BALDWIN FILTERS
a CLARCOR company

ENGINEERING BULLETIN 93-11

September 14, 1993

Cleaning of Heavy-Duty Air Filter Elements

Baldwin heavy-duty air filters will withstand washing. However, as a matter of policy Baldwin Filters, like other filter manufacturers, having no control over the washing process can not and does not recommend the washing of air filters and does not warrant filters which have been washed.

Since some vehicle owners and maintenance supervisors, concerned with lowering their operating costs, clean and reuse their heavy-duty air filter elements. Here are some factors to consider before you decide whether cleaning or washing of heavy-duty air filter elements is appropriate for your vehicle or fleet:

- Used heavy-duty air filter elements, after the most thorough cleaning, usually have 85 percent of the life when new; each subsequent cleaning yields progressively reduced dust capacity.
- Re-use of cleaned heavy-duty air filter elements, because of their shortened service life, increase the likelihood of improper air filter servicing. Each time the air intake system is serviced, it is exposed to the chance of mis-service.
- Cleaning must be done with care to avoid damaging the heavy-duty air filter element, which may cause dust leaks. Careful inspection of the cleaned filter is of crucial importance.
- Air filter element manufacturers do not warrant products once they have been cleaned.

If you desire to clean your heavy-duty air filter elements for re-use, here are two methods most commonly used:

1. It is best to use a commercial heavy-duty air filter element washing service whose operators are trained in proper washing techniques and inspection precautions. Some commercial air filter element washing services do warranty the elements they wash; select a service that does, and make sure their warranty covers repair of engine damage resulting from a defective washed element.
2. If a commercial washing service is not available, the most effective cleaning method is to soak the element in water which contains a non-sudsing detergent. Prevent dirty water from making contact with the clean side of the filter. After soaking, as previously described, rinse the element from the "clean" side to the "dirty" side to dislodge the dirt, with water pressure not exceeding 40 PSI without a nozzle. A pressure nozzle must not be used, as it may damage the filter element. After washing, the filter must be completely dry before it is placed back into service. It will dry by itself in one or two days' time, or less if special convection dryers are available for this purpose. Warm air must be circulated, with temperature less than 160oF. Do not use a light bulb to dry the element.

Inspection of the cleaned element is critically important. Inspect for holes and tears in the pleats by looking through the element toward a bright light. Any obvious damage will cause light to show through. Check for torn, loose, or partially-compressed gaskets, and for dented metal parts. If you install a replacement gasket, make sure it is of proper dimensions (cross section and diameter) and of proper durometer (resistance to compression).

Make sure the element identification part number is still visible. Mark the date of washing on the element end cover.

Filters that have passed final inspection should be placed in a sealed box and stored in a clean, dry place. For easy identification, mark the date the filter was cleaned on the outside of the storage box.

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If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

Filter Manufacturers Council

Filter Knowledge, Unfiltered

Technical Service Bulletin 06-2

Heavy-Duty Diesel Engine Air Filter Collapse

Most reputable filter manufacturers design their air filters to operate well beyond recommended engine intake restriction service points. In fact, there is usually a safety factor of at least 2-3 times over the stated service point. However, there are circumstances when filter collapse can take place. When an engine is operated with a filter that's collapsed, there is a good chance that unfiltered air is getting to it, which could result in costly repairs. Most of the time poor maintenance is the cause, but there are some operating conditions to consider as well.

Collapse of a heavy-duty air filter is defined as a permanent deformation of the unit after airflow is removed. This occurs when the pressure drop across the filter exceeds the design limit of the device. Because of the safety factors built-in when the filter is engineered, this is an unusual event and is normally preventable.

A common cause of filter collapse is not paying attention to the service point recommended by the engine manufacturer. Diesel engines typically have an intake element service point of 20-30" H_2O (5–7.5 kPa), depending on the manufacturer. As stated above, exceeding this by an incremental amount won't cause the filter to collapse, as they are designed to withstand a much higher level of restriction. However, because filters tend to load very quickly after a certain point, not servicing them soon after the maximum allowable restriction is reached (as recommended by the engine manufacturer) can end up causing a very high level of pressure drop across the filter, and may result in a collapse condition. The best way to avoid this is to install and monitor a restriction measuring device (gauge, pop-up indicator, dash light, etc.) and replace the element when it indicates the service point has been reached.

Another possibility of filter collapse is sub-standard element construction or remanufacture. Generally, obtaining air filters from a reputable manufacturer will avoid this issue. Quality heavy-duty air filters are made with materials that can withstand high levels of pressure drop and resist collapse, while sub-standard elements may not.

It is also important to inspect all filters before installation. Dented liners or end caps may result in a loss of structural integrity and filter collapse.

Damage may be present but not very visible. If the filter shows any sign of damage, don't use it. This is especially critical when using cleaned elements (refer to TSB 89-4R2). Couple the possibility of damaged filters with weakened media (if it were washed or cleaned with too high of a pressure) and the filter may have a much lower resistance to collapse.

Operating conditions should be considered as well. For example, high levels of soot (generally from diesel engine exhaust) can plug an air filter rapidly. This may shorten the life of a filter dramatically, and if a restriction indicating device isn't monitored closely, can result in extremely high pressure drop across the filter that may cause it to collapse. If high levels of soot are experienced, the cause of the ingestion should be investigated and, if possible, corrected. These include (but are not limited to) proximity of the intake to the exhaust, exhaust leaks near the air intake, vehicles operating or idling in close quarters and operating in certain areas where exhaust concentrations are high can result in high levels of soot.

Extremely high levels of water ingestion can be a concern, too. Although most filters can take a certain amount of moisture with no problems, large amounts of water can weaken and plug the filter media long enough to cause collapse. However, this is an unusual situation because most vehicles that are likely to be used in these types of conditions have a water separation device installed. One possibility of excessive water ingestion often not accounted for is the introduction of high levels of moisture during washing of the vehicle. The best practice is to ensure the engine is not operating during washing and water is not sprayed directly into the engine air intake.

In summary, following the engine manufacturer's service recommendations, using quality undamaged products and using a restriction indicating device are the best practices to prevent air filter collapse. If element collapse occurs, it is important to ascertain whether lack of maintenance caused the problem or if the vehicle is used in conditions that dramatically shorten filter life, and then take corrective action to keep it from happening again. For additional information about servicing heavy duty air filters refer to TSB 89-3R3.

For additional information, contact:

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Administered by Motor & Equipment Manufacturers Association

Air Filter Micron Rating v. Life and Efficiency Ratings

Occasionally questions arise about the micron ratings and test procedures on air cleaners and replacement air filters. Typically, air cleaners and air filters are not assigned a "micron rating". Micron rating is a term used in liquid filtration. Air filters are evaluated for life and efficiency using an industry-wide standard (ISO 5011). The following should clarify the questions surrounding this issue.

Filter life is measured in total grams fed or in hours of lab life and is determined by testing at a standard test dust concentration of l g/m3 (0.028 g/ft3) for single-stage air cleaners or 2 g/m3 (0.056 g/ft3) for multistage units at either a constant or variable airflow. The end of the life testing is determined using the restriction method. When the predetermined restriction service point is reached, the test is stopped and the filter is weighed. The amount of test dust held by the filter is considered the capacity or life of the filter. The life of an air cleaner requires some additional consideration. Many air cleaners have inertial separators included in the housing. These inertial separators remove up to 98% of the dust that is fed during one of these tests. Therefore, the inertial separator efficiency must also be evaluated.

Element efficiency is calculated by determining the increase in weight of an absolute filter (an absolute filter captures any dust that passes the test filter) located downstream of the test filter vs. the weight of the total dust fed.

Table 1 details the particle size distribution of the standard test dust used for life and efficiency evaluations (ref. ISO 12103-1).

Table 1
Particle Size Distribution by Weight %

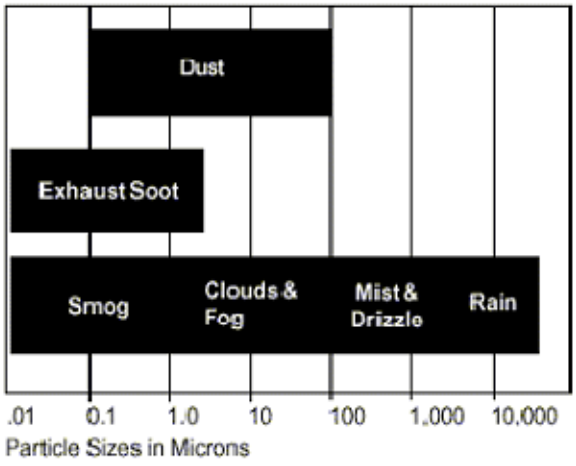
Size (Microns)	*Fine**	*Coarse**
0 - 5	39 ±2	12 ±2
5 - 10	18 ±3	12 ±2
10 - 20	16 ±3	14 ±3
20 - 40	18 ±3	23 ±3
40 - 80	9 ±3	30 ±3
80 - 200	-----	9 ±3

* **Fine** grade dust is used to test primary dry air cleaners and **coarse** grade dust is used to test 2-stage air cleaners.

Fine test dust is used for testing primary dry air cleaners, which are most often used in on-road and automotive applications, and coarse dust is used for multistage air cleaners that typically use inertial separators and operate in very dusty applications.

Table 2 lists common contaminants found in field environments, as well as their particle size ranges. Although field conditions vary from one location to the next and from time to time, this test allows for a standard means of comparison and a laboratory method of evaluating air cleaner life and efficiency.

Table 2
Common Field Contaminants vs. Size



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BALDWIN FILTERS
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ENGINEERING BULLETIN 08-1

May 6, 2008

Baldwin Fuel Filters Compatible with Certified Bio-Diesel Blends

Baldwin fuel filters currently in use in petroleum-based diesel applications are compatible with certified biodiesel blends up to and including B20. Our laboratory has conducted extensive soak testing with various blends of biodiesel. Through this testing, we have verified that the materials used in our current fuel filters are compatible with certified biodiesel blends up to and including B20.

Biodiesel, n. – a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100, and meeting the requirements of ASTM D 6751.

Biodiesel blend, n. – a blend of biodiesel meeting ASTM D 6751 with petroleum-based diesel fuel designated BXX, where XX is the volume percent of biodiesel.

Overview

Biodiesel is an alternative fuel that is rapidly growing in use. However, biodiesel received a bad reputation after the problems that occurred in Minnesota in 2005 when some states mandated the use of B2 biodiesel blend statewide. One of the problems was very short fuel filter life. Further research revealed that the problems encountered were not due to the use of the biodiesel blend, but rather the use of biodiesel that did not meet the ASTM D 6751 specifications. The use of biodiesel that does not meet specifications may cause problems within the fuel system. **One false perception of biodiesel is that it can be made by simply mixing raw vegetable oil, waste vegetable oil or animal fats with diesel fuel. Due to their high glycerin content, these feed stocks must be refined and catalyzed to make biodiesel that meets the ASTM D 6751 specification.**

Filter Plugging

Biodiesel has some solvent properties and will act as a solvent in the fuel. Blends greater than B20 may have enough of a solvent effect to break down the varnish deposits on the walls of the existing fuel storage tanks or fuel systems. The break-down of these varnish deposits will contaminate the fuel with particulate, which can cause fuel filters to plug rapidly. Once the contaminant is removed from the fuel, the fuel filter life should return to normal. Biodiesel blends up to B20 should have minimal solvent effects on existing fuel systems and blends below B5 should have no solvent effect above that of regular diesel fuel meeting ASTM D 975 specification. Blends of B5 and below should also meet the ASTM D 975 specifications for diesel fuel.

Filter plugging problems can be prevented by effectively cleaning storage tanks before introducing biodiesel. Filter plugging can also be minimized by using low blends of biodiesel and/or ensuring the biodiesel that you are using is from a quality source meeting the ASTM D 6751 specifications. BQ9000 is a quality certification that certifies biodiesel suppliers that provide quality biodiesel meeting the ASTM D 6751 specification.

Using High Blends of Biodiesel

Filters that are used in special applications using high blends of biodiesel, those near B100 or unblended B100, should use solvent resistant materials. Continued use of standard rubber materials commonly found on most popular fuel filters may result in deterioration or swelling of the material, which may result in leaks.

Reprinted in part with permission from the Filter Manufacturers Council in reference to the published Technical Service Bulletin TSB06-1.

If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

Filter Manufacturers Council
Filter Knowledge, Unfiltered

Technical Service Bulletin 06-1

The Effects of Biodiesel on Fuel Filters

Biodiesel, n. – a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100, and meeting the requirements of ASTM D 6751.

Biodiesel blend, n. – a blend of biodiesel meeting ASTM D 6751 with petroleum-based diesel fuel designated BXX, where XX is the volume percent of biodiesel.

Overview

Biodiesel is an alternative fuel that is rapidly growing in use. However, biodiesel received a bad reputation after the problems that occurred 2005 when some states mandated the use of B2 biodiesel blend statewide. One of the problems was very short fuel filter life. Further research revealed that the problems encountered were not due to the use of the biodiesel blend, but rather the use of biodiesel that did not meet the ASTM D 6751 specifications. The use of biodiesel that does not meet specifications may cause problems within the fuel system. One false perception of biodiesel is that it can be made by simply mixing raw vegetable oil or waste vegetable with diesel fuel. Due to the high glycerin content in vegetable oil, these feed stocks must be refined and catalyzed to make biodiesel that meets the ASTM D 6751 specification.

Filter Plugging

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Filter plugging problems can be prevented by effectively cleaning storage tanks before introducing biodiesel. Filter plugging can also be minimized by using low blends of biodiesel and/or ensuring the biodiesel that you are using is from a

quality source meeting the ASTM D 6751 specifications. BQ9000 is a quality certification that certifies biodiesel suppliers that provide quality biodiesel meeting the ASTM D 6751 specification.

Filter Compatibility

Most fuel filters currently used in petro-diesel applications are compatible with bio-diesel blends up to B20. Check with your filter manufacturer for verification.

Using High Blends of Biodiesel

Filters that are used in special applications using high blends of biodiesel, those near B100 or unblended B100, should use solvent resistant sealing materials. Continued use of standard sealing materials commonly found on most popular fuel filters may result in deterioration or swelling of the material, which may cause leaks.

For more information on biodiesel visit www.biodiesel.org Website. This site is not affiliated with the Filter Manufacturers Council.

For additional information, contact:

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Filter Manufacturers Council

Filter Knowledge, Unfiltered

Technical Service Bulletin 07-2

Biodiesel and Fuel Filter Service Intervals

There is a lot of interest in biodiesel, so this TSB will address the benefits, challenges, and myths surrounding this fuel.

Biodiesel is an alternative fuel that is produced from renewable resources. It is derived from either plant or animal oils which are processed to produce biodiesel. Pure biodiesel contains no petroleum, is biodegradable, nontoxic, and is effectively free of sulfur. It is created through a chemical reaction called transesterification. Fatty Acid Methyl Esters and glycerin are two of the products created from this process. Methyl Esters are what we call biodiesel, and glycerin is a commodity which is used by the manufacturers of personal care products.

There seems to be some confusion as to what exactly constitutes biodiesel. A common question asked is if raw vegetable or animal oil is the same as biodiesel. The short answer is no. Biodiesel has been extensively tested for health and performance characteristics and is legally registered with the Environmental Production Agency (EPA) as a legal motor fuel. Fuel-grade biodiesel must be produced to stringent industry standards (ASTM D6751) to insure proper performance. This cannot be said of raw vegetable oil.

Biodiesel is commonly blended with petroleum diesel. These blends are labeled as BXX. For example, B2 represents a mixture containing 2% Biodiesel and 98% petrodiesel. Biodiesel has attained “mainstream” status in blended formulations ranging from B2 – B20. In most cases, biodiesel in a B20 or lower blend can be used in compression ignition (diesel) engines with little or no modification. Presently there are no recommended uses for blends above B20.

Once seen as the less refined relative of the gasoline engine, the modern diesel boasts technology and complexity that would have been hard to imagine years ago. These advances, in part due to tightening EPA regulations, have created a shifting landscape to which diesel engine manufacturers have had to adapt.

Fuel delivery systems have seen sweeping changes in system pressures and mechanical tolerances. Combine this with diesel fuel that has been stripped of its lubricating properties during the removal of sulfur (TSB 07-1) so that it meets tough new regulations, there is the potential for greatly accelerated injector wear and premature failure. Laboratory studies have shown conclusively that biodiesel

in concentrations as low as B2 can replace these lost lubricants and reduce the potential for accelerated fuel system wear.

When preparing to convert to a biodiesel blend it is important to be aware that biodiesel has a “solvent” quality that will clean the fuel delivery system. This typically translates to changing fuel filters more often as the system releases accumulated contaminants. The duration of this process depends upon the overall cleanliness of the fuel system. The amount of time the system has been in use, along with the quality of fuel and the level of preventative maintenance the system has seen, are all contributing factors. After this initial clean-up, you can expect a return to normal fuel filter service intervals.

Biodiesel also has different handling characteristics than petrodiesel. It has both a higher cloud and pour point than petrodiesel, which may affect its use in cold climates. Considerable research is being devoted to improving the cold-weather performance of biodiesel. Additionally, biodiesel has 8% less energy in its pure form than petroleum diesel. Both of these factors are effectively negated when it is blended with petrodiesel.

For additional information, contact:

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BALDWIN FILTERS
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ENGINEERING BULLETIN 99-1

July 29, 1999

Cummins Hard Starting

Over the last couple of years, there have been occasional complaints of hard starting problems with late model Cummins electronic engines. The first fuel filter product introduced with this engine did not contain an internal standpipe. This was later added by the OE presumably to address this starting problem.

Since 1997, the Baldwin BF1259 has similarly contained this internal standpipe. Despite this design change, some engines have continued to experience hard starting problems. At the time of the standpipe's introduction, some customers reported the problem went away while others continued to experience problems. Customers reported that Cummins made changes to the engine's electronics that in some cases had a positive impact, but not in all cases.

Hard starting was not related to only the BF1259. It was reported to us that the problem exists regardless of the brand of fuel filter they tried. The conclusion from Baldwin's standpoint was that the hard starting problem was probably not caused by the fuel filter regardless of manufacturer, but was primarily due to the engine's electronics.

In January of this year, we made a change to the BF1259's internal element seal, centertube, and standpipe to improve other aspects of its performance. The element seal was changed to a higher grade of Nitrile material, and the centertube and standpipe were replaced with a unique design that incorporates both of the previous components with a single one-piece centertube that also serves as the standpipe.

While we did not intend that these changes would or could address the hard starting problems with these engines, we have seen positive effects. Customers that we have worked with on hard starting problems are reporting that the newest design of the BF1259, produced since January of 1999, has made a positive impact on these engines.

Please use this information to communicate to your customers how this Baldwin product may help them with the hard starting problems encountered on Cummins electronic engines. Results have been very positive with these changes and we believe the BF1259 now offers even greater performance advantages over the OEM product for this application.

**If you have further questions,
please contact our
Service Engineering Team at (800) 822-5394.**

Ethanol and Fuel Filter Service Intervals

Many gasolines are blended with materials called oxygenates. Oxygenated blended fuels are used to help lower emissions. A common material used as an oxygenate is ethanol. While ethanol can be made from a variety of grains and other materials, in North America corn is the primary source. Ethanol used for fuel is an ethyl alcohol made in facilities that produce fuel grade ethanol. The fuel grade ethanol is then blended in a percentage with gasoline to make a finished motor fuel.

Often called gasohol, E10 (10% ethanol/90% gasoline) contains more oxygen so it burns cleaner and helps reduce emissions. E10 also very effectively removes accumulated deposits throughout the fuel system often leading to a shortened fuel filter life. When introduced into a dirty system, the cleansing properties of the ethanol removes the varnishing and deposits from the fuel tank, lines, injectors and other points in the system. The fuel filter traps and holds this contamination and quickly reaches its dirt holding capacity. Once the system is clean, accelerated fuel filter plugging would no longer be experienced and normal service intervals should return.

When distribution and delivery systems are not kept clean, ethanol can “clean” these systems and introduce contaminants into the vehicle’s fuel system. If the distribution network is properly maintained and the gasoline is clean going into the vehicle, then a plugged vehicle fuel filter due to the use of E10 is a very rare occurrence. In addition, today’s gasoline contains detergents that keep the fuel system clean and prevents deposits from forming.

Since the 1980’s, all vehicles worldwide have been manufactured with fuel systems that are designed to use E10. Even manufacturers of small engines have designed and manufactured their engines to be E10 capable.

Beginning in the mid 1990’s, vehicle manufacturers introduced some automobiles and light trucks that are capable of using a fuel that is 85% ethanol and 15% gasoline (E85). These vehicles have systems that have the correct sensors and components that can properly use the E85 fuel. While all gasoline automobiles and light trucks can use E10, not all can use E85. Only those vehicles identified as a Flex Fuel Vehicle (FFV) are capable of using the E85 gasoline. A FFV can use any gasoline from

100% unleaded to 85% ethanol. Special fuel filters are required for these applications.

As with the lower percentage blends, E85 is a very effective cleaning agent and if placed in a dirty system, or dispensed through a dirty distribution system, shortened filter life may be experienced until the system is clean.

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ENGINEERING BULLETIN 06-2

June 6, 2006

Baldwin Filters for New Racor® Housings PF7889 Series and PF7890 Series

Baldwin Filters released the PF7889 series and the PF7890 series filters to fit the latest Racor housings. These housings from Racor utilize a valve that must be engaged to allow fuel to flow through the housing. The two pictures below (Figures 1 & 2) illustrate how the valve must be engaged. The newly designed Baldwin filters utilize end caps with keys to engage this valve. The design of the end caps on the Baldwin filters has the keys nearly flush with the end of the filter, as opposed to recessed keys in the Racor filters, to prevent infringement of patents on the Racor design. This difference in design results in the Baldwin filters being approximately 1 1/2 inches shorter than the Racor filters. However, Baldwin Filters has verified through laboratory testing that the PF7889 series and PF7890 series filters provide sufficient filtration efficiencies and contaminant capacities to meet the performance of the respective Racor filters.

The new Baldwin PF7889 series and PF7890 series filters can also be used in the older Racor housings where the obsolete PF589 and PF590 series filters were once used. The inside diameter of the top end cap of these filters sets against a step in the center-post of the housing to retain the filter within the housing. The seal is made by the interference fit between the integral post seals in the end caps and the center-post of the housing. Figure 3 illustrates how the new filter design fits in the old Racor housings in comparison with the Racor filter on the right.

Baldwin Filters continues to offer innovative solutions to your filtration needs. The PF7889 series of filters supersedes the PF589 series and the PF7789 series. The PF7890 series of filters supersedes the PF590 series and the PF7790 series.

Flow-Control valve found in new Racor housing

Figure 1

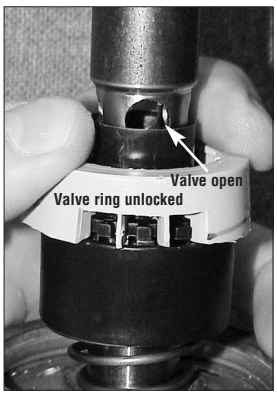

Figure 2

Cutaway view of new filters in old housing

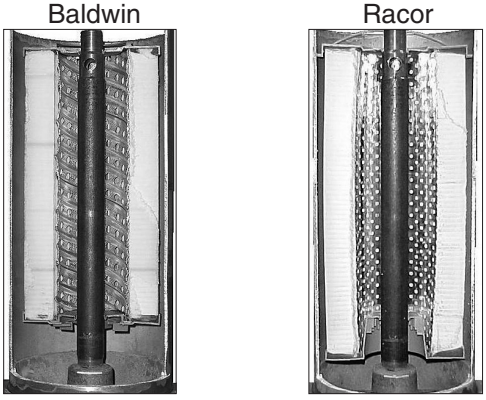

Figure 3

(See Baldwin Form 339 (R 2/06) for more information on these products)

There is no association or affiliation between Baldwin Filters and Racor.
Racor® is a registered trademark and division of Parker Hannifin Corp.

**If you have further questions,
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ENGINEERING BULLETIN 94-14

December 13, 1994

Diesel Fuel Contamination and Fuel Filter Plugging

Fuel contamination is a fact of life. Preventing problems and equipment damage associated with contaminated fuel is primarily the responsibility of the end user. These responsibilities include the proper and timely replacement and servicing of the filters; selection of the fuel source, grade, and blend; and use of heaters, separators, and additives as required.

Fuel filters capture unwanted contaminants from the fuel. Left unchecked, these contaminants may cause serious and expensive damage to many system components including pumps, lines, and injectors. Fuel contaminants have many sources. Most sources are external to the fuel system itself, that is, most contaminants come with the fuel that is delivered to the fuel tank. As it comes from the refinery, diesel fuel is clean. Contaminants in diesel fuel are generally introduced in fuel storage systems through mixing, transferring, and storage.

Fuel filters naturally build resistance to the flow of fuel as they go about their job of removing unwanted contaminants from the fuel system. Fuel systems, unlike lube systems, do not have the opportunity for bypass flow and consequently, as flow through the fuel filter decreases, decreased performance of the fuel system and the engine will result. Fuel filters will become restricted or plugged over their life - this is an expected result. A thorough investigation of the filter and the fuel source should be conducted anytime a fuel filter is suspected of delivering less than its expected life.

Some common contaminants found in today's fuels might include:

Water — is the greatest concern because it is the most common form of contaminant. Water may be introduced into the fuel supply during fueling when warm, moisture laden air condenses on the cold metal walls of fuel tanks or from poor housekeeping practices. The effects of water in diesel fuel can be serious. Water can cause a tip to blow off an injector, or reduce the lubricity of the fuel which can cause seizure of close tolerance assemblies such as plungers.

Once in the system, water can be removed by using water separating filters or devices. Long term prevention of problems associated with water in fuel is best accomplished by obtaining fuel from reputable suppliers capable of providing high quality fuel. Further, fuel tanks should be kept well filled to prevent condensation, and fuel should be drawn from the top of a tank if possible, as water is heavier than diesel fuel and tends to settle to the bottom of tanks.

Wax — while desirable as a source of energy in fuel, control in cold weather operation is needed. Wax crystals form as a result of cold temperature precipitation of paraffin. Temperatures below a fuel's cloud point will result in wax precipitation and filter plugging. To prevent plugged filters due to wax formation, the cloud point of fuel must be at least - 12 degrees Celsius (10º F) below the lowest outside temperature. Fuel suppliers blend diesel fuel based on local anticipated cold weather conditions. For example, fuel purchased in the West or South may not be suitable for operating conditions in the Midwest or North.

Fungus and Bacteria — these microorganisms live in water and feed on the hydrocarbons found in fuel. Called Humbugs for short, these active and multiplying colonies will spread through a fuel system and quickly plug a fuel filter. The fuel filter will have a slime coating over the entire surface of the media. Bacteria may be any color, but is usually black, green, or brown. Draining the fuel system will reduce microbial activity, but it will not eliminate it. The only way to eliminate microbial growth once it has started, is to clean and treat the system with a biocide.

Asphaltines — are components of asphalt that are generally insoluble and are generally present to some extent in all diesel fuel. These black, tarry asphaltines are hard and brittle, and are made up of long molecules. Fuel with a high percentage of asphaltines will drastically shorten the life of a fuel filter.

Sediment and other solids — often get into fuel tanks and cause problems. Most sediment can be removed by setting or filtration. Fuel filters designed for specific applications will remove these harmful contaminants before they cause further system wear and damage.

In no case should a more "open" filter be substituted to fix a perceived problem with premature plugging. Plugged filters will develop as the filter works to remove unwanted contaminants from the fuel system. Filter manufacturers design fuel filters to provide the level of filtration protection specified or required by the OEM manufacturer. Substitution of a more "open" filter may prolong a filters life before plugging occurs, but it will also allow unwanted contaminants to pass downstream which will eventually affect the life of other, more expensive fuel system components.

If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

Solving Winter Diesel Fuel / Fuel Filter Problems

Engine Power Loss
Diesel engine power loss during winter operation is a common occurrence and source of complaint. Unless there is a component failure within the engine, the problem can usually be traced back to paraffin crystal formation in the fuel which restricts flow through fuel filters. Freezing temperatures can also cause any emulsified water to form a fuel/ice slush, further restricting filters. Frequently, fuel filters are blamed for the problem when, in fact, the problem is caused by the effect of cold weather on summer grade #2 diesel. (Refer to FAQ: Heavy Duty – Diesel Fuel Filtration)

The Cloud Point is the temperature at which paraffin, which is naturally present in #2 diesel fuel, begins to form cloudy wax crystals. When the fuel temperature reaches the cloud point, these wax crystals flowing with the fuel coat the filter element and quickly reduce the fuel flow, starving the engine. Typical cloud point temperatures range from: -18°F (-28°C) to +20°F (-7°C), but may occasionally be as high as +40°F (4.4°C). #1 diesel fuel (or kerosene) contains very little paraffin, and therefore has cloud and pour points near -40°F (-40°C).

The Pour Point is the temperature at which the paraffin in the fuel has crystallized to the point where the fuel gels and becomes resistant to flow. Pour points also vary but they usually occur from 10°F (5.6°C) to 20°F (11.1°C) below the cloud point.

Solving the Problem
As long as #1 diesel or a winterized diesel blend is used during winter conditions, most fuel related winter problems can be avoided. However, encountering poor quality or unconditioned fuel is inevitable, so some precautions should be made when operating in cold weather. Depending on the severity of winter operating conditions, many operators may choose to protect their equipment through the use of fuel additives, fuel heaters, and fuel water separators.

A Word of Caution: Never add gasoline or alcohol to diesel fuel to help with cold weather operation. The practice creates an explosion danger and will damage the fuel injection system.

Cold Flow Improvers
The only way to actually lower the cloud point temperature is to dilute #2 diesel with #1 diesel or kerosene. However, this lowers the fuel heat value and can be an expensive solution. Alternately, widely available cold flow improvement additives may help delay filter plugging. They lower the pour point of diesel fuel several degrees, but do not change the cloud point temperature. Instead, cold flow improvers work by altering the paraffin crystal shapes to needle-like forms.

More of the needle-shaped crystals can pass through the filter element, slowing the plugging process.

Fuel Heaters
Heating diesel fuel above the cloud point can help avoid winter engine power loss. There are three common sources of heat energy that are available for fuel heating: electric heaters, engine coolant and return fuel heaters.

Electric Heaters come in two types, Positive Temperature Coefficient (PTC) and resistance. Because of on-vehicle power limitations, electric heating cannot sufficiently heat high fuel flows. However, if paraffin wax begins to plug the fuel filter, the flow through the filter begins to slow until the flow rate is low enough for the fuel heater to be effective, and the filter can still pass sufficient fuel to allow the engine to run and warm. This flow may not be sufficient to run the engine under load.

PTC heaters use disc-shaped heating elements that are attached to a heat sink plate which transfers the generated heat to the flowing diesel fuel. They are most effective when fuel is constantly moving over them to take the heat away. When flow stops and/or the temperature rises, PTC heaters will self regulate to a lower current draw.

Resistance heaters are like the heating elements used in kitchen ranges. These produce constant heat whether the fuel is moving or not. Blanket or wrap-around supplemental heaters are available that can be fastened to the outside of filter housings for severe weather conditions. These, however, are only energized when the vehicle is parked. They operate on 110 VAC along with engine block and tank heaters and allow easy start up in cold weather.

Engine Coolant is another source of heat energy that, through the use of a heat exchanger, can transfer excess cooling system heat to the fuel. In conjunction with electric heat at engine startup, a coolant/fuel heat exchanger can supply an enormous amount of heat to the fuel, effectively eliminating any chance of cold fuel filter plugging.

Return Fuel Heaters work by allowing the engine heated "return fuel" to enter back to the inlet side of the filter instead of directly back to the fuel tank. The warm return fuel makes up a major portion of the inlet fuel, reducing the amount of cold fuel supplied from the tank. A thermally controlled valve diverts all the return fuel to the fuel tank when the fuel in the tank is warm.

For additional information, contact:

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Administered by Motor & Equipment Manufacturers Association

Diagnosing Hydraulic Filters with Collapsed Center Tubes

Today's hydraulic systems commonly incorporate some sort of filtration in the system design. The most common filtration used in hydraulic systems involves cartridge or spin-on filter elements. When diagnosing hydraulic system malfunctions or performance problems, or when conducting routine maintenance, a review of the system's filter(s) should be conducted. If, during the inspection of the filter the element's center tube is found to have collapsed, further system inspection and servicing must be conducted.

Hydraulic systems that make use of a cartridge or spin-on filter should incorporate a filter by-pass valve that is located somewhere between the inlet and out let flow pattern of the filter. The purpose of the by-pass valve is to relieve excessive differential pressure. Differential pressure is the difference in fluid pressure between a filter's inlet (dirty) side, and the filter's outlet (clean) side. The most common cause of high differential pressure is the filter becoming filled with contamination, a condition commonly known as "plugged". As the filter's media becomes more and more contaminated, it becomes more restrictive to the flow of fluid, and thus causes an increase in differential pressure. By-pass valve settings differ from system to system. Most hydraulic systems have the by-pass valve located somewhere in the vicinity of the filter's mounting base.

If a filter is found to have a collapsed center tube, the diagnosis can be one of a by-pass valve malfunction, whether permanent or temporary. If the valve does not relieve the differential pressure, this pressure will increase to the point where center tube damage occurs. High differential pressure may also be caused by an intermittently or permanently malfunctioning fluid pressure regulating valve. If both or either of the valves malfunctions, the increased differential pressure may result in damage to the filter.

Malfunction of the by-pass valve and fluid pressure regulating valve may be caused by any one or a combination of the following:

- Sticky surfaces caused by cold hydraulic fluid
- Hydraulic fluid high in chemical contamination (water, acids, etc.)
- Improper servicing (cleaning) of the by-pass valve assembly during filter change

At times the filters used on a hydraulic system may be spin-on type filters that incorporate a by-pass valve assembly within the filter. These valves are designed to allow for the appropriate amount of flow through the filter, should the differential pressure presented to it be of sufficient quantity to activate the valve.

Hydraulic filters can be subjected to periods of very high flow. If this flow is excessive, the by-pass valve may not be able to handle all of t he flow that is suddenly presented to it. This would cause very high differential pressure. This too could cause a collapsed center tube. Additionally, this could also occur on a system equipped with a cartridge style filter. If the flow of hydraulic fluid suddenly overwhelms the by-pass valve assembly, excessive differential pressure will occur, as will possible filter damage.

High flow rates may be caused by the following:

- Malfunctioning valves or valve bodies
- Sudden shift in direction of the fluid within the system
- A rapid return of fluid to the tank (i.e., a load being dropped quickly)
- Momentary malfunction of the system's pressure regulating valve

Any time a filter is discovered to have a collapsed center tube, the system's components should be checked carefully, and serviced as necessary. In addition, the center tube collapse probably resulted in excessive contamination being presented to the entire system. We recommend that the system be serviced and cleaned thoroughly prior to the equipment being returned to use.

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Filter Manufacturers Council

Filter Knowledge, Unfiltered

Technical Service Bulletin 96-3R2

Hydraulic Filtration and Contamination

All hydraulic systems have a common need for protection from harmful contaminants. Contamination control means effective filtration. Filtering particles large enough to be harmful to your system prevents damage and allows the longest possible filter service life. Maintenance costs can be minimized through contamination control practices and proper filter application (refer to your manufacturers recommendations for your particular application).

Contaminants, the natural enemy of hydraulic systems, cause the majority of all failures. If not controlled, even particles too small to be seen can reduce hydraulic system efficiency. System efficiencies may be significantly reduced before a problem is recognized. Contamination affects hydraulic systems in many ways.

- Corrosion of hydraulic systems from acids that form due to fluid breakdown and mixing of incompatible fluids in the system
- Increased internal leakage which lowers the efficiency of pumps, motors, and cylinders. It decreases the ability of valves to control flow and pressure accurately. It also wastes horsepower and generates excess heat.
- Sticking of parts due to sludge or silting. Silting is a collection of fine particles in critical areas, which will impair proper system operation.
- Seizure of parts or components caused by large amounts of contaminants getting stuck in the clearances.

There are several major sources for system contamination.

- Contamination present at the point of manufacture
- Replacement hydraulic fluid contamination
- Environmental contamination
- System wear contamination
- Contamination introduced during the servicing process

Built-in contamination, or primary contamination, is caused during the manufacture, assembly and testing of the hydraulic components. Metal filings, small burrs, pieces of thread sealing tape (other sealing compounds), sand and

other contaminants are routinely found in initial clean up filtration of newly manufactured systems. These can be the most damaging particles to your system. Using a filter based on the manufacturers recommended filtration rating can prevent early catastrophic system failure.

Replacement hydraulic fluid is often contaminated to a level that may be higher than acceptable for most hydraulic systems. Some manufacturers address this issue by filtering hydraulic fluid prior to system filling or just "topping-off" a system. Check the hydraulic fluid to be sure it meets the latest ISO codes for the system in which it will operate.

Contamination can enter the hydraulic system fluid supply through quick couplings, rod seals, breather caps, worn cylinder rods and by other means.

The internal operation of the system generates contaminates that need to be removed. Internal components can generate minute particles that will contaminate a hydraulic system.

When systems are checked or disassembled for inspection or repair, the system is vulnerable to dust and air borne contaminates. These contaminates can adhere to filler caps, breathers, funnels, transfer pumps and replacement parts. Care must be taken during all repairs to keep the system free from contaminates.

In order to work on hydraulic systems properly and safely, you should:

- Clean exterior surfaces of dust, dirt, oil, etc. before removing covers
- Make sure new parts are clean
- Use a vigorous wash when cleaning parts
- Keep parts protected prior to assembly
- Protect system openings use covers, tape, plastic wrap, etc.
- Clean transfer containers, funnels, nozzles, etc.
- Use covers to protect drums from becoming dirty or wet around their lids
- Filter fluids before filling sumps, don't remove filler screens
- Clean filters for all hydraulic fluid handling
- Use clean-out filters to clean system after assembly

For further information about hydraulics refer to the latest FMC Technical Service Bulletins 96-1, 96-2 and 97-1.

For additional information, contact:

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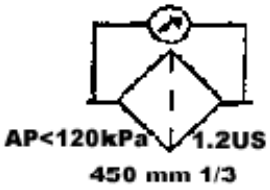
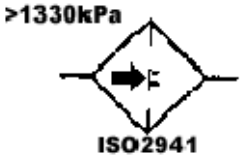
Hydraulic Filter Performance Criteria

Hydraulic or Fluid Power systems come in many sizes and shapes. They can be simple or complicated in their design, however all hydraulic systems need protection from harmful abrasive particles. Early fluid power systems were simple and filters were nonexistent. Today we see fluid power systems as fast growing and ever changing. This is due to the fact that fluid power systems are being used in place of various power transmitting devices such as belts, chains, cables, shafts, etc. Fluid power systems are becoming more sophisticated through tighter tolerances, faster cycle times and higher pressures. This puts more demand on the filtration system. The filter is a very important component in the fluid power system. System filters are becoming more efficient and more numerous. Placement of the filters in the hydraulic system is becoming more critical; strategic locations are necessary due to the sensitive, close tolerance components within the system.

To ensure that you are receiving the correct replacement filter for each of your applications, you need to review the performance criteria recommended by the original equipment manufacturer. This service bulletin can be used as a review of the requirements you may encounter and what those requirements mean to you. The four major criteria for performance are: Resistance to Flow, Collapse Strength, Structural Integrity and Capacity/Efficiency. Other criteria could be flow fatigue, hydrostatic burst, vibration durability and impulse fatigue tests.

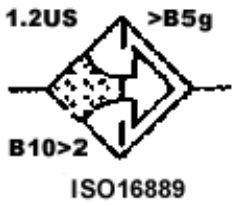


Resistance to Flow or differential pressure shows how pressure drop occurs across the filter or how much resistance to flow the filter imparts to the system. This resistance, sometimes referred to as pressure drop or delta P (ΔP), has a direct bearing on the filter life. Be sure you note the viscosity and flow of the fluid used in determining these criteria.



Collapse Strength is determined by the ISO 2941 test. Collapse strength is the minimum acceptable differential pressure at which a structural failure of the filter element and/or center tube will occur. When a filter reaches a level of plugging or a cold start occurs or a combination of both, an increase in pressure is seen between the inlet (dirty side) and the outlet (clean side). If this differential pressure is great enough, the filter element and/or center tube can rupture or collapse. This is serious because unfiltered fluid and damaged filter components can then be routed back into the system (see TSB 96-2R1 for diagnosing collapsed center tube failures).

Structural Integrity or Bubble Point is determined by the ISO 2942 test. This test ensures that the filter media does not leak due to holes or improper assembly. In this test, the filter element is submerged in test fluid and slowly pressurized until bubbles appear.



Capacity/Efficiency can be determined from the ISO 16889 Multi-pass test. This test will tell you how much contaminant the filter will retain and the efficiency of the filter in removing the contaminant. This is a laboratory test that is very difficult to compare to the real world, but it will give a relative comparison of the different filter manufacturers, if the test conditions are the same. The capacity is usually given in grams of standardized test contaminant. The efficiency is given as a Beta ratio.

Beta Ratio is a formula used to calculate the filtration efficiency of a particular filter using the data from multi-pass testing. Part of the ISO 16889 standard says the maximum reliable filtration ratio is Beta(x) = 75. This is commonly known as the "absolute" rating for the filter. Anything above Beta(x) = 75 cannot be statistically verified. The Beta(x) = 2 is commonly known as the "nominal" rating.

To convert a Beta ratio to efficiency is simple: (Beta Ratio-1)/Beta Ratio = Filter Efficiency. The Beta(x) =2 efficiency is (2-1)/2 = 1/2, the efficiency is 50%. The Beta(x) = 75 efficiency is (75-1)/75 = 74/75 = .98666 or 98.67%. The (x) after the word Beta denotes the size particle that is being considered. Therefore, Beta (10) = 4 means that the filter in question is 75% efficient at removing 10 micron size contaminants and larger from the hydraulic system (see TSB 89-5R3 and TSB 04-2R1 for further information on micron ratings and Beta ratios).

The International Rating System for fluid contamination levels is called the ISO rating code (ISO stands for The International Organization for Standardization, along with ANSI - American National Standards Institute, NFPA - National Fluid Power Association and SAE - Society of Automotive Engineers - these organizations establish standards for testing fluid power components). Most equipment manufacturers publish filtration level requirements using the ISO code. There is no direct relationship between filter manufacturers published Beta ratings that describe the media efficiency performance levels and the ISO code which describes the system cleanliness level. The ISO code for a system will be determined by oil sampling

analysis. ISO 4406 establishes a two-factor code (X/Y) to express fluid cleanliness in terms of a range of particles per milliliter. The "X" factor represents the particles larger than 5 microns. The "Y" factor represents the particles larger than 15 microns. For example, ISO code 11 has between 10 & 20 particles, 12 has 20 to 40 particles, 13 has 40 to 80 particles, each ISO number doubles the particle count per milliliter.

For additional information, contact:

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ENGINEERING BULLETIN 05-1

February 1, 2005

Medium Pressure Hydraulic Spin-on Filters

In our continuing effort to improve our products, we will begin manufacturing the medium pressure hydraulic spin-on filters with a seamless can and aluminum baseplate.

The new L-Lock™ design filters will have an o-ring gasket instead of the larger molded gasket used on current filters. **The new L-Lock design filters will need to be installed 1/2 turn after gasket contact** instead of 1 1/4 turns needed for the current product, resulting in easier installation. Also, the L-Lock design filters will be lighter in weight and have more thread engagement.

With the new L-Lock aluminum baseplate design, the threaded post on the filter base or the threads in the filter baseplate MUST be lubricated before installation to prevent thread damage.

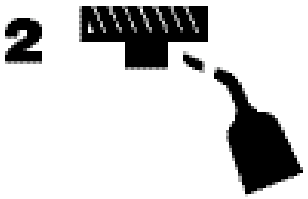
This will be a running change, so there will be no part number changes. You may see both the old design and the new design filters in the same shipment while inventories are gradually converted to the new design. The 4" diameter filters were scheduled to begin transitioning to the L-Lock design in January. The 5" diameter filters will begin their phase in to the L-Lock design in March. The hydraulic filters to be changed to the L-Lock design are listed below.

4" Diameter

BT8840-MPG	BT8847	BT8853-MPG
BT8841-MPG	BT8848-MPG	BT8855-MPG
BT8842-MPG	BT8849-MPG	BT8856-MPG
BT8844	BT8850-MPG	BT8861
BT8845	BT8851-MPG	BT8862
BT8846	BT8852-MPG	BT8863

5" Diameter

BT8870-MPG	BT8875-MPG	BT8878-MPG
BT8873	BT8876-MPG	BT8879-MPG
BT8874-MPG	BT8877-MPG	BT8880-MPG



Note: This pictogram will be added to the filter.

If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

Filter Manufacturers Council

Filter Knowledge, Unfiltered

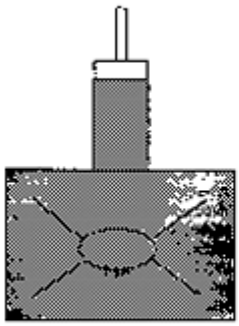
Technical Service Bulletin 96-1R1

Hydraulic Systems

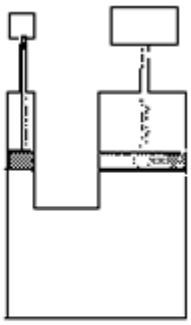
As hydraulic driven equipment becomes more sophisticated, the need increases for a better understanding of its operation and maintenance. Hydraulic systems can be either simple or complex. They can operate at high temperatures (e.g. 60°C, 140°F), pressures and rapid cycle times. We will divide the broad subject matter of hydraulics into smaller topics and cover each in separate bulletins. This will provide you with a better understanding of each subject. This opening bulletin will give you some basic understanding of hydraulics. Future subjects to be covered will include sources of contamination, filter performance indicators, hydraulic fluid additives, recycling and preventive maintenance.

To begin, the basic law of hydraulics is stated by Pascal, "pressure at any point in a static liquid is the same in every direction and exerts an equal force on all equal areas." (See Figure 1) Fluids are virtually incompressible, mechanical forces may be directed and controlled by means of fluids under pressure.

FIGURE 1



Pascal's Law: Pressure at any one point in a static liquid is the same in every direction and experts equal force on equal areas.



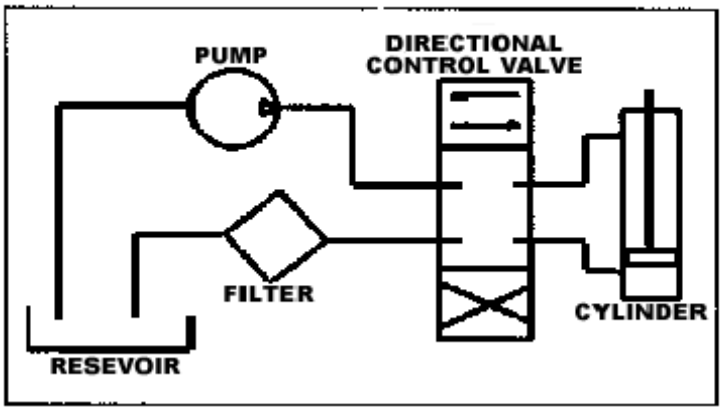
Mechanical forces can be transmitted, multiplied, and controlled by hydraulic fluid under pressure because force equals pressure times area.

Most hydraulic circuits contain five basic mechanical components: a reservoir, a filter, a pump, flow control valves, and a cylinder or actuator (see Figure 2).

There is also the hydraulic fluid to consider. No matter how sophisticated the system gets, the hydraulic fluid in the system performs four simple functions:

1. Transmit power
2. Lubricate the pump, valves and seal
3. Protect the system by removing contaminants
   - Moisture
   - Dirt
   - Heat
   - Air
4. Sealing internal components

FIGURE 2



The pressure applied to the fluid will give the fluid the power necessary to transmit a force within the system. As the sophistication of the system increases, the work required of the fluid will also increase. The fluid transmits power while it lubricates the components which it flows through. The hydraulic fluid, as a lubricant, reduces friction in the components by producing a barrier or film which separates the surfaces that will roll or slide past each other.

Viscosity is a measure of a fluid's resistance to flow. A fluid that has a high resistance to flow (high viscosity) is like cold molasses or SAE 140 weight gear oil. A fluid that has a low resistance to flow (low viscosity) is like water or SAE 10 weight hydraulic oil. Viscosity of the fluid is directly related to its ability to lubricate. A high viscosity fluid generates greater film thickness between lubricated surfaces because it has a greater resistance to being squeezed out from between the lubricated surfaces (viscosity requirements are system specific; refer to your manufacturers recommendations for your particular application). Viscosity of the fluid will change with the temperature of the fluid. Raising the

temperature of the fluid will decrease its viscosity. Conversely, lowering of the temperature will increase its viscosity.

In many instances, the fluid is the only seal against pressure inside a hydraulic component where no seal ring exists between the valve spool and body to minimize leakage from high to low pressure areas. The close mechanical fit and oil viscosity determines leakage rate.

To keep friction and wear of the system to a minimum, the proper filtration must be specified and you must use a fluid of the correct viscosity while operating the system within the proper design parameters.

For further information about hydraulics refer to the latest FMC Technical Service Bulletins 96-2, 96-3, and 97-1, as well as the NFPA (National Fluid Power Association) Publications Catalog.

For additional information, contact:

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Filter Knowledge, Unfiltered

Technical Service Bulletin 89-2R2

Incorrect Flow Direction in Liquid Filters

Normally liquid filters are designed to flow only in one direction. With few exceptions, this is from the outside in.

Incorrect flow direction occurs when the lines to a filter housing or remote mounted adapter base are reversed. This situation may occur during an overhaul and/or when a retrofit filter kit is installed. There may also be cases when the vehicle comes from the factory with an incorrect installation.

Symptoms to look for:

1. In the case of a depth-type element, media migration is possible. Usually, the element body and endcaps will be bulged and distorted, plus the oil flow/pressure may be affected due to a restricted or plugged (with media from the element) oil pump intake screen.

2. If the element contains pleated media, ruptured or distorted pleats are a possibility. In this case, the pleats will be bulged towards the outer body with contaminant buildup on the inside of the pleated media.

3. In the case of a filter with an anti-drain back valve, the oil flow may be restricted or blocked entirely. This could result in low or loss of oil pressure, plus distortion to the filter due to excessive pressure.

4. When a by-pass valve is involved, it will be inoperable. This could result in restricted and perhaps total loss of oil flow.

In all cases of incorrect flow, the element/filter performance (efficiency, capacity and resistance to flow) will be affected, which could result in equipment damage.

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Revised October 2005

BALDWIN FILTERS
a CLARCOR company

ENGINEERING BULLETIN 98-6

June 16, 1998

Oil Analysis: Using the Results

Effective oil analysis is the best method to accurately determine maximum oil and filtration service intervals. Oil analysis consists of various tests performed on each sample of oil returned to the laboratory. The results of these analyses, when compared, reveal lubricant condition, contamination levels, and wear rates of oil-lubricated components.

The results of an oil analysis provide information about several characteristics of the oil. An understanding of these results helps get the most life out of the oil. The characteristics of the oil that should be monitored, as recommended by most oil companies and other sources that offer oil analysis, are: viscosity, fuel dilution, water and/or coolant (ethylene glycol), total solids, and spectrographic analysis.

Viscosity is the most important single property of lube oil. In used oil analysis, the test is performed to determine whether the oil has thickened or thinned excessively. Abnormal results indicate that some operational or maintenance defect exists that should be corrected.

Fuel Dilution is the most common cause of oil thinning in diesel engines. Excessive fuel dilution is caused by improper operation, such as extended idling, low compression, and/or defects in the fuel delivery system. The results of fuel dilution are reported as percentage by weight or volume.

Water can contaminate diesel engine crankcases as a product of combustion or due to coolant leaks. Water contamination is very seldom found in diesel engine oil samples. Engines that operate for long periods of time create enough heat to evaporate contaminating water. Most engine manufactures set a maximum limit of 0.2% water contamination in their engines. However, evidence of ethylene glycol in crankcase oil indicates that coolant is leaking into the lube system and warrants corrective action.

Total Solids, the quantity of insoluble material in the oil, is a good general indicator of lubricant contamination level. Fuel soot normally accounts for most of the material measured in the solids test. Limits should be furnished by individual laboratories since test procedures and results vary considerably from one lab to another.

Spectrographic Analysis assists in identifying abnormal internal wear, coolant leaks, and dirt contamination. Results are usually reported in parts per million.

Accurate interpretation of test data is one of the most important parts of any oil analysis program. Continued use of test data and lab recommendations helps to provide users with an in-depth understanding of the test results. The user can combine lab results with maintenance history to derive a clear view of engine condition.

**If you have further questions,
please contact our
Service Engineering Team at (800) 822-5394.**

Spin-On Engine Oil Filter Applications

Spin-on filters are still the most popular design for liquid filtration on internal combustion engines. The spin-on design offers an efficient, quick and clean method for servicing liquid filters. The spin-on is by far the preferred method of filter design on automobile and mobile heavy duty equipment.

Over the years, a proliferation of filter sizes has evolved. These include length, diameter, sealing gasket diameter and thread size variation. The internal design of spin-on filters also vary. Some designs utilize internal by-pass valves and/or anti-drain back valves. Filtration media used in different models also vary depending on different service and engine requirements. Operating pressure requirements can also differ from model to model.

With all the different spin-on filter models available in the market today, the user must use extreme caution not to use a wrong filter for their particular application. There are filters that look alike and may even fit different engine mounting bases with the same thread size. However, this does not constitute and guarantee that the correct filter is being used. Mis-application problems could be very serious. Wrong thread size is one of the common mistakes. Failure to use the recommended filter with the correct thread size could result in improper mating of the filter to mounting base. A loose thread fit may cause a leak, back-off, fatigue failure or loss of filter. Any of these cases can cause engine damage or fire. A "tight" thread fit can cause leakage, thread seizure or cross threading, resulting in damage to the engine mounting base and filter. A multitude of thread sizes are used in spin-on filters. Both metric and United National threads are widely used. Some of the metric and United National threads are close in size to the U.S. threads and a spin-on filter may "fit" a mounting base and yet have a different thread than the base. The Society of Automotive Engineers (SAE) has published a Recommended Practice that identifies dimensional characteristics and mounting configurations of filter base mountings. This Recommended Practice, SAE J-363 lists the thread sizes of the more commonly used spin-on filters and their recommended application.

Other considerations of mis-application include getting the wrong combination of by-pass settings, anti-drain back valves, filterability characteristics, operating pressure, sealing gasket diameter, interference and by-pass valve elimination. Failure to use the filter recommended by the filter manufacturer could interfere with proper engine protection.

Filter design and application is a complex process requiring the proper order of components. Don't take the chance of altering this order which could result in equipment damage or hazardous operation. The key to eliminating these problems is application. Be sure that the source of recommended application is a correct one. Filter manufacturers' application recommendations should be followed.

When it comes to choosing the correct filter, one cannot solely rely on cross-reference, "fit" or "feel". Verify application information according to the filter manufacturer's catalog.

For additional information, contact:

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Filter Knowledge, Unfiltered

Technical Service Bulletin 88-3R2

Diagnosing Engine Oil Filters With Collapsed Center Tubes

When a collapsed center tube or element is discovered, the natural tendency is to assume something is wrong with the filter (Fig. 1). This is not the case, but is a symptom of problems with internal engine components.

Most engines incorporate within the oiling system a by-pass valve across the inlet and outlet of the full flow oil filter. The valve is designed to open and by-pass oil around the filter and/or element when the restriction reaches its opening pressure (Fig. 2). The by-pass flow circuit insures oil flow to the engine when there is a significant restriction across the filter due to plugging or cold start conditions. Typically, engine manufacturers design by-pass valves to open at a pressure differential of approximately 10 to 30 psid with some as low as 4 psid (28 kPad), with some opening as high as 75 psid (500 kPad). Some engine manufacturers have the by-pass valve located in the filter mounting base on the engine, while others locate the valve in the filter. Either way, the same purpose is served.

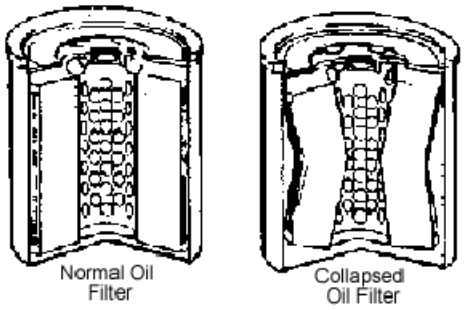

FIGURE 1

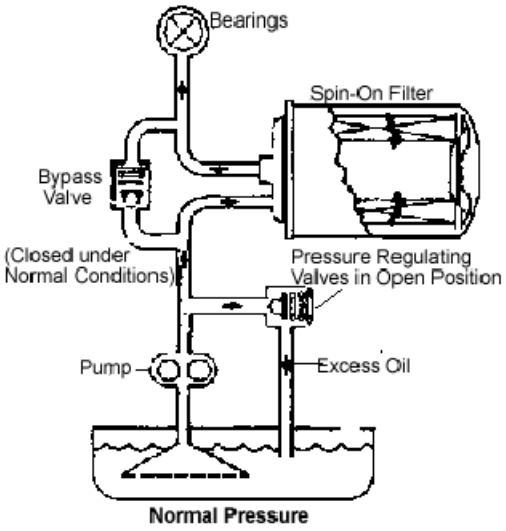

FIGURE 2

Oil filters are designed to withstand, without collapsing, differential pressures significantly greater than those experienced under normal operating conditions.

Therefore, when a center tube or element has collapsed, it is usually the result of a "sticking" or otherwise malfunctioning by-pass valve.

A collapsed center tube or element can lead to a loss of filtration and oil flow to the engine. There is the possibility that interior parts of the filter or filter media may be physically displaced and could migrate into the oiling system interfering with the oil flow.

The malfunction of the filter by-pass valve, as well as the subsequent collapse of the center tube or element, may not be visually apparent. However, a catastrophic failure of the engine may result due to the seizure of a piston, connecting rod, or main crankshaft bearings among other failure possibilities.

The malfunction of filter by-pass valves and pressure regulating valves has been traced to:

- sticky surfaces caused by cold, highly viscous oil;
- oil contaminated by excessive condensation, coolant, or oxidation;
- improper oil drain and filter change intervals;
- carbon grit that temporarily jams a valve;
- sudden acceleration of the engine with any of the above conditions.

An oil filter with a collapsed center tube or element indicates a malfunction within the system. Inspection of the system and a review of the engine’s performance and maintenance history should be conducted.

For additional information, contact:

Filter Manufacturers Council
P.O. Box 13966
Research Triangle Park, NC 27709-3966
Phone: 919/406-8817 Fax: 919/406-1306
www.filtercouncil.org
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Oil Pump Prime

Immediately after an oil change, one of the most confusing issues to face the typical do-it-yourselfer or professional mechanic is lack of oil pressure on engine start-up.

Although not a common occurrence, it is possible that the oil pump may lose its prime during the oil change.

When the used engine oil is drained from the engine, the oil may also drain from the oil pump pickup tube and possibly from the oil pump itself. When new engine oil is added, the pump's pickup tube inlet again becomes submerged, trapping air in the tube on the suction side of the oil pump. The trapped air will cause cavitation of the pump and prevent it from producing oil flow and subsequent oil pressure. The low oil pressure light will remain on or the oil pressure gauge will register little or no pressure when the engine is started.

Many installers tend to blame this on the oil filter and assume that the filter is blocking the flow of oil. Since the filter is now suspect, the installer will install a second filter. Sometimes this solves the problem because the trapped air was released when the first filter was removed. In such a case, the oil filter is not the problem; often there is a simple solution.

If the low oil pressure light remains on or the oil pressure gauge reads little or no pressure within 30 seconds of engine start-up, stop the engine. Remove the filter and fill with clean oil (if possible) and reinstall. Oil pressure should return to normal within ten seconds after starting the engine. If the above procedure fails, it may be necessary to remove the filter and use an oil squirt can, with clean engine oil, to squirt oil into the oil filter's mounting base inlet hole, which is adjacent to the threaded mounting stud. Next reinstall the filter. This should prime the pump.

Replacing the oil in the crankcase immediately after draining will prevent the oil pump from losing its prime.

Make sure the oil filter is installed correctly. Printed installation instructions will be found either on the filter itself or on the filter box.

For additional information, contact:

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Filter Manufacturers Council

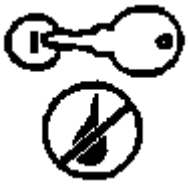
Technical Service Bulletin 99-3R1

Universal Oil Filter Installation Symbols

The symbols in this bulletin are offered as a standard that may be adopted independently by filter manufacturers in order to provide a uniform graphical representation of various steps used to properly install oil filters. The filter installation steps represented by these symbols are provided in multiple languages to assist installation in numerous market regions.

1. 	English Spanish French German Italian Dutch Portuguese Japanese	Clean filter base Limpie la base de montaje del filtro Nettoyez la base du filtre Filteranschraubflaeche reinigen Pulire la base del filtro Filterbasis reinigen Limpe a base do filtro フィルター底を拭きます。
2. 	English Spanish French German Italian Dutch Portuguese Japanese	Seat gasket Coloque el empaque Inserez le joint Dichtung einsetzen Inserire la guarnizione Pakking plaatsen Coloque a gaxeta / junta de vedacáo ガスケットを取付けます。
3. 	English Spanish French German Italian Dutch Portuguese Japanese	Fill filter with oil Ponga aceite en el filtro Remplissez le filtre d'huile Filter mit Oel befuellen Riempira il filtro dell 'olio Filter met olie vullen Ponha óleo no filtro フィルター—にオイルを給油します。

4. 	English Spanish French German Italian Dutch Portuguese Japanese	Oil gasket Aceite el empaque Lubrifiez le joint Dichtung einoelen Lubrificare la guarnizione Pakking olien Lubrigique o filtro com óleo ガスケットにオイルを塗ります。
5. 	English Spanish French German Italian Dutch Portuguese Japanese	Hand tighten Apriete a mano Serrez á la main Mit der Hand anziehen Avvitare a mano Vastschroeven met de hand Apoerte com a máo 手でしっかり閉めます。
6. 	English Spanish French German Italian Dutch Portuguese Japanese	Complete tightening Apriételo Totalmente Reserrez completement Vollstaendig anziehen Stringere forte Volledig vastschroeven Aperte-o totalmente 最後までしっかり閉めます。
7. 	English Spanish French German Italian Dutch Portuguese Japanese	Fill engine with oil Ponga aceite al motor Remplissez le monteur d'huile Ol nachfuellen Riempira il motore dell 'olio Olie in de motor doen Ponha óleo no motor エンジンタンクに給油します。
8. 	English Spanish French German Italian Dutch Portuguese Japanese	Check oil level Revise el nivel de aceite Verifiez le niveau d'huile Oelstand pruefen Controllare la pressions dell 'olio Oliepeil controleren Meça o óleo オイルを確認します。

9. 	English Spanish French German Italian Dutch Portuguese Japanese	Start engine, check for leaks Arranque el motor, revise fugas Demarrez le moteur, verifiez les fuites Motor anlassen und auf undichte Stellen überprue fen Avviare il motore, controllare le perdite Motor starten, controleren naar lakken Arranque o motor / verifique vazamentos エンジンをかけてオイル漏れしないか確認します。
10. 	English Spanish French German Italian Dutch Portuguese Japanese	Check oil pressure Revise la presión del aceite Verifiez la pression d'huile Oeldruck pruefen Controllare la pressions dell 'olio Oliedruk controleren Verifique a pressáo do óleo 油圧をチェックします。
11. 	English Spanish French German Italian Dutch Portuguese Japanese	Please recycle Por favor recicle Recyclez s'il vous plait Bitte wiederverwerten Per favore reciclare Gelieve te recycleren Por favor, recicle オイルフィルターはリサイクルしましょう。

For additional information, contact:

Filter Manufacturers Council
P.O. Box 13966
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Used Filter Recycling Hotline: 800/993-4583
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The Micron Rating for Media in Fluid Filters

A micron rating for a fluid filter is a generalized way of indicating the ability of the filter's media to remove contaminants by the size of particles it is exposed to. The micron rating does not properly or fully describe either the efficiency or the contaminant-holding capacity of the filter media. **ENGINE AIR FILTER MEDIA IS NOT RATED BY MICRON SIZE.** (Refer to TSB 04-3, Air Filter Life and Efficiency Ratings)

What does the word micron mean? The word micron is another term for micrometer (1 millionth of a meter). A micrometer is a unit of linear measure in the metric system used to measure distance from one point to another. It is used like the inch, foot, centimeter and millimeter to measure length, width or diameter of objects. Its scientific notation is µ. Some linear equivalents are 1 inch is 25,400 microns and 1 micron is .000039 inches. Some comparative sizes are:

Diameter of average human hair 70 microns
Lower limit of visibility (naked eye) 40 microns
White blood cells 25 microns
Talcum powder 10 microns
Red blood cells 8 microns
Bacteria 2 microns
Carbon black 0.6 microns
Tobacco smoke 0.5 microns

A filter that is marked or rated "10 micron" has some capability to capture particles as small as 10 micrometers. However, when you see a filter marked "10 micron", you do not know exactly what this means unless you also have a description of the test methods and standards used to determine the filter rating. The results from the different test methods may not be comparable as their methodology varies greatly.

The two most popular reported media ratings are a nominal micron rating (50%) and an absolute micron rating (98.7%). A nominal rating usually means the filter's media can capture a given percentage of particles of a stated size. For example, a filter might be said to have a nominal rating of 50% for particles 10 micrometers in size or larger. An absolute micron rating can be determined by single-pass or multi-pass testing and is usually obtained by passing a test fluid containing particles of a known size through a small, flat sheet of filter media. Any particles

that pass through the media are captured and measured. An absolute rating is also expressed in the form of a percentage of the size of particles captured.

Until recently, there has not been one universally accepted test method to measure or describe the media pore size or the size of particles a filter media can capture and hold. Depending on which test method was used, the same filter media could be rated with different micron ratings, thus leading to confusion regarding how well the filter's media actually performs. Fortunately, there now exists a test procedure called multi-pass testing or Beta ratio testing (β) which is, a universally accepted test method that yields readily comparable test results. Multi-pass testing has been recognized by SAE (SAE J1858), ISO (ISO 4548-12, lube oil and ISO16889, hydraulic or fuel), ANSI (American National Standards Institute) and NFPA (National Fluid Power Association).

Multi-pass testing uses a specified contaminant, of known sizes, added regularly in measured quantities to the fluid which is pumped continuously through the filter. Measured samples of fluid are then taken at timed intervals from the upstream and downstream sides of the filter. The contaminant in the samples is measured for particle sizes and quantities of each size or range of sizes. From these upstream and downstream measurements, a Beta ratio is formulated by dividing the number of particles of a particular size in the upstream flow by the number of particles of the same size in the downstream flow.
For example:

$$\beta_x = \frac{\text{\# of particles upstream}}{\text{\# of particles downstream}}$$

β stands for Beta
X represents the size of particle checked
$X_{(c)}$ per ISO 16889

$$\beta_{10} = \frac{1{,}000}{500} \quad \text{or} \quad \beta_{10} = 2$$

In this example, the equation provides the following information: regarding 10-micrometer or micron size particles, the filter media tested has a Beta ratio of 2. This information is helpful but not useful without knowing what the ratio actually means. To translate the Beta ratio into meaningful information, subtract 1 from the original ratio and divide that answer by the original ratio. This answer represents the efficiency of the media at the specified particle size. For this example, take the Beta ratio of 2, subtract 1 from it and divide that answer by the original ratio of 2 or 2 - 1 = 1 ÷ 2 = 50% efficient at removing 10-micrometer or micron size particles. This formula is used to translate any Beta ratio into a percent efficiency at removing the size of particle tested. Here are a few Beta ratios and their corresponding efficiencies:

Beta Ratio	Efficiency
2	50%
10	90%
20	95%
75	98.7%
100	99%
200	99.5%
1000	99.9%

Beta ratio information can also be stated as $\beta_{5/10/20}$ = 2/20/75. In this example, the media tested removed 50% of 5-micrometer or micron size particles, 95% of 10-micrometer or micron size particles and 98.7% of 20-micrometer or micron size particles presented to it. This same ratio information can also be stated as β 2/20/75 = 5/10/20. Both equations state the same information in two different ways and are both accepted by the industry.

Multi-pass testing provides an accurate, universally accepted, comparable test method to describe the efficiency of a media's ability to remove certain size contaminants. It can also determine the total contaminant holding capacity of the filter as well as some of its differential pressure capabilities. Its use eliminates the inaccuracies and confusion caused by the use of "micron ratings". For further information, see TSB 97-1R1, Hydraulic Filter Performance Criteria and TSB 04-2R1, ISO Updates to Multi-pass Liquid Filter Test Procedures.

For additional information, contact:

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BALDWIN FILTERS
a CLARCOR company

ENGINEERING BULLETIN 95-11

November 14, 1995

Filter Performance and Micron Ratings

Micron Ratings are arbitrary values assigned to filters or media. Although a "micron" is a length (1 millionth of a meter), a "micron rating" is not actually a measured value. The micron rating for a filter quotes a particle size without establishing the filter's efficiency at removing that size of particles. A window screen will remove some 5 micron particles, but it will not be very efficient. Since a micron rating cannot be verified, filter manufacturers are safe in assigning any number that they want. Baldwin does not recommend comparing filters based on micron ratings.

To compare filters, the filter industry has established standardized tests for measuring performance. These tests include Life and Efficiency Tests (SAE J726, J806, and J905) and Beta Ratio Tests (SAE J1858). These SAE standardized test methods, along with the meticulous recording of test conditions, ensure that filter comparisons are "apples to apples."

Life and Efficiency Tests measure the filter's ability to remove a standardized contaminant from a standardized fluid that is flowing at a constant rate and a constant temperature. The test continues until the contamination trapped in the media raises the differential pressure drop across the filter to a specific, predetermined level. Life and Efficiency Test results will include a Time Weighted Efficiency (%) and a Capacity (grams).

Beta Ratio Tests are by far the most accurate and objective way to compare the performance of filters. A Beta Ratio Test measures a filter's ability to remove particles of given sizes. In other words, the test measures the filter's efficiencies at specific particle sizes. The beta ratio test equipment actually counts the particles in the fluid before the filter and after the filter. This ratio is the Beta Ratio.

$$ß = \frac{Particles\ Upstream}{Particles\ Downstream} = \frac{20{,}000\ particles}{1{,}000\ particles} = 20$$

The beta ratio will generally be between 1 and 75. Beta ratios can also be converted to efficiencies using the following formula:

$$\left(\frac{ß - 1}{ß}\right) x\ 100 = Efficiency\ (\%)$$

Examples:

$ß_{10} = 2$: (2-1) / 2 x 100 = 50.0% efficient for 10 micron particles.
50% efficiency is generally considered nominal.

$ß_{15} = 75$: (75-1) / 75 x 100 = 98.7% efficient for 15 micron particles.
$ß = 75$ is generally considered absolute.

In summary, equipment owners should consider several factors when choosing filters for their applications. For best results, customers should consult the latest edition of the Baldwin Applications Book and Cross-Reference Product Guide and select filters based on Original Equipment Manufacturer (OEM) part numbers. When comparing filters, the questionable nature of micron ratings encourages users to try to obtain standardized test information for apples-to-apples product comparisons.

If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

Filter Manufacturers Council

Technical Service Bulletin 97-8R1

The Impact of Dents on Canister Filters

Filter manufacturers often receive used filters involved in warranty investigations due to a crack in a filter canister. In many cases the crack is located within or near a dent in the canister. This evidence predominantly indicates that the dent caused the crack and that the failure was not within the control of the filter manufacturer. Once the steel canister is dented, a concentration of stress in the canister material is created, making the canister more susceptible to fatigue.

The fatigue to the material results from the pressure pulses within the system. The pressure is regulated by a pressure regulating valve. This valve is spring operated and intermittently opens and closes to regulate the pressure. Once the pressure exceeds the setting of the spring in the regulating valve, the valve will open and relieve pressure until the spring can expand and close the valve. This function is repeated continuously during the operation of the system, creating a pulsing effect. The canister of the filters is subjected to the same pulsation. However, unlike the spring in the pressure regulating valve, the canister material is susceptible to failure after such fatigue.

Filters are designed with a low carbon steel to resist fatigue and are formed so the stress created by the pulses in the system are equalized over the surface area of the canister. A dent provides an area of stress concentration from pressure pulses and can greatly shorten the fatigue life of the canister.

Filters that are dented prior to or during installation should not be used. Filters dented after installation should be replaced immediately. The cost of replacing a dented filter is much less than the cost of the damages that could result from a dented filter that fails during service. If you receive filters that were dented prior to your receipt, you should contact your filter supplier for corrective action.

For additional information, contact:

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BALDWIN FILTERS
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ENGINEERING BULLETIN 99-4

July 29, 1999

Installation Instructions for Spin-On Filters

The spin-on filter is replaced more often than any other service part on your vehicle or equipment. To ensure normal filter service life and prevent leakage or possible damage to the application, proper filter installation is very important. However, filter replacement is often considered to be a minor service procedure and proper installation may be overlooked.

The following procedure should be followed when replacing spin-on filters.

1. Remove the installed filter using a filter wrench, if necessary.
2. Clean mounting base, making sure the old filter gasket is not stuck to the base.
3. Apply a light film of clean oil to the new gasket. Note: Never use grease to lubricate the gasket.
4. Spin the new filter on carefully, avoiding cross threading. Some engine manufacturers may recommend pre-filling the filter.
5. After the sealing gasket contacts the mounting base, tighten the filter the required number of turns per the instructions found on the filter, box, or service manual.

If there is any uncertainty about how much the filter needs to be turned, the use of an index mark may be beneficial.

The procedure would be as follows:

1. Spin the filter on by hand until the gasket makes contact with the surface of the mounting base.
2. Place an aligned index mark on the mounting base and the filter.
3. Turn the filter to the proper amount specified on the filter, box, or service manual.

Example: If one full turn is recommended after gasket contact, tighten the filter until the index mark on the filter is re-aligned with the index mark on the mounting base. This will ensure that the filter is properly tightened to the mounting base. Keep in mind that on some applications (especially heavy-duty applications) a filter wrench may be necessary. DO NOT OVER TIGHTEN. Over tightening is not necessary or beneficial.

Occasionally, there are concerns about damaging the threads on the stud of the mounting base. This condition could occur if extreme force is applied and the filters are over tightened over a period of service intervals. When using a filter wrench, utilize caution to prevent damaging the filter canister.

If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

Filter Manufacturers Council

Filter Knowledge, Unfiltered

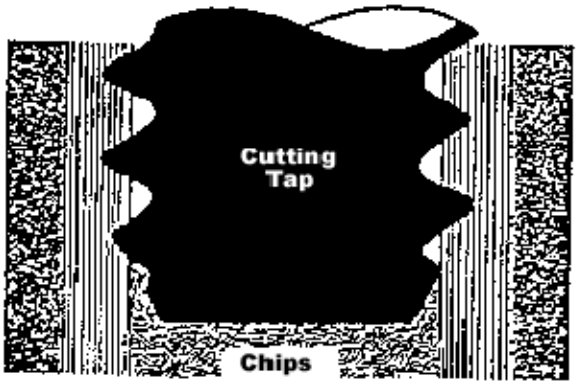
Technical Service Bulletin 94-3R2

Spin-On Filter Threads

The spin-on filter has become the most popular and widely applied design for liquid filtration products. Among other physical and performance differences, today's spin-on filters are manufactured with a variety of different thread sizes. Threads in the filter's baseplate are designed and manufactured in accordance with the Unified Screw Thread System. The Unified Screw Thread standards were established in 1948 to provide internationally accepted basic thread standards for an integrated system of threads for fastening purposes in mechanisms and structures.

Spin-on filters are manufactured with specifically sized internal threads in their baseplate. Filter threads are produced by one of two manufacturing methods. These methods are commonly called cut or formed (rolled). Both processes produce threads by inserting a high speed tap into a preformed hole. Rolled threads and cut threads gauge identically and are completely interchangeable. The difference between the two threads is the way they are produced. The forming tap used to produce rolled threads displaces the metal in the hole while cut threads utilize a tap that removes metal.

Whether cutting or rolling threads, the hole must be the proper size in order to attain the correct thread height percentage and specified minor diameter. The preformed hole should be sized so the thread percentage is between 60 to 75%. Threads produced with a height above 75% require excessive tapping torque, results in accelerated tap wear, increases the incidents of tap breakage and may also result in engagement interference when installation is attempted. Further, thread strength studies and tests have proven that there is no appreciable increase in thread strength with an increase in thread percentage above 60%.



While many people's perception is that cut threads come to a point at their crest, in actuality, the crest of a properly cut and sized thread is flat. In order for a cut thread to have a pointed crest, it would be necessary for the thread to be 100% height and the cutting tap minor diameter root shaped in a "V" and sharp enough to cut the metal.

The height of a thread is determined by the size of the preformed hole. With cut threads, the preformed hole size will be the minor diameter of the thread. If the hole is the same size as the tap's minor diameter, the thread would be produced at 100% height. As previously mentioned, thread height of 100% is not necessary or desirable. Therefore, the size of the preformed hole must be larger than the tap's minor diameter by enough to produce 60 to 75% height of thread.

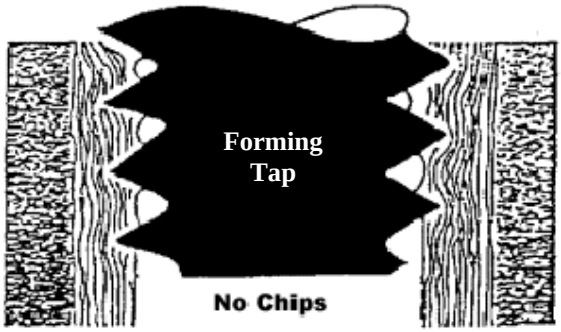
Forming threads offers many advantages over cutting threads. One of these advantages is the fact that rolled threads are cleaner since the forming tap displaces metal and no metal chips or fragments are produced. Cutting taps produce metal chips that may interfere with the tapping process, cause poor tap lubrication and tap binding or breakage. Additionally, chips produce by a cutting tap must be removed from the baseplate and thread area before the filter is assembled. Because of the absence of chips, forming taps are far less likely to bind or break and are designed without flutes making them much stronger than a cutting tap. Forming taps do not have a cutting edge that can become dull. These characteristics result in tap life of 3 to 20 times longer and a production speed of 1.5 to 2 times faster than cutting taps.

Because of the difference in the way they are made, rolled threads require a larger preformed hole size than cut threads. Unlike cut threads, the preformed hole size for rolled threads is not the minor diameter of the finished thread. The preformed hole size is a standard diameter specified by the design size of thread being produced and the percent of thread desired.

Rolled threads are generally stronger than cut threads due to cold working of the metal in conjunction with the fact that the grain flow of formed threads follows the

contour of the thread. Further, primarily because metal is not cut away, rolled thread production greatly decreases the possibilities of producing oversized threads.

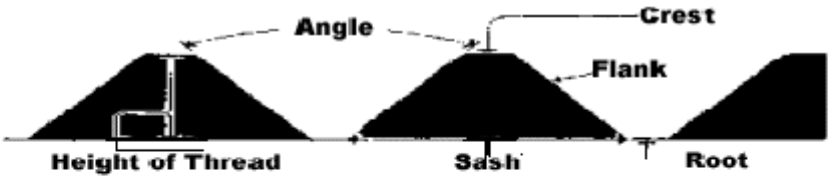
One of the most commonly misunderstood characteristics of rolled threads is the "dip" or "cup" in the crest of the thread. Since forming taps rearrange the metal and the proper height of the thread is between 60 to 75%, the crest of rolled threads have a concave shape due to the flow of the metal. When observed by one not familiar with thread formation or type, the concave crest of a rolled thread is often interpreted as thread damage and/or a manufacturing error.

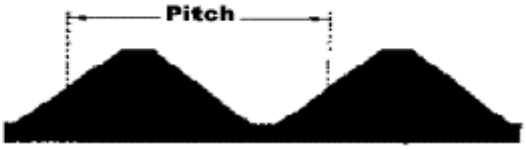


Thread terminology has also been somewhat standardized. Some of the more common terms and definitions are:

ALLOWANCE: The intentional or prescribed difference between the thread design size and the thread basic size.
ANGLE: The angle included between the flanks of the thread, measured in an axial plane.
BASE: The bottom section of a thread.
BASIC SIZE: The theoretical control point or base from which size measurements and the limits of allowances and tolerances are calculated. Basic size is based upon a full 100% height thread.
CREST: The top surface joining the two flanks of a thread. The crest of an external thread is at its major diameter. The crest of an internal thread is at its minor diameter.
DESIGN SIZE: The basic size with allowance applied and from where the limits of size are derived by the application of a tolerance.
EXTERNAL THREAD: A thread rising up from the external surface of cylindrical or conical structure. An example of external thread is the mounting stud on the engine filter mounting base.
FLANK: The surface of the thread which connects the crest with the root.
HEIGHT OF THREAD: The distance between the crest and the base of thread measured normal to the axis. Height of thread is described as a percentage of a full (100%) thread.
INTERNAL THREAD: A thread on a cylindrical or conical internal surface. An example of internal thread would be the threads in the baseplate of a spin-on

filter.
MAJOR DIAMETER: The largest diameter of a straight thread.
MINOR DIAMETER: The smallest diameter of a straight thread.
PITCH: The distance from a point on a screw thread to a corresponding point on the next thread, measured parallel to the axis and on the same side of the axis. The pitch equals one divided by the number of threads per inch. For metric threads it is the number following the major diameter size. (expressed in millimeters)
ROOT: The bottom surface joining the flanks of two adjacent threads. The root of an external thread is at its minor diameter and the root of an internal thread is at its major diameter.
THREADS PER INCH: The number of threads in one inch of length.
THREADS PER MILLIMETER: The number of threads in one millimeter of length.
TOLERANCE: It is not possible to reproduce in exact detail, the theoretically perfect size threads as drawn on a design print or as detailed in the basic size. Therefore, a slight variation between the theoretically perfect threads and each unit of actual production is allowed and expected. The total amount by which a specific dimension is permitted to vary is called the tolerance.





ROLLED VS. CUT THREAD DIAGRAM

ROLLED THREAD DETAIL

CUT THREAD DETAIL

For additional information, contact:

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BALDWIN FILTERS
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ENGINEERING BULLETIN 98-5

May 19, 1998

Substituting Filters

Today there is an ever increasing number of filter applications in automotive, heavy-duty and industrial businesses. This, of course, results in larger inventories for filter manufacturers and distributors. This situation may make some distributors want to consolidate filters to reduce the number of filters that they must inventory.

While there are many filters that seem similar and may, in fact, fit some of the same applications, we strongly recommend exercising caution when making such substitutions. The internal components of certain filters may differ while the filters appear to be identical. The internal components include: anti-drainback valves, by-pass valves, post seals and filtering elements among others. Each of these components has a specific purpose in the function of the filter. Each of these items must be considered when substituting filters to assure that the performance of the required filter is not impaired.

A difference as simple as the setting of the by-pass valve, with all other components being the same, can affect the protection the filter provides for the equipment. Baldwin Filters evaluates the filters recommended by the original equipment manufacturers to design the proper Baldwin replacements. Our engineering practices assure that our filters meet or exceed the performance requirements of the respective original equipment manufacturers. These measures enable Baldwin Filters to provide warranty on the applications of our filters without affecting the original equipment manufacturer's warranties.

Substituting filters with "will fit" replacements that are not listed by the application can affect or even void the warranties on the filter and the equipment. Use only the product specified in the current Baldwin Cross-Reference and Application guides to assure the proper filtration performance is achieved.

**If you have further questions,
please contact our
Service Engineering Team at (800) 822-5394.**

Non Serviceable Transmission Filters

Automatic transmissions are becoming more complex every year. Once controlled by vacuum, modern transmissions have been transformed into computer command centers made up of various solenoids and other electronic gadgetry that control the operation of the transmission.

New technology brings changes to transmission filter service maintenance. Some manufacturers require literally no scheduled maintenance. Several auto manufacturers have no scheduled maintenance until the vehicle has 100,000 miles on the drive train.

Non serviceable transmission filters were introduced in the 70s. Almost every manufacturer now has a transmission that is non serviceable. Caution and care must always be taken when replacing any transmission filter. The non serviceable ones require extreme scrutiny. Non serviceable transmission filters consist of four different styles. Almost every automatic transmission has a filter that could be replaced. The term non serviceable means that a partial or total disassembly of the transmission and other related internal parts is required for filter service.

The first style is one that does not have the traditional pan. The transmission case consists of two pieces split vertically. For any internal repairs (including filter replacement) the transmission needs to be removed and disassembled into the two halves.

The second style has a primary filter located internally and one or more secondary filters accessible through a gasket sealed pan. Replacing the primary filter would require partial or total disassembly of the transmission.

The third style has the primary filter located internally, and an external accessible filter. Two examples would be either an external spin on or a cooler line style filter. Replacing the primary filter, would require partial or total disassembly of the transmission.

The fourth style also contains a pan and gasket. Special circumstances are attached to this filter replacement. A valve body or other parts may need removal with the filter. Sometimes this type may appear simple to an inexperienced individual trying to change the filter. Many problems could occur when attempting to change the filter. Loose nuts, mis-adjustment, and internal component

damages are just a few of the problems associated with servicing this type of transmission. Attempting to change the filter on this type of transmission could lead to a shorter life of the transmission, a premature break down, or a major overhaul.

Before changing any transmission filter, (especially late models) always refer to the instructions when included in the kit or the manufacturer's service manual for proper filter service.

For additional information, contact:

Filter Manufacturers Council
P.O. Box 13966
Research Triangle Park, NC 27709-3966
Phone: 919/406-8817 Fax: 919/406-1306
www.filtercouncil.org
Administered by Motor & Equipment Manufacturers Association

Filter Knowledge, Unfiltered

Technical Service Bulletin 85-1R2

Manufacturers' Warranty

Consumer purchasers of filters are sometimes told that an aftermarket brand of replacement filter cannot be used in the consumer's vehicle during the warranty period. The claim is made that use of an aftermarket brand will "void the warranty," with the statement or implication that only the original equipment brand of filters may be used. This tends to cast doubt on the quality of the aftermarket filter.

That claim is simply not true. If the consumer asks for the statement in writing, they will not receive it. Nevertheless, the consumer may feel uneasy about using replacement filters that are not original equipment. With the large number of consumers who prefer to use an aftermarket filter this misleading statement should be addressed.

Under the federal Magnuson-Moss Warranty Act, the Clean Air Act and general principles of the U.S. Federal Trade Commission Act, a manufacturer may not require the use of any brand of filter (or any other article) unless the manufacturer provides the item free of charge under the terms of the warranty.

If the consumer is told that only the original equipment filter will not void the warranty, they should request that the OE filter be supplied free of charge. If they are charged for the filter, the manufacturer may be violating the Magnuson-Moss Warranty Act or other applicable law.

By providing this information to consumers, the members of the Filter Manufacturers Council (FMC) intend to combat the erroneous claim that the use of a brand of replacement filter other than original equipment will "void the warranty."

It should be noted that the Magnuson-Moss Warranty Act is a U.S. federal law that applies to consumer products. The U.S. Federal Trade Commission has authority to enforce the Magnuson-Moss Warranty Act, including obtaining injunctions and orders containing affirmative relief. In addition, a consumer can bring suit under the Magnuson-Moss Warranty Act.

For additional information, contact:

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BALDWIN FILTERS
a CLARCOR company

ENGINEERING BULLETIN 94-8

May 17, 1994

Use of Baldwin Products in Aircraft Applications

Frequently we are asked if Baldwin products may be used in aircraft applications - the answer is no!!

No Baldwin product is designed or manufactured for any aircraft application. Furthermore, no Baldwin products are approved by the FAA for these applications.

While it may be tempting or possible to find a Baldwin product which appears to fit in an aircraft application, don't do it. Our warranty will not apply, and any liability which might result should a failure of any type occur, would not fall upon Baldwin. As stated in our catalog, we cannot be responsible for misapplications, and we advise our distributors to follow this guideline also.

**If you have further questions,
please contact our
Service Engineering Team at (800) 822-5394.**

BALDWIN FILTERS
a CLARCOR company

ENGINEERING BULLETIN 94-1

January 11, 1994

Supplemental Coolant Additives

We frequently answer many questions about supplemental coolant additives (SCAs) and their application in heavy duty diesel engines. Most often, simple answers are available for what might seem like a college chemistry exam. Here are some simple answers to the most frequently asked questions.

Which SCA should I use in my engine? With Baldwin, the choice is yours. If you use antifreeze, you may use either Baldwin's BTE or BTA Plus products. If you do not use antifreeze, you must use Baldwin BTA Plus. The following chart provides further selection information for various situations.

Option	Caterpillar	Cummins	Detroit Diesel	Mack	Navistar
Change coolant	BTE	BTE	BTE	BTE	BTE
Use OEM type	BTE	BTA PLUS	BTE	BTE	BTE
Have used 2000	BTE	BTE	BTE	BTE	BTE
Have used 3000	BTE	BTE	BTE	BTE	BTE
Have used DCA2	BTE	BTE	BTE	BTE	BTE
Have used DCA4	BTA PLUS	BTA PLUS	BTA PLUS	BTA PLUS	BTA PLUS
Plain water	BTA PLUS	BTA PLUS	BTA PLUS	BTA PLUS	BTA PLUS

Can I mix one type of SCA with another or another brand? Yes. In general, all SCAs are compatible with one another. No serious engine damage will result when SCAs are mixed either intentionally or by accident. However, because all SCAs are not chemically the same, the best practice would be to avoid mixing. When changing from one type to another (BTA Plus to BTE for example), Baldwin recommends the system be drained and flushed first. The major difficulty which might be experienced with mixtures of SCAs could be in the use of a test kit. Test kits work best when you know the type of SCA in the system.

How long will SCAs remain in the system before they need replenished? Generally, adequate levels of SCA will remain in the system for a normal service interval of 12,000 to 15,000 miles. SCA chemicals deplete with engine usage, therefore, they must be replenished periodically. Proper preventative maintenance utilizing a test kit such as Baldwin's CTK5026 is necessary for long cooling system life. This simple test will quickly and accurately determine the concentration of SCA chemicals remaining in the system.

More information is available about Baldwin SCAs and their application. Form 742, - Understanding Supplemental Coolant Additives and the video PKG455 - Understanding Supplemental Coolant Additives are now available and contain the latest information on this important topic.

If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

The Color of Antifreeze

Until recently, the color of the most commonly used antifreezes for both light duty and heavy-duty engine cooling systems was predominately green. Its change interval is normally about every two years or 30,000 miles (50,000 km) of use. Then, long life (LLC) / extended life (ELC) coolant / antifreeze was introduced in an effort to reduce maintenance costs, downtime and environmental disposal costs and issues. With the introduction of this totally new concept, antifreeze manufacturers wanted to differentiate this new product from existing antifreezes. To accomplish this, they introduced different colored dyes for their LLC / ELC products. Orange and red dyes were used first; now it appears there may be virtually no limit to the different dye colors that may be used.

The purpose of this bulletin is to describe the dye colors currently available, the chemical technologies being used and which vehicle manufacturers are using which technology based on the information that is readily available at the time this bulletin was published. The member companies of the FMC are confident this issue is not static and new technologies and dye colors will continue to be introduced in the future.

Antifreeze is used in cooling systems to both lower the freeze point of water and raise its boiling point. It is also used as a carrier for different types of additives such as sodium silicate to protect aluminum from corrosion, anti-foaming agents and other corrosion inhibitors. Although straight antifreeze actually freezes and boils quicker than tap water, when mixed with water in the proper proportions (a 50% / 50% mix is ideal) in a cooling system, it greatly increases the cooling system's ability to perform its designed function of removing heat from critical engine parts and to enhance the service life of the various cooling system components.

Inorganic Acid Technology (IAT) is the chemical composition for the traditional antifreezes that are green in color. An IAT can be used with either ethylene glycol (EG) or propylene glycol (PG). The normal IAT service life is two years or 30,000 miles (50,000 km).

Organic Acid Technology (OAT) was the first LLC / ELC introduced in North America in 1994. OAT antifreeze had been widely used in Europe before its introduction in North America. OAT can be either EG or PG but is mostly EG based. Its first dye colors were orange and red. These dye colors are still used by General Motors and Caterpillar. Green, pink and blue have been added to the list

of available OAT antifreezes. It is recommended that OAT not be mixed with any other antifreeze technology. The normal OAT antifreeze service life is 5 years or 150,000 miles (250,000 km).

Hybrid Organic Acid Technology (HOAT) is a combination of IAT and OAT with nitrites added. This makes HOAT suitable for use in both light duty and heavy duty systems. Currently, two manufacturers are using HOAT for their vehicles. Daimler/Chrysler's version is dyed orange and contains 10% recycled antifreeze. Ford Motor Company's version is dyed yellow and does not contain any recycled antifreeze. Both of these HOAT antifreezes use the marketing designator of GO-5. They are compatible with each other but mixing them with IAT or OAT is not recommended. The normal HOAT antifreeze service life is 5 years or 150,000 miles (250,000 km).

Nitrated Organic Acid Technology (NOAT) is an OAT with nitrates added. This makes NOAT also suitable for use in both light duty and heavy duty systems. NOAT and HOAT are very similar in performance characteristics. Currently, no OEM vehicle manufacturer is using NOAT. The normal NOAT service life is 5 years or 150,000 miles (250,000 km).

Since antifreeze is clear when it is manufactured, and water is clear, dye is used to color the antifreeze for identification and marketing purposes. The color of antifreeze is no longer an accurate indicator as to whether it is an IAT, OAT, HOAT or NOAT formulation. Further, some antifreeze manufacturers market a "universal" antifreeze they say is compatible with all OAT, HOAT and NOAT formulations. These "universal" formulas are not for use with IAT and they will not convert an IAT to an LLC/ELC antifreeze. Mixing IAT with OAT, HOAT or NOAT antifreezes will not damage your vehicle's cooling system; however the mixture will negate the long life/extended life attributes of these formulations.

In conclusion, there are currently two oranges, two reds, green, dark green, yellow, blue, blue-green, clear and pink dye colors available. With this variety of dye colors and more to come, the service technician's ability to properly service and maintain light duty and heavy duty cooling systems properly will be greatly challenged. It is imperative the technician be fully aware of what the vehicle manufacturers' requirements for antifreeze are and those recommendations be carefully followed. For further information regarding cooling system maintenance, refer to TSB's 88-1R3, 89-1R2, 97-2 and 02-1.

For additional information, contact:

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BALDWIN FILTERS
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ENGINEERING BULLETIN 99-3

July 29, 1999

Extended Life Antifreeze/Coolant

A new type of antifreeze, referred to as extended life or long life, is now available in the marketplace. These products are available from several manufacturers under various brand names, but in general all carry the long life/extended service life names. General Motors and Caterpillar have both used these antifreezes in their equipment from the factory for a period of time.

Cummins Engine Company announced in a memo dated July 16, 1999, that these materials based on Organic Acid Technology (OAT) are not compatible with their engines. Cummins is reporting that these long life antifreezes cause degradation of silicone seals in their engines after 80,000 to 100,000 miles of service. Cummins, therefore, is not recommending the use of long life coolants in their engines.

Baldwin Filters is also concerned with the problems that may arise due to this situation. Cummins is not specifically detailing which seals are degrading; however, deterioration of any engine seal is of concern. For example, leakage of coolant into the lube oil system will very quickly cause the oil filter to become plugged, disallow flow, and consequently filtration of the oil as is intended in the system. Bypass of unfiltered oil will occur. Other effects of coolant mixed with the oil, such as corrosion to bearings, may also occur.

At this time we have not been notified of any of these seal failures and resulting further engine damages, but we want our Cummins customers to be aware of this potential situation. Similarly other non-Cummins customers may also want to address this issue with their engine company, requesting a statement of compatibility with their engine systems.

**If you have further questions,
please contact our
Service Engineering Team at (800) 822-5394.**

BALDWIN FILTERS
a CLARCOR company

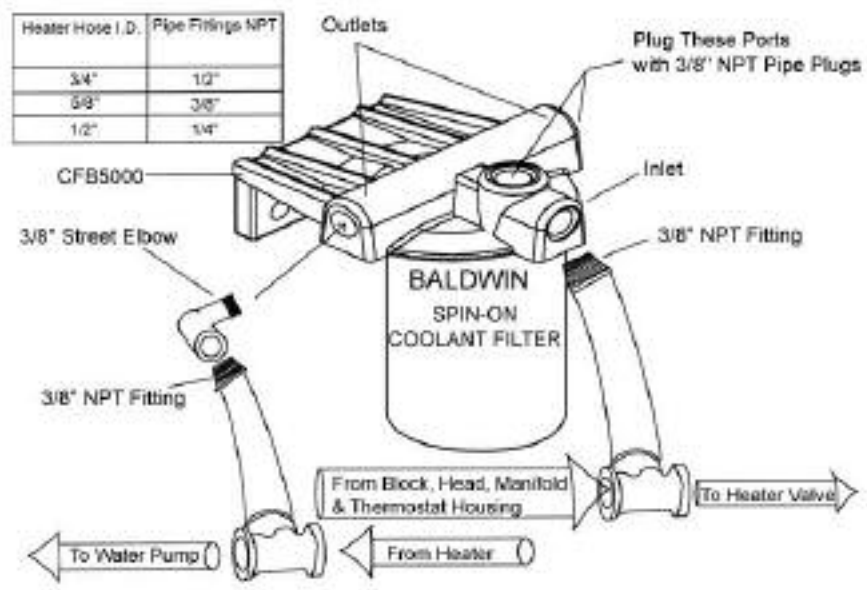
ENGINEERING BULLETIN 00-1

January 4, 2000

Protect Your Diesel Engine Against Cavitation Erosion

Most heavy-duty diesel engines have wet sleeve cylinder liners, which allow coolant to circulate on the outside of the cylinders to effectively dissipate heat. These wet sleeve liners are susceptible to a failure mechanism known as cavitation erosion if the coolant system is not properly maintained. Cavitation erosion occurs when vapor bubbles, which form due to the rapid side-to-side motion of the liner during the operation of the engine, implode against the outer liner wall. Cavitation erosion can damage liners in as few as 250 hours or 12,000 miles in engines operated with straight water with no supplemental coolant additive. Left untreated, cavitation erosion will eventually erode through the entire liner wall, allowing coolant to enter the lubrication system.

Baldwin Filters has a proven method to protect engines against cavitation erosion. With the proper use of Baldwin Supplemental Coolant Additives (SCAs) and filters, you can be assured that your engine is protected from the damage caused by cavitation erosion. If your application is not already equipped with a coolant filter base, the addition of the Baldwin CFB5000 according to the following diagram will allow the use of several different coolant filters depending on the requirements of the application. Please see Baldwin Form New-24 "BTE Coolant Product News" and Form 502 Baldwin Filters "Pure Perfomance Coolant Brochure" for additional details on SCAs and filters.



The Baldwin BW5200 controlled release coolant filter will also work with the CFB5000 coolant filter base in your cooling system. This filter is designed to release Supplemental Coolant Additives into the coolant system at the same rate that they deplete. Extensive field testing has shown that the BW5200 can maintain the proper level of Supplemental Coolant Additives in the coolant system up to 150,000 miles of service. The Baldwin BW5200 also maintains a constant rate of release up to 3,000 hours of service.

If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

Filter Manufacturers Council

Filter Knowledge, Unfiltered

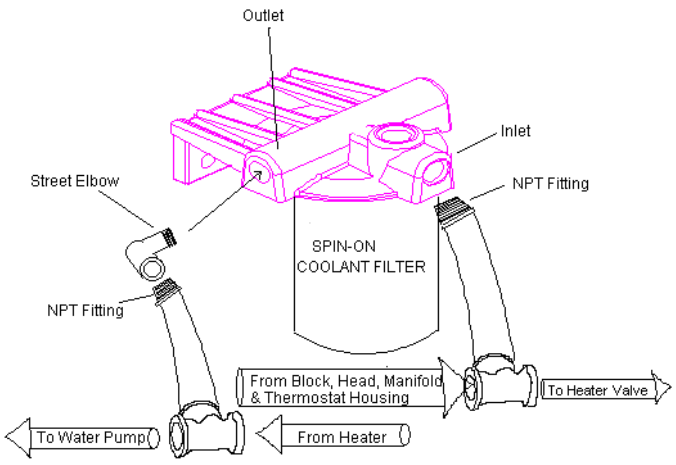
Technical Service Bulletin 02-1R1

Coolant Filtration - Products and Compatibility

For over 50 years, the performance of heavy duty cooling systems has been protected and enhanced by the use of coolant filtration and chemical additives. In recent years some new coolant system technologies have been introduced. As with anything new, questions regarding use and compatibility always arise. The following should clarify what is available and how these products should be properly used.

Most heavy-duty diesel engines have wet sleeve cylinder liners, which allow coolant to circulate on the outside of the cylinders to effectively dissipate heat. These wet sleeve liners are susceptible to a failure mechanism known as cavitation erosion if the coolant system is not properly maintained. Cavitation erosion occurs when vapor bubbles, which form due to the rapid side-to-side motion of the liner during the operation of the engine, implode against the outer liner wall. Cavitation erosion can damage liners in as few as 250 hours or 12,000 miles (20,000 km) in engines operated with straight water with no supplemental coolant additive (SCA's). Left untreated, cavitation erosion will eventually erode through the entire liner wall, allowing coolant to enter the lubrication system.

With the proper use of SCA's and filters, you can be assured that your engine is protected from the damages caused by cavitation erosion. If your application is not already equipped with a coolant filter base, installing a remote coolant filter according to the following diagram will allow the use of several different coolant filters depending on the requirements of the application.



The coolant system products used today can be divided into three basic categories. These categories are based on the recommended service intervals for the various products. Before a particular product is chosen for use, the vehicle or equipment owner or maintenance person must make a decision as to how often they want to perform coolant system maintenance. Once this decision has been made, the appropriate coolant filter, SCA and antifreeze can be placed into service.

The first category can be termed **traditional or standard coolant products**. They can be in the liquid form separate from the filter or a solid form inside a filter. These are the original coolant filtration products that are designed to be used with conventional ethylene or propylene glycol antifreeze. They have a recommended service interval of 10,000-15,000 miles (15,000 – 25,000 km) or 250 hours. It is recommended that a total system flush, re-fill and chemical re-inhibiting of a coolant system using the standard products be done every two years. It is also recommended that a full laboratory coolant analysis be done once a year on these systems.

The second category is a product designed to be in service for 120,000 miles (200,000 km) or 12 months. This chemistry can be referred to as "**need" or "slow release" type**. This type of SCA can be in the liquid form or in the solid form inside a filter. The use of the filter version is most popular. This product is designed for use with conventional ethylene or propylene glycol antifreeze. A total system flush, re-fill and re-inhibiting of a coolant system using this product is recommended every two years. It is also recommended that a full laboratory coolant analysis be done once a year on these systems.

The third category can be termed **extended life or long life coolant products**. These are anti-freeze products that contain different inhibitors than those used in supplemental coolant additives. The long life or extended life products contain Organic Acid Technology (OAT) inhibitors. SCA's **are not used** with the extended life or long life anti-freeze products containing OAT inhibitors. The recommended service interval for the extended life or long life products is 150,000 miles (250,000 km) or one year.

From a product compatibility standpoint, filter manufacturers that offer coolant products and SCA's in their product lines have gone to great lengths to make their products totally compatible with others that are in the same category. Caution should be taken to avoid over or under concentration of chemicals if a change is made from one supplier to another. It should also be noted that most coolant product manufacturers offer test strips for quick, in-field testing of the chemical levels in the coolant. These strips are designed to accurately test only that manufacturer's product. They will not accurately test another manufacturer's product.

Finally, if a coolant known as "fully formulated" is used, consumers must find out what exactly is in it. Sometimes it is just water and antifreeze mixed together. To properly use this type of coolant in a heavy duty application, some category of SCA must be used. Other times, fully formulated means water, antifreeze and SCA's are pre-mixed together. Typically this type of fully formulated coolant is an extended life product and no other SCA's need to be added.

Although there are more heavy duty coolant system products available today than ever before, their use is relatively simple as long as each category's design parameters are understood and followed. For further questions regarding coolant products, please contact your filter supplier.

For additional information, contact:

Filter Manufacturers Council
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www.filtercouncil.org
Administered by Motor & Equipment Manufacturers Association

BALDWIN FILTERS
a CLARCOR company

ENGINEERING BULLETIN 99-2

July 29, 1999

Coolant System Maintenance

We frequently answer many questions regarding coolant system maintenance. Many questions involve proper system top off, differences between supplemental coolant additives (SCAs), and compatibility between different SCAs. Some information on these topics follows.

PROPER COOLANT SYSTEM TOP OFF

Properly maintaining a coolant system often involves refilling the system with small amounts of coolant to replace losses due to small leaks, evaporation, or engine maintenance. In order to maintain effective coolant system balance and freeze protection, a 50/50 mixture of antifreeze and water pre-charged with SCA chemicals should be used. Often 100% water or antifreeze is used to top off the system. This may dilute SCA chemical concentrations and can sacrifice system protection. Also, a good quality water such as distilled or deionized should be used when filling or topping off a coolant system. This high quality water helps protect against corrosion and scale build-up.

DIFFERENCES BETWEEN SUPPLEMENTAL COOLANT ADDITIVES

There are basically two different classes of Supplemental Coolant Additives on the market, Conventional and Organic Acid.

CONVENTIONAL

Conventional SCAs are the traditional formulas based on nitrite/borate or nitrite/molybdate inhibitors. These SCA inhibitors are used with coolants commonly colored green, blue, purple, or pink. Baldwin Filters' BTE and BTA PLUS formulas fall into this class of SCAs.

ORGANIC ACID

Organic acid SCA formulas have more recently been introduced to the US market. These are based on organic acid inhibitors commonly referred to as OAT(Organic Acid Technology) Coolants. They can also be referred to as NOAT(Nitrited Organic Acid Technology) if nitrite has been added to the formula to help protect against liner cavitation. Both of these inhibitor formulas are used in coolants commonly colored orange or orange-red.

COMPATIBILITY BETWEEN DIFFERENT SUPPLEMENTAL COOLANT ADDITIVES

Because they protect the coolant system through different chemistry, conventional and organic acid SCAs are NOT compatible. Cross contamination by as little as 10% can reduce the effectiveness of both formulas and reduce protection in a coolant system. Below is a chart which summarizes compatibility.

SCA	Class	Coolant Color	COMPATIBILITY			
			BTE	BTA +	OAT	NOAT
Nitrite/Borate (BTE)	Conventional	Green, Blue, Purple, Pink	YES	YES	NO	NO
Nitrite/Molybdate (BTA PLUS)	Conventional	Green, Blue, Purple, Pink	YES	YES	NO	NO
OAT	Organic Acid	Orange, Orange-red	NO	NO	YES	YES
NOAT	Organic Acid	Orange, Orange-red	NO	NO	YES	YES

If you have further questions, please contact our Service Engineering Team at (800) 822-5394.

Filter Manufacturers Council
Filter Knowledge, Unfiltered

Technical Service Bulletin 88-1R3

Cooling System Maintenance for Heavy Duty Engines

Improper cooling system maintenance can result in various cooling system problems and failures.

The chart shown below is a listing of the six most common problems seen in heavy duty cooling systems. Along with each problem is a description of how it occurs, how it affects the engine and, most importantly, how to prevent it.

PROBLEM	HOW IT HAPPENS	WHAT IT CAN DO	PREVENTION
Rust*	Oxidation within the system.	Clog the system. Cause accelerated wear.	The inhibitors in a quality supplemental coolant additive (SCA) prevent the oxidation for rust to occur.
Scale (Water Hardness)	Present in all tap water are salt minerals, especially calcium and magnesium. These minerals can solidify and adhere to hot metal surfaces.	1. Clog system passages. 2. Deposit on high temperature areas and reduce the heat transfer rate, causing hot spots. This results in uneven metal expansion, scuffing, scoring, accelerated ring wear and eventually, cracked heads and/or blocks.	A quality supplemental coolant additive (SCA) helps to keep salt minerals in suspension so they cannot deposit on engine metal surfaces or clog passages.
Acidity (pH)	1. Glycol antifreeze reacts with oxygen in the air and forms acid. 2. A loose head gasket or other leakage can allow sulfuric acids formed by the burning of fuel to leak into cooling system.	Corrode iron, steel and aluminum.	A quality supplemental coolant additive (SCA) neutralizes acids to prevent corrosion.
Pitted Cylinder Liners	Constant vibration of the cylinder liner causes a momentary vacuum to form on its surface. Coolant boils into the vacuum and vapor bubbles implode on the surfaces of the liner, digging into unprotected liners.	Cause pits which can extend over time, through the thickness of the liner and allow coolant to enter the combustion chamber or crankcase.	A quality supplemental coolant additive (SCA) coats the liner with a thin film to protect it from cavitation erosion without impeding heat transfer.
Foam	Foam (the aeration of coolant) occurs from air leakage into the system or low coolant levels.	Adds to the cavitation erosion problem, particularly in the areas of water pump impellers.	A quality supplemental coolant additive (SCA) has an antifoam agent to prevent formation of air bubbles. This foam prevention agent is effective at all temperatures, even during startup.
Pitted Water Pump Impellers	Flow rates and turbulence are high at the impeller blade. This causes cavitation. In addition, there is a possibility that abrasive particles are present in the system.	Cause loss of pump efficiency and total pump failure.	A quality supplemental coolant additive (SCA) protects the impeller from cavitation erosion and the coolant filter removes particulate matter to reduce abrasive wear on cooling system components.

**It should be noted that rust can appear even within a chemically protected system when oil is present in the coolant. If you do notice the presence of rust, the oil cooler should be inspected for possible leaks.*

STARTING RIGHT
Before changing the coolant, the system should be thoroughly flushed to remove any contamination. A clean system is free of solid and liquid contaminates including oil.

MAKE-UP WATER
Proper coolant system maintenance requires a quality make-up water. All make-up water is corrosive but water with high mineral content cannot be made fit for use. Therefore, it is recommended that distilled water be used. Water softened by some type of salt or chloride process should not be used. Most engine manufacturers have established specifications for water used in their engines. The following chart shows some of these specifications.

	Caterpillar	Cummins	Detroit
Hardness	100ppm	300ppm	170ppm
Chlorides	40ppm	100ppm	40ppm
Sulfates	100ppm	100ppm	100ppm
Total Dissolved Solids	340ppm	500ppm	340ppm

ANTIFREEZE
Ethylene glycol, propylene glycol or long life/extended life, should be used in the cooling system year-around. The glycol in the antifreeze provides both freeze and boil-over protection. It also provides a stable environment for gaskets and seals. These same gaskets may shrink using water-only systems and leakage could occur.

Some of the major problems in cooling systems occur due to antifreeze-related problems. One of the most publicized problems is silicate gelation/dropout. The two major causes of this problem are:

1. High silicate antifreeze
2. Over-concentration of antifreeze and/or SCA.

All antifreezes used in today's heavy duty engines should meet GM 6038M or ASTM D-4985 specifications for silicate content. The antifreeze concentration should be held between 40% and 60% (40% antifreeze and 60% water to 60% antifreeze and 40% water). A 50% blend is ideal. The use of a refractometer or hydrometer will insure the glycol concentration levels are maintained properly.

Another problem caused by over-concentration is water pump leakage. In a study by Cummins Engine Company, 54% of the water pump failures they examined

occurred due to over-concentration. Seventy-eight percent of the total pumps examined showed over-concentration regardless of the cause of the failure.

SUPPLEMENTAL COOLANT ADDITIVE (SCA)
Using the proper amount of a high quality SCA is very critical in preventing the problems mentioned in this bulletin. When filling a cleaned system with fresh antifreeze and water, an SCA is required. These additives may contain inhibitors not found in today's antifreeze.

When pre-charging, be sure to use the proper pre-charge filter for the cooling system or 4 ounces of liquid SCA per gallon (30ml per liter) of coolant. The 4 ounces per gallon (30ml per liter) requirement is based on the most commonly used SCA. In either case, be sure to follow the SCA manufacturer's instructions.

SERVICE
SCAs are depleted during the process of protecting the metal surfaces which are in contact with the coolant. These additives must be replenished through the use of filters containing SCAs or a liquid SCA at specified intervals to maintain the proper concentration levels.

PERIODIC DRAINING AND FLUSHING
Antifreeze breaks down due to temperature cycles within the cooling system. The coolant can also become contaminated by dirt, oil combustion gases and spent inhibitors. While a high quality coolant filter will remove the solid contaminants, it may not remove the oil or combustion gases.

There are several types of SCA test kits on the market. The primary types check one or more of the following:

1. Sodium Nitrite
2. Molybdate
3. pH
4. Freeze point

Use the test kit recommended by your SCA supplier. **CAUTION:** Test strips or testers which register the pH as the sole determining factor in adding your SCA should not be used.
For further information regarding antifreeze, refer to TSB-97-2 and TSB-05-2.

For additional information, contact:
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