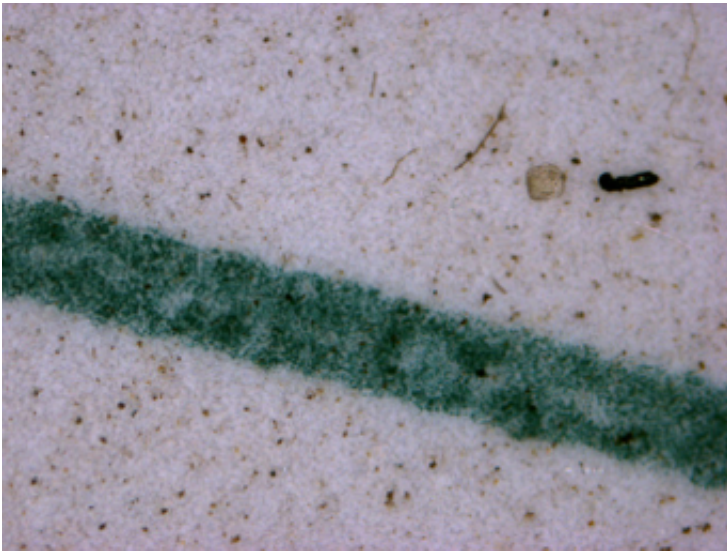
Windblown dust. The fine particles in the image are windblown sand particles and can ingress without proper breathers.
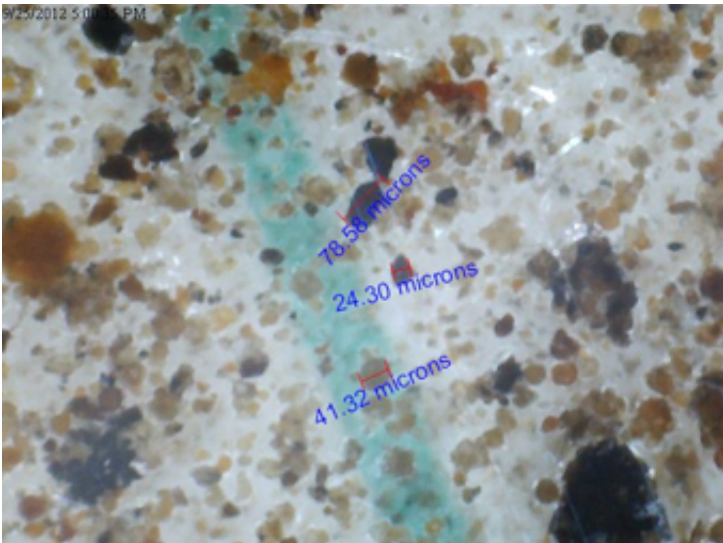
Coarse sand. Large granular sand is from an outside source, dusty conditions, lack of breathers, open caps or access ports, etc.
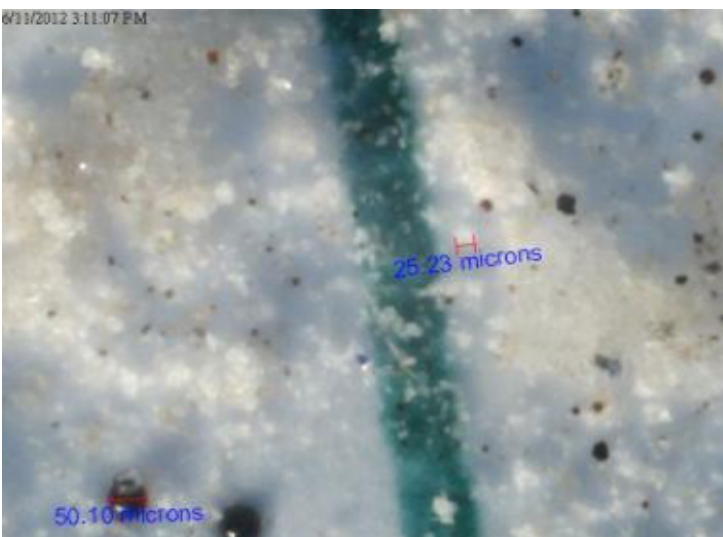
Diatomaceous Earth (silica based granular filtration media), typically from the oil production process at the refinery.

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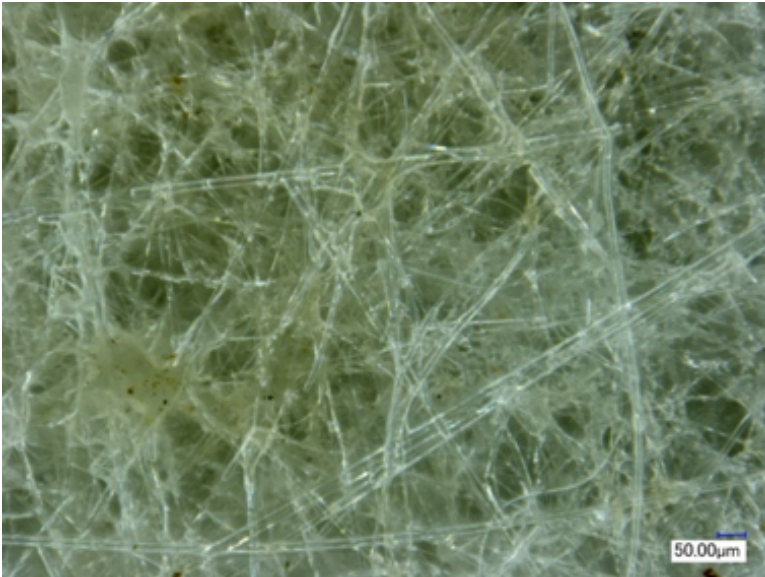
Glass (silica) media fibers or other environmental contamination source, fiberglass insulation, etc.

Metal contaminants
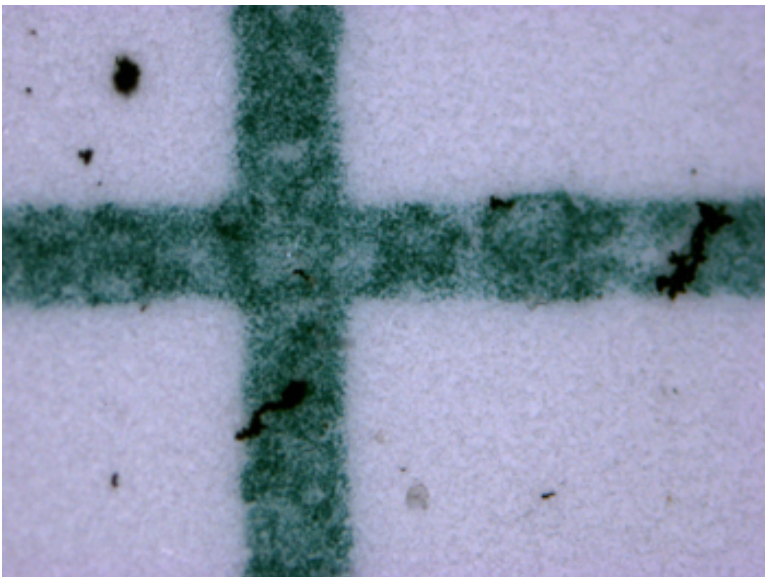
Iron

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.
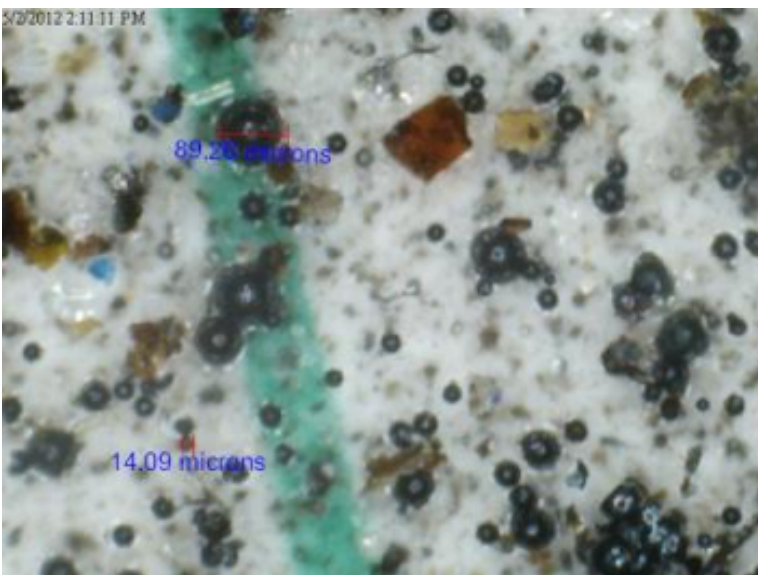
Weld debris from tank building or piping repair etc.

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.
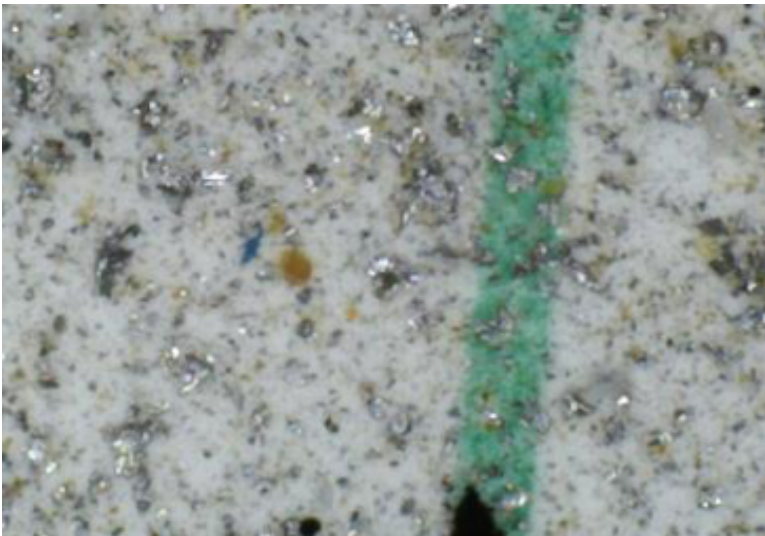
Grinding or wear debris (bright metal). Can be contamination from component manufacture, service or generated in a system that is incurring damage.
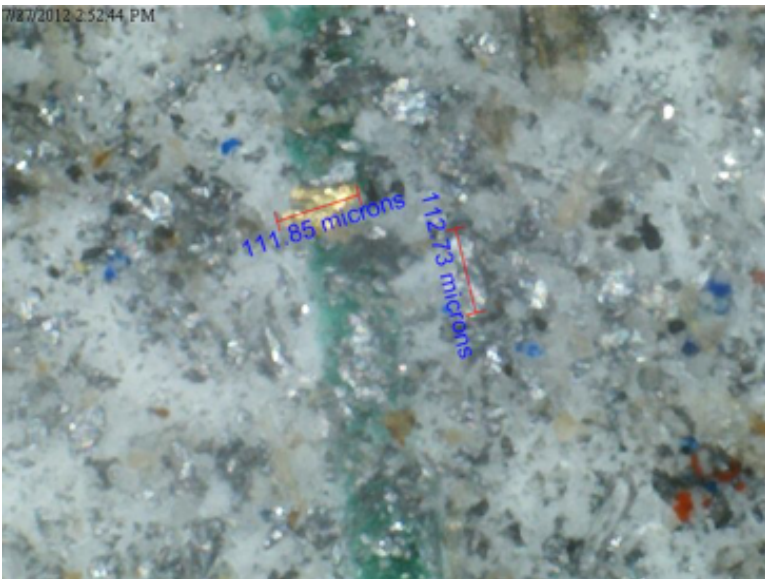
Bright metal with a large 111-micron piece of brass visible.
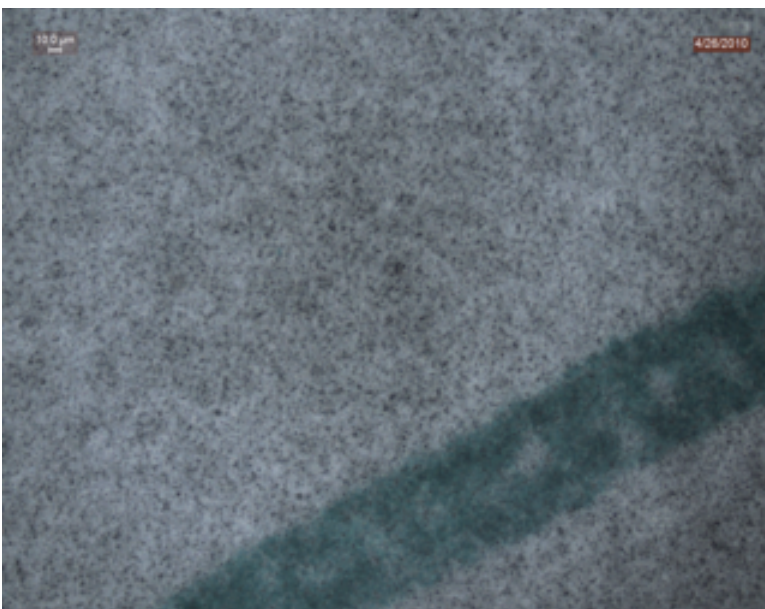
1-2um iron fines can ingress on cylinders etc. or be derived in the system. Note this is a very high-resolution image to show the fine particulate. It is very hard to discern sub 4um particulate as individual particles at lower resolution, with the scope included the kit. It may appear as a gray background but is technically not counted in the ISO count (only 4um and larger).

Soft contaminants
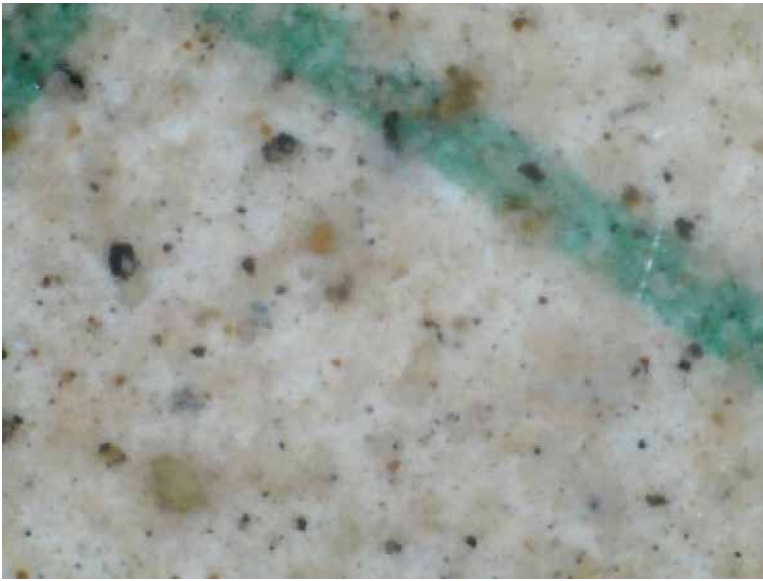
Soft contaminants

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.
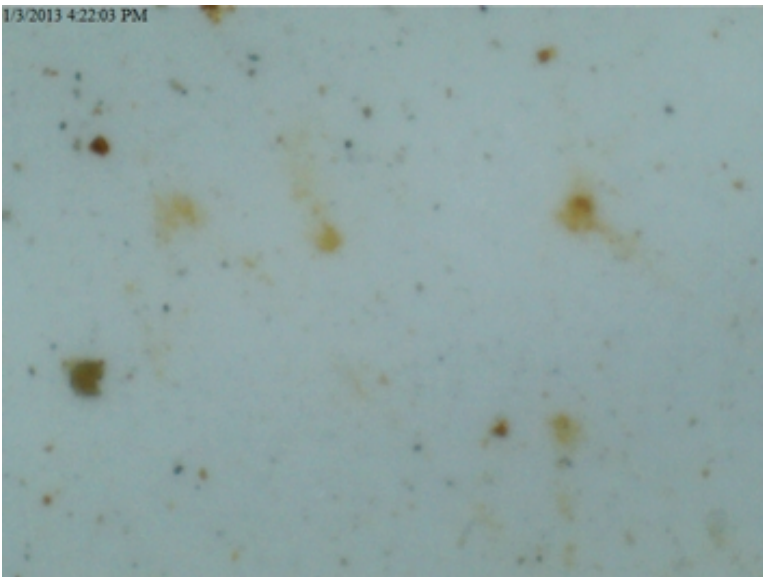
Glycerin solids from biodiesel

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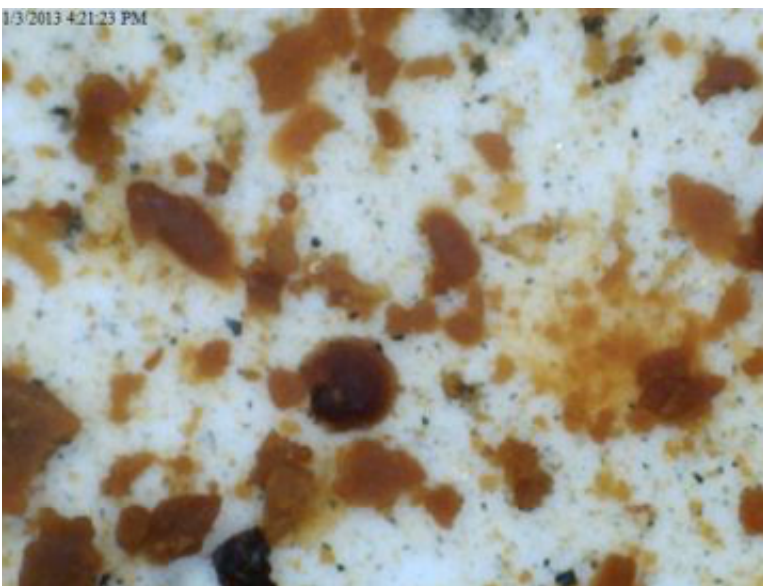
Glycerin solids from fuel in tank bottoms

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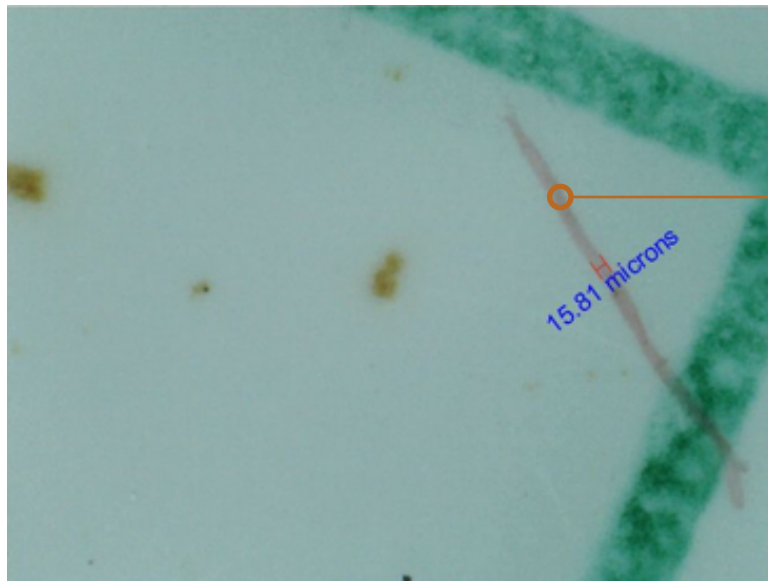
Cellulose fibers can be from media or outside contamination in many applications.

15.81-micron wide cellulose fiber in a sample.

This is a cellulose fiber

15.81 microns
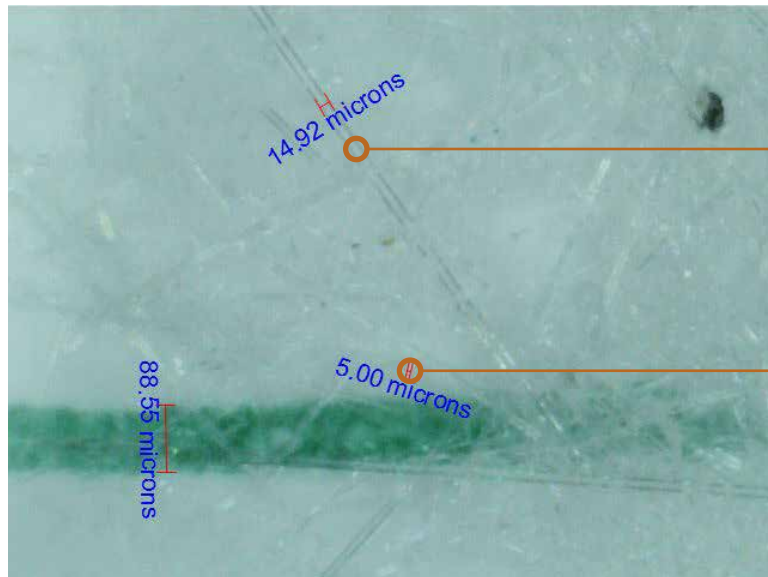
Glass fiber

This is a plastic fiber

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

14.92 microns

5.00 microns

88.55 microns

Clear plastic fiber

This is a plastic fiber

Understanding ISO Codes

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		

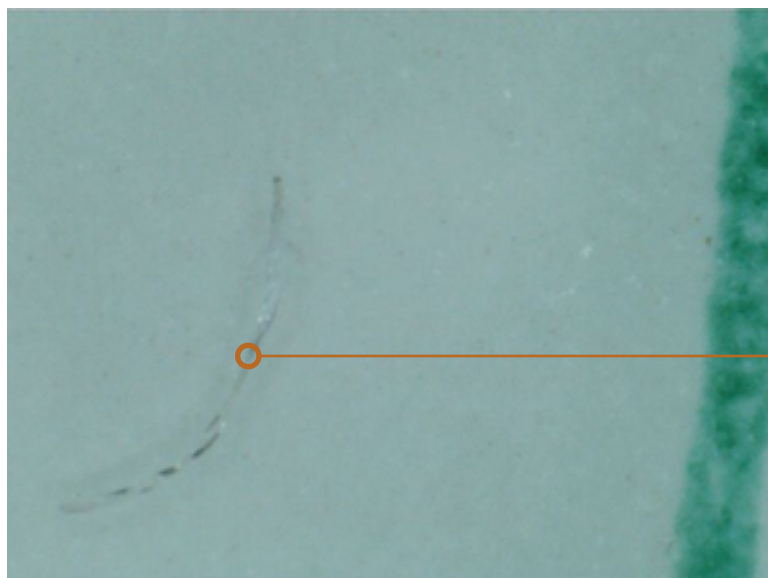| Particle Size	Particles per Milliliter	ISO 4406 Code Range	ISO Code
$4\mu_{(c)}$	69	40~80	13
$4.6\mu_{(c)}$	35		
$6\mu_{(c)}$	7	5~10	10
$10\mu_{(c)}$	5		
$14\mu_{(c)}$	0.4	0.32~0.64	6
$21\mu_{(c)}$	0.1		
$38\mu_{(c)}$	0.0		
$68\mu_{(c)}$	0.0		

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	($\beta x = 200$)	2000 - 3000 psi	($\beta x = 200$)	> 3000 psi	($\beta x = 200$)
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 Celestron Deluxe handheld digital microscope set directly on patch and focused at 400x

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	11,543	23,085
23	4,000,000	8,000,000	1,000,000	2,000,000	400,000	800,000	40,000	80,000	5,771	11,543
22	2,000,000	4,000,000	500,000	1,000,000	200,000	400,000	20,000	40,000	2,886	5,771
21	1,000,000	2,000,000	250,000	500,000	100,000	200,000	10,000	20,000	1,443	2,886
20	500,000	1,000,000	125,000	250,000	50,000	100,000	5,000	10,000	721	1,443
19	250,000	500,000	62,500	125,000	25,000	50,000	2,500	5,000	361	721
18	130,000	250,000	32,500	62,500	13,000	25,000	1,300	2,500	188	361
17	64,000	130,000	16,000	32,500	6,400	13,000	640	1,300	92	188
16	32,000	64,000	8,000	16,000	3,200	6,400	320	640	46	92
15	16,000	32,000	4,000	8,000	1,600	3,200	160	320	23	46
14	8,000	16,000	2,000	4,000	800	1,600	80	160	12	23
13	4,000	8,000	1,000	2,000	400	800	40	80	6	12
12	2,000	4,000	500	1,000	200	400	20	40	3	6
11	1,000	2,000	250	500	100	200	10	20	1	3
10	500	1,000	125	250	50	100	5	10	1	1
9	250	500	63	125	25	50	3	5	0	1
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

Donaldson.
FILTRATION SOLUTIONS