

APPENDIX G
Post-Test Engine Inspection



T/S STATE OF MICHIGAN

Post-Test Inspection

11/28/11 - 12/1/11

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Worklist

Caterpillar Post-test Worklist

Date: 11/28/11

1. #4 engine: Pull out the fuel injectors; visually inspect condition and test for opening pressure and leakage. Reinstall the injectors upon completion of borescoping.
2. #4 engine: Remove inspection crankcase covers and visually inspect with borescope the condition of cylinders liners.
3. #4 engine: Test/calibrate the fuel pumps on the engine.
4. #4 engine: Inspect and photograph the cylinders with borescope when the injectors and crankcase covers are removed for testing. Note the condition. Crank engine and observe inlet/exhaust valve condition. Need borescope with photographic capability. Ensure all photographs clearly depict wear pattern of liner liners, liner honing markings, piston wear pattern, and upper end landing.
5. #4 engine: Adjust inlet & exhaust valve timings.
6. #4 engine: Remove fuel oil meters inlet and outlet to the engine and replace with flexible hose provided by ship.
7. #4 engine: Remove intake manifold taps and reinstall pipe plugs.
8. #4 engine: If possible, perform visual inspection of turbocharger (hot end) blades. Use borescope with camera.
9. #4 engine: Change fuel filters
10. #4 engine: Take lube oil sample and send out for analysis.
11. #4 engine: Replenish oil level and provide replacement for oil used during test
12. #4 engine: Provide written details of results of Items 1, 2, 3, 4, and 7 including all photos taken during Item 3 and 7. Also provide results of Item 9.

Optional

1. #1, #2, and #3 engine: Open up two (2) power packs per engine, as designated by pulling out fuel injectors from the corresponding power packs on each engine; visually inspect condition and test for opening pressure and leakage. Reinstall the injectors on completion of Optional Item 2.
2. #1, #2, and #3 engine: Inspect and photograph the cylinders with borescope when the injectors are removed for testing. Note the condition of the cylinder liners. Crank engine and observe inlet/exhaust valve condition for each cylinder, including the underside of the cylinder heads. Need borescope with photographic capability. Ensure all photographs clearly depict wear pattern of liner liners, liner honing markings, piston wear pattern, and upper end landing.
3. #1, #2, and #3 engine – Take lube oil sample and send out for analysis
4. Provide written details of results of Items 1 and 2 including all photos taken for all three engines. Also provide results of Item 3.

Observations

Post test inspection and picture/video inspection

After the fuel testing I removed all twelve fuel injection nozzles and visually inspected finding normal carbon color and build up. Pressure tested the nozzles and the post test pressures and operation of the nozzles were the same as the pretest. All test results are included. Barred the engine over and checked valve lash finding very little difference since the valves were set before the fuel testing. All measurements are included. Borescoped all twelve cylinders and turbo compressor wheel with two different borescopes. Took video and pictures which are included in this report. After all inspections were done I did not see anything abnormal. The effects of the biofuel were the same as running on #2 ultra low diesel fuel.

INSPECTED all twelve cylinders through the injector bore. Visually seen typical cross hatch all the way to the top of the cylinder liner. The top keystone piston ring wear was minimal on the liner and was hard to see where it began. The liners had a light brown oil stain more noticeable at the top of the liner from normal oil coating. The exhaust valves were clean on the stem side and had a very clean seating mark. The inlet valve stems are gummed from the crankcase fumes disposed into the intake system. Some of the stems are very wet looking. The seating area is hard to see. The piston tops had a very black and dry soot covering. All findings were typical of normal engine operation.

Valve Lash

Valve lash measurement

Cylinder	Valve Lash (in)	
	Intake	Exhaust
1	0.015	0.037
2	0.015	0.036
3	0.018	0.035
4	0.015	0.036
5	0.015	0.036
6	0.015	0.036
7	0.015	0.035
8	0.016	0.036
9	0.015	0.035
10	0.015	0.036
11	0.016	0.035
12	0.016	0.035

Nozzle Test Pressure

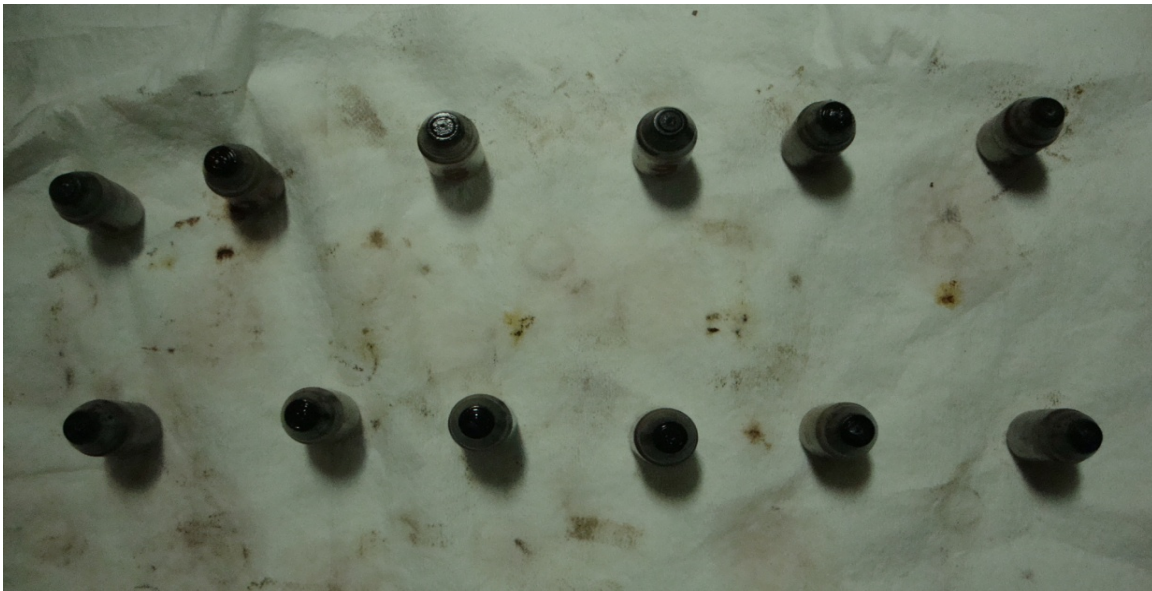
Fuel Injection Nozzle Pressure Test

Cylinder	Valve opening pressure (psi)	Spray pressure (psi)	Spray pattern	Pressure held for 30 seconds (psi)
1	450	500	good	300
2	450	475	good	300
3	475	500	good	400
4	475	500	good	350
5	475	500	good	350
6	475	500	good	350
7	475	500	good	450
8	525	550	good	400
9	500	525	good	350
10	490	525	good	300
11	480	500	good	300
12	475	500	good	300

Fuel Nozzle Pictures



Nozzles Pulled After Testing Completed



Typical Nozzle Tip Condition - Top View

Fuel Nozzle Pictures



Nozzle Tip Condition Views - Cyl # 9 SSDG #4



Nozzle Tip Condition Views - Cylinder #9 SSDG#2 Comparison

Fuel Nozzle Pictures



Nozzle Tip Condition Views

Borescope Pictures

Borescope Details

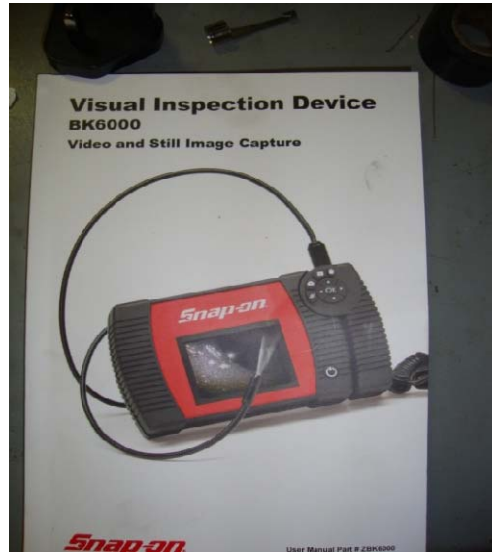
Components Borescoped

All Cylinders - SSDG #4

#9 and #10 Cylinders on SSDG #2, #3, and #4



Caterpillar Service Rep Borescoping

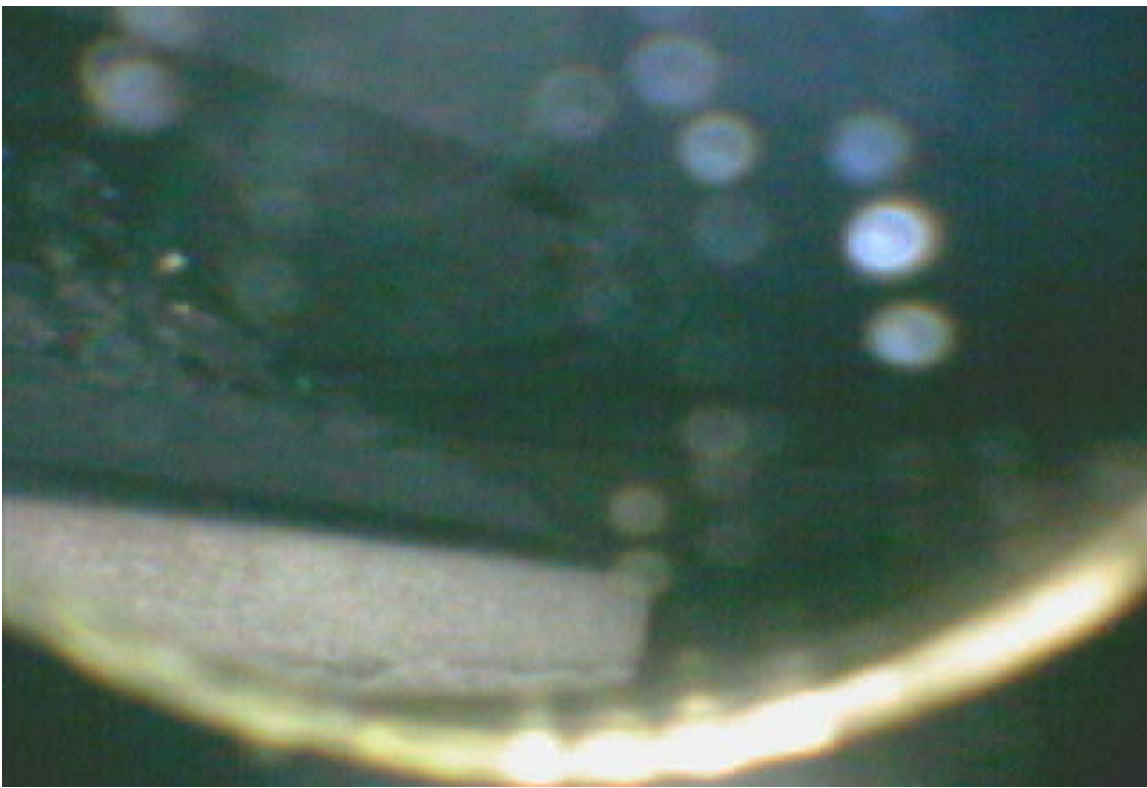
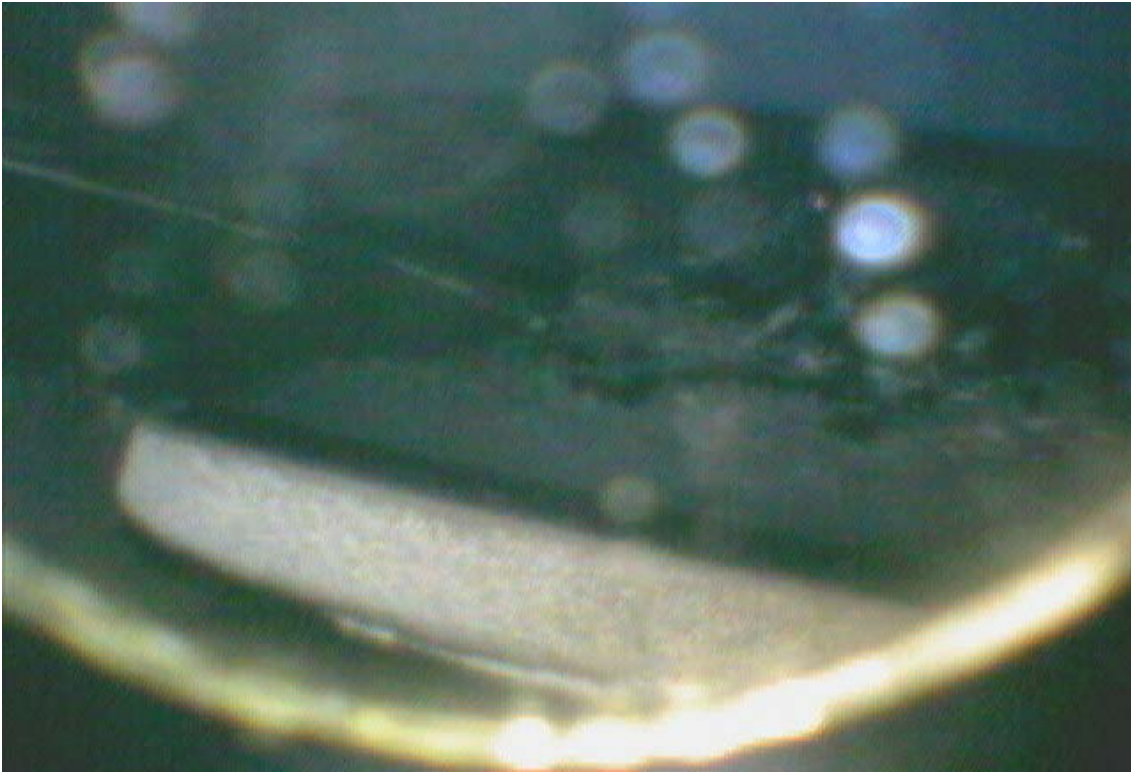


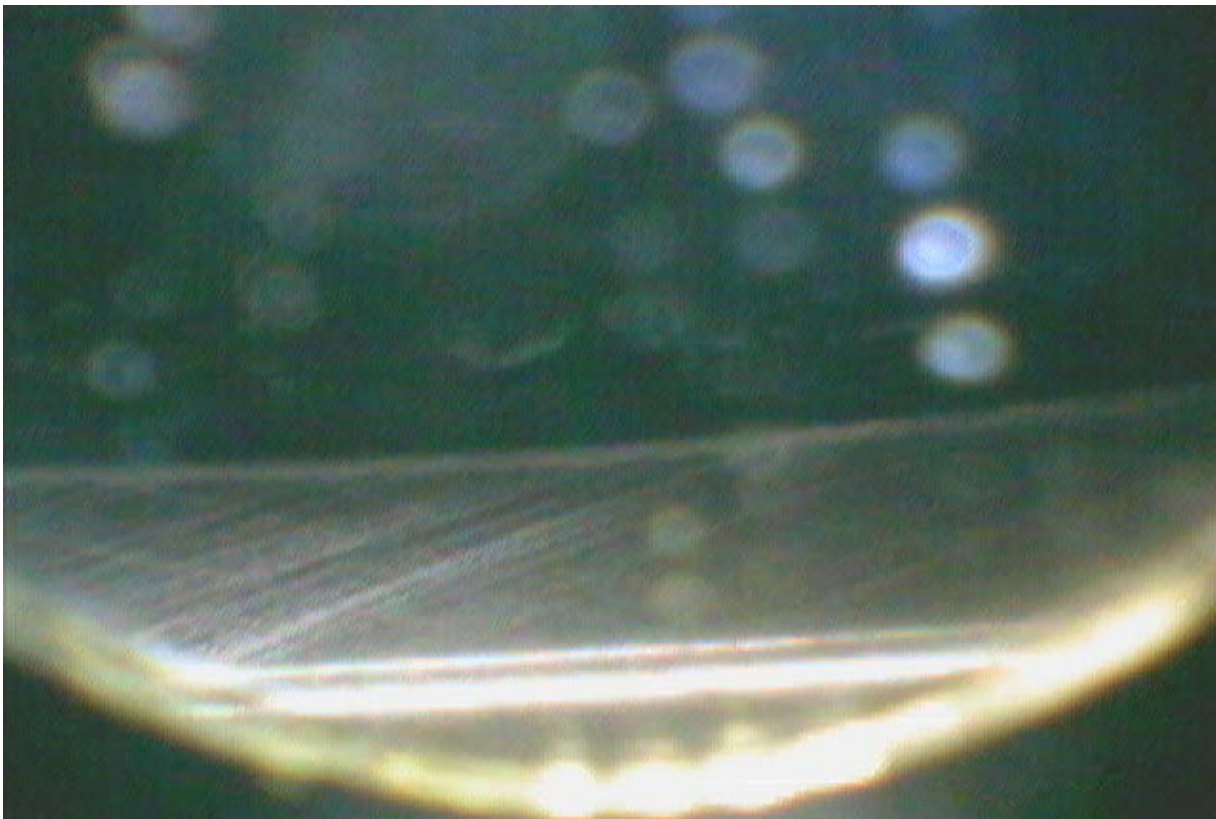
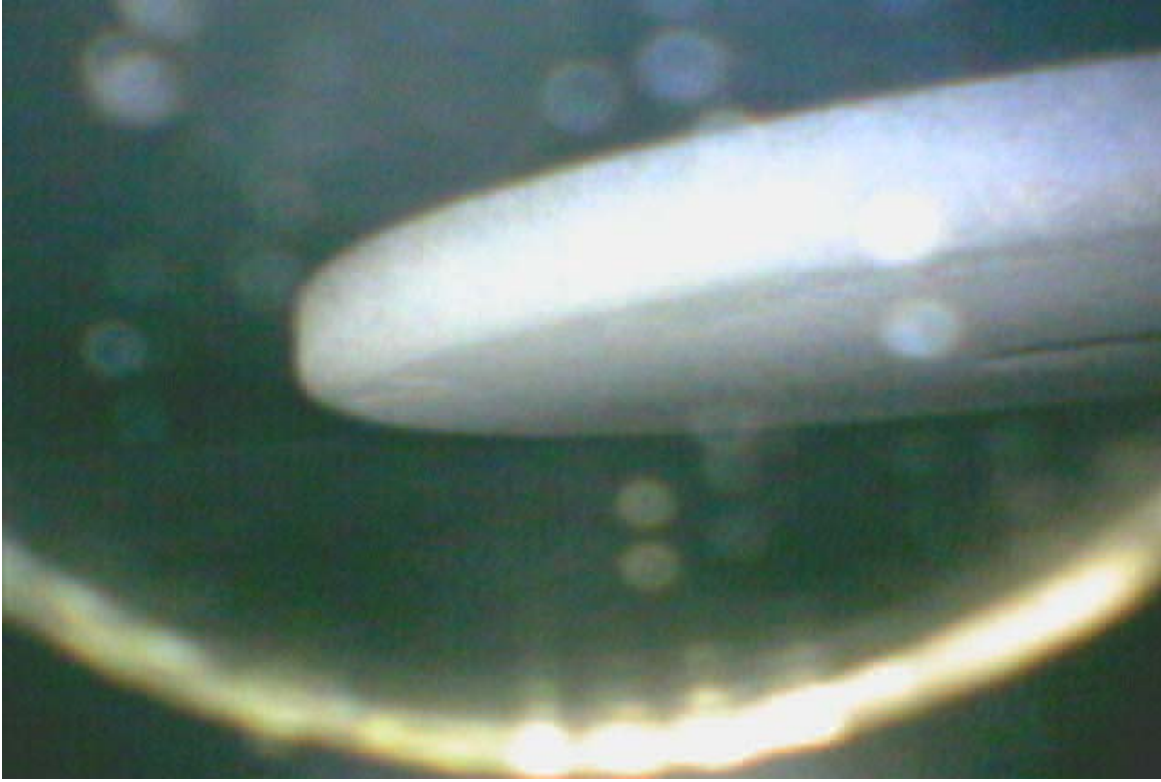
Snap-on Borescope

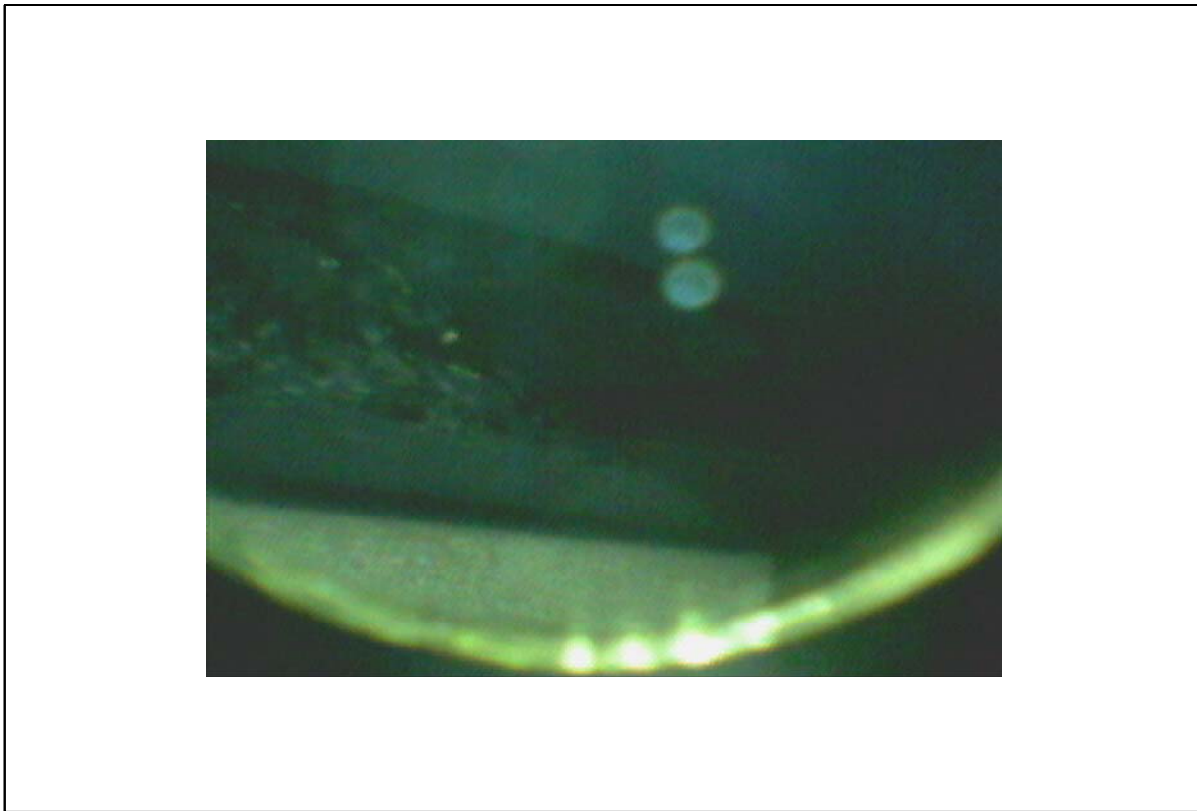
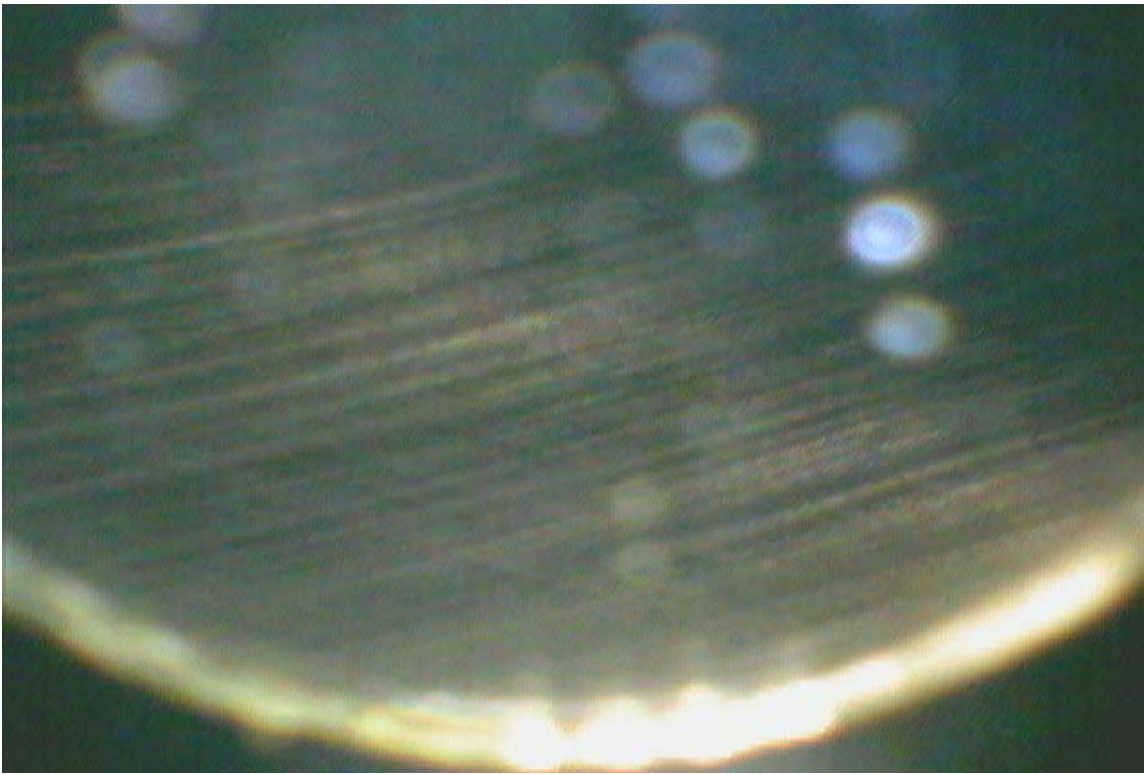


Borescope Instrument Setup and Inserted in Cylinder Nozzle Hole

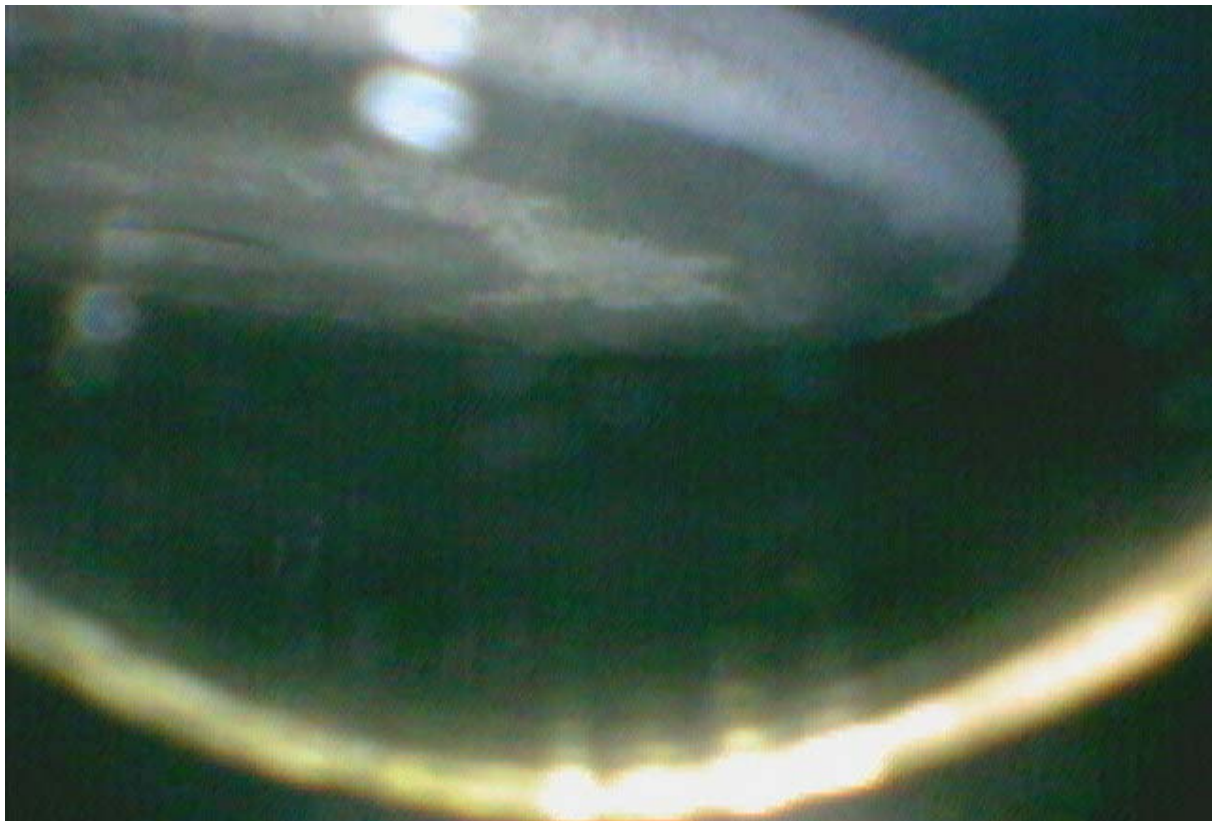
MDG #4 - Cylinder 1

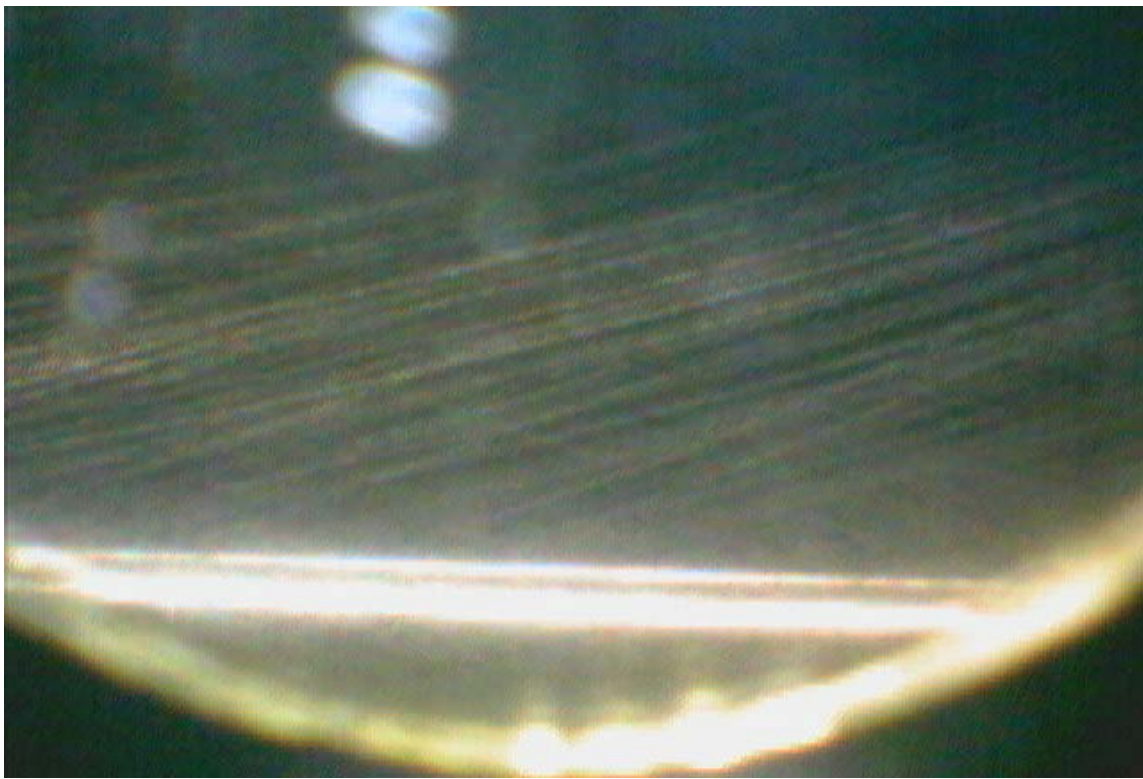


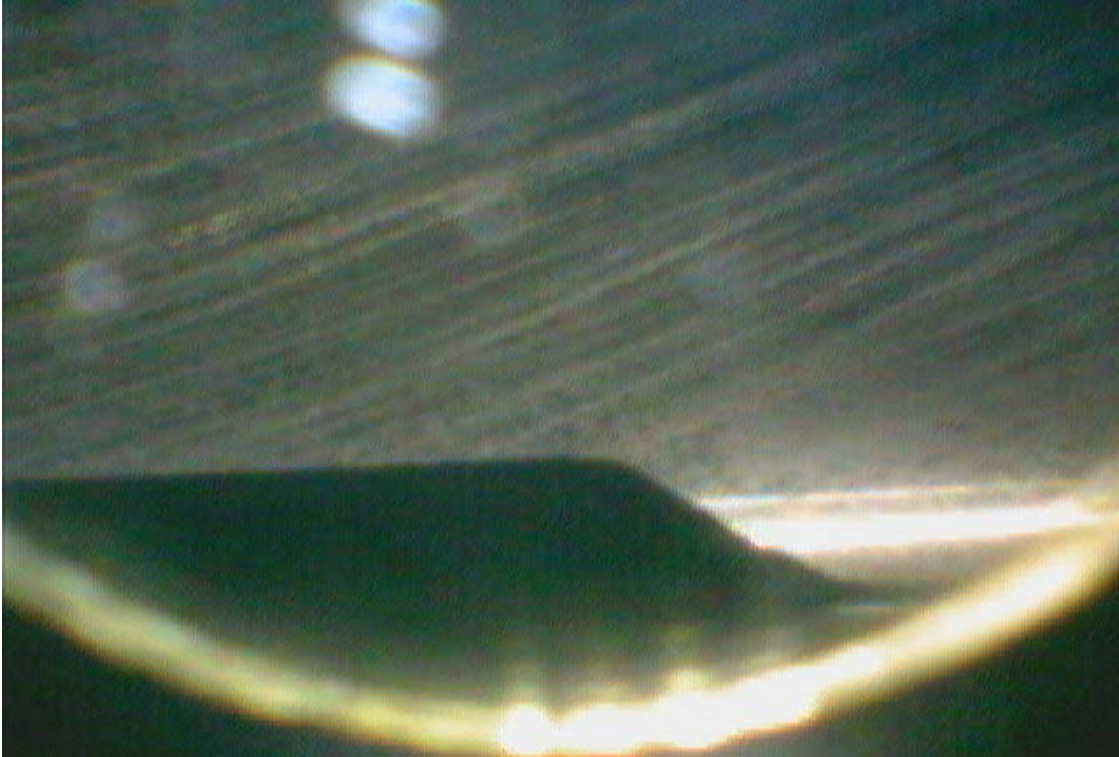




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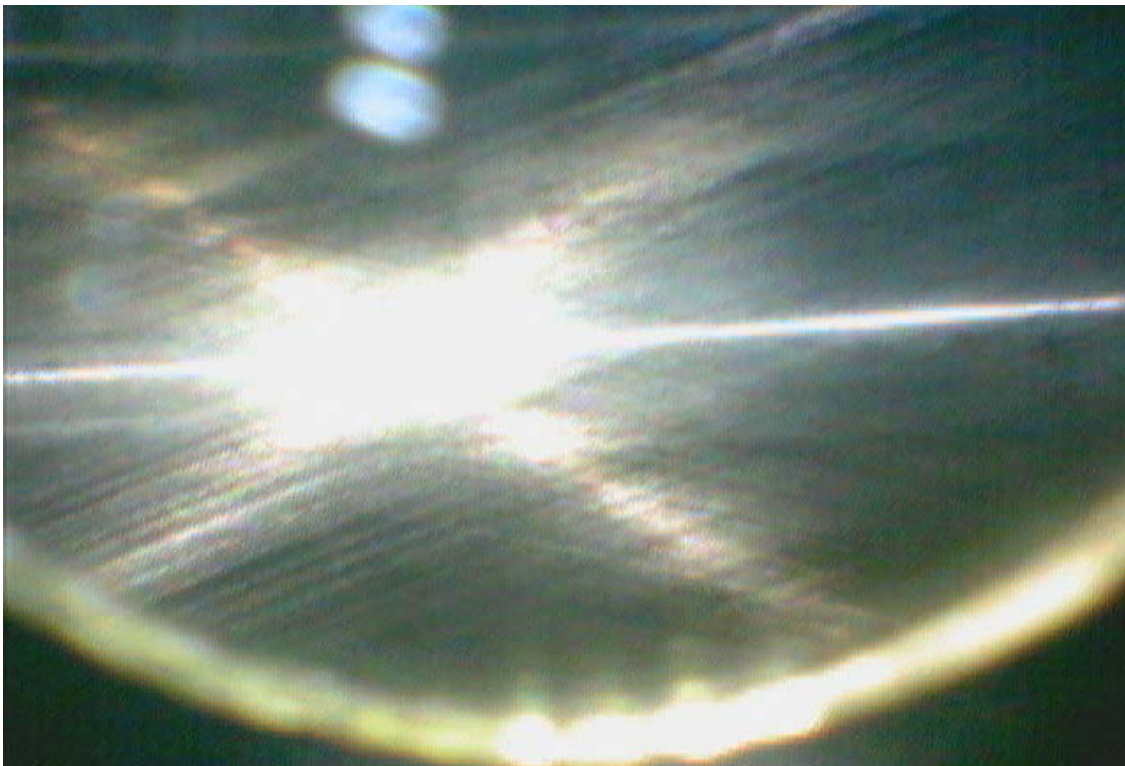
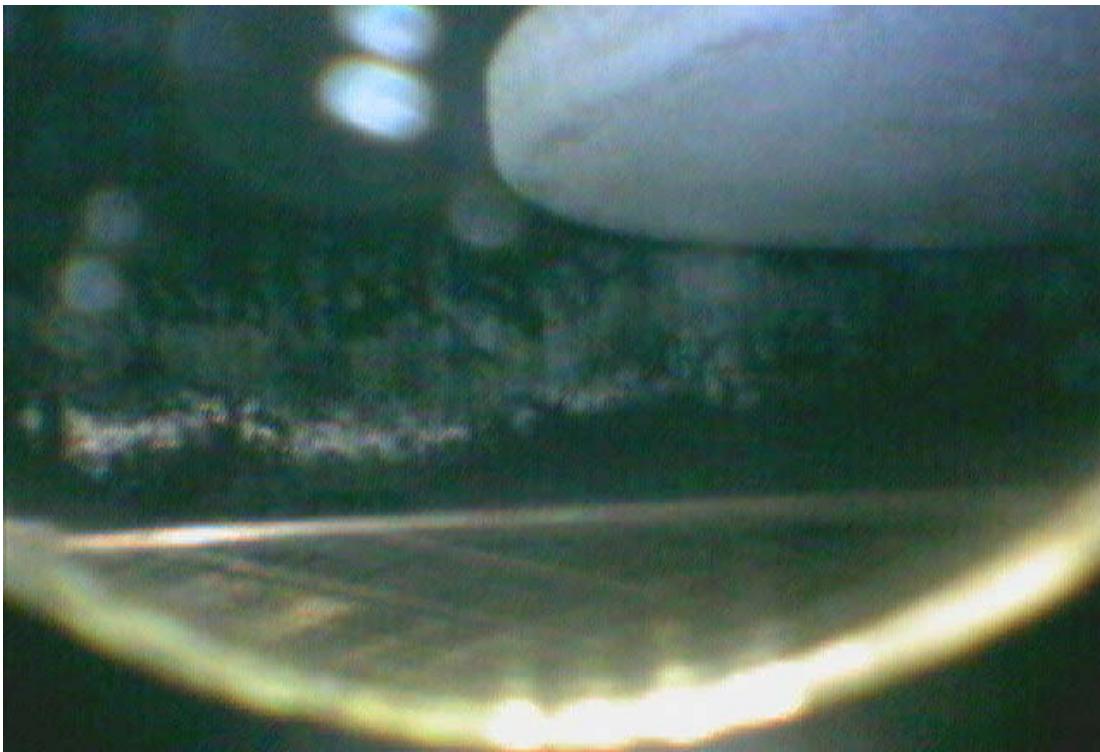


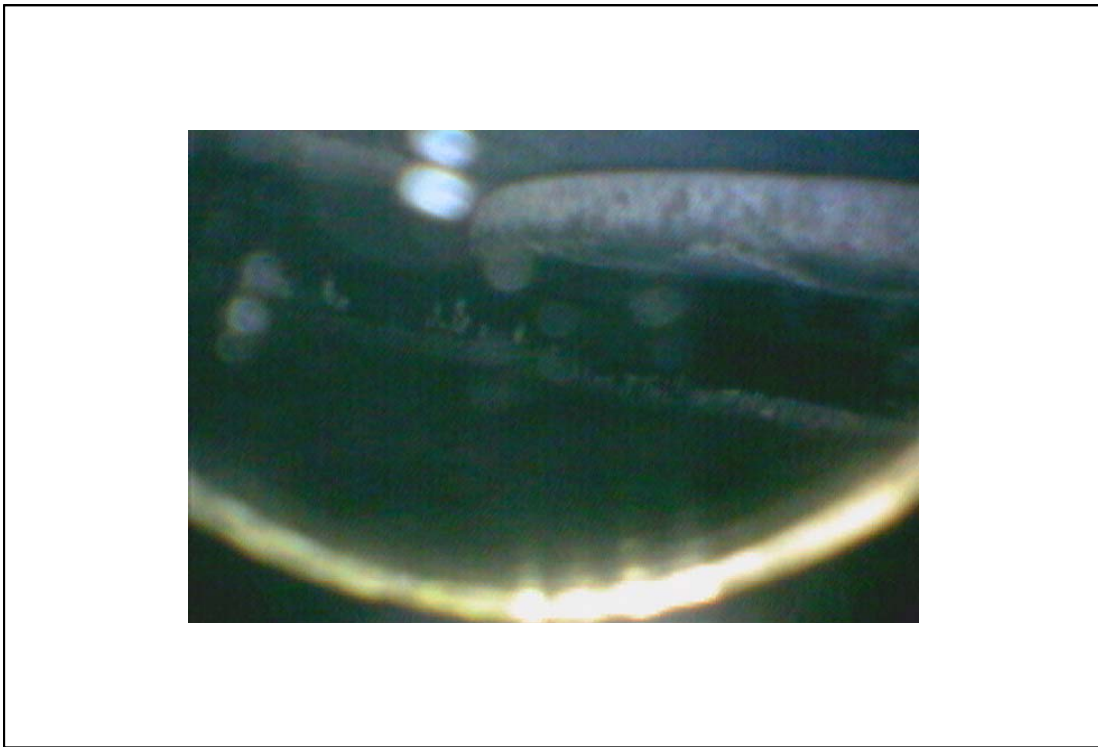




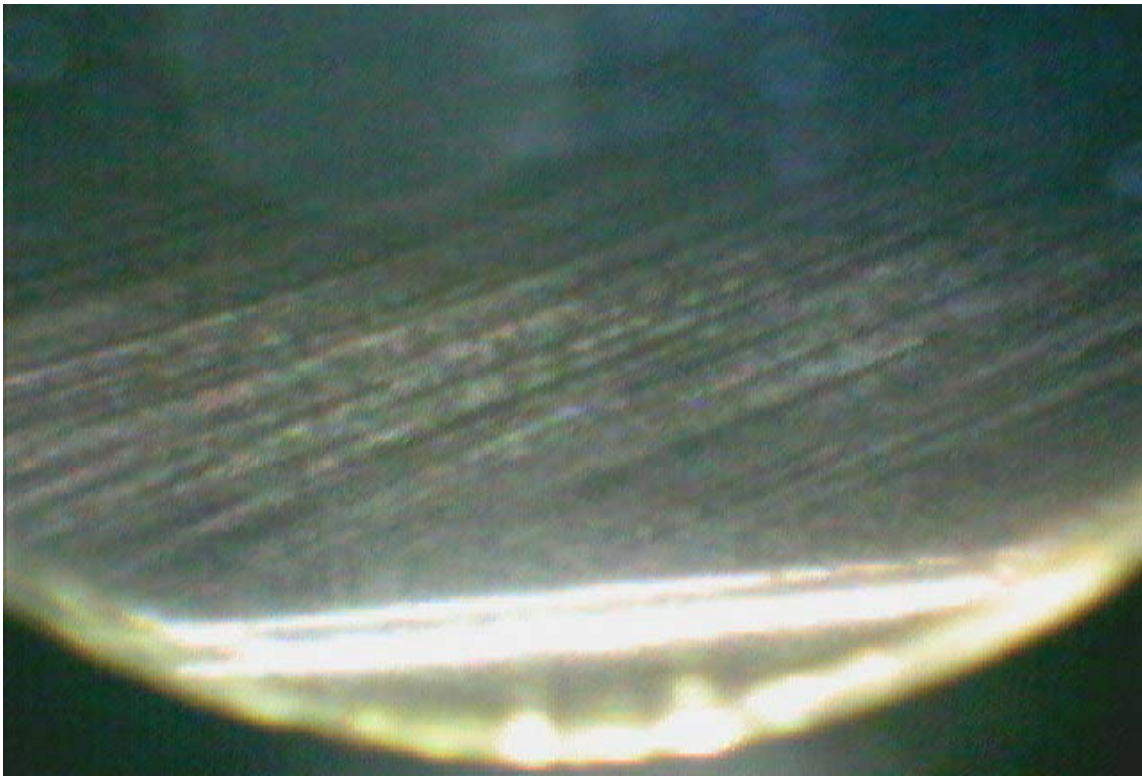
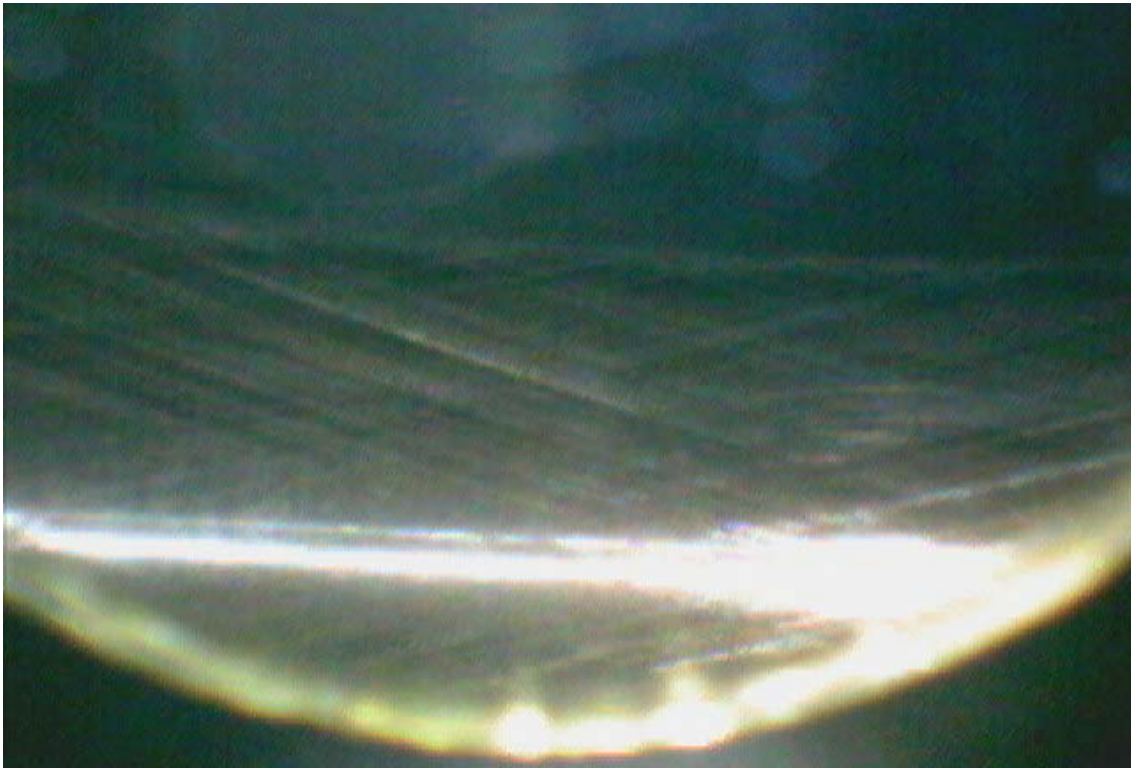
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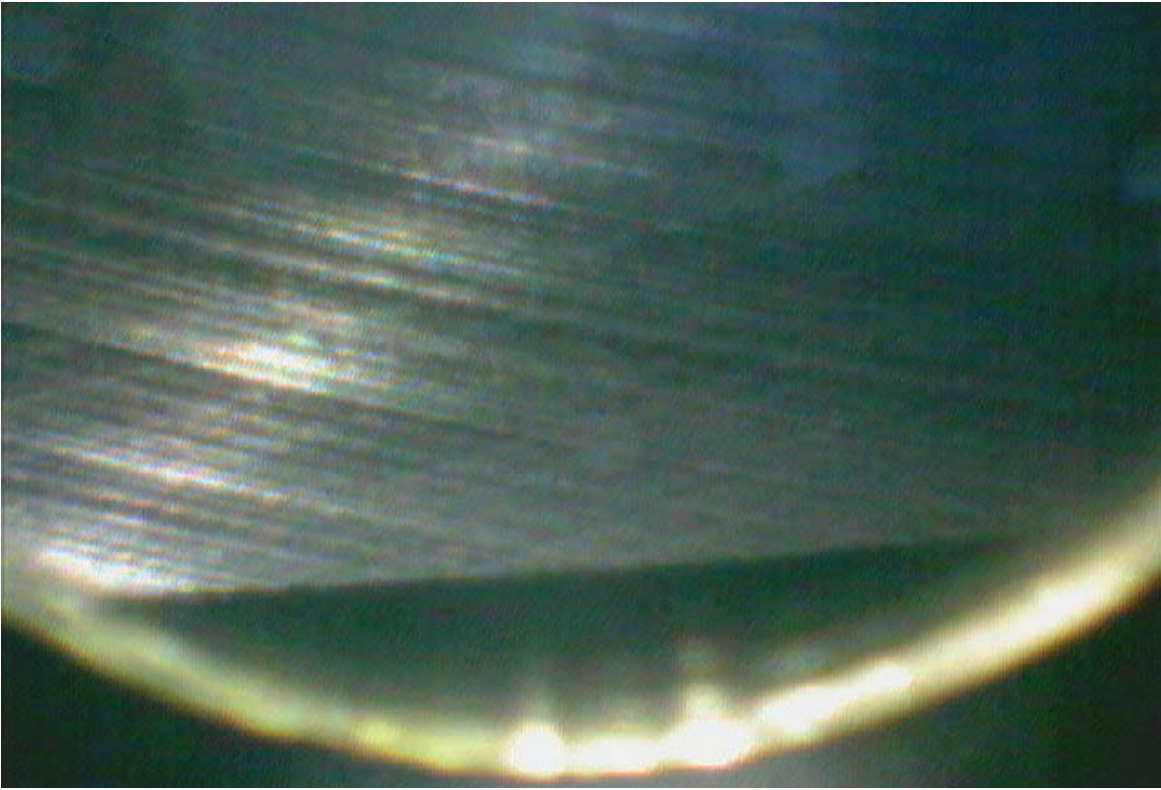




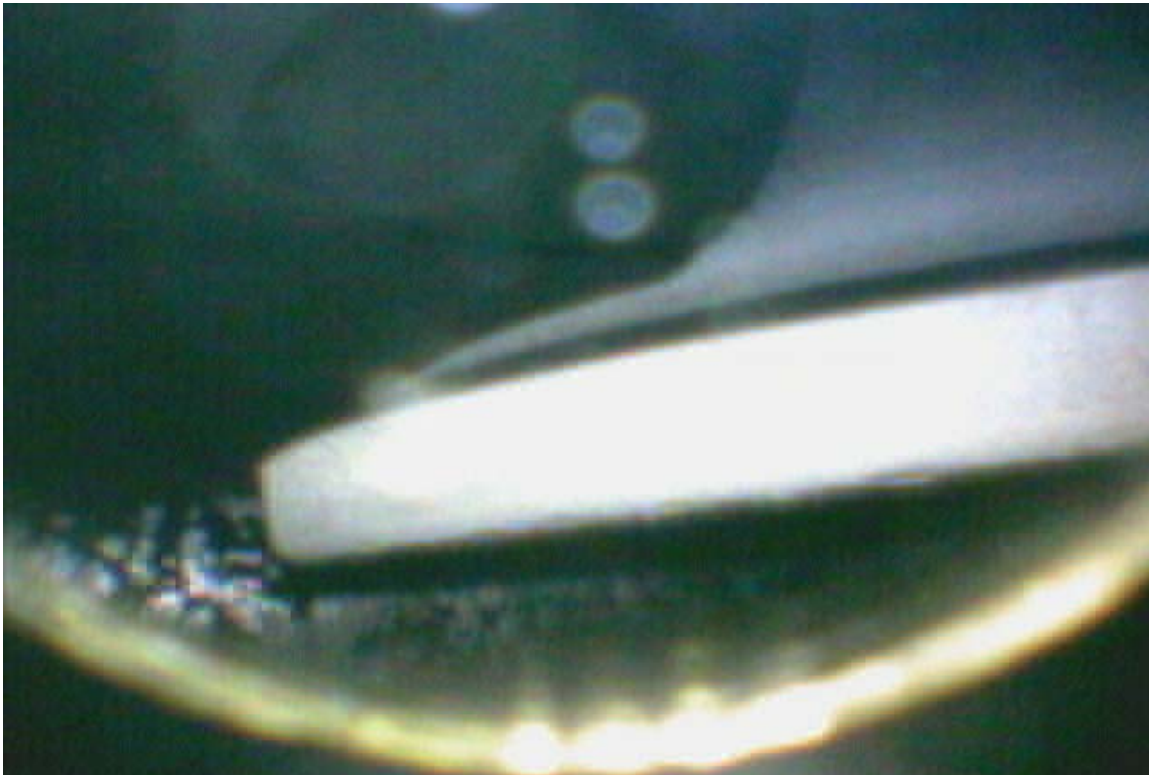




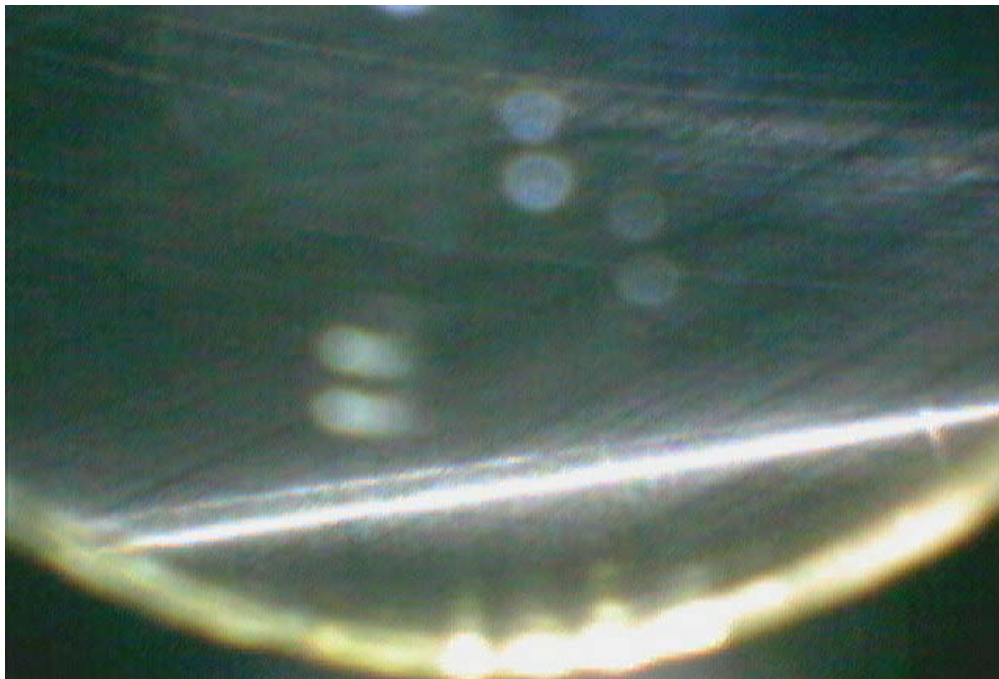




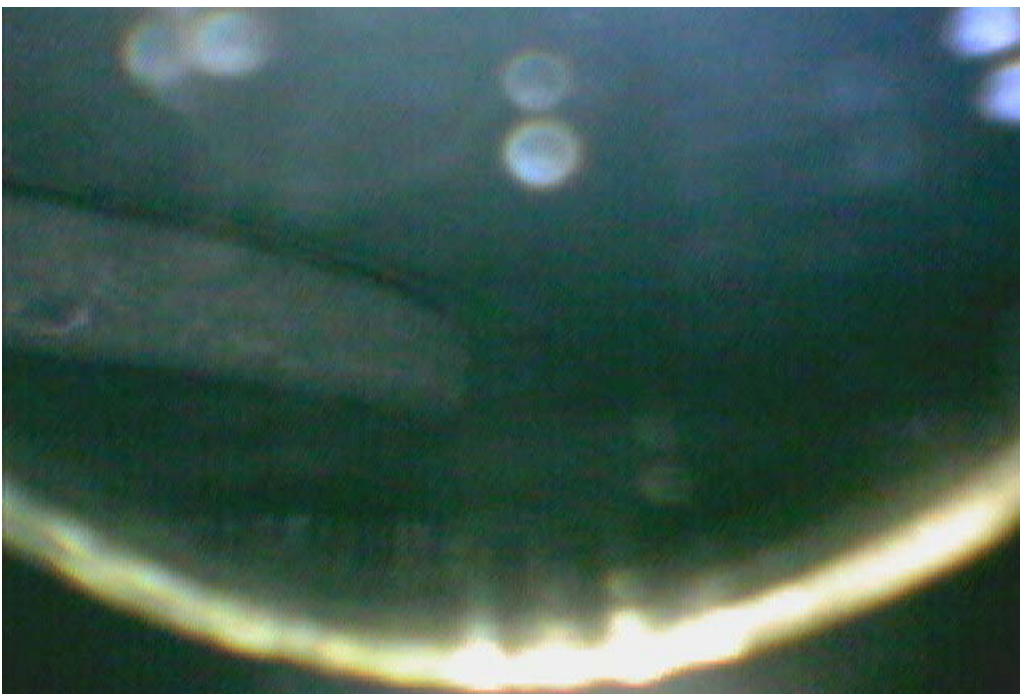
MDG #4 - Cylinder 5

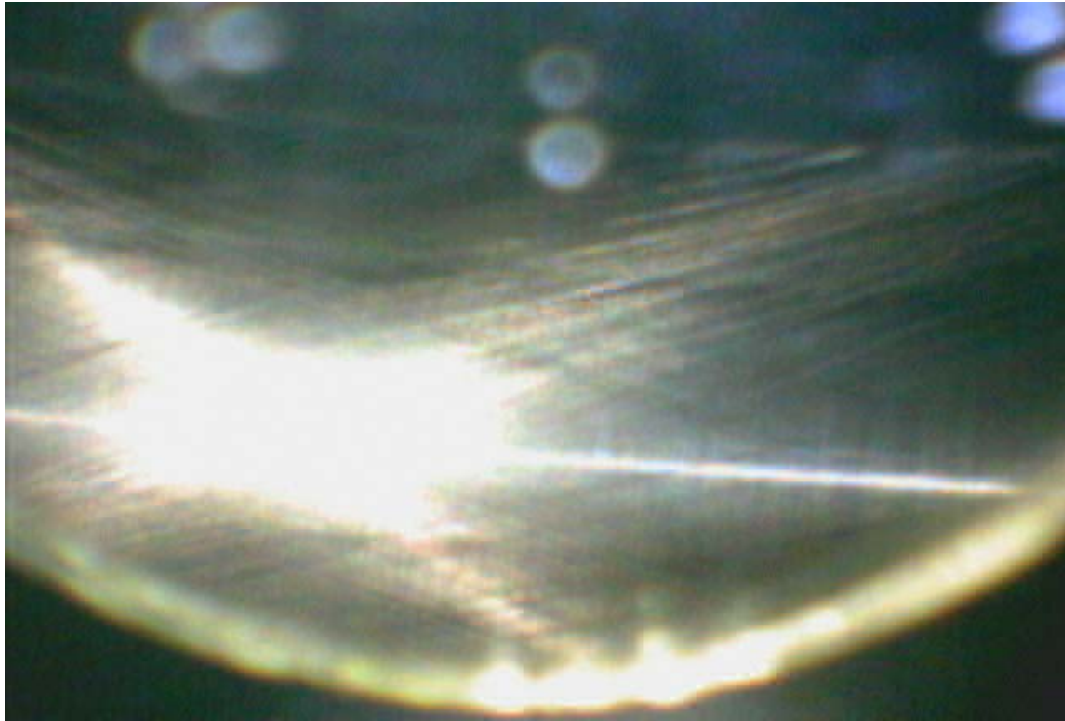






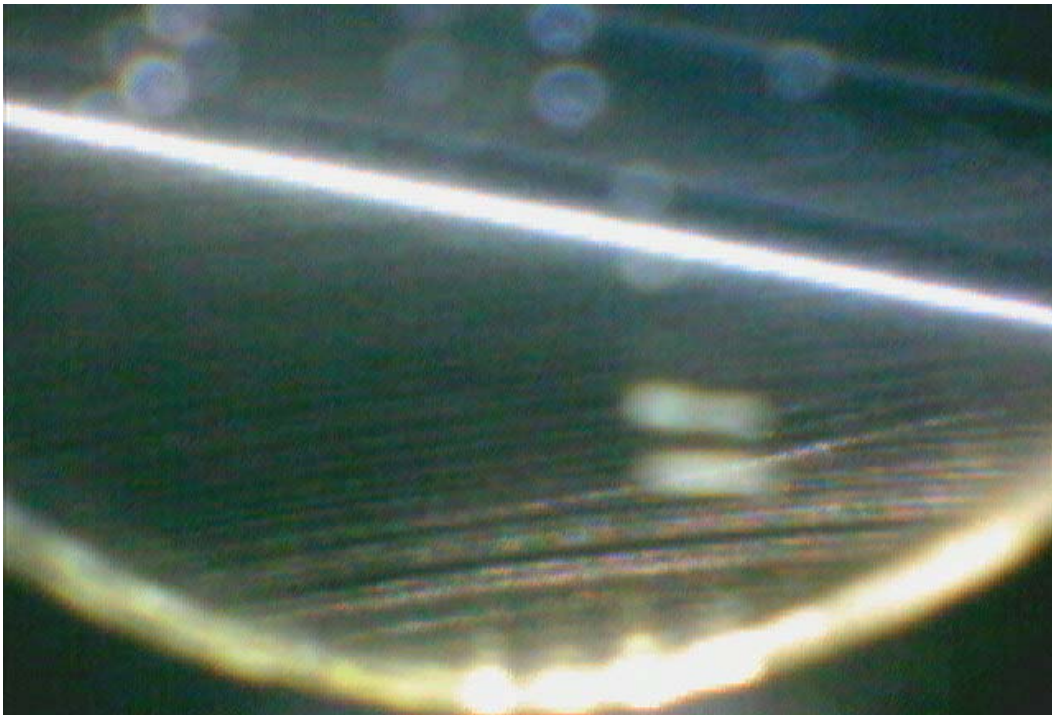
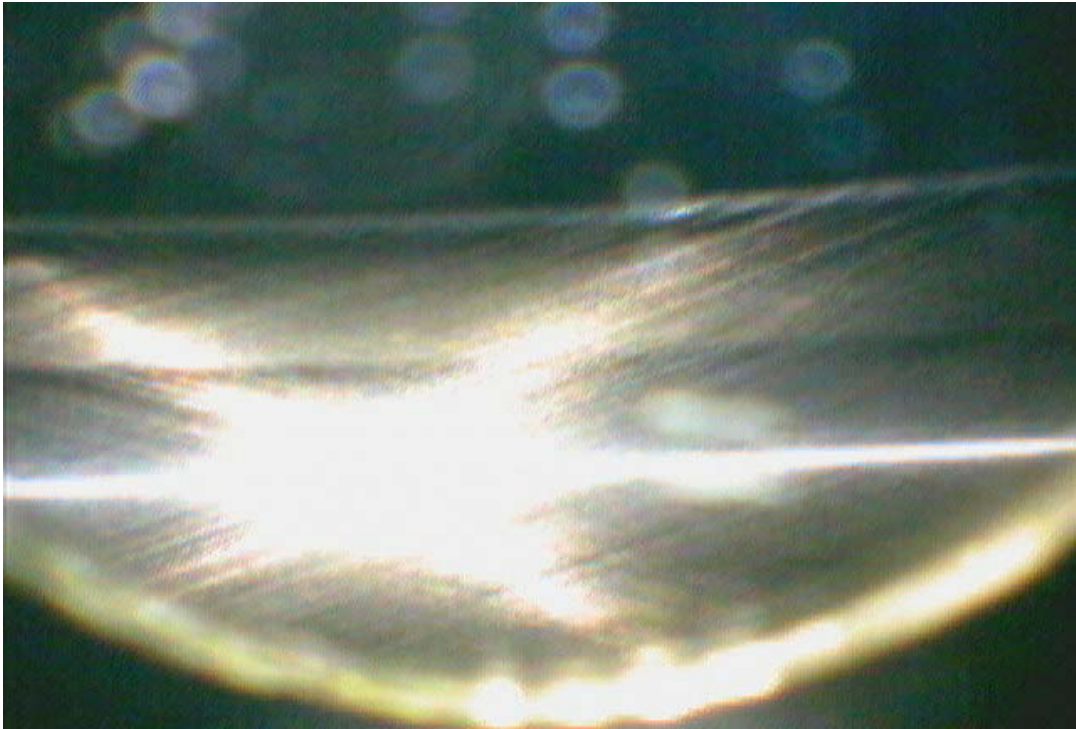


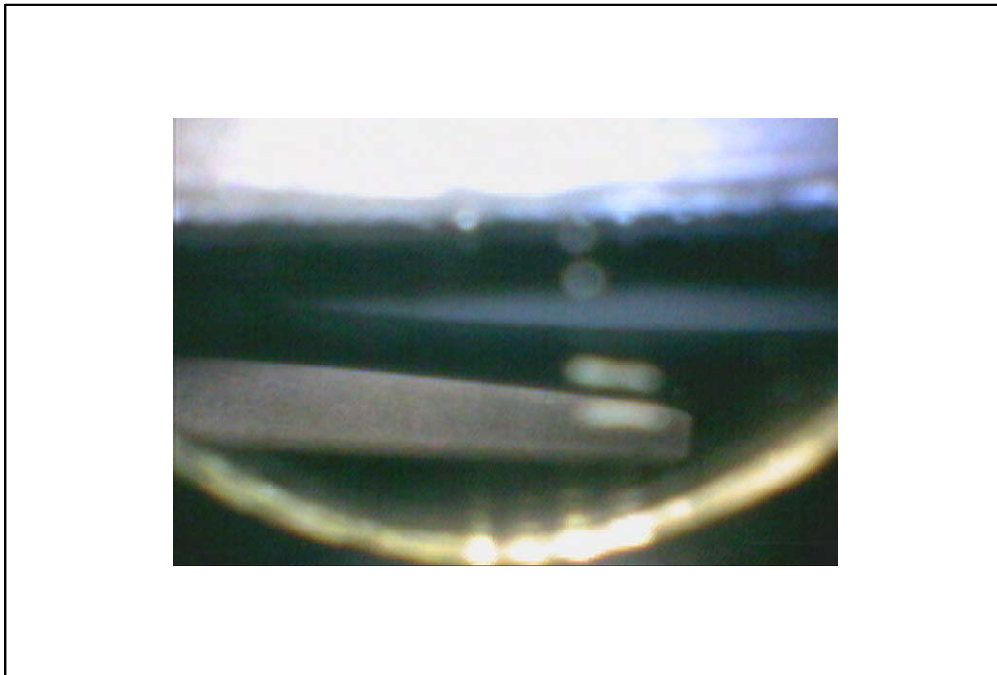
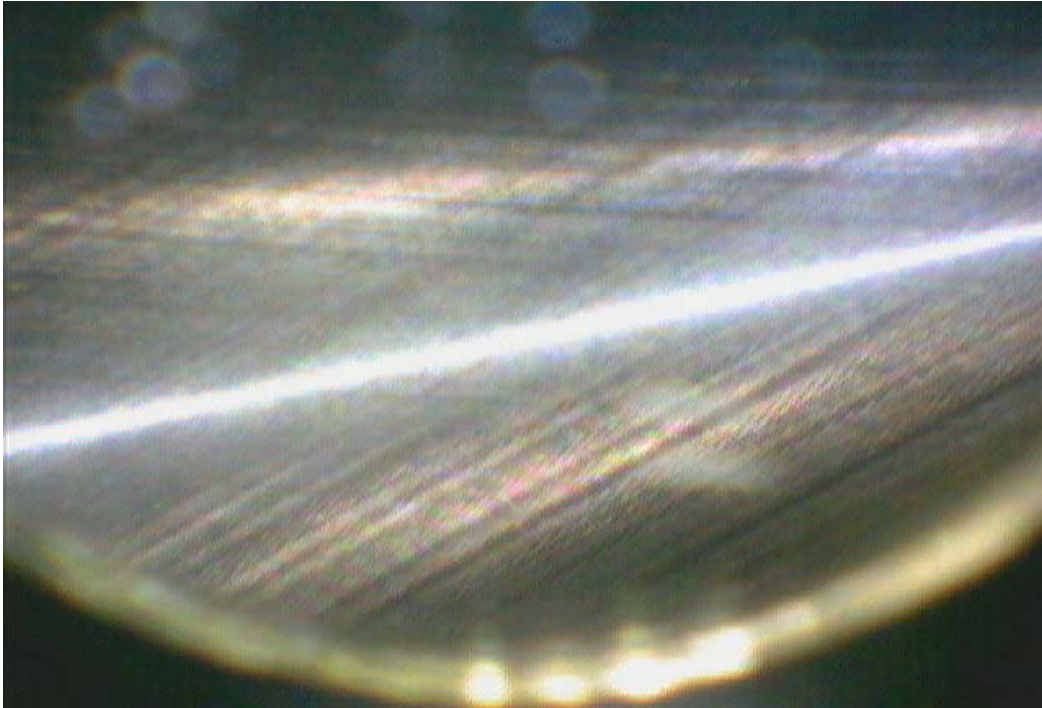


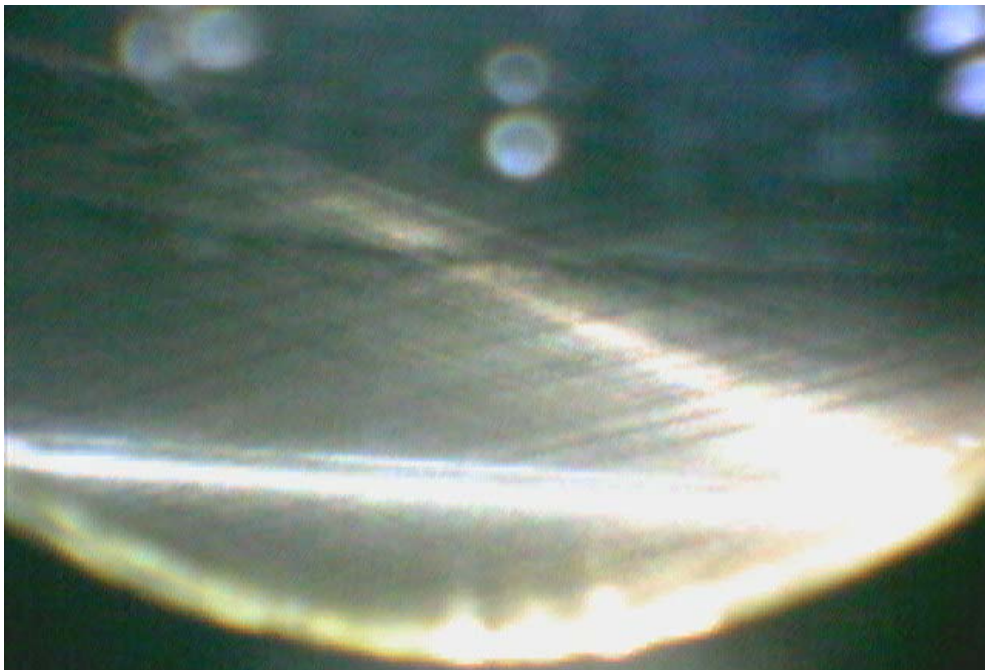


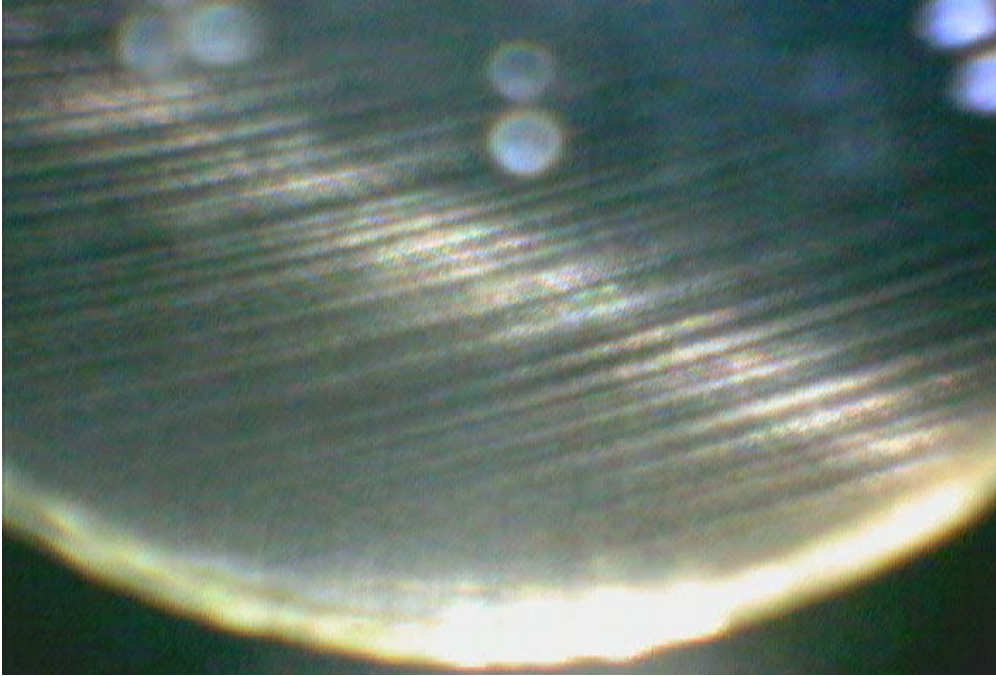


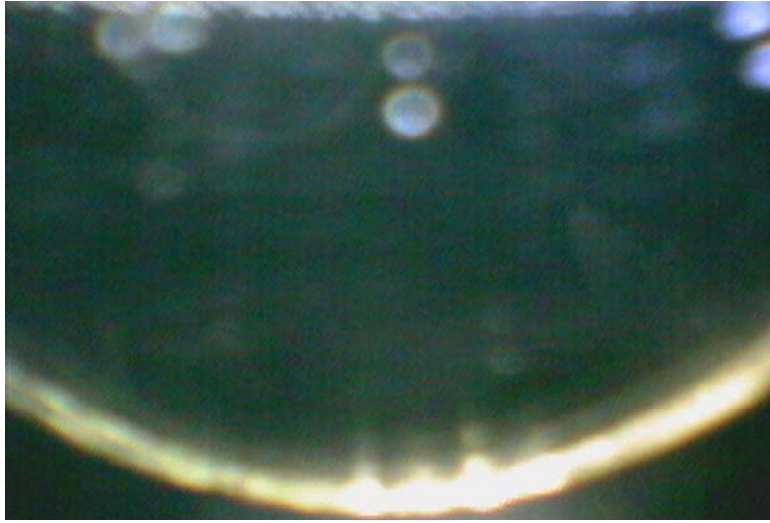


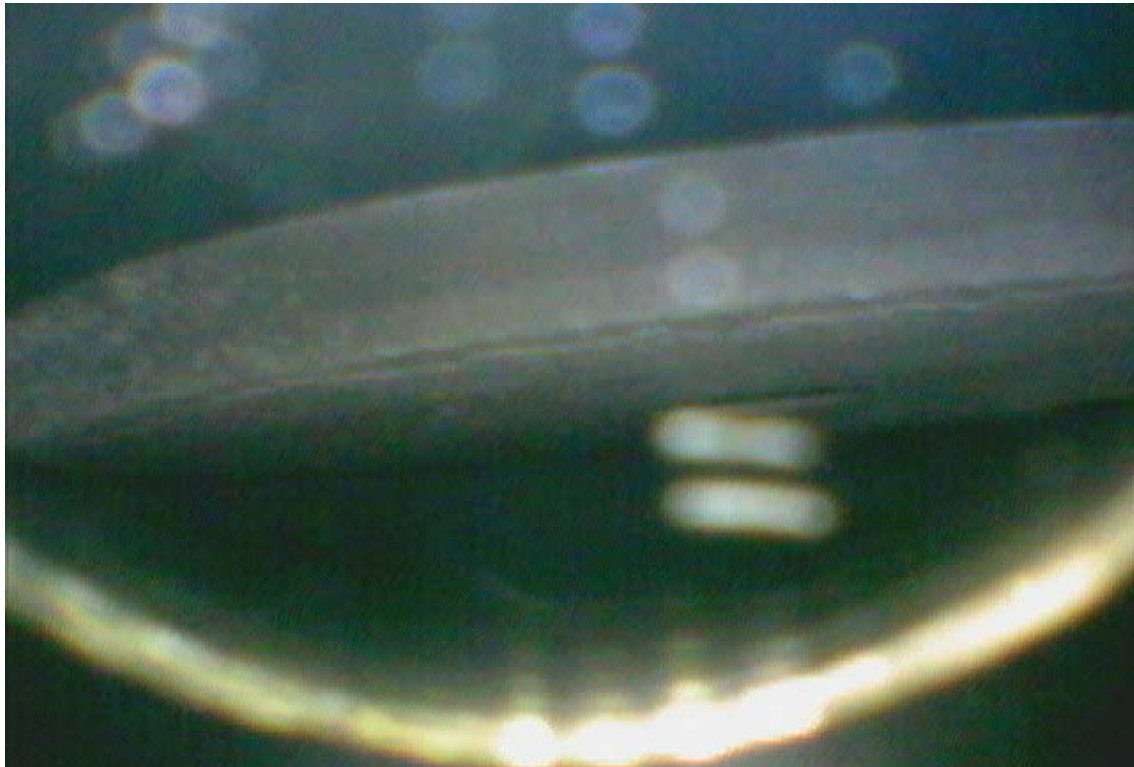


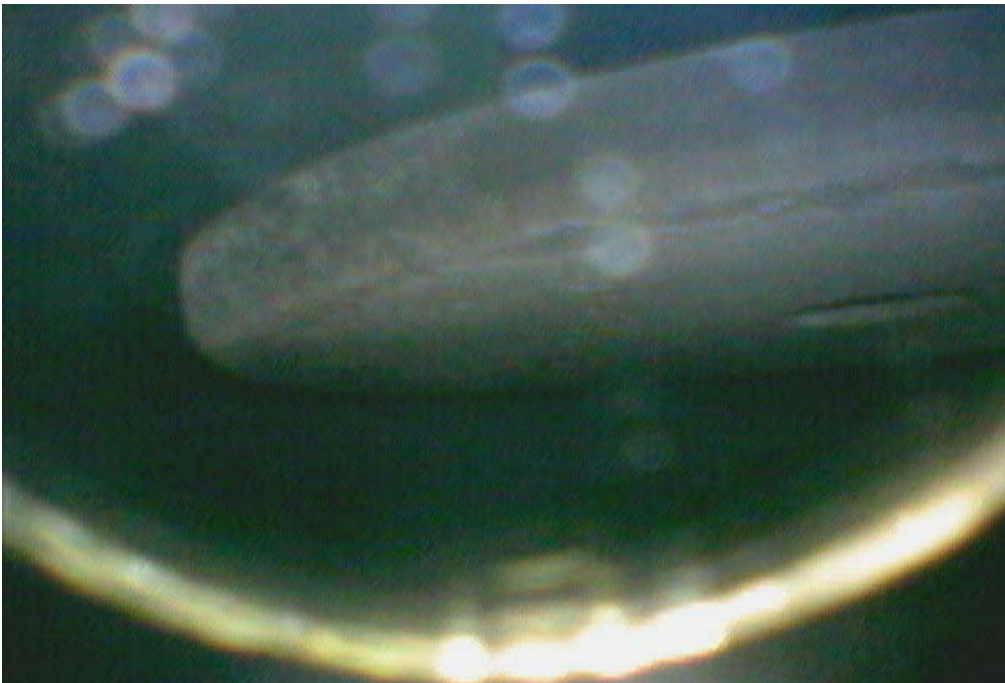
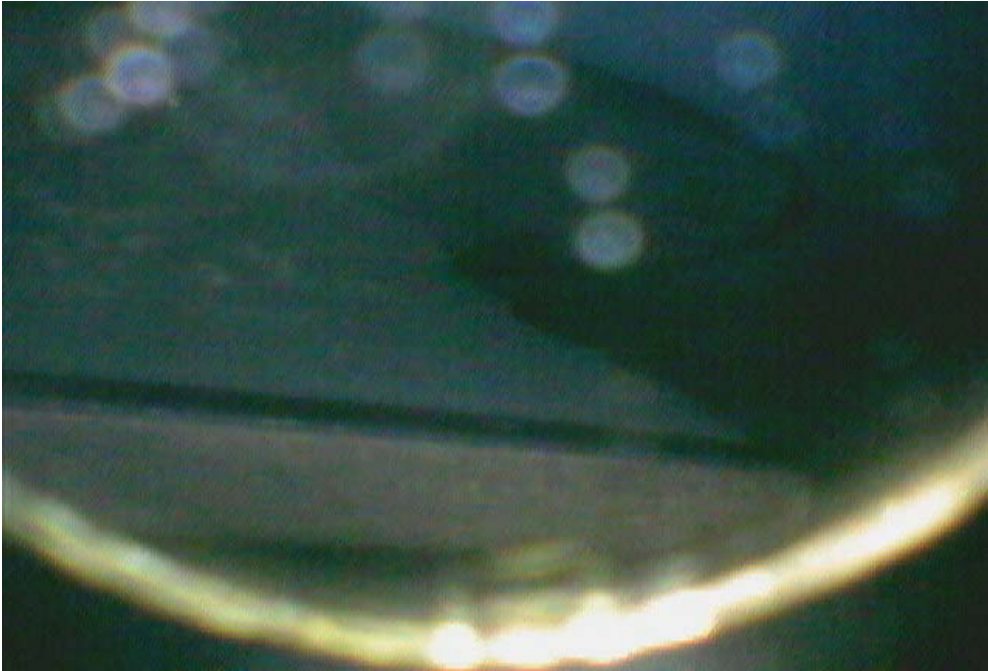


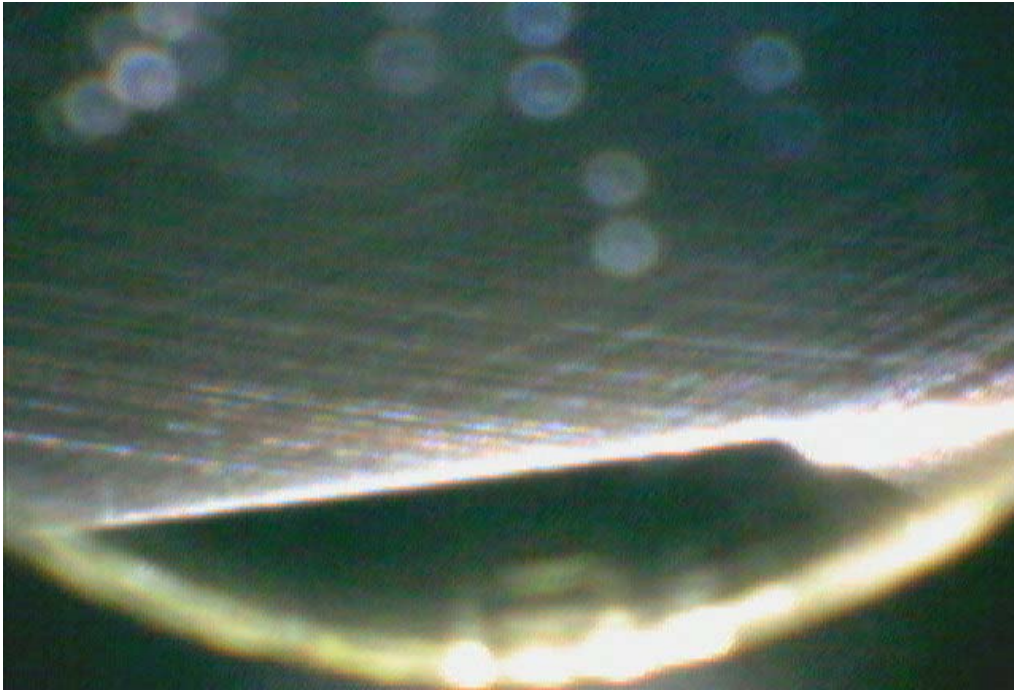
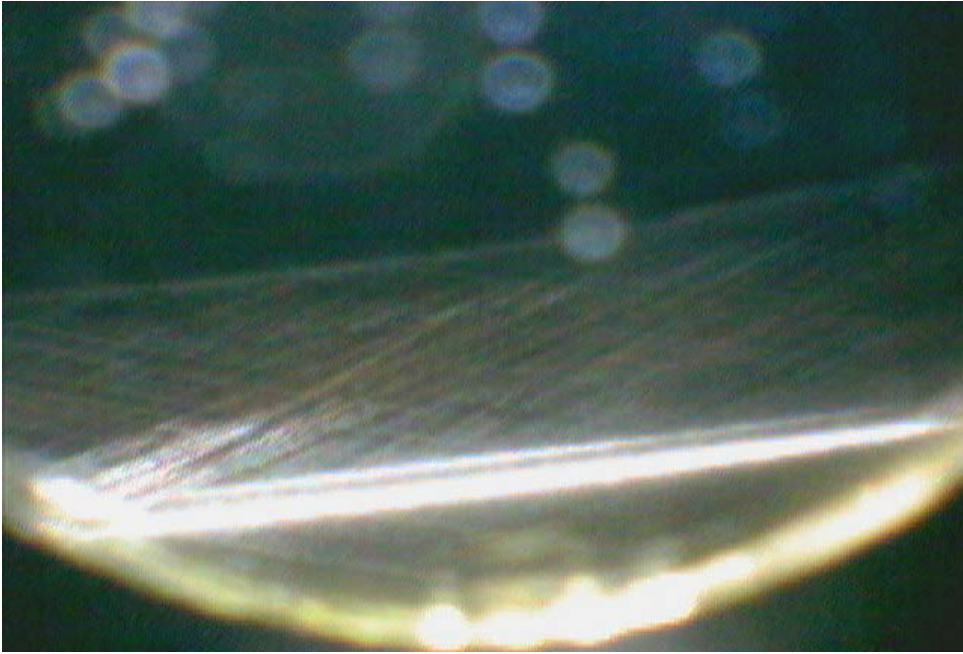


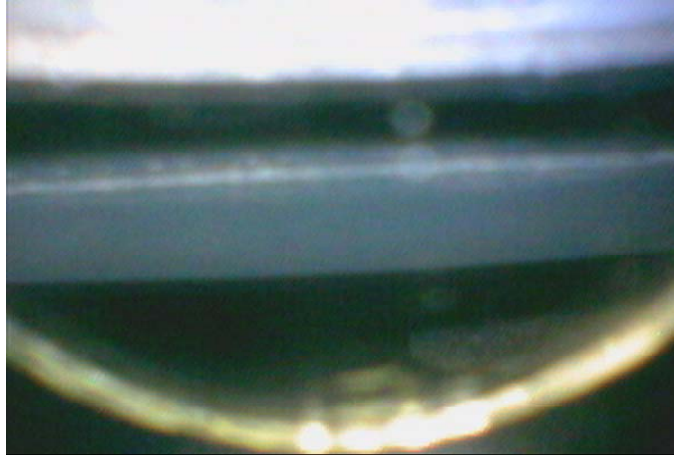






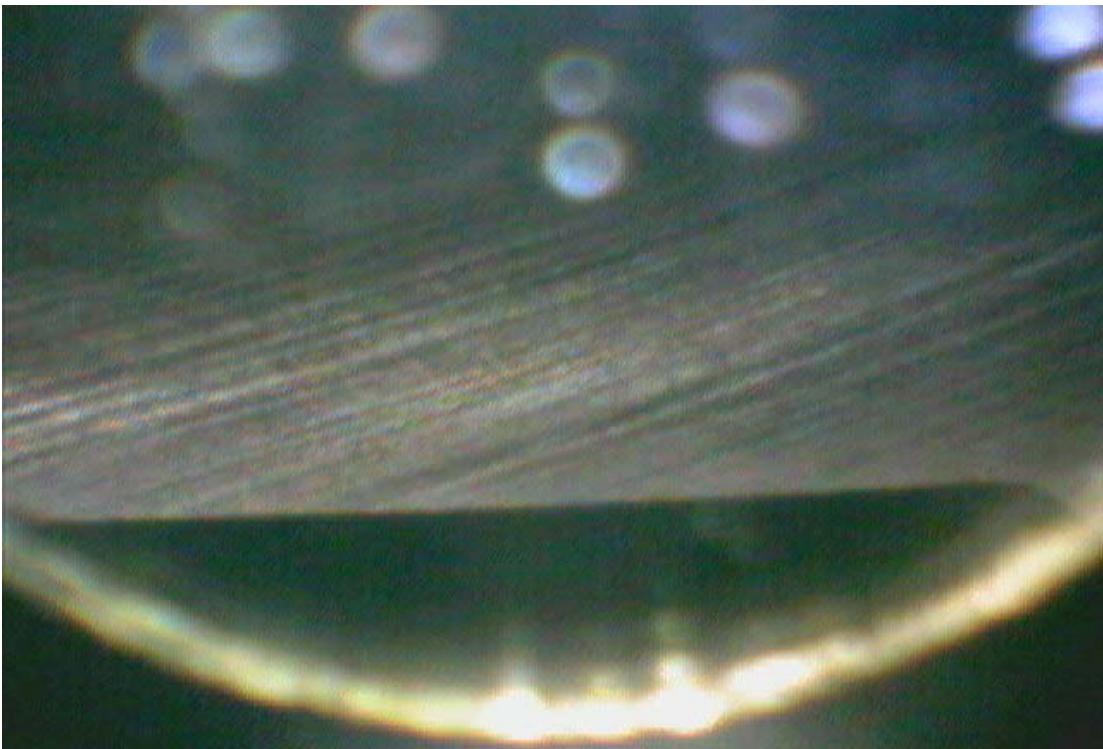
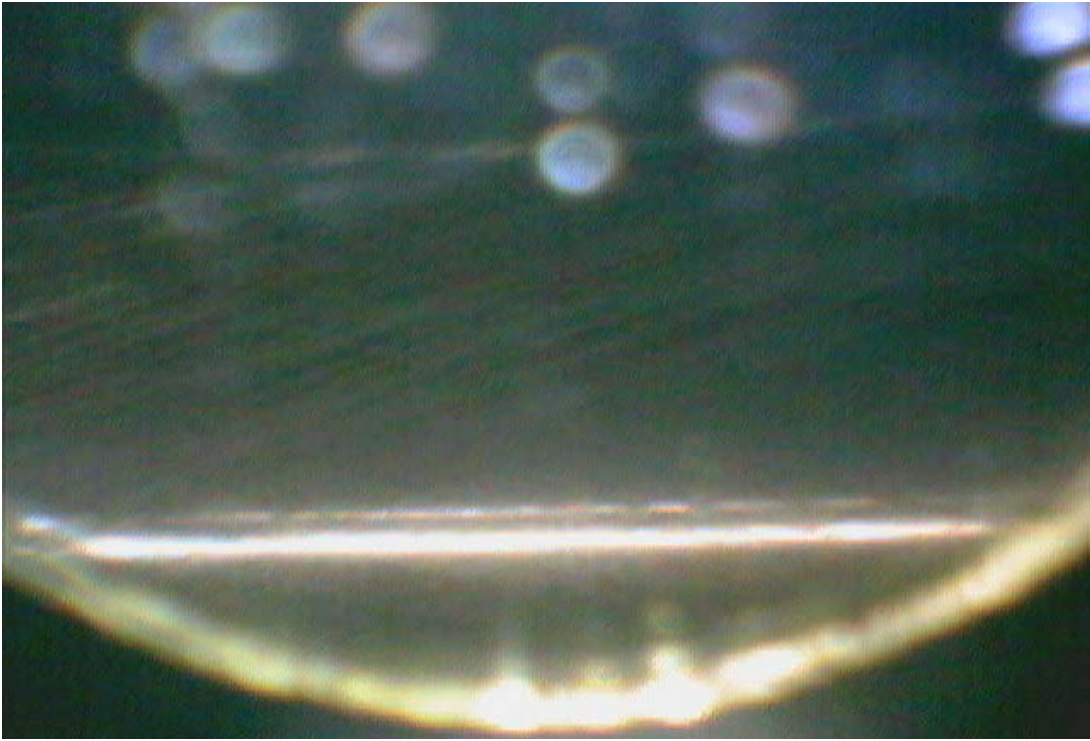


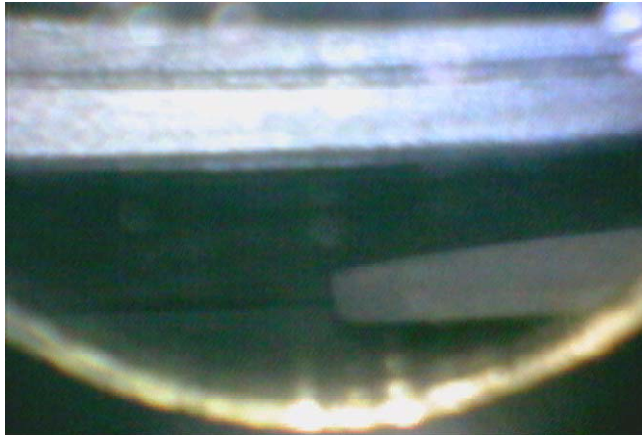


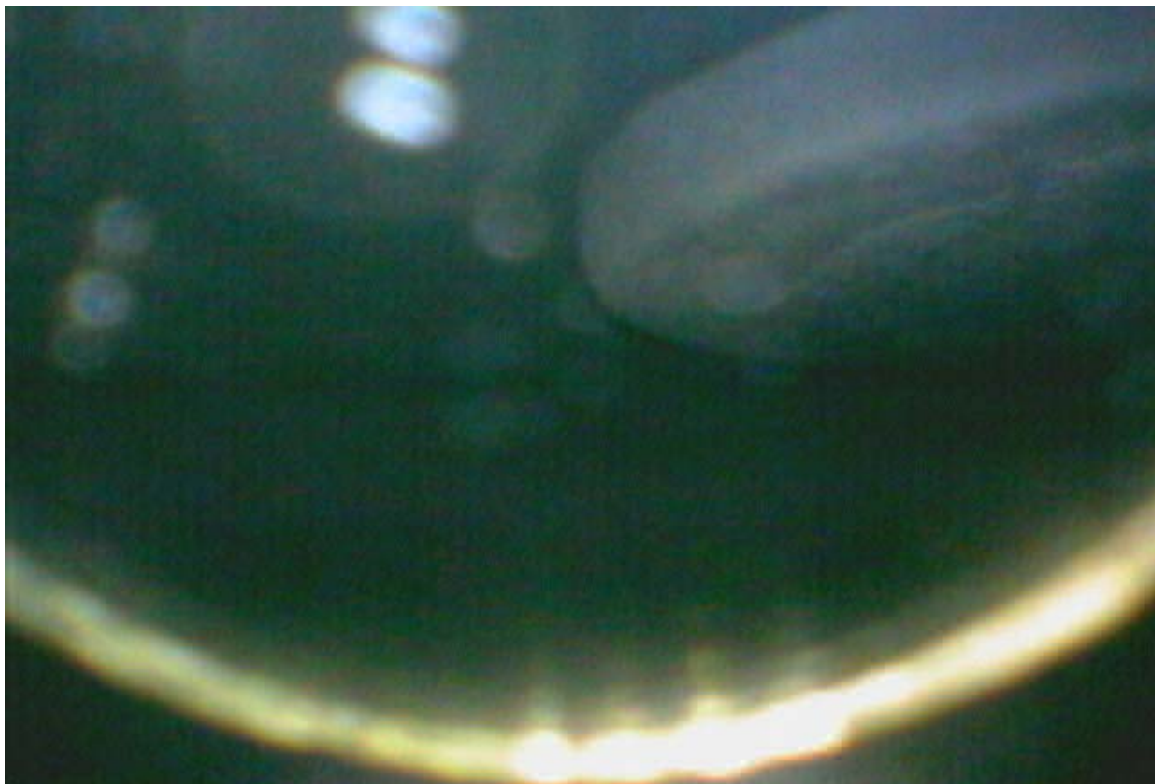


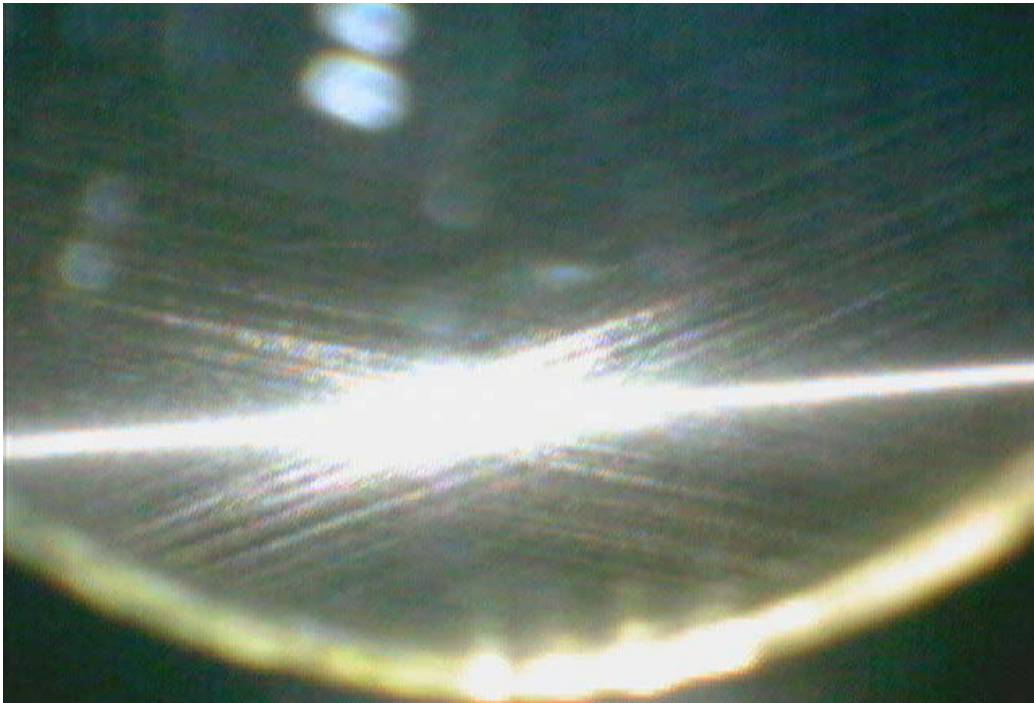
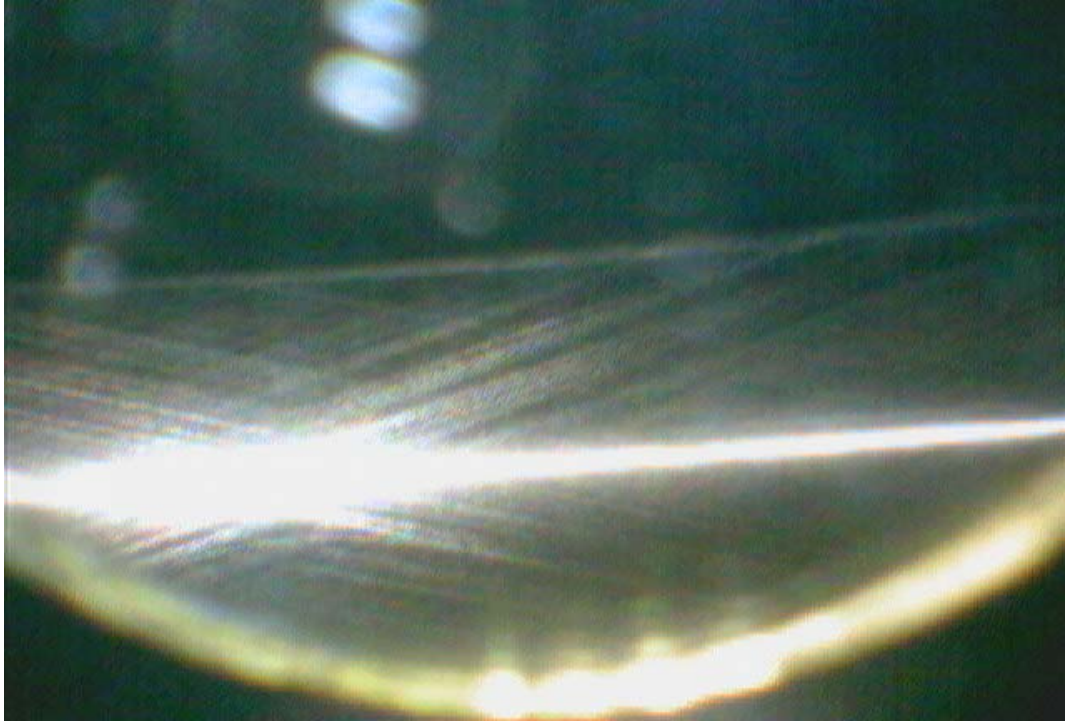


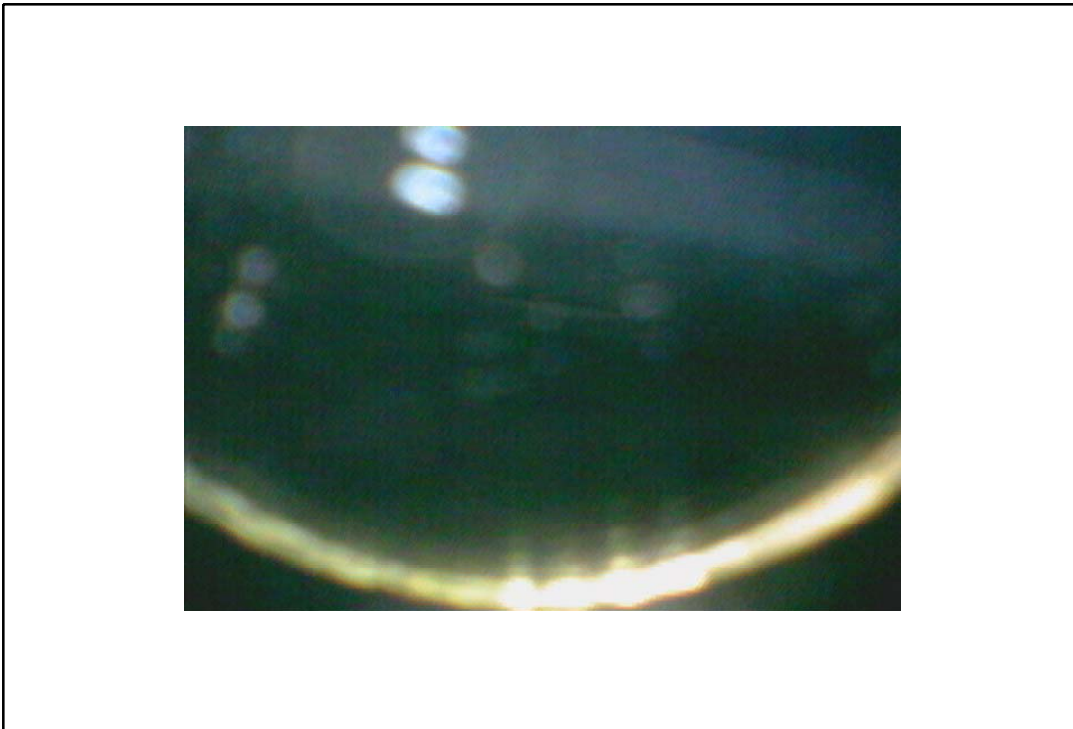
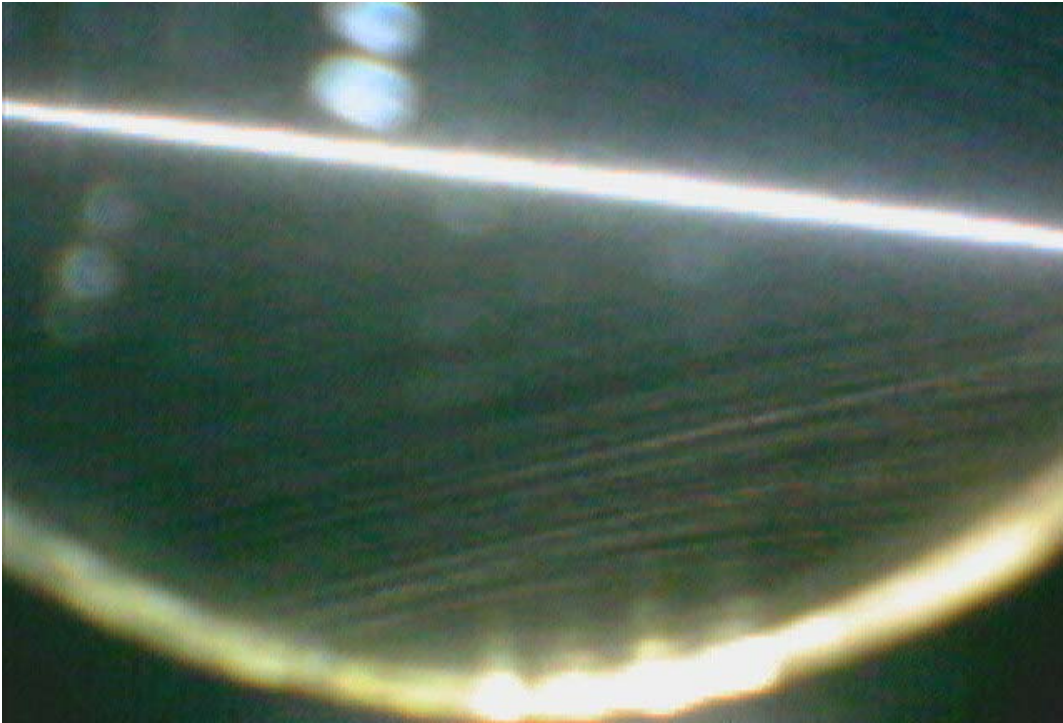


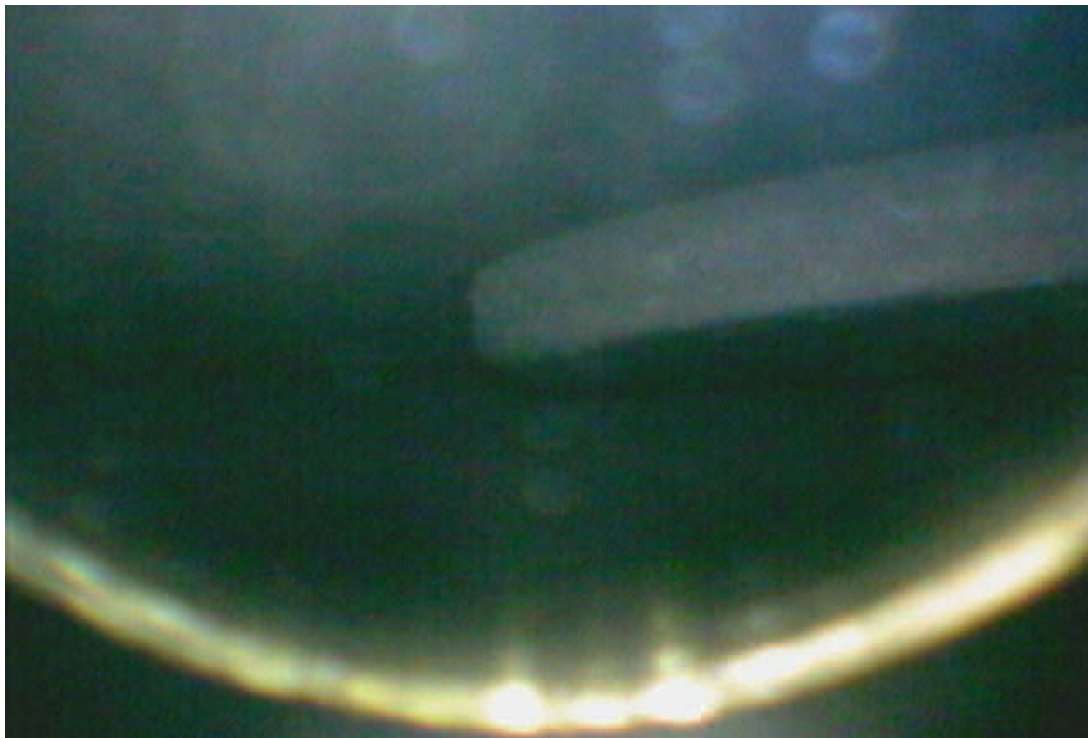


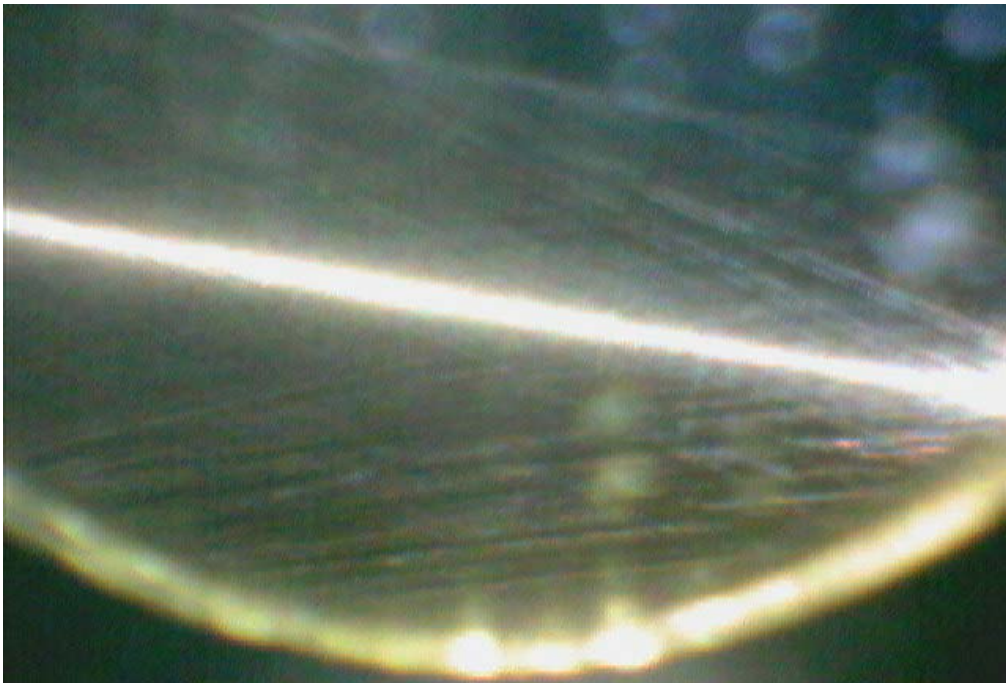


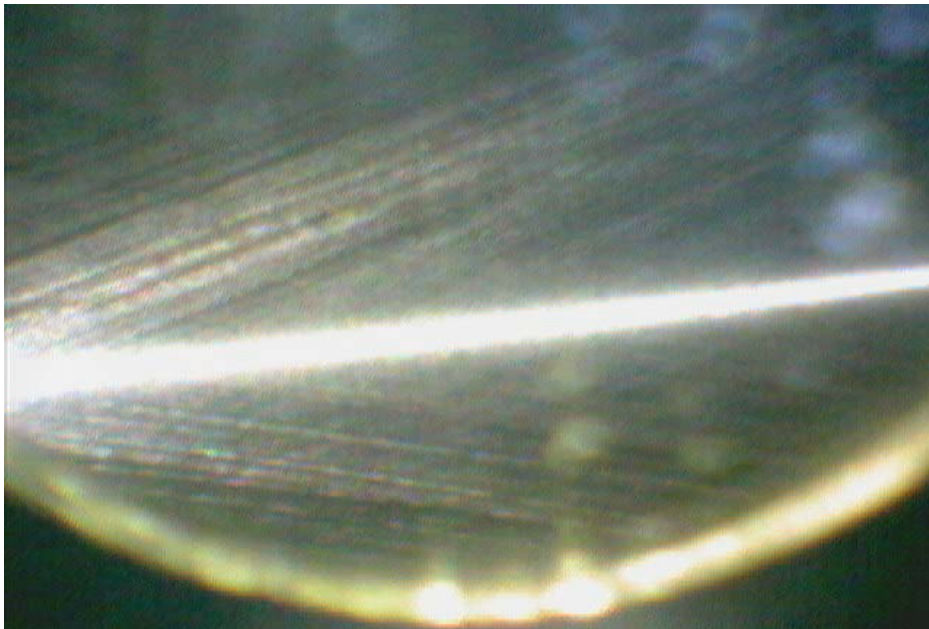


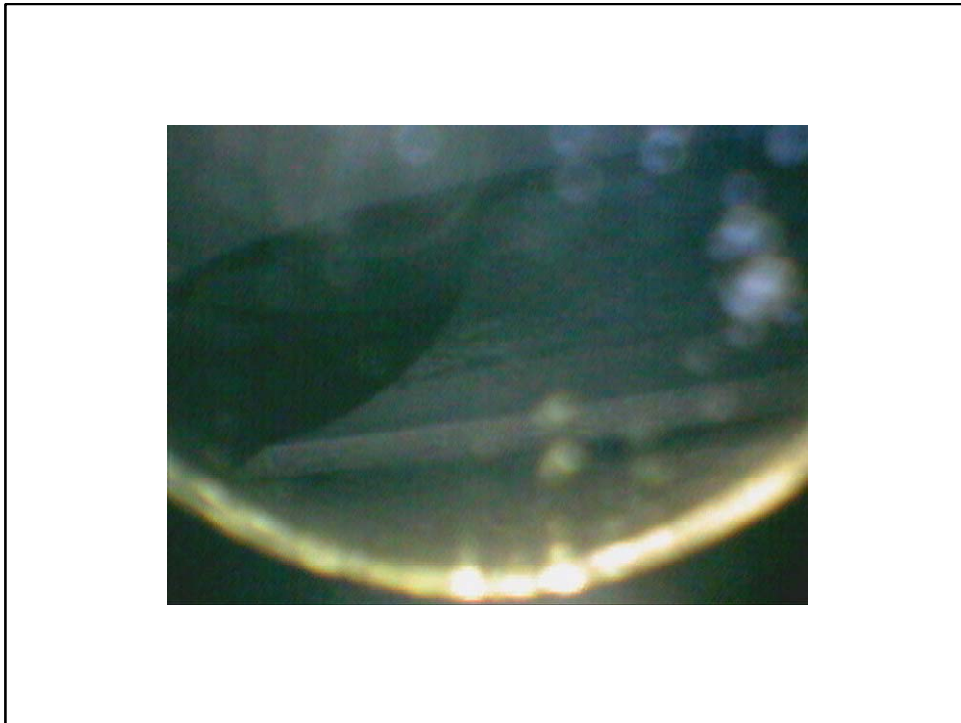
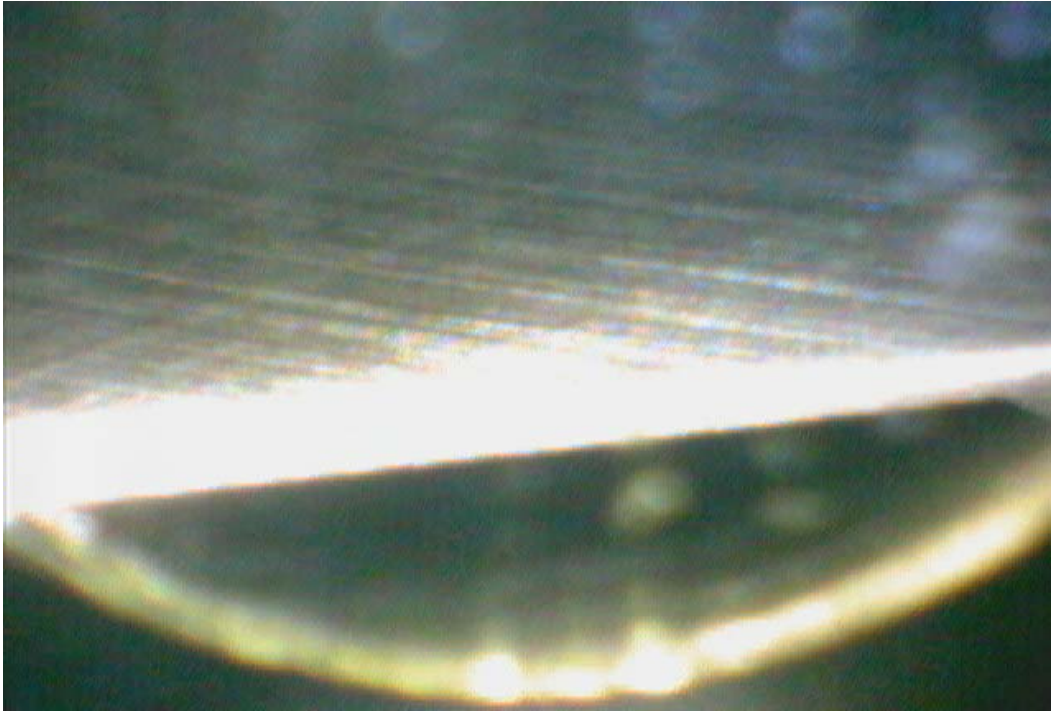




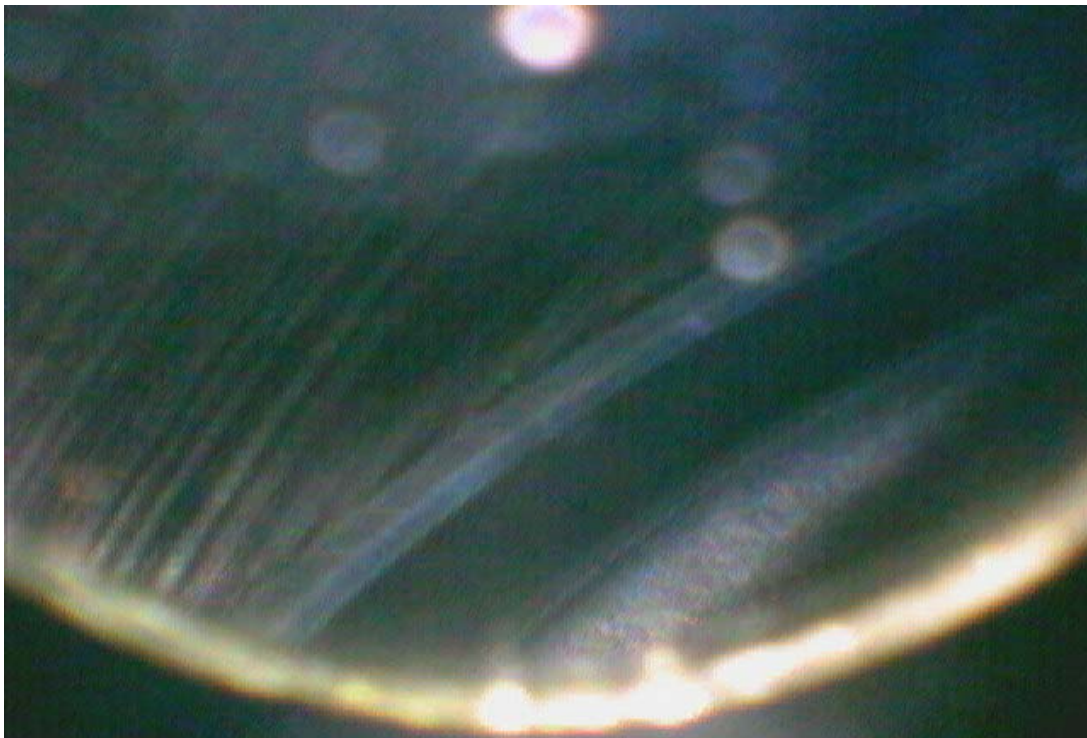
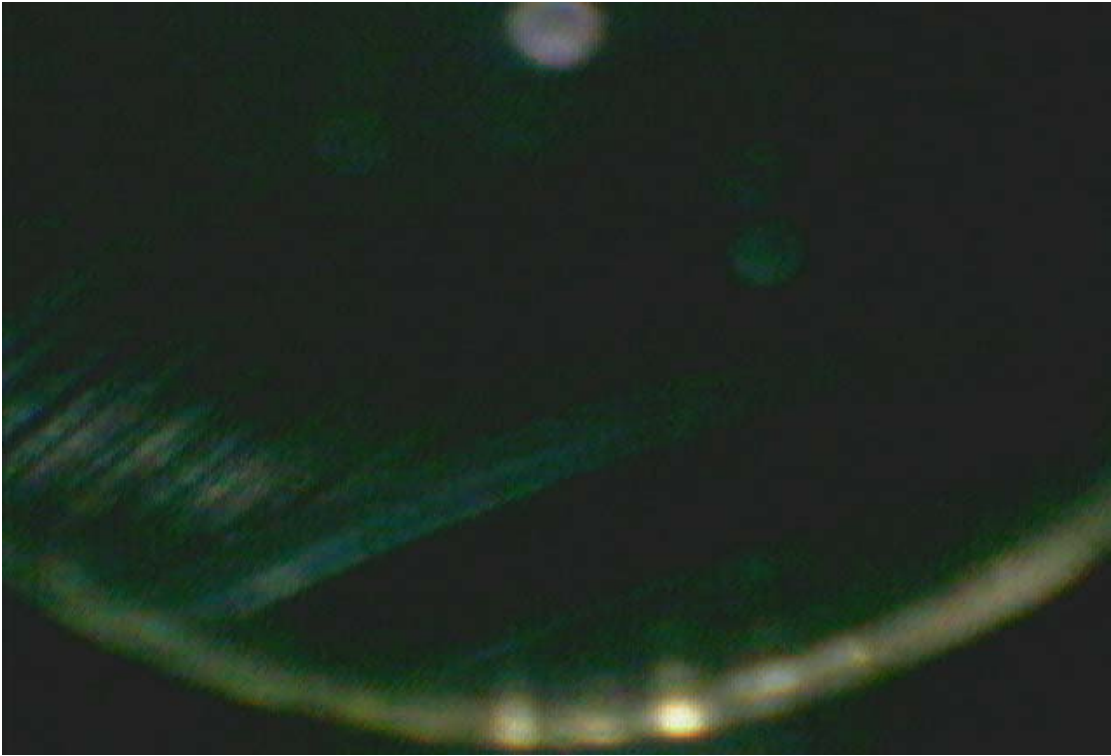


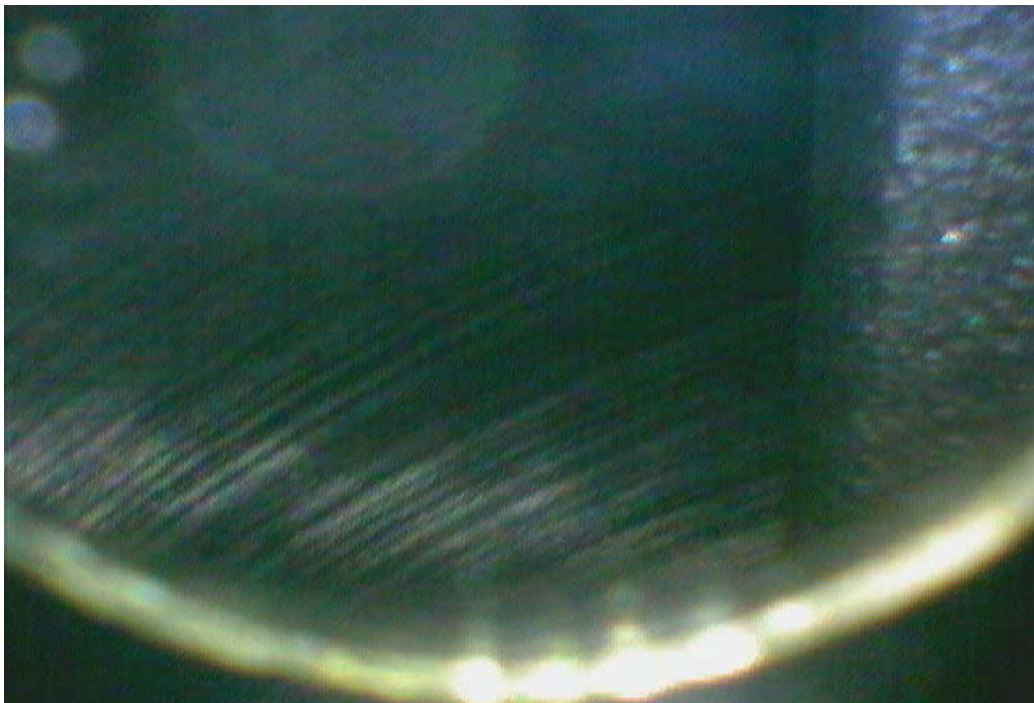


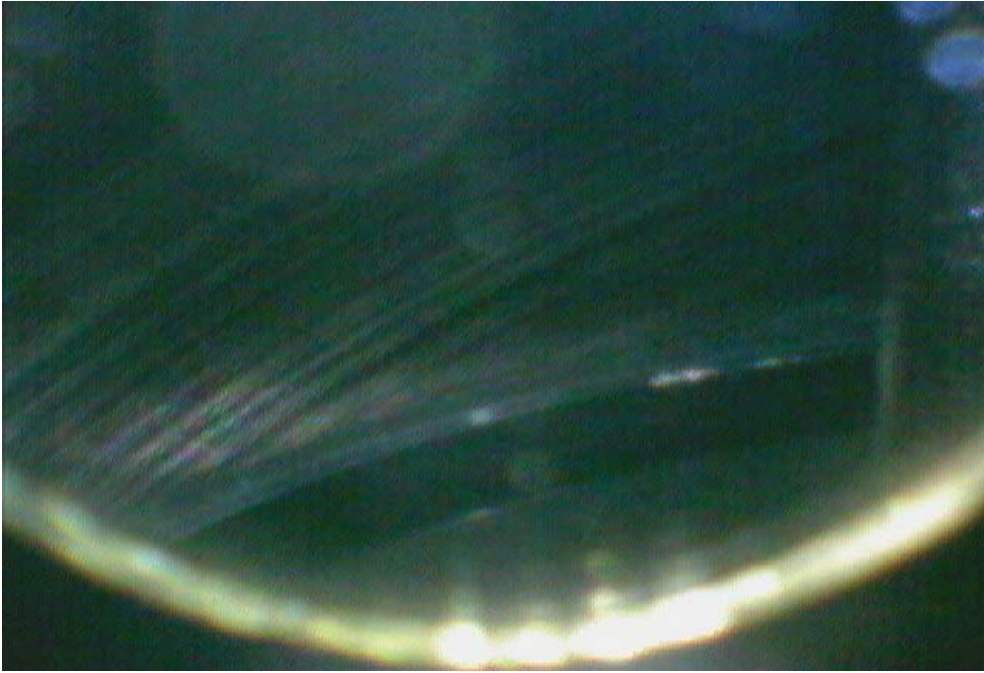


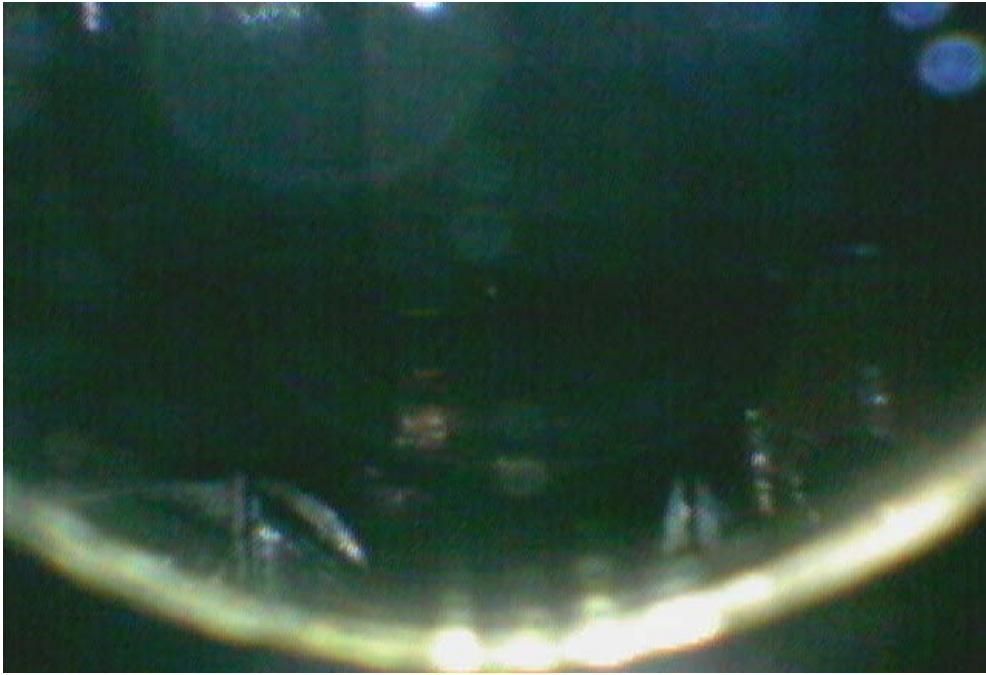


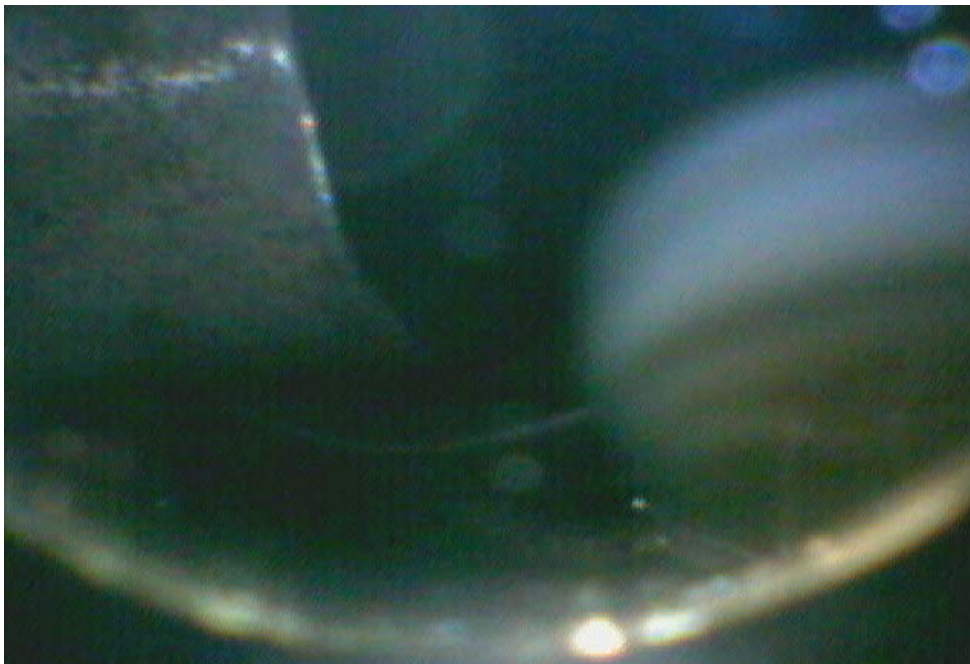
MDG #4 - Lower End



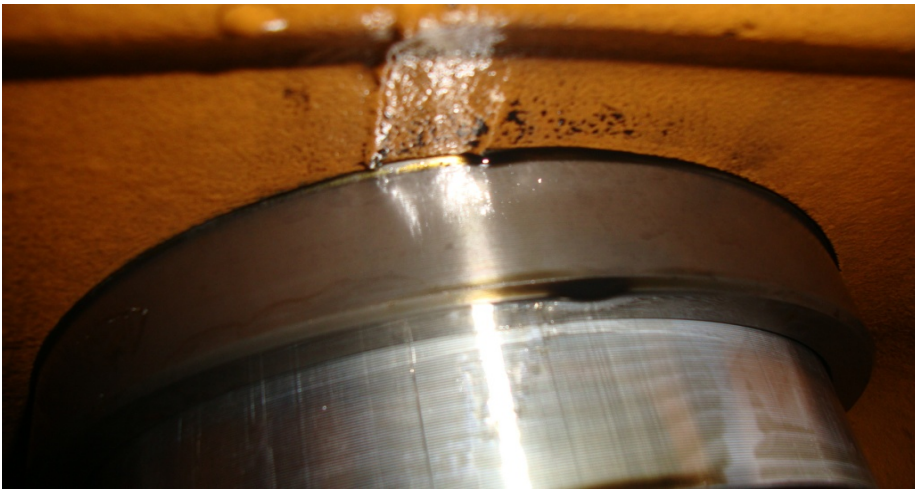




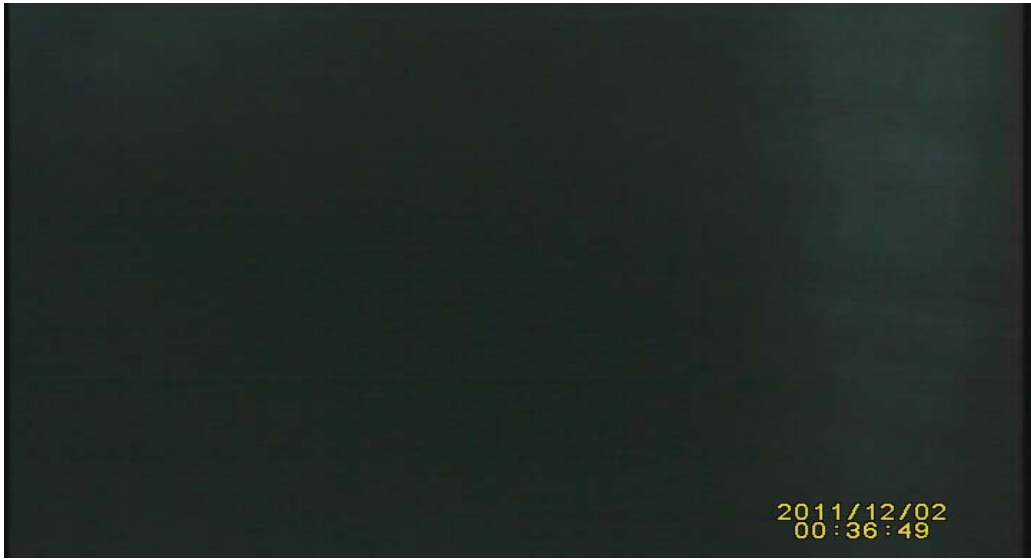




MDG #4 - Lower End



MDG #4 - Stack & Turbo



MDG #4 - Stack & Turbo



MDG #4 - Stack & Turbo



MDG #4 - Stack & Turbo



MDG #4 - Stack & Turbo





MDG #4 - Stack & Turbo



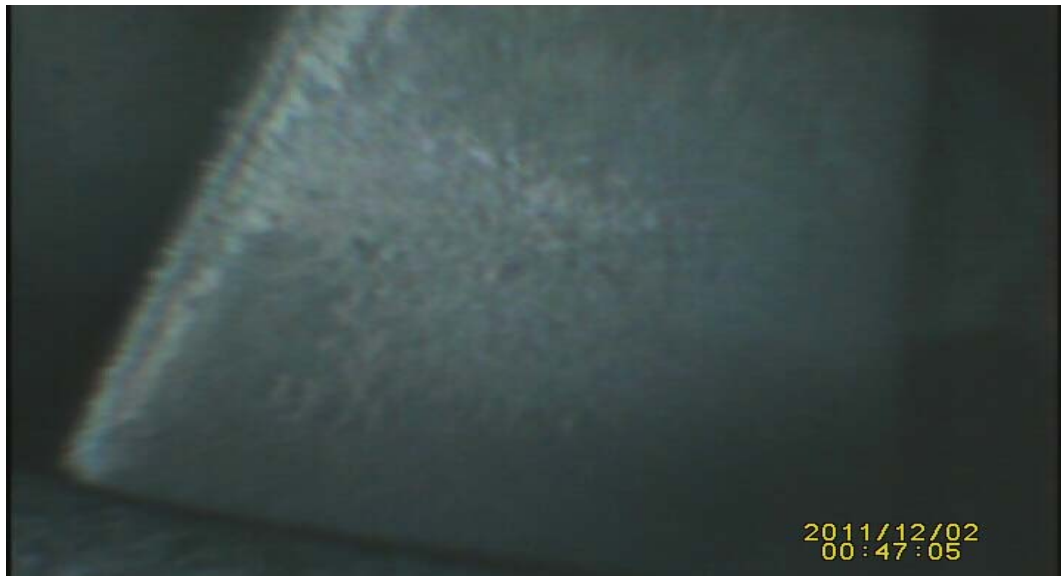
MDG #4 - Stack & Turbo



MDG #4 - Stack & Turbo



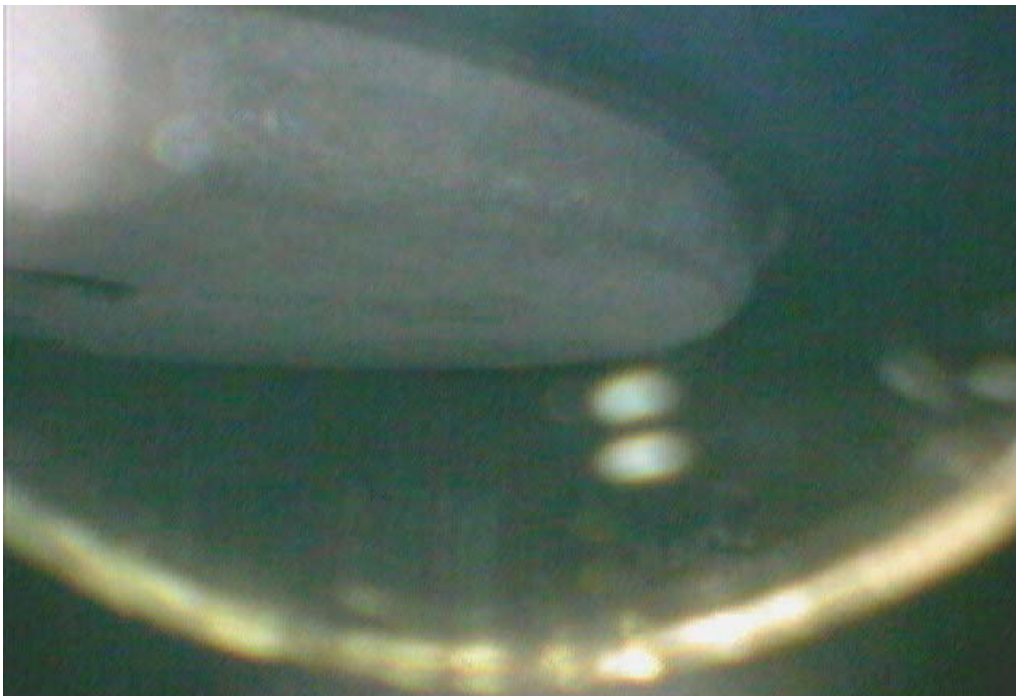
MDG #4 - Stack & Turbo

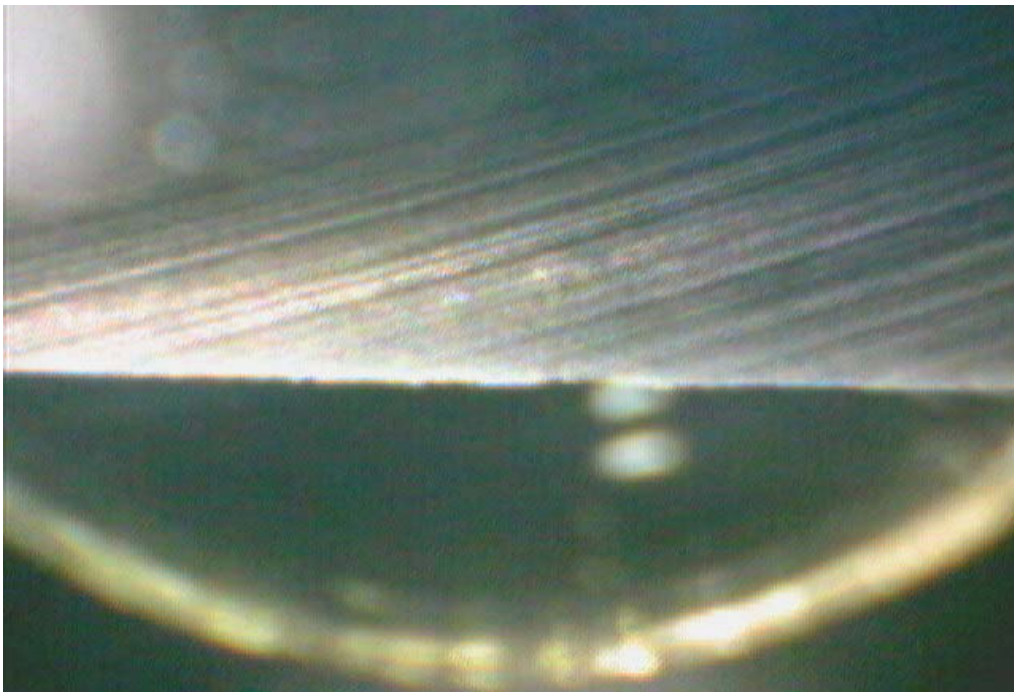


MDG #4 - Stack & Turbo



MDG #1 - Cylinder 9









MDG #1 - Cylinder 10

