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## Absolute Bypass Oil Filtration…

# A Solution to Contaminated Engine Lube Oil

**White Paper Sponsored By:**

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## Absolute Bypass Oil Filtration…

# ABS - A Solution to Contaminated Engine Lube Oil

### I. Synopsis

This paper describes the Racor Absolute Oil Cleaners which are a solution to reducing contaminant in engine oil, giving longer engine life, extending oil change intervals and reducing the waste stream of contaminated oil and filters into landfill sites.

### II. Introduction

Racor Division of Parker Hannifin, is well known for providing fuel, oil and air filtration solutions for original equipment engines in trucks, marine, Ag and industrial applications. The Absolute Bypass Oil Cleaner (ABS) is one of many oil filter systems that Racor offers for any engine, gas or diesel. For many years the ABS filters were used successfully to reduce damaging particulate in hydraulic systems. ISO cleanliness standards are very important for hydraulic systems and the ABS has been successful in reducing particle counts well with-in manufactures standards, and below. By adapting the ABS unit to the engine market, a substantial breakthrough in oil cleanliness has been accomplished. Utilizing state of the art analyzers and technology in particle shape classifying such as the Q200 and oil condition monitoring, we have documented a reduction in particulate, (wear particles) and extended oil condition for cleaner oil and longer oil drain intervals.

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The ABS unit operates strictly as a kidney loop system which uses engine oil pressure to flow oil through the dense high capacity multi-layered, cellulose media then returning the clean oil back to the engine sump. The flow of the oil is minimal and without impact to the volume of oil required to properly lubricate the engine. This is accomplished by restricting oil flow through an orifice on the oil return side of the filter. When sized correctly, the flow of oil allows the complete crankcase oil volume to be circulated several times an hour, thus reducing the contaminant particulate level many times lower than norm, and in some cases less particulate then the new oil contained when poured out of the bottle.

In addition to the reduction of wear particulate, the cellulose media is able to absorb a high concentration of moisture. If the moisture is left unchecked it will cause the breakdown of the lubricant causing oxidation which occurs when oxygen attacks the oil. This process is accelerated by added heat, metal catalysts and the presence of moisture. This process leads to high viscosity and deposit formation, prevents additives from performing properly, causes increase in TAN (Total Acid Number), and the decrease of the TBN, (Total Base Number of additive).

## III. The Problem – Abrasion, Fatigue, and Adhesion

An engine is a contaminant manufacturing device so it's no wonder that regardless of the care taken and oil used, wear still occurs. Of course using proper oil for the application, coupled with OE filters certainly will reduce wear issues related to friction, temperature, viscosity and operational shear issues. Operating / frictional wear is one thing but contaminants can enter an engine through many ways including combustion particulate forced passed the piston rings into the crankcase. Piston rings are not a perfect seal and there is always a slight amount of combustion leakage, but when fuel combusts prematurely or late in the in the combustion cycle the rate of blow-by is increased allowing a path for abrasive and acidic products to travel south in the cylinders sending these products into the oil sump and mixing with the lube oil.

First you must identify and quantify abrasion, fatigue, adhesion, and corrosion because each has a different root cause, different particle appearance and different corrective actions. An effective oil analysis program utilizes oil sampling for elemental analysis, additives and oil quality and for particulate size and type distribution, wear debris analysis. The WDA can be done on the engine oil by gravimetrics or by sectioning a dirty filter, washing off the particulate and analyzing the results.

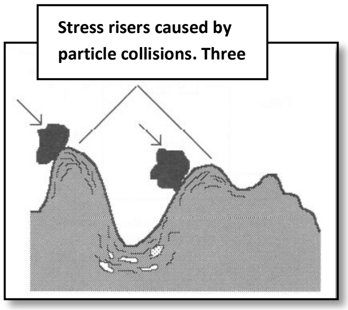
Abrasive wear particles are commonly the result of soot, dust or dirt in the oil. These particles become wedged or embedded between moving parts thus allowing them to cut into the harder rotating or sliding parts. The corrective action for abrasion is better filtration.

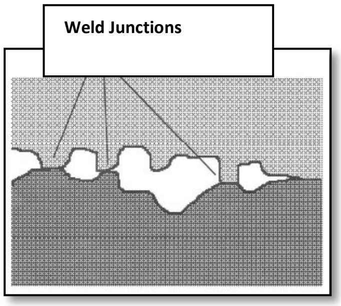
## IV. Types of Wear

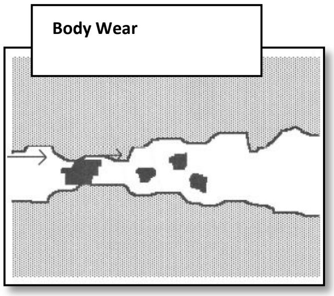
Fatigue wear is the result of repeated cyclic loading of surfaces with compression and shear or compression and tension. This can happen to a bearing or a gear where the load is continual and possibly misalignment from the original assembly. Surface fatigue can also start with particle contamination which is why we would include it in this paper.

Adhesion is the result of two parts that are allowed to make contact with each other either because of inadequate lubrication, the wrong lubrication or high shear loads. This is called boundary wear or boundary lubrication. Abnormal adhesion is caused when lubrication does not support the component loads and components are allowed to make contact with each other.

**In the absence of contaminants,** two body interactions occur when the lubricating film is too thin to prevent contact between two moving surfaces. Two-body contact also can occur between a hard contaminant particle and a stationary surface. As the fluid flows around a stationary object, any particle carried by the fluid can impact on the objects surface. This can lead to one or more of the wear mechanisms discussed here.

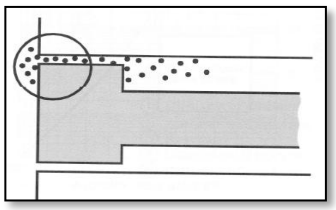


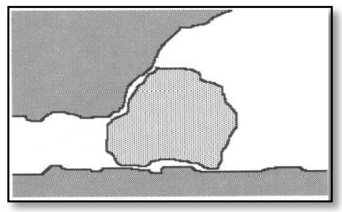



## V. Secondary Effects of Wear

Moving parts are separated by a thin film of oil to prevent making contact with each other causing friction and wear. If you were to think of this oil film as tiny ball bearings that keep the moving components separated so they cannot rub on each other you would see how important the oil film is. The secondary effects of wear come in play when the fluid is allowed to contain particles that are small enough to flow in the lubricating fluid and over time wear away the surface of the components causing reduced performance first and eventually a complete failure. Once the initial wear begins, the particle count in the fluid increases and so does the rate of wear. The wear cycle compounds until failure. Do to the problems discussed here; there is the need for a level of filtration that removes particulate down to an acceptable level.





Third bodies or particles get between gaps or clearances of components that should be separated by a film of lubrication. Unfiltered particles continue to work on the moving parts generating more and more wear particles until failure occurs. Clearly, the particle size and quantity of particulate has a large impact on the wear and the interference of the moving parts. Lube oil analysis is used to determine the lube oil quality/condition and to give a snap shot of the overall condition of the engine. This is much like a blood test for our bodies.

This section has dealt with particulate which requires a test that actually counts the particles and categorizes them based on size distribution, the test is ISO 4406. This is a procedure providing cleanliness codes which is a standard to quantify particulate contamination.

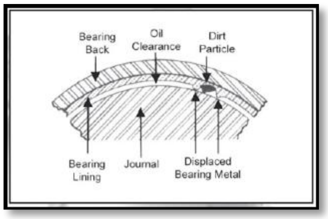
## VI. Journal Bearing Wear

Every moving part in an engine will eventually wear out. Each part has a life span which is dependent on many things. If all parts lived out their full expected life then a maintenance mechanic's job would be fairly simple. The simple fact is that we cannot expect all parts to fail just because the life span has been reached. I mentioned earlier that oil analysis is like a blood test for our bodies, and in the same way a Mechanic must be like a Doctor and be capable of diagnosing his patient whether it is an engine, gear train or hydraulic system. The information below is from Clevite 77® Engine Bearing Failure and Analysis Guide.

**Major Causes of Premature Bearing Failure:**

- Dirt............................................45%
- Misassemble..............................13%
- Misalignment.............................13%
- Insufficient Lubrication...............11%
- Overloading................................8%
- Corrosion....................................4%
- Improper Journal Finish..............3%
- Other..........................................3%

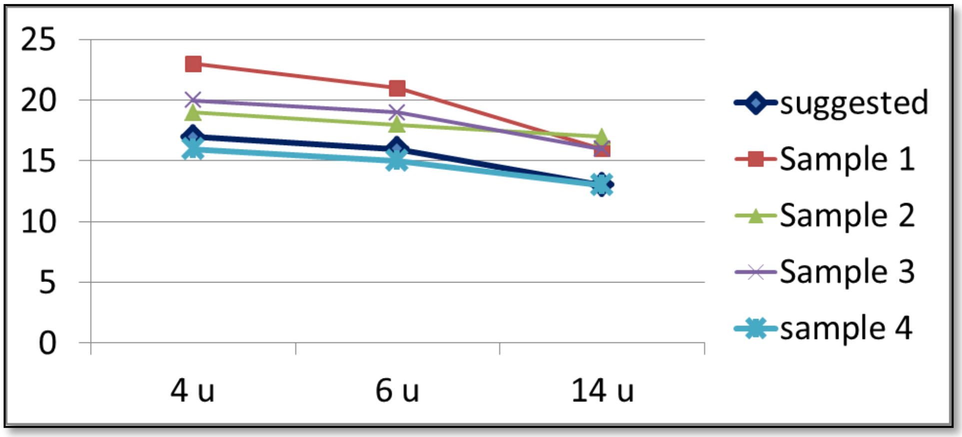
By studying the information above you can see that if a mechanic simply replaces the worn part whether it is a bearing or other component without finding the root cause of failure, the new component will be subjected to the original cause of failure. A point to be made here is the highest cause of bearing failure is dirt, thus good filtration is the most important thing to be concerned with on an engine or hydraulic system. The following is an example of a set of bearings scored from dirt in the lube oil supply and a description of a bearing and journal.




There is another source of contamination that we need to discuss. It isn't as bad as the issues discussed above but when you start looking into the source of particulate in contaminated fluid then you cannot overlook the actual oil that is being put into the engine during service. The container could be a quart or gallon from the local parts store, a 55 gallon drum or bulk storage tank located on the premises. Not all new oil is as clean as we might think right out of the bottle or tank. In bulk storage, the contaminants could be self-induced through poor storage practices, but consider the smaller unopened container from the parts house. There is a possibility that oil supplier cleanliness may not be what you would think or expect.

Some lab tests were performed on new oil from the local parts house. The oil particle analysis result was less than impressive. I was surprised to find out that many new oils are refined but may not be satisfactorily filtered before packaging. As I found with particle counts on new and used oil I could see that in some cases, the new oil had more particulate than after an engine was run 500 miles using a bypass.

The ISO cleanliness codes are measured and categorized as 4 micron/6 micron/14 microns. Standard target cleanliness specs for diesel engines are 17/16/13, so if you are adding oil that is 23/21/16, standard filtration will not get oil clean enough to reach the target cleanliness level, pointing out the need to have a secondary bypass oil filter to get the oil to the proper cleanliness spec.




The graph on the left shows the suggested ISO cleanliness and the results of 4 samples of oil taken right out of the bottle. It is clear that only one sample (#4) meet the suggested oil cleanliness spec. The other three are above spec right out of the bottle.

## VII. Solution – Better Oil Filtration

Racor produces a product called Absolute Oil Cleaners. These are bypass, or secondary oil filtration products that can filter down as low as 3 micron. They are available with elements in different levels of 3, 5 and 10 micron filtration.

The elements are made with an engineered multi-layered cellulose media which means they are also an absorbent allowing them to hold engine damaging moisture.

The Absolute bypass oil cleaner has two sizes in a die-cast aluminum housing and carbon steel or stainless steel multi-element housings for almost any size engine or hydraulic system.


## VIII. Case Studies – Racor Engine Test Cell

An oil sample was taken on an engine in the Racor lab after being run up to operating temperature. A Racor bypass ABS10450 filter housing with a 5 micron element was installed. The engine was then run for 9 hours of running time, an oil sample was taken and particles quantified by using the Laser Net Finds Q200 particle classifier. There was a significant particle reduction in just a short time running on the dyno.

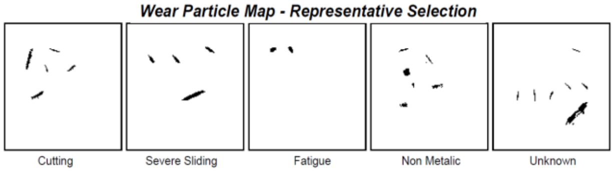
## Particle Classification

### Before Bypass

| Max Diameter Method | (Part/ml) | Max(um) | Mean(um) | 20-25um | 25-50um | 50-100um | >100um |
|---|---|---|---|---|---|---|---|
| Cutting Wear | 7.8 | 56.2 | 35.1 | 1.6 | 4.7 | 1.6 | 0.0 |
| Severe Sliding Wear | 49.8 | 69.5 | 40.9 | 7.8 | 28.0 | 14.0 | 0.0 |
| Fatigue Wear | 3.1 | 21.2 | 21.2 | 3.1 | 0.0 | 0.0 | 0.0 |
| Non Metallic Wear | 20.2 | 59.3 | 31.1 | 9.3 | 7.8 | 3.1 | 0.0 |
| Unclassified Wear | 29.6 | 89.1 | 29.0 | 14.0 | 14.0 | 1.6 | 0.0 |

Free Water (ppm) 0

Wear Particle Map - Representative Selection

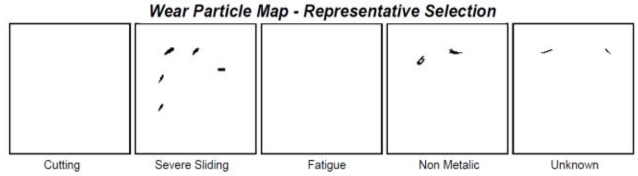



### After Bypass

| Max Diameter Method | (Part/ml) | Max(um) | Mean(um) | 20-25um | 25-50um | 50-100um | >100um |
|---|---|---|---|---|---|---|---|
| Cutting Wear | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Severe Sliding Wear | 7.4 | 29.7 | 24.2 | 5.9 | 1.5 | 0.0 | 0.0 |
| Fatigue Wear | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Non Metallic Wear | 3.0 | 38.3 | 34.0 | 0.0 | 3.0 | 0.0 | 0.0 |
| Unclassified Wear | 3.0 | 29.7 | 25.3 | 1.5 | 1.5 | 0.0 | 0.0 |

Free Water (ppm) 0 Viscosity (cP) 16.33

Wear Particle Map - Representative Selection




## ISO Cleanliness Codes

### Before

| ISO 4406 (1999) | | |
|---|---|---|
| | Part/1 ml | |
| >4um(c): | 4,992.8 | 19 |
| >6um(c): | 1,354.4 | 18 |
| >14um(c): | 163.4 | 15 |

### After

| ISO 4406 (1999) | | |
|---|---|---|
| | Part/1 ml | |
| >4um(c): | 1,680.1 | 18 |
| >6um(c): | 308.9 | 15 |
| >14um(c): | 7.4 | 10 |

**Comparison – After Bypass**

4 Micron = 66% Fewer Particles

6 Micron = 77% Fewer Particle

14 Micron = 95% Fewer Particles

**Oil Condition Monitoring** – Example of extended oil change with Racor bypass installed on an over the road truck with a Cummins ISX engine. The truck / engine had approximately 771,980 miles at the beginning of the test.

| Fluid Run Time | 5822 | 10,000 | 8,000 | 30,000 | 21,421 |
|---|---|---|---|---|---|
| Total Miles | 75,243 | 69,421 | 59,421 | 51,421 | 21,421 |
| Iron | 48 | 43 | 36 | 40 | 30 |
| Aluminum | 4 | 4 | 3 | 3 | 1 |
| Silicon | 5 | 4 | 4 | 5 | 3 |
| Viscosity | 16.1 | 16.1 | 16.0 | 16.1 | 15.7 |
| Soot** | 3.2 | 2.3 | 2.5 | 2.3 | 1.3 |
| Oxidation | .24 | .19 | .15 | .22 | .12 |
| Nitration | .19 | .12 | .14 | .16 | .12 |
| Sulfation | .31 | .17 | .20 | .20 | .12 |
| TBN | 5.1 | 5.2 | 4.8 | 4.0 | 5.5 |
| Filter Change* | No | No | Yes | Yes | yes |

*Bypass filter elements changed at each first 3 intervals and oil topped off. **Soot was the deciding factor for changing oil and filters. ***The filter assembly used was a single element, Racor ABS10450 with a 5 micron, ABS20470 element installed.

## IX. Conclusion

The addition of a Racor Absolute Bypass Oil Cleaner adds contaminant capacity and increases the cleanliness level of the oil many times over by reducing engine wear particles 66% - 95% in a very short time. Lube oil continues to get cleaner as the engine runs and in most cases will have less particulate after many hours or miles of run time than the oil had when it was poured from the bottle / tank as new oil.

## X. Financial Benefits

Racor Bypass filtration can reduce the overall maintenance cost associated with large fleets, saving thousands of dollars annually.


As the case study illustrates engine lube oil service can be extended safely as long as the oil quality is monitored through oil analysis and all components measured are with-in manufactures specifications. Using oil analysis allows the operator to work with predictive and proactive maintenance rather than reactive maintenance.

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## For additional Oil Filtration information, please see the following brochures:

Brochure 7518 - Racor Absolute Bypass Oil Cleaners
Brochure 7984 - Racor Oil Filtration Product Guide
Brochure 7460 - Racor Lubrication Systems
Brochure7774 - Beneficial Effects of Bypass Filtration for Contamination Reduction in Diesel Engines
Lube Oil Analysis – A guide to monitoring lube oil by David Cline (iBook)

Check out these published articles on www.racornews.com.

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- When to Change Engine Oil 05/15/14
- Liquid Filtration Systems 05/28/14
- Prolonging or Extending Engine Oil Service 05/28/14

**References:**
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Training Dept. Hydraulics group, Parker Hannifin Corp.
Lube Oil Analysis, A Guide for Monitoring Lube Oil, by David Cline
Lab tests performed in Parker Racor Lab – Modesto California
Rev. 102814 dc

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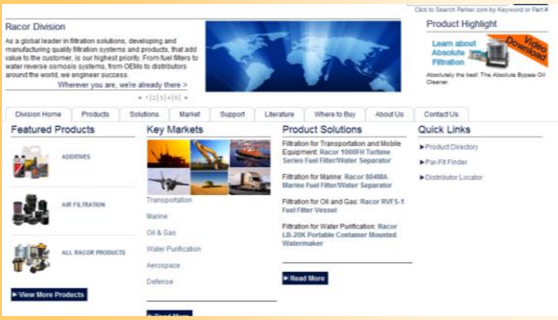


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