The Conserver™ Oil Purification Unit Next Generation Filtration Systems, LP

Third Party Validation and Water Removal Capability Study

What is the Conserver™ Oil Purification Unit?

The purification unit cleans and dries oil and hydraulic fluids at a rated efficiency while extending drainage periods dramatically. The units are scalable and adaptable to a wide variety of applications, including gasoline and diesel engines, turbines, transformers, generators, and all hydraulic systems. The Conserver™ extends the life of oil and lubricants, protects the environment, and significantly cuts the total cost of ownership through reduced equipment wear and maintenance cost.

How does it work?

The Conserver™ is designed with two active oil purification processes. The first is a specially designed micro-glass element that collects particulates. The second active process is the patented moisture removal chamber. The fluid passes through the chamber where the moisture is separated from the oil through evaporation and then removed from the system. These two processes clean the fluid, extend the drainage period, and dramatically increase the life of the oil and the equipment.

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Advantages of using the Conserver™

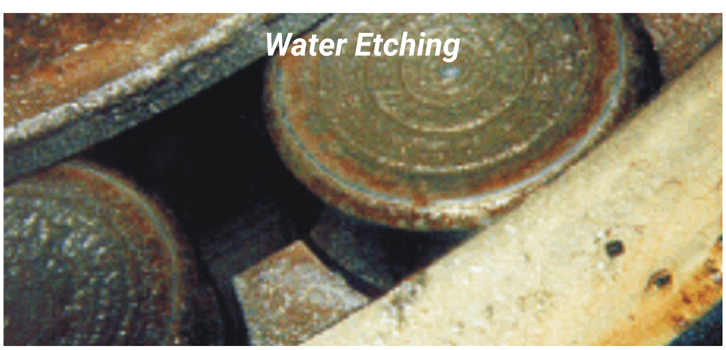
- Removes emulsified, dissolved, and free water from lubricating fluids
- Dramatically extends life and efficiency of oil and equipment
- Achieves greater energy efficiency by reducing the amount of fossil fuels used

Why is this Important?

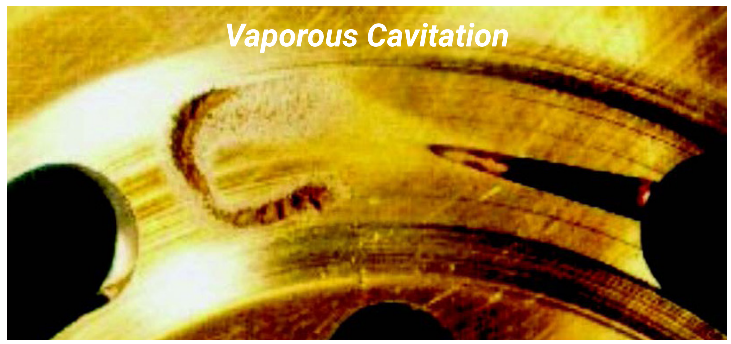
The effects of water are insidious. Failure due to water contamination may be catastrophic, but it may not be immediate. Many failures blamed on lubricants are truly caused by acids which can form from moisture. The following are some of the effects of moisture present in oil:

- Shorter component life due to rust and corrosion
- Water etching/erosion and vaporous cavitation
- Hydrogen embrittlement
- Oxidation of bearing/hydraulic components
- Wear caused by loss of oil film or hard water deposits

Water attacks iron and steel surfaces to produce iron oxides. Water teams up with acid in the oil and corrodes ferrous and nonferrous metals. Rust particles are abrasive. Abrasion exposes fresh metal which corrodes more easily in the presence of water and acid.

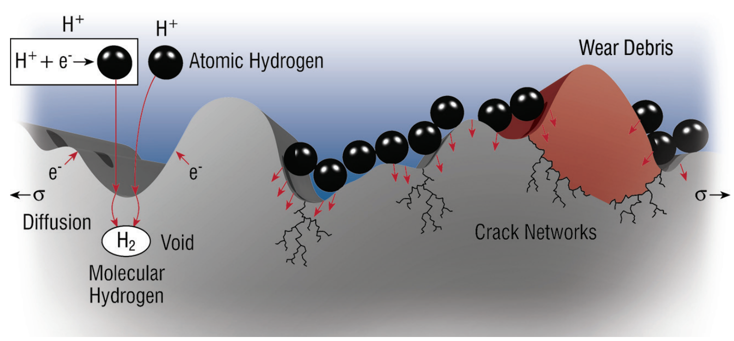


Water etching can be found on bearing surfaces and raceways. It is primarily caused by generation of hydrogen sulfide and sulfuric acid from water-induced lubricant degradation.



Water vapor implodes under pressure next to an adjacent surface with great force in the form of a needle-like microjet, which causes localized surface fatigue and erosion. Water contamination also increases the oil's ability to entrain air, thus increasing gaseous cavitation.

Hydrogen Embrittlement



Water is attracted to microscopic fatigue cracks in balls and rollers by capillary forces. Once in contact with the free metal within the fissure, the water breaks down and liberates atomic hydrogen. This causes further crack propagation and fracture. High tensile-strength steels are at greatest risk. Sulfur from additives (extreme pressure (EP), antiwear (AW), etc.), mineral oils and environmental hydrogen sulfide may accelerate the progress of the fracture. Risk is posed by both soluble and free water.

Oxidation

Many bearings have only a limited volume of lubricant and just a scintilla of antioxidant. High temperatures flanked by metal particles and water can consume the antioxidants rapidly and rid the lubricant of the needed oxidative protective environment. The negative consequences of oil oxidation are numerous but include corrosion, sludge, varnish and impaired oil flow.

Additive Depletion

We've mentioned that water aids in the depletion of antioxidants, but it also cripples or diminishes the performance of a host of other additives. These include AW, EP, rust inhibitors, dispersants, detergents and demulsifying agents.

Water can hydrolyze some additives, agglomerate others or simply wash them out of the working fluid into puddles on sump floors. Sulfur-phosphorous EP additives in the presence of water can transform into sulfuric and phosphoric acids, increasing an oil's acid number (AN).

Oil Flow Restrictions

Water is highly polar, and as such, has the ability to mop up oil impurities that are also polar (oxides, dead additives, particles, carbon fines and resin, for instance) to form sludge balls and emulsions. These amorphous suspensions can enter critical oil ways, glands and orifices that feed bearings of lubricating oil.

When the sludge impedes oil flow, the bearing suffers a starvation condition and failure is imminent. Additionally, filters are short-lived in oil systems loaded with suspended sludge. In subfreezing conditions, free water can form ice crystals which can interfere with oil flow as well.

Aeration and Foam

Water lowers an oil's interfacial tension (IFT), which can cripple its air-handling ability, leading to aeration and foam. It takes only about 1,000 ppm water to turn your bearing sump into a bubble bath. Air can weaken oil films, increase heat, induce oxidation, cause cavitation and interfere with oil flow; all catastrophic to the bearing. Aeration and foam can also incapacitate the effectiveness of oil slingers/flingers, ring oilers and collar oilers.

Impaired Film Strength

Rolling element bearings depend on an oil's viscosity to create a critical clearance under load. If the loads are too great, speeds are too low or the viscosity is too thin, then the fatigue life of the bearing is shortened. When small globules of water are pulled into the load zone the clearance is often lost, resulting in bumping or rubbing of the opposing surfaces (rolling element and raceway). Lubricants normally get stiff under load (referred to as their pressure-viscosity coefficient) which is needed to bear the working load (often greater than 500,000 psi).

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Water Removal Capability Study

Bonavista Technologies, Inc.
http://bonavistatech.com/

Gary Ferrell, Ph.D., P.E., President
Vic Harlan, Project Engineer

Bonavista was founded in 1995 by Dr. Gary Ferrell with the goal of supporting the filter testing business with first class equipment and testing technology. Dr. Ferrell has a Ph.D. in mechanical engineering from Oklahoma State University and was the Director of Technical Services at Purolator Products.

From the early days, Bonavista customers included most automotive oil filter manufacturers in the U.S. and Europe. Fast forward to 2020. Bonavista has now produced specialized test rigs for nearly every liquid filter manufacturer on earth. Our customers include aviation, hydraulic, automotive and fuel filter manufacturers on every continent except Antarctica. Our test rigs test to the accepted ISO standards and are often used to develop new ones. Virtually 80%+ of every oil filter prototype is tested on a Bonavista test rig.

Bonavista also offers testing services and has developed a test lab for particle counting test rigs. One of the Bonavista test rigs is utilized for fuel/water separator testing using ISO 16332 techniques. The development of this test rig required precision titration (water concentration) techniques to be developed.

Next Generation Filtration Systems, LP approached Bonavista about testing the Conserver™ product. To truly get an unbiased test, Bonavista had to first eliminate outside influences and make certain that water elimination was performed only by the Next Generation device.

Scope of Work

Bonavista proposed rebuilding an existing test rig (B26-042) to meet these general quote requirements:

- Potentially changing the circulation pump to maintain suspension of water droplets.
- Test Fluid: MIL-PRF-5606 (Later changed to ISO 46 Hydraulic oil)
- We would add a means to extract test fluid and present it to the Conserver H2.
- We add a method of extracting samples for later analysis (Karl Fisher Titration).
- The test sink would be modified to a closed sink system with no exposure to outside air.
- Create a method to prepare test oil repeatedly before contaminant (water) is introduced.
- 35oC to 50oC temperature control range.
- 480 VAC, 60 Hz, 15A required for B26-042.
- Distilled water to be used as a contaminant

Next Generation Filtration Systems, LP provided a Conserver H2 for the study.

- Power Requirements: 220VAC, 60 Hz, 30A with Neutral
- Fluid connections: 3/8” JIC Inlet, ½” JIC Outlet
- Fluid Filtration Option (removed for study)
- Metrohm 831 Karl Fischer Titrator and 860 Thermoprep for Sample analysis.

Third party independent verification of Validation results.

- Validation: Shows test setup can maintain a specific level of contamination over time.
- Verification provided by: Environmental Testing, Inc. Oklahoma City, OK 73118.

Provide results of 3 tests at varying levels of contamination.

- Contamination was chosen to be 2500, 10,000 and 40,000 ppm (parts per million).
- These roughly correspond to heavy, severe, and extreme levels of contamination.

Test System

The test system contained a reservoir in the form of a test sink, circulation, and sample pump. The test sink was sealed to eliminate evaporative losses. Entry and exit ports were provided for both pumps and the Conserver H2. Atmospheric humidity that could affect test results was also removed with the sealed sink.

The circulating, sealed test system provided a continuously mixed solution from which samples were taken. A centrifugal pump was used to provide high volume movement through the system. This ensured water droplets could not separate and settle out of the flowing mixture. A homogeneous mixture was required and maintained. No water could either escape or fall out of the mixture, where it could not be measured.

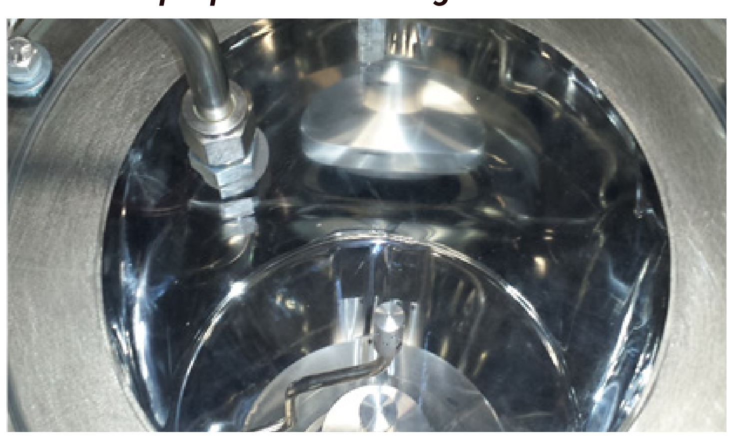
A separate, parallel circulating path with much lower flow rate was added to provide samples without exposing the mixture to air. A small pump was used to ensure constant movement through this path. The path of the mixture began in the middle of the test sink allowing samples to be drawn from a turbulent, well mixed area. The path returns to the inlet of the main circulation pump. Valves were installed before and after the pump. These provided a means to introduce water to the sealed system as well as a sample extraction point.

SAE J1488 Fuel/Water separation test standard was chosen to borrow validation criteria for this study. This standard most closely matched the chosen first test contamination level. J1488 requires that the mixture be maintained within a tolerance of ±250 ppm of the expected result for 1 hour.

Physical Features

Conserver™ H2 Installed w/o filter option.

Sealed sink with circulation and sample ports in submerged locations.



Validation

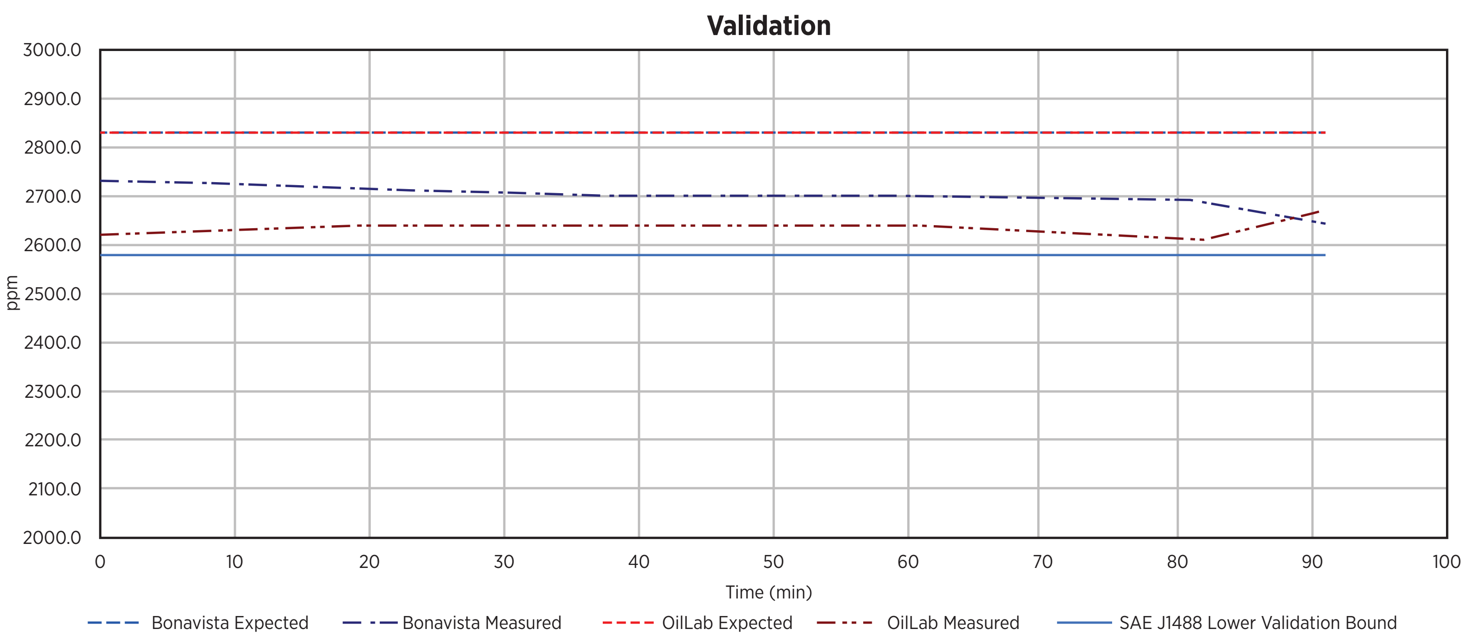
Validation was performed on the test rig to show no loss of water over time. This is to ensure the results obtained in testing are entirely from the use of the Conserver H2. A parallel set of samples was collected during this time. These samples were shipped to an independent lab to have the results verified.

SAE J1488 Fuel/Water separation test standard was chosen to borrow validation criteria for this study. The amount of water necessary to produce an approximate contamination of 2500 ppm was calculated and introduced. The oil/water mixture was allowed to circulate for 20 minutes to thoroughly mix the water.

J1488 states that validation samples be taken every 10 minutes, giving 6 samples in 1 hour. The time between samples was increased to every 20 minutes due to time per analysis being larger than 10 minutes. This gave a total time of 1 hour 40 minutes for the Validation.

The graph below shows the consistent water contaminant level being maintained for the duration of the test. Both Bonavista and the Independent result are within the J1488 bounds for accepting the validation, proving the test rig lost no water to any undiscovered action.

The expected result is slightly higher than the measured results. This is due to a small loss of water in the transfer of the desired water to the circulating test fluid and the repeated handling of samples. The water lost represents approximately 0.7 grams of water. Further automation of the sampling and initial water delivery could improve the results, bringing the measured result much closer to the theoretically calculated expected result.



Testing

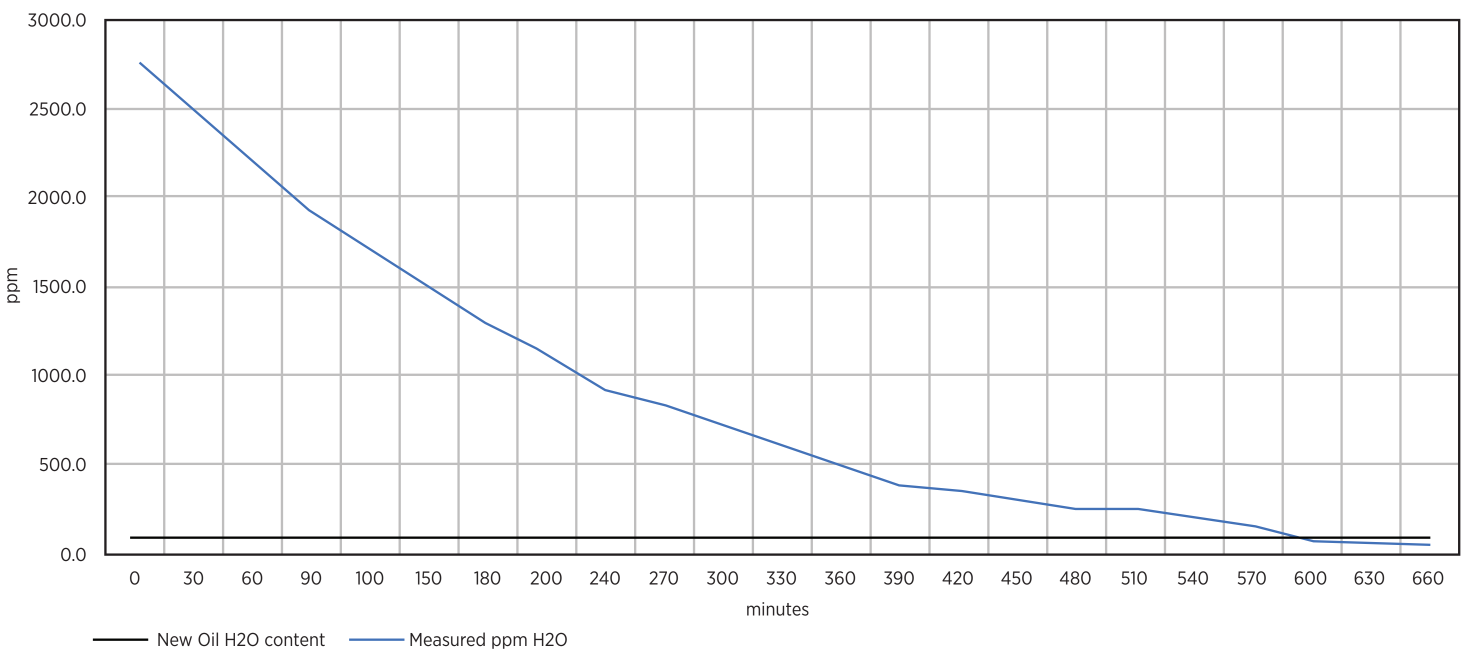
Testing was performed at 3 levels of water contamination. These roughly represent a heavy, severe, and extreme level of water contamination. Distilled water was chosen over de-ionized water as the contaminant. The distilled water more closely represents an atmospheric condensate likely to be found in equipment reservoirs.

The pre-filter assembly was removed from the Conserver™ H2. This option was not needed as the test fluid could be controlled, prepared in regard to hard, particulate matter. New, well filtered fluid from a commercial supplier was used for testing. Also, a concern was the internal volume of the filter. This large increase in volume compared to the hose transporting fluid to the device slows the fluid in its travel. This reduction in speed allows gravity a much greater chance to "pull" water droplets from the moving fluid where they cannot be measured.

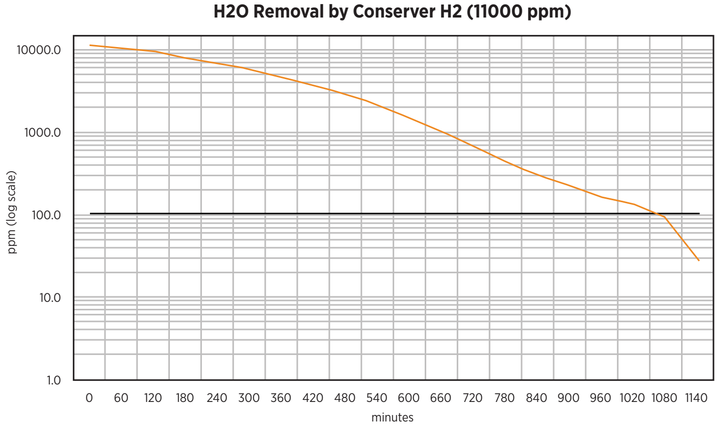
Due to the potential for the filter assembly to act as a water trap, removal of the filter assembly was performed. The Conserver H2 does not operate on the classical ideal of filter. The contaminant, water, does not pass through a media or membrane barrier to be removed from the test fluid. Different physical principles are used to remove the water.

Preparation for testing included measurements of the new fluid water content as well as the water content in the test sink before water addition. These values are needed to interpret the results obtained. Test results follow on the next pages.

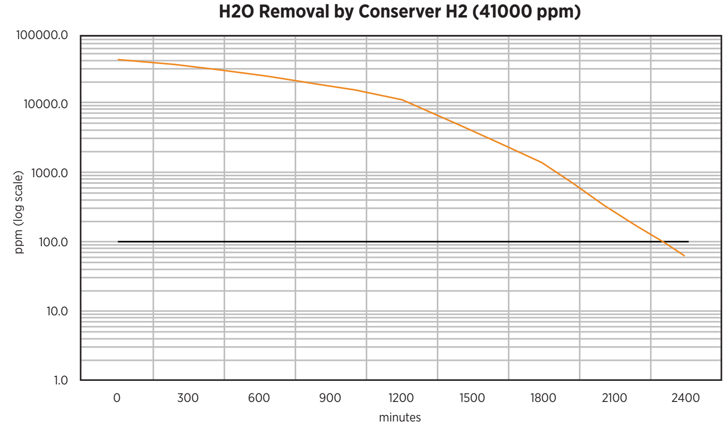
H2O Removal by Conserver H2 (2750 ppm)



H2O Removal by Conserver H2 (11000 ppm)



H2O Removal by Conserver H2 (41000 ppm)

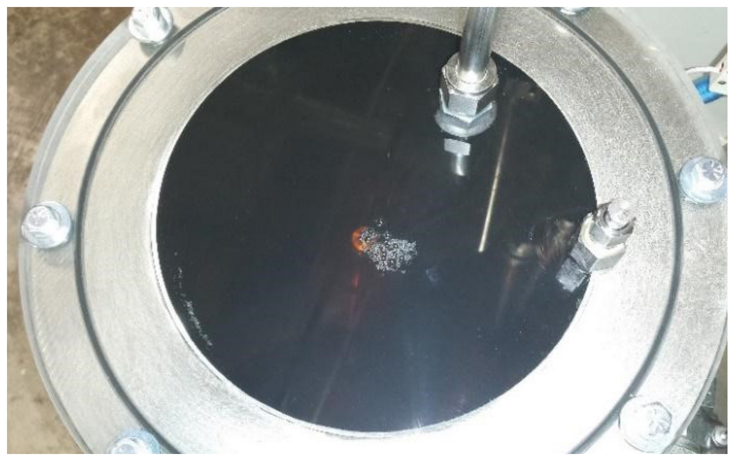


Starting at 40,000+ ppm

Starting at 10,000+ ppm

Starting at 2500+ ppm

Ending at <100 ppm



Concluding Remarks

Each test was performed by adding water only once at the outset of the test. This was done to bring the water contamination to a known level. The is to show the Conserver™ H2's ability to remove large quantities of water. The testing leads to an expectation of an extremely low value (as measured in ppm) being maintained with continuous use. The value represents a balance between water ingression from other sources and the removal rate of the Conserver™ H2.

All three test results show the Conserver H2 continuously removing water. The removal rate varied with the initial contamination level of the fluid in question. In each case, Conserver H2 was able to remove all the water added to the test. The water content of the test fluid was lower than the "new" fluid water content when each test was terminated. This represents an improvement, in terms of water content, over the new fluid used for testing.

Universal Application

Our focus is creating tailored units for every customer. The Conserver™ Oil Purification Unit by Next Generation Filtration Systems, LP cleans and dries oil and hydraulic fluids at a rated efficiency while extending drainage periods dramatically. The systems are scalable and adaptable to a wide variety of

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applications, including gasoline and diesel engines, turbines, transformers, generators, and all hydraulic systems. We use our technical knowledge, application expertise, and production and engineering capabilities to consistently deliver quality, high-performance products that will fit any industry's needs.

Industries that we currently service consist of:

- Industrial & Manufacturing
- Transportation
- Construction
- Marine
- Land & Offshore Oil & Gas Equipment
- Critical Services

Worldwide Patents

Next Generation Filtration Systems, LP is dedicated to delivering quality custom oil optimization systems no matter the application. To protect our technology, we have been issued eleven patents. These patents include:

- 6 Patents in the USA
- 2 Patents in China
- 2 Patents in Australia
- 2 Patents in Europe

Patented worldwide and Proudly manufactured in the U.S.A.

Contact Us

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1. The Conserver™ Purification Systems are scalable and adaptable to a wide variety of applications, including gasoline and diesel engines, turbines, transformers, generators and all hydraulic systems. Pictured above are the Conserver™ H1 and H2 base model units.

2. The Conserver™ H1 base model unit.

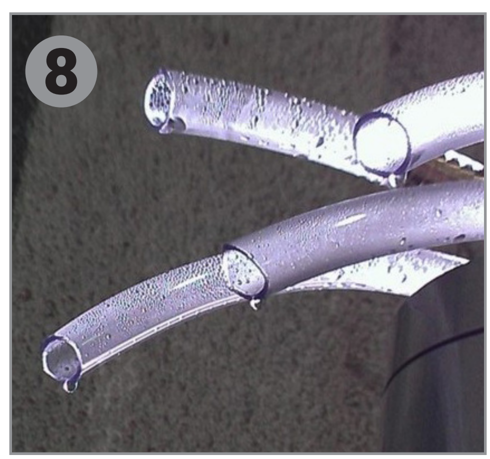
3. This custom skid-mounted Conserver™ System is equipped with four HI4 purification units and two filter canisters. The unit is designed for systems with reservoirs or holding tanks up to 300 gallons. The system's unique control box measures flow, pressure and temperature, supplying the necessary logic and controls to ensure the unit performs properly.

4. Four HI4 Conserver™ units mounted on a custom stationary skid. The system is installed near a large reservoir at a paper mill.

7. The HI2 Conserver™ Oil Purification Unit installed on a lime kiln gearbox.

6. This CAT 3520 landfill generator is equipped with a single HI4 Conserver™ Oil Purification Unit.

7. A single HI2 Conserver™ Oil Purification Unit installed on a CNG gen set.



8. The Conserver™ Oil Purification System technology removes water from oil as an ongoing process - including dissolved water. These two photos show water being removed from a 30- and 100-gallon hydraulic system.

9. Using the Conserver™ Oil Purification System on diesel, gasoline, or compressed natural gas engines will save millions of gallons of fossil fuels and increase the life of the engine. This photo shows an H2 Conserver™ Unit installed on a cement truck.

10. The Conserver™ Oil Purification System cleans and dries oil and hydraulic fluids – extending drainage periods dramatically and reducing equipment and engine wear. In this photo a single HI4 Conserver™ Unit is mounted near a 100-gallon reservoir.