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**FIELD SALES TOOLS SERIES**

# REFUSE HAULERS AND OFF-ROAD EQUIPMENT

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### Refuse Hauler Statistics

Refuse haulers serve an important function in our society. They are also a great sales opportunity for the lubricants industry. Consider that refuse haulers collect garbage from:

- 75,000,000 homes
- 7,000,000 businesses
- 100,000 government enterprises

Refuse Haulers and off road vehicles and equipment are unique pieces of machinery that have different lubrication needs than automobile, light truck and the over-the-road vehicles. Other vehicles can travel at high rates of speed which will allow oil change intervals to be measured by miles traveled. Refuse haulers and off road equipment travel much smaller distances at low speeds and spend much of their operating life in stop-and-go and forward/backward motion, neither of which is conducive to measuring drain intervals by miles. That is the reason oil service life is measured by time, or "hours of operation" when considering their vehicles.

AMSOIL Dealers have the opportunity to provide the operators of these types of vehicles and equipment the same wear and cost saving benefits that AMSOIL is able to provide to the automobile, truck and over the road vehicles. To demonstrate the benefits directly on this type of equipment, AMSOIL participated with a refuse hauling organization in an innovative lubricant and maintenance program trial evaluation. This document will include the results of this trial, which provided cost savings and operating profitability while delivering enhanced fleet performance, fleet reliability and dependability.

Armed with this information, an AMSOIL Dealer will have additional opportunities for increasing sales of AMSOIL products. Although the trial was conducted on refuse haulers, the results can be applied to off road applications as well. This has the potential of opening up even more sales opportunities. This document will also review what AMSOIL has determined to be the optimum prospects for the AMSOIL Dealer, and offers advice for how to proceed with sales calls to these prospects.

### Solid Waste Management Industry

To begin, we will first take a look at the industry in which the refuse haulers are utilized. The solid waste management industry provides a critical function and vital public service that ensures the health and safety of citizens across the United States. These industry service providers range from national companies with fleets numbering in the thousands to local providers with a single hauler vehicle. Altogether, these service providers collect garbage from 75 million homes, 7 million business and over 100,000 government enterprises.

Here are some additional industry statistics to give you more background information as well as an indication of the type of the sales potential that exists with the "heavy metal" these operations are running.

#### • Number of Organizations:

An estimated 27,000 organizations operate within the Solid Waste Management Industry. More than 55% of these entities were in the public sector. Of the remainder, 45% were privately held, while only 0.1% were publicly traded.

#### • Hauling Operations:

Approximately 15,500 solid waste industry organizations (57%) conducted only waste hauling operations and did not own a solid waste facility.

#### • Revenues:

The solid waste industry generated an estimated total revenue, net of intra-industry payments, of \$43.3 billion. Approximately 76 percent of this amount was generated by the private sector. Excluding the segment of the industry that is primarily engaged in the operation of scrap metal yards and recycling operations, total industry revenue was equal to \$39.8 billion.

#### • Relative Size of the Industry:

The solid waste industry directly accounts for roughly one-half of one percent of the nation's gross domestic product (GDP). However, the industry's industrial output and employment are typically larger than the individual economies of several states, including North Dakota, Vermont, and Wyoming.

#### • Economic Impacts:

The solid waste industry contributes over \$96 billion in revenue, 948,000 jobs and just over one percent of U.S. GDP to the nation's economy on an annual basis. This includes all direct, indirect and induced effects resulting from solid waste industry activities. For every dollar of revenues generated by the industry, a total of \$1.23 in additional revenues were generated in the economy through the multiplier effect. Similarly, for every job in the solid waste industry, the multiplier effect created an additional 1.58 jobs outside the industry.

- **Tax Impacts:**

On an annual basis the solid waste industry contributes over \$14.1 billion in direct, indirect, and induced taxes to federal, state, and local governments.

- **Employment and Compensation:**

The solid waste industry employs approximately 367,800 people. Total industry compensation, including benefits, was estimated at \$10.0 billion. Based on these figures, employees in the solid waste industry were paid an average of \$27,200 per year, including benefits.

- **Waste Quantities:**

An estimated 544-600 million tons of solid waste are processed in the United States annually. Approximately 68% is land filled, 5% is incinerated, and 27% is recycled.

### The Refuse Hauler

Let's take a look at the equipment itself, the refuse hauler or garbage truck. There are three basic models of garbage truck:

- **Front Loaders-** generally service commercial and industrial sites using dumpsters. They have large prongs on the front which are carefully aligned with arms on the dumpster. The dumpster is then lifted over the truck, until it is upside-down and the trash will then fall out into the receptacle.

- **Rear Loaders-** commonly service residential areas. They have an opening at the rear that a trash collector can throw garbage bags or empty the contents of trash cans into. Often they have a lifting mechanism to automatically empty wheeled bins (from both residential and commercial premises) without the operator having to lift the waste by hand. They are usually equipped with some type of compactor that will compress the garbage, and move it towards the front of the vehicle.

- **Side Loaders-** are versions of either front or rear loaders that lift small trash containers or have openings on either side to deposit trash. Some side loaders are equipped with a mechanical remote-control arm that grasps a trash container, such as a wheeled bin and empties it into the truck in the same manner as front loaders. This type of garbage truck requires only one arm-operator/driver but residents must

position their wheeled bins carefully near the curb and at least two yards away from nearby objects.

Steel is a major component of refuse hauler vehicle bodies, loaders and other waste handling equipment. Steel makes up between 90 and 95% of the weight of a complete refuse hauler. That's 13,500 to 14,250 lbs. of steel in an average 15,000-pound body. A refuse hauler is a completely different animal than an over the road vehicle. The body is much more complicated than the chassis they are mounted on. The "tail" behind the hauler is very different from the trailers used by over the road fleets. This is also what makes the vehicles very expensive.

The intense amount of weight involved contributes to severe and demanding shock loads which the vehicle's lubricants are subjected to each time the hauler is put in drive. Getting "heavy metal" like this moving literally tears up the haulers lubricants!

Downtime, scheduled or unscheduled, will always be a part of the waste removal company's operational considerations. **Unscheduled downtime is the enemy of this work truck.** Refuse haulers take a lot of abuse on a daily basis, working in a stop-and-go environment. They can have up to three hundred stops in one day. In many parts of the country, they must operate in a wide variety of weather conditions. Regardless of the conditions, the vehicles have got to be out working and doing their job or the public and businesses get upset and the garbage starts piling up.

### Refuse Hauler Factoids

- The solid waste management industry operates over 136,000 refuse collection trucks, 12,000 transfer vehicles, and 31,000 dedicated recycling vehicles (179,000+ vehicles total.)
- The average refuse hauler travels 25,000 miles and uses 8,600 gallons of fuel a year, getting under 3 miles per gallon
- More than 40% of the refuse haulers on the road are over 10 years old
- A typical diesel-powered refuse hauler costs more than \$170,000

### Sales Tip

It is estimated that even a small refuse hauling company will spend up to \$25,000 a year on parts and service per refuse hauler.

## Off Road Equipment

- Backhoe Loaders
- Cold Planers
- Compacters
- Crawler Carriers
- Dozers
- Excavators
- Graders
- Feller Bunchers
- Forest Machines
- Forwarders
- Loaders
- Pipelayers
- Paving Equipment
- Mining Equipment
- Off-Highway Tractors and Trucks
- Scrapers
- Shovels
- Skidders
- Skid Steer Loaders

### Sales Tip

People operating off road equipment can appreciate the analogy of operation related to the refuse haulers:

- 15,000 lbs of metal in stop-n-go service
- Constant varying loads
- High idle, low speed operation
- Relied upon for specific function

### Sales Tip

Keep in mind that hydraulically actuated lifting mechanisms also represent a lube oil sales opportunity. And, if any of the hydraulic motors run via a PTO (power take off) link to the hauler's engine, that refuse hauling truck engine is constantly subject to hard work...even when in park!

## Off Road Equipment

When we refer to off road equipment in this sales tool, we are referring to the equipment primarily used in construction. Please do not confuse this equipment with recreational off road vehicle that more appropriately falls in the power sports category. Construction equipment is similar to refuse hauling equipment in that they do not travel at high rates of speed or travel great distances. Just as is the case for refuse haulers, service intervals are calculated in time or hours of service rather than miles. There are many different pieces of equipment that fall under this category. To the left are some examples.

Although these off road vehicles are similar to refuse haulers in that they represent a great deal of heavy metal operating on the ground, they also have their differences based on specific applications.

The operating environment of such applications is the first major factor to take into consideration. As the name "off road vehicle" implies, off road equipment is quite often operating in very dirty and dusty conditions off of the paved roadways. This can greatly affect the equipment and the lubricants working in these extreme conditions. Specifically, it can shorten the life of both if not properly monitored and maintained.

### Hours Versus Miles

Anyone attempting to sell lubricants to either of these markets should become familiar with the hours versus miles comparison. Most people are familiar with a "distance" measurement when considering the amount of service life available in a lubricant. This is true for an oil drain interval and vehicle service intervals (changing transmission fluids, tire rotations, etc.). Consumers have spent most of their lives following the recommendations of OEM's (Original Equipment Manufacturers) and auto/truck dealerships telling them that they must change their oil every 3,000 miles.

Of course, AMSOIL Dealers have become accustomed to challenging this way of thinking. And another challenge to face is the fact that there are many types of vehicles, equipment and machinery that do not travel the distances of automobiles. In these situations, one must measure service intervals in hours of operation.

Let's take a look at some common time intervals, referenced in hours:

- **8 hours in a "standard" work-shift**
- **24 hours in a day**
- **40 hours in a "standard" work-week (8 hours/day x 5 days)**
- **168 hours in a week (24 hours/day x 7 days)**
- **2,080 work hours in a standard work-year (40 hours/week x 52 weeks)**
- **8,760 hours in a year (24 hours/day x 365 days)**

You've probably seen recommended "hour intervals" from OEM's for other pieces of equipment that do not travel long distances or at high rates of speed. There are lawnmowers, air compressors and generators, just to name a few. All of these items measure their maintenance intervals in hours since it is impractical to measure miles. Most of the more modern units even come with an hour meter, which tracks how long the engine has been in use (working or sitting and running at idle speed.)

How does this apply to the refuse hauler? We have already determined that these vehicles travel an average of 25,000 miles in a year. If we break that down by a standard work-year (the hauler will most likely have to be running each workday and every week of the year) it will average 12 mph. One must also consider the driving conditions of each hauler. This 15,000-lb. vehicle is constantly stopping and starting after each pick-up. It can also be running in every weather condition possible. And its weight alone, not considering the waste it is picking up along the way, is a very heavy load. By taking these factors into consideration, one can see why it is impractical to track the oil change and maintenance intervals by the mile. This is the reason why refuse haulers determine oil drain intervals on a set time period (every month for example) or a set number of operating hours.



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# **REFUSE HAULERS AND OFF-ROAD EQUIPMENT**

## **The AMSOIL 3-X Trial**

### **Refuse Hauler Success Testimonial**

## The AMSOIL 3-X Trial - Refuse Hauler Success Testimonial

During the year 2000, the key management team for an upper-Midwest regional refuse hauling company approved and sanctioned an innovative lubricant and maintenance program trial evaluation to determine if cost savings could be achieved with an extended oil drain program. This program was to be coordinated and supported by AMSOIL INC. The data that was gathered through the trial period demonstrated that an AMSOIL extended oil drain program could reduce fleet maintenance costs and deliver enhanced fleet performance, fleet reliability and dependability, as well as overall operating profitability.

### The AMSOIL 3-X Program

The primary challenge was to develop a program that would allow for the safe and cost effective extension of engine oil drain intervals. In this case, the standard drain interval was 300 hours with inspections at 150-hour intervals where fluids were checked and an overall vehicle safety inspection took place. The AMSOIL goal was a threefold extension in oil service life. Of utmost concern was the need to not negatively impact the integrity of fleet performance and reliability while decreasing costs. Simply put: there was no tolerance for program initiatives that would result in truck downtime - whether it occurred in the shop or remotely when on the road.

### Oil Analysis

A comprehensive oil analysis program was utilized to safely extend motor oil drain intervals and to continuously monitor equipment performance.

- AMSOIL consulted with CTC Analytical, an unbiased third-party oil analysis laboratory (the largest in the U.S.) to determine industry recognized condemning limit wear rates applicable to fleets in waste/refuse hauling service and with a variety of OEM engine types.
- OIL ANALYZERS INC. also conducted oil analysis testing.
- AMSOIL INC. was responsible for communicating with management on any/all issues or problems uncovered when reviewing the oil analysis data.

- The account agreed that all involved locations would react upon the oil analysis data results.

### AMSOIL 3-X Program Guidelines

<b>Every 450 Hours-</b>	<b>Change full flow oil filter(s) and fuel filters. Sample oil for analysis.</b>
<b>Every 900 Hours-</b>	<b>Change full flow oil filter(s), engine oil and fuel filters. Sample oil for analysis.</b>
<b>Every 6 Months-</b>	<b>Sample gear oil and transmission fluids for analysis.</b>
<b>Every Two Years-</b>	<b>Change gear oil in differentials. Change transmission fluid. Sample gear oil and transmission fluid for analysis.</b>

**NOTE:** Prior to switching any unit over to AMSOIL, a sample was taken from that like point and submitted for a baseline oil analysis. This helped the laboratory establish a baseline for each unit, as well as to obtain a general overall fleets condition assessment before going into the test.

### Trucks Involved

At the onset of the AMSOIL-3X Program in 2000, 12 trucks were converted to AMSOIL AME SAE 15W-40 Synthetic Motor Oil. These trucks used engines from four primary engine OEM's: Volvo, International, Mack, and Caterpillar. Due to the success of the trial at its conclusion, a total of 172 trucks had been successfully integrated into the AMSOIL-3X Program. Which means that the data collected in this fleet trial covers a statistically significant fleet size, over a statistically significant time period of five years.

### Oil Drain Intervals Extended

- The AMSOIL-3X Program was successful in extending engine oil drain intervals from 300 hours to 900 hours, with an oil filter change occurring at 450 hours.
- This represents a **300% improvement**, resulting in increased truck availability and reduced shop time.

### Oil Filter Usage Extension

- Oil filter change intervals were extended from 300 hours to 450 hours, representing a **150% improvement**.
- On an annual basis, the average truck will use 4.75 fewer oil filters thereby delivering a reduction in oil filter purchases and disposal costs.

### Oil Usage Reductions

- The safe extension of engine oil drain intervals resulted in a savings of 55.8 gallons of engine oil per truck per year.

### Fuel Filter Usage Extension

- Fuel filter change intervals were extended from 300 hours to 450 hours, representing a **150% improvement**.
- On an annual basis, the average truck will use 4.75 fewer fuel filters thereby delivering a reduction in fuel filter purchases and disposal costs.

### Labor Hours Saved

- Labor savings achieved by using the AMSOIL 3 X program result in savings of **4.38 hours per truck per year** of maintenance expenses.
- Even greater savings are realized when these savings are applied to the entire fleet.

### Viscosity

- Even with a three-fold **(3X)** extension in the engine oil drain interval, there was not a single instance where AMSOIL AME 15W-40 Synthetic Motor Oil thickened or thinned beyond Critical Alarm Condemning Limits, even in the presence of fuel dilution.

### Total Base Number

- AMSOIL engine oil is so well fortified with a maximum performance additive package that the TBN averaged 11.7 at 900 hours service.
- This is an incredible 585% above the Critical Alarm Level of 2.0, even with a 3X extension in oil drain interval.

### Fuel Soot

- The AMSOIL engine oil demonstrated a tenacity to handle engine soot loading with the test fleet averaging 2.2% soot contamination at 900 hours service.
- When compared to a conventional soot loading condemnation level of less than 5% at any hour interval of service, AMSOIL delivers better soot control at 900 hours service than what most oils deliver at 300 hours.

### Fuel Dilution

- Because of the account's proactive maintenance program, not a single test truck ever exceeded the 3% fuel dilution critical condemnation level, even with 900 hours service.
- The value of the oil analysis program surfaced when five (5) trucks entered the fuel dilution "caution zone" (1.5% to 3%). However, the maintenance staff quickly responded and eliminated any catastrophic failure.
- The AMSOIL engine oil pulled its weight and did not back down in performance, nor allow any catastrophic wear to occur.

### Water

- AMSOIL engine oil averaged only 0.0525% water contamination after 900 hours service, well below the conventional alarm level of less than 0.1%!
- Oil analysis caught two trucks with leaking water jackets, and the fleet management team quickly reacted and corrected the engine deficiency with no engine failure. This was done at the expense of the manufacturer (Mack Trucks) because the testing "proved" a water leak existed.

### **Calcium (Ca)**

- AMSOIL AME 15W-40 engine oil employs calcium as the primary reserve alkalinity and detergent/dispersant agent. New oil is additized with approximately 3700 ppm (parts per million per milliliter of oil), which is roughly 3-4 times the treat level of conventional, or other "so-called" performance engine oils.
- Data demonstrates that the AMSOIL calcium add-pack provides unprecedented levels of performance. At the end of the 3X extended engine oil drain interval (900 hours), calcium averaged 4,400 ppm.
- There is more calcium at the end of the 3X extended oil drain interval than when it was started for three reasons:
  - (1) The extremely robust calcium treat levels and the nature of the Ca add-pack.
  - (2) The sweetening of the engine oil when the oil filters are changed at 450 hours and make-up oil is added.
  - (3) Calcium associates and bonds with soot.
- Calcium is the detergent/dispersant mechanism used to carry the contaminants to the oil filter. Some extremely small soot particles, with bound up Ca, will pass through the oil filter. Oil analysis can detect this bound-up calcium.
- In summary, the performance of the AMSOIL calcium additive demonstrates the oils ability to keep the engine clean, minimize oil oxidation and provide a platform for stabilized TBN performance - all of which correlates to safe, 3X extended engine oil drain intervals.

### **Phosphorus (P)**

- Phosphorus is utilized as an anti-wear/extreme pressure additive designed to reduce wear and minimize frictional heat, which subsequently helps to minimize oil oxidation.
- This is a very important component of AMSOIL AME. The AME engine oil contains approximately 1250 ppm of phosphorus when new.
- Data demonstrates that at the end of the 900-hour (3X) engine oil drain interval, phosphorous levels averaged between 1200 and 1250 ppm.
- This level of anti-wear and extreme-pressure performance is necessary for safe extended engine oil drain intervals, and assures the maintenance staff the peace of mind that their costly fleet engine investment is receiving maximum wear protection.
- Most importantly, with this level of wear protection the fleet is assured of receiving the longest possible engine service life available from any engine oil available in the world.

### **Zinc (Zn)**

- Zinc is the third leg of the proprietary AMSOIL AME add-pack chemistry and is utilized as the primary anti-oxidation agent. It also contributes some anti-wear performance to the oil.
- Minimizing oil oxidation is a key component for the safe extension of engine oil drain intervals and long oil service life.
- When new, AMSOIL AME engine oil starts with 1370 ppm of Zn.
- At the end of the 3X extended engine oil drain interval, Zn levels were virtually equivalent to new oil specification levels.
- Once again, the fleet benefits from the use of AMSOIL premium quality AME 15W-40 synthetic engine oil. AMSOIL utilizes this proprietary additive chemistry technology to deliver safe 3X extended engine oil drain intervals.

## **AMSOIL Oil Performance - Primary Wear Metal Conclusions**

### **Iron (Fe)**

- Even with a 3X extension in engine oil drain intervals, AMSOIL engine oil delivered an unbelievable 89% reduction in the iron wear metal rate. AMSOIL averaged only 0.056 ppm/hour at 900 hours service.
- The condemning iron wear rate is set at 0.500 ppm/hour for oils at 300 hours service. This demonstrates that the wear-arresting quality of the AMSOIL engine oil is irrefutable, and the costly and critical iron containing components in the fleet (crankshafts/camshafts/piston cylinders and rings/bearings) are being protected.

### **Copper (Cu)**

- Copper is a metal found when bearings are wearing out.
- The AMSOIL engine oil delivered an astonishing 85% reduction in Cu wear at 900 hours of service, which correlates to a nominal 0.0248 ppm/hour wear rate. This is well below the condemning limit of 0.1667 ppm/hour for other oils at 300 hours service. Fleet owners and maintenance specialists are wise to pay close attention to copper wear rates when discussing vehicle service life.

### **Lead (Pb)**

- A 95% reduction in lead wear rates greatly helps to support the decision to use AMSOIL engine oils.
- Lead is a soft metal and is one of the first to show up.
- Lead wear rates for the AMSOIL test fleet averaged 0.00856 ppm/hour at 900 hours, well below the 300 hour condemning limit of 0.1667 ppm/hour when conventional engine oils are used.
- Reduced lead wear means reduced bushing wear and longer engine service life.

### **Tin (Sb)**

- Tin wear rates are compared to Copper wear rates since both metals are part of alloyed steels, with both elements found on oil cooler surfaces.
- AMSOIL engine oil delivered an overall 97% lower wear rate at 900 hours service (0.00258 ppm/hour), then the 300 hour condemning wear rate limit (0.0833 ppm/hour).

### **Aluminum (Al)**

- As was the case with other wear metals, the use of the AMSOIL engine oil, even with a 3X extension in engine oil drain intervals, resulted in a wear rate of only 0.0149 ppm/hour.
- These results demonstrate a aluminum wear rate 75% below the condemning wear rate limit of 0.06 ppm/hour for other oils at 300 hours service.

## **Chromium (Cr)**

- As testimony to the wear reducing abilities of AMSOIL synthetic engine oil, it is important to recognize that a 97% reduction in chromium wear rates signifies superior wear protection where engine power is generated - in the cylinders. Critical piston rings must perform as needed, and AMSOIL delivers lasting performance.
- The AMSOIL wear rate was a an insignificant 0.00139 ppm/hour at 900 hours when compared to the 300 hour condemning wear rate maximum of 0.083 ppm/hour.

## **Nickel (Ni)**

- Use of the AMSOIL engine oil, even with a 3X extension in engine oil drain intervals, resulted in a wear rate of only 0.000655 ppm/hour. This demonstrates an incredible 98% below the condemning wear rate limit of 0.02667 ppm/hour for other oils at 300 hours service.

### **Silicon (Si)**

- The use of AMSOIL synthetic engine oil reduced silicon (dirt) contamination by an average of 76% - and this was accomplished with a 300% increase in the engine oil drain interval, and a 150% extension in the length of the filter change interval.
- Because the AMSOIL product is fortified to capture and hold on to contaminants, and because the test fleet maintenance shop kept a close vigil on their oil filter change intervals, dirt ingestion was controlled and held at bay - and critical wear surfaces never saw the catastrophic wear effects caused by dirt.
- This fleet test also demonstrated that the use of high performance AMSOIL super duty oil filters makes a difference in keeping engines clean and the results would have been even better with the new AMSOIL Ea nanofiber filter technology.

### **Boron (B) and Sodium (Na)**

- These contaminants are monitored due to their presence in engine coolants.
- The maintenance department watched closely for these engine contaminants. The team reacted to oil analysis data that indicated contaminants were present and coolant leaks were fixed before engine failure occurred.

## Oil Performance Summary

**The AMSOIL-3X program uses advanced lubricants and technology to increase drain intervals to 900 hours or three times the normal engine oil drain interval.**

**The AMSOIL-3X program has demonstrated and delivered a threefold extension in engine oil drain intervals, thereby delivering the following agreed upon test objectives:**

- Maximum truck availability for optimum fleet utilization
- Superior fleet performance
  - More available power
  - Improved fuel economy
  - Better emissions performance
- Significantly reduced overall engine oil costs
  - Reduced oil consumption
  - A 3X reduction in waste oil disposal costs
  - A 1.5 X reduction in oil filter disposal costs
- Lower oil filter costs
  - Better filter efficiency: 150% improved utilization
  - Lower filter disposal costs
  - Lower inventory requirements
- Improved cold weather performance
  - Instant oil pressure
  - Improved productivity: Warm-up time reduced
  - Reduction or elimination of block heater usage
- Significant reductions in maintenance labor costs
- Saving per truck at over \$781 per year
- Public relations benefits as an environmental leader by reducing lubricant usage and environmental impacts

### Protecting the Fleet is Essential

#### Oil Monitoring is Critical -

- Oil analysis samples were taken every 450 hours under the AMSOIL-3X program.
- The oil analysis program checks for abnormal engine wear, oil condition including oxidation and Total Base Number and provides indicators of other mechanical problems.

#### No Oil Problems -

- Oil analysis primarily uncovers problems with oil breakdown. Due to superior product quality these problems did not materialize.
- Instead, the following mechanical problems were uncovered before leading to costly repair and downtime:
  - Fuel dilution
  - Coolant leaks
  - Excessive fuel soot

#### Timeliness -

- Oil analysis concerns are communicated by Oil Analyzers INC. technical reports directly and immediately to fleet management.

#### Easy Implementation -

- Vehicles in the AMSOIL-3X program were equipped with a safe, easy to use sample valve.
- Installed on the oil galley, the valve pictured below allows for a collection of a uniform oil sample very quickly with ease and minimal possibility of contamination.

## Cost Analysis Assumptions

This section quantifies the benefits of the AMSOIL-3X Program. Savings data is based on information obtained on the refuse hauling test fleet involved in the study. These savings are substantial. Many other benefits are intangible or have not been completely verified. Reasonable conclusions are outlined using the data presented.

### Definitions -

- **Labor Rate:** The hourly payment to an employee.
- **Burdened Labor Rate:** The labor rate plus benefits and burdened overhead costs on an hourly basis.
- **Mineral Oil:** Traditional motor oils or gear lubes made from paraffinic or naphthenic base stocks refined from crude oil.
- **Synthetic Oil:** Synthesized man-made base stocks without the impurities of mineral oil. Synthetics can be designed for performance in temperature extremes and may exhibit superior life over conventional mineral oils.
- **Transynd:** Proprietary synthetic transmission fluid marketed jointly by Castrol and Allison. Other suppliers have been restricted from gaining approval from Allison.

### Fleet Assumptions -

<b>Fleet Size</b>	<b>28,000</b>
<b>Fleet Mechanic Rate</b>	<b>Average: \$40.00</b> <b>Burdened: \$65.00</b>
<b>Driver Labor Rate</b>	<b>Burdened: \$40.00</b>
<b>Average Hours Per Truck Pre Year (residential)</b>	<b>2,600</b>
<b>Number of Oil Changes Per Year at 300 Hours</b>	<b>9.66</b>
<b>Oil Change Labor Time</b>	<b>1 Hour</b>
<b>Oil Analysis and Filter Change Labor Time</b>	<b>0.5 Hour</b>

## Maintenance Comparison Tables -

### 2600-Hour Service Interval

Note: Some engines (Mack Engines) require multiple filters and elements.

Service Interval (Hours)	Oil Filter Service $\Delta$	Fuel Filter Service $\Delta$	Labor Hours	Oil Usage Gallons
Beginning (0)	1	1	1	10
300	1	1	1	10
600	1	1	1	10
900	1	1	1	10
1,200	1	1	1	10
1,500	1	1	1	10
1,800	1	1	1	10
2,100	1	1	1	10
2,400	1	1	1	10
2,600* (next interval 2,700)	0.66	0.66	0.66	6.6
<b>TOTAL</b>	<b>9.66</b>	<b>9.66</b>	<b>9.66</b>	<b>96.6</b>

### AMSOIL 3-X Service Interval

Service Interval (Hours)	Oil Filter Service $\Delta$	Fuel Filter Service $\Delta$	Labor Hours	Oil Usage Gallons
Beginning (0)	1	1	1	10
450	1	1	0.5	1
900	1	1	1	10
1,350	1	1	0.5	1
1,800	1	1	1	10
2,250	1	1	0.5	1
2,600* (next interval 2,700)	0.78	0.78	0.78	7.8
<b>TOTAL</b>	<b>6.78</b>	<b>6.78</b>	<b>5.28</b>	<b>40.8</b>

### Annual Usage Improvements Utilizing AMSOIL 3-X

	Oil Filter Service $\Delta$	Fuel Filter Service $\Delta$	Labor Hours	Oil Usage Gallons
Per Truck	4.75 Less*	4.75 Less*	4.38 Less	55.8 Less
Fleet Difference	133,056 Less*	133,056 Less*	133,056 Less	1,562,400 Less*

\*Based on 1.65 filters per truck, explained in the next section.

$\Delta$  = Change

## Savings Analysis

### Lube Cost Savings

Using the AMSOIL-3X program resulted in significant labor reductions for this waste refuse hauler. One standard man-year is defined as one worker working 52 weeks a year at 40 hours per week, or 2,080 hours. If you take the 122,640 hours the AMSOIL program saves the company, and then divide that by the 2,080 hours in a standard man-year, one finds an aggregate reduction of 58.96 men/year. Simply put, that is the equivalent of about 60 less mechanics in the organization.

At a burdened labor rate of \$65.00 per hour, the cost impact for the hauler company becomes even clearer. Just saving 4.38 hours per truck by using the AMSOIL program (as illustrated in the previous charts) is quite significant.

**This equates to burdened labor savings of \$284.75 per truck or \$7,971,600.**

### Oil Filter Cost Savings

Using the AMSOIL-3X program results in 2.88 less oil filter services per truck per year, or 80,640 fewer filter services fleet wide per year.

However, the savings are actually understated because approximately two-thirds of the fleet (66%) have engines with two filters. By calculating that approximately 18,840 trucks have two filters instead of just one actually makes the amount of oil filters used per truck total to 1.65 filters each.

The amount of filters used per truck can be determined by utilizing the following calculation:  $(28000 \times 33\% \times 1 \text{ filter}) + (28000 \times 66\% \times 2 \text{ filters})$ . Filter savings resulted due to the reduction of 133,056 filters used fleetwide, or 4.75 filters per truck. This accounts for filters purchased, inventoried, installed and disposed of by the company. Savings were based on estimated Fleetguard average national fleet filter pricing of \$17.00 per filter.

**Oil filter efficiency established during the AMSOIL-3X program resulted in savings of \$80.78 per truck or \$2,261,592!**

### Fuel Filter Cost Savings

Fuel filter savings parallel oil filter savings in the previous analysis. Using the AMSOIL-3X program results in 2.88 less fuel filters per truck per year, or 80,640 less filter changes fleetwide per year.

Since approximately two-thirds of the fleet have engines with two filters, the number of filters saved per truck filter change has been calculated at 1.65. Filter savings result in 133,056 (4.75 per truck) fewer filters purchased, inventoried, installed and disposed of by the company. Savings are based on estimated national fleet fuel filter pricing of \$5.00.

**Fuel filter cost reductions under the AMSOIL-3X program resulted in savings of \$23.76 per truck or \$665,280!**

### Oil Filter Disposal Cost Savings

Using previously established oil filter analysis data, some oil disposal savings are realized. Using the AMSOIL-3X program results in 133,056 fuel and oil filters to dispose of at an average estimated cost for some locations of \$0.25 per filter.

While this may not be a financially significant savings at only \$1.19 per truck, a reduction in the number of oil filters used exhibits strong environmental stewardship and could result in some savings as well.

**Savings in reduced oil filter disposal costs: \$33,264!**

### Oil Usage Savings

Using the AMSOIL-3X program had an extremely positive environmental and patriotic impact for the company. Maximizing oil life with AMSOIL AME resulted in a 57.8% reduction in lubricant usage. This is excellent for the environment, exhibits exceptional environmental commitment and demonstrates a reduction in America's dependence on foreign oil.

**The study showed a reduction in lube oil consumption of 55.8 gallons per truck or 1,562,400 gallons fleetwide annually!**

### Oil Purchase Cost Increase

Based on market intelligence and usage of 96.6 gallons per year per truck, the oil acquisition costs for the competitive mineral product is \$8,817,648 (96.6 gallons x \$3.26 per gallon x 28,000 trucks). The cost for the AMSOIL product based on 40.8 gallons per truck is higher at \$11,949,504 (40.8 x \$10.46 per gallon x 28,000 trucks). This accounts for a net lubricant purchase increase of \$3,131,856.

This is based on the 2003 oil price for AMSOIL AME of \$10.46 per gallon compared to competitive mineral oil products priced at an average of \$3.26 per gallon. On a per truck basis the lubricant purchase cost for the mineral oil is \$314.92, while the synthetic oil purchase price is \$426.77. Other factors such as reduced inventory carrying costs, improved cash flow, improved emissions performance and improved fuel economy are not factored into this calculation.

**Increase of \$3,131,856 or \$111.85 per unit.**

### Oil Analysis Savings

The AMSOIL-3X program utilizes a comprehensive oil analysis program that substantially reduced unscheduled downtime, identified problems that could be covered under warranty policies and resulted in catching problems that, if left unchecked, could have resulted in costly engine overhauls.

In the last year of the program, of the approximately 85 trucks under the AMSOIL oil analysis program, three engine coolant leaks and one potentially major fuel problem were uncovered. If undetected these problems would have resulted in engine overhauls at an internal cost of \$8,000. But due to manpower limitations for heavy maintenance, the problems would have been outsourced for \$12,000 each.

These findings support a problem rate of 4.7%. At that rate, such repairs would have cost the local fleet \$48,000. This scenario is also not unusual and could be applied to the entire fleet. The AMSOIL comprehensive program could catch 1,316 such problems annually in the entire fleet. This could potentially result in significant cost savings.

The cost for a comprehensive oil analysis program in 2003 was approximately \$9 per sample or \$1,708,560 for the 189,840 samples (sample volume is based on 450 hour oil analysis intervals for the entire fleet of 28,000 vehicles) taken over the course of a year. The return on investment would be approximately 9 to 1, which is not unusual for a well-managed program such as the AMSOIL-3X program.

Savings in repair cost:  
1,316 problems caught  
at \$12,000 each= \$15,792,000

Oil Analysis Program cost: - \$ 1,708,560

**Savings Using the  
AMSOIL-3X Oil Analysis: \$14,083,440  
or \$502.98 per unit**

## AMSOIL 3-X Program Cost Analysis Summary

Expense Area	Savings Per Truck	Fleet Savings
Labor Cost Savings	\$284.70	\$7,971,600.00
Oil Filters	\$80.78	\$2,261,592.00
Fuel Filters	\$23.76	\$665,280.00
Oil Filter Disposal	\$1.19	\$33,624.00
Subtotal	\$392.66	\$10,932,096.00
Oil Purchase Cost Increase	(\$111.85)	(\$3,131,856.00)
Net Savings	\$278.58	\$7,800,240.00
Oil Analysis Savings	\$502.98	\$14,083,440.00
<b>TOTAL AMSOIL 3-X Savings</b>	<b>\$781.56</b>	<b>\$21,883,680.00</b>

Totals used in the above table were found in previous examples.

## Summary Fleet Trial Conclusions

The AMSOIL-3X program results demonstrate to owner/operators of refuse haulers and off road equipment that significant wear and cost saving benefits are available by switching their maintenance programs to include AMSOIL synthetics. Reducing the amount of downtime any "work" vehicle such as the refuse hauler or off road equipment experiences is the key point when discussing a maintenance program. Owners of these vehicles have made sizeable investments in their purchase, and it is essential to maximize the amount of time that they keep their rolling investments in service. All owner/operators plan for scheduled downtime for service and safety checks on the equipment, but unexpected and unscheduled downtime is not planned for. Unscheduled downtime is the enemy of the work truck and off road equipment.

AMSOIL has demonstrated through the comprehensive AMSOIL-3X test program that the use of AMSOIL products will help to reduce unscheduled downtime. By extending oil drain intervals by utilizing oil analysis, the AMSOIL-3X program provides the following benefits:

- Premier engine protection with the finest synthetic motor oil available on the market.
- Extension of the service life of the vehicles and equipment.
- Cost savings realized by reduced oil/filter consumption.
- Problem identification through oil analysis to minimize the necessity of high cost repairs and overhauls, thus reducing unscheduled downtime.
- Maximize resource utilization through reduced unscheduled downtime via extended drain intervals.

The owner/operators of refuse services, contractors, construction companies and hauling services are all good businesses that would benefit from an AMSOIL program. Here at AMSOIL INC., we pride ourselves on providing user programs that help the small fleet compete and thrive. For these operations, vehicle and equipment availability is paramount. When you are working with fleets, downtime must be minimized. AMSOIL is your solution.



*The First in Synthetics®*

**FIELD SALES TOOLS SERIES**

# **REFUSE HAULERS AND OFF-ROAD EQUIPMENT**

## **The AMSOIL 3-X Trial**

### **Addendum - Technical Support Documentation**

## Addendum - Technical Support Documentation

Oil analysis data was utilized to provide scientifically documented evidence of the ability of AMSOIL AME SAE 15W-40 Motor Oil to safely extend engine oil drain intervals to three times (3X) normal drain intervals (from 300 hours to 900 hours). The very nature of providing technical justification for full program implementation requires the presentation of significant volumes of data. A basic overview on the data can be summarized as follows:

- Composite data from hundreds of oil analysis samples were compiled from actual fleet units. This data was analyzed, evaluated, and compared to oil condemning limits as a means to demonstrate and prove that the AMSOIL-3X Program provides safe extended engine oil drain intervals thereby generating significant bottom line cost savings.
- Oil condemnation limits were NOT arbitrarily set by AMSOIL INC. CTC Analytical, the largest independent oil analysis laboratory in the United States, shared their experience and condemnation levels with AMSOIL technical experts.
- CTC provided AMSOIL the condemnation limits presented in this report. The performance of the AMSOIL AME SAE 15W-40 Synthetic Motor Oil was compared against the CTC-provided condemnation limits to provide irrefutable proof that the AMSOIL AME Synthetic Motor Oil has delivered the fleet the absolute ultimate in engine protection and performance.
- The CTC Analytical condemnation limits were based upon:
  - Hard data from millions of engine oil samples that exist in CTC's massive database.
  - Data spanning many, many years and including results from all CTC laboratories throughout the United States.
  - CTC's data is all-inclusive, and covers every major known OEM engine type.
  - CTC's condemnation levels were set and based upon data generated from fleets in all types of service and using every known engine oil including;
    - +Straight mineral or petroleum engine oils.
    - +Petroleum-synthetic blend engine oils.
    - +Synthetic engine oils based upon Group III base stocks.
    - +Synthetic engine oil based upon genuine PAO (Polyalphaolephin) synthetic base stocks.
- Certain oil performance characteristics such as wear metal levels increase through use instead of decreasing.
- Other oil performance characteristics may deplete through service instead of increasing.
- The data presented is actual data from this comprehensive fleet test program.

## Physical Properties

The physical properties of an oil are the most important factors in determining its quality as a lubricant. This section includes ASTM (American Society of Testing and Materials) approved laboratory test data on the following physical parameters:

- Viscosity
- Total Base Number
- Fuel Soot
- Fuel Dilution
- Water

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise.

## Viscosity

### Oil Analysis

#### Category:

Performance Characteristic

#### Source:

Viscosity is a measure of an oils resistance to flow at a given temperature. It is measured several different ways but the Kinematic method following ASTM procedure D-445 is typically used for oil analysis. For diesel engines, the oil is measured at 100°C, and is reported in centistokes (cSt). SAE 15W-40 engine oils are considered in grade if they are within approximately 10% of 15 cSt. That range is from 12.5 cSt to 16.3 cSt. Without respect to other complications, oil is generally suitable for continued use up to one grade beyond specifications. This is usually a condemning range of from 9.3 cSt or less to 21.9 cSt or more.

### Analysis

#### Results:

Average viscosity values were compared at all service levels, including 900-hour service levels, which are 3X normal service levels. It should be noted that data was also included from oil samples at the 450-hour filter change interval so that the overall effectiveness of the AMSOIL program could be measured. Four fleet classifications were evaluated and viscosity was measured using standard ASTM testing procedures. The results are listed in the chart below:

Vehicle Type	Condemning Viscosity Range* at Any Hour Level	% of Units Beyond Condemning Range (at 900 hours service)
International DT-466	<9.3cSt or >21.9cSt	0.0%
Volvo 230 & 290	<9.3cSt or >21.9cSt	0.0%
Mack E-300 and E-350	<9.3cSt or >21.9cSt	0.0%
Caterpillar (Mixed fleet)	<9.3cSt or >21.9cSt	0.0%
<b>FLEET AVERAGE</b>	<b>&lt;9.3cSt or &gt;21.9cSt</b>	<b>0.0%</b>

### Conclusions:

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil excelled at maintaining viscosity, even when confronted with mechanical problems such as fuel dilution.
2. The 3X extension in motor oil drain intervals from 300 to 900 hours did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and absolutely deal with contaminants.

**Independent of other factors, viscosity control is excellent and further engine oil drain extensions could be achieved.**

## Total Base Number

### Oil Analysis

**Category:** Performance Characteristic

**Source:**

Total Base Number (TBN) is the amount of reserve alkalinity in the oil. The higher the reserve alkalinity of the oil, the better the oil's ability to combat acid formations created in the combustion process. Simply put, an oil that can maintain a TBN reserve can effectively combat oil oxidation and deliver extended engine oil service life.

TBN is expressed numerically. High TBN oils have a better ability to extend oil life. AMSOIL AME engine oil has a TBN that is significantly higher than most oils on the market, starting out at 12.0. This provides the end user the peace of mind that extended engine oil drain intervals can be safely achieved. TBN additives deplete over time. When oil reaches a TBN value below 4.0, its ability to fight acid formation should be evaluated. Many oil manufacturers do not make the initial additive investment necessary to deliver higher TBN values. In fact, most of the motor oil market seems to test at an optimum point of TBN values around 9.0. To increase TBN from 9.0 to 12.0 requires an exponential increase in additives (and costs for those additives). AMSOIL product philosophy is one of maximizing product performance, not minimizing product quality, as is clearly illustrated in our higher TBN levels.

**Analysis Results:**

Average TBN rates were compared at all service levels including 900-hour service levels, which are three times the normal service levels. It should be noted that data was also included from oil samples at the 450-hour filter change interval so that the overall effectiveness of the AMSOIL program could be measured. Four fleet classifications were evaluated, and TBN levels were measured using standard ASTM testing procedures. The results are listed in the chart below:

Vehicle Type	Condemning Limit TBN* at Any Hour Level	Average AMSOIL TBN Value (at 900 hours service)	% Above Alarm Level with AMSOIL Running 3X Longer
International DT-466	2.0	12.0	600%
Volvo 230 & 290	2.0	11.6	580%
Mack E-300 and E-350	2.0	11.6	580%
Caterpillar (Mixed fleet)	2.0	11.6	580%
<b>FLEET AVERAGE</b>	<b>2.0</b>	<b>11.7</b>	<b>585%</b>

**Conclusions:**

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a superb job fighting engine oil acids and allowed for longer oil usage, which translates directly to lower cost of operation.
2. Overall, TBN, which declines with use, did not even come close to falling below oil condemning safety levels for a single unit, and averaged 585% above condemnation levels.
3. The 3X extension in motor oil drain intervals, from 300 to 900 hours, did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection. AME absolutely dealt with oil oxidation issues and long oil life was safely achieved!
4. Independent of other factors, there is a lot of acid fighting ability in the AMSOIL product, and further oil drain extensions are possible.

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise.

## Fuel Soot

**Oil Analysis Category:**

Performance Characteristic

**Source:**

Fuel soot is a by-product of engine combustion. Oil viscosity will thicken if fuel soot overwhelms an oils soot dispersion capabilities. Fuel soot at high levels is known to cause wear in many engine components. Many oil analysis labs and OEM's believe that elevated soot at 3-5% is cause for concern. Soot at higher levels is interpreted as a definite concern, even though these concerns may not in fact be supported by test data.

**Analysis Results:**

Average Fuel soot percentages were compared at all service levels including our 900-hour service levels, which are three times the normal service interval. It should be noted that data was also included from oil samples at the 450-hour filter change interval so that the overall effectiveness of the AMSOIL program could be measured. Four fleet classifications were evaluated and soot levels were measured using standard ASTM testing procedures. The results are listed in the chart below:

Vehicle Type	Conventional Oil Condemnation Limit* Any Hour Level	Average AMSOIL Soot (at 900 hours service)	Question: Any Corresponding Engine Wear @ 3-X Longer?
International DT-466	>5%	2.4%	NO
Volvo 230 & 290	>5%	3.3%	NO
Mack E-300 and E-350	>5%	1.5%	NO
Caterpillar (Mixed fleet)	>5%	1.6%	NO
<b>FLEET AVERAGE</b>	<b>&gt;5%</b>	<b>2.2%</b>	<b>NO</b>

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise.

**Conclusions:**

1. On average, fuel soot did not rise above 5% for the fleet. Even in extreme cases with soot at 10% (the highest level), wear rates did not approach condemnation limits.
2. The Volvo fleet had the highest average soot rate, but consisted primarily of older (5+ years) units that are in severe stop-n-go service applications such as rear loader and side loaders. Even though 11.67% of the samples exceeded 3% soot levels, the Volvo fleet performed exceptionally well with wear limits considerably below condemning limits. Soot in engines protected with AMSOIL AME engine oil did not suffer any adverse effects.
3. The International fleet consists of mostly 2001 model year or newer recycler vocation trucks with stop-n-go operation. 29.6% of the units experienced soot readings greater than 3% due to injector design (oil pressure fed injectors with retarded timing), design (retarded injection to meet EPA requirements) and operational issues (idling and running not up to proper operating temperature). Even though almost 30% of this fleet exceeded 3% soot levels, neither viscosity nor wear increased. Once again, engines protected with AMSOIL did not suffer any adverse effects from soot.
4. Both Caterpillar and Mack engines exhibited exceptional soot performance.

## Fuel Dilution

### Oil Analysis

**Category:** Performance Characteristic

**Source:**

Fuel dilution is not necessarily indicative of oil performance, but rather demonstrates defective engine systems. The principal causes of dilution are a defective fuel injection system, a defective air inlet (obstructed air filter), incomplete combustion due to too low a working temperature, badly regulated valves or insufficient compression. Unfavorable for the engine, heavy fuel dilution of the oil causes a lower viscosity and thinner protective oil film. Dilution of used engine oil can be measured precisely by gas chromatography (GC) or by Fourier Transform Infrared spectroscopy (FTIR), or a flashpoint tester.

Dilution is considered heavy when values exceed >4% by volume. Technology also allows for fuel dilution detection at much lower "caution or nominal" levels. This allows A problem to be detected before it becomes destructive when dilution reaches 2.0% (which means this would be a good time to pull a vehicle out of service). However, even fuel dilution at 2% becomes damaging if left unchecked. The majority of problems uncovered relate to faulty fuel injector operation. The AMSOIL-3X Program uncovered many problems before costly engine component failure could occur. Several of these problems were the result of improper electronic settings for new equipment that was handled in the warranty period. Note that fuel dilution is usually undetectable without oil analysis. A benefit of this program is the ability to identify destructive situations before expensive repairs were necessary.

**Analysis Results:**

Average fuel dilution was compared at all service levels including 900-hour service levels, which are 3X normal service levels. It should be noted that data was also included from oil samples at the 450-hour filter change interval, so that the overall effectiveness of the AMSOIL program could be measured. Four fleet classifications were evaluated and fuel dilution levels were measured using standard ASTM (infrared analysis) testing procedures. The results are listed in the chart below:

Vehicle Type	Condemnation Limit Fuel Dilution* Any Hour Level	Number of Units Exceeding Alarm Level (4%)	Number of Units Exceeding Caution Level (2%)
International DT-466	4.0	0	3
Volvo 230 & 290	4.0	0	1
Mack E-300 and E-350	4.0	0	1
Caterpillar(Mixed fleet)	4.0	0	0
<b>FLEET AVERAGE</b>	<b>4.0</b>	<b>0</b>	<b>N/A</b>

**Conclusions:**

1. In instances where fuel dilution is present, AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a superb job protecting fleet equipment.
2. Fortunately, fuel dilution problems were given top priority by the account fleet management and the oil analysis staff. Properly armed with this useful information, fleet management was able to secure most repairs under warranty. This proves that benefits of using a comprehensive oil analysis program cannot be understated, nor over-emphasized.

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise.

## Water

**Oil Analysis Category:**

Performance Characteristic

**Source:**

Water is primarily the result of coolant jacket leaks and is commonly found contaminating Mack engines. If left unchecked, sludge can form and oil viscosity will increase. Additional complications include glycol leaks and bearing failure. The presence of water can only be determined by oil analysis.

**Analysis Results:**

Average water percentages were compared at all service levels including our 900-hour service levels, which are three times normal service levels. It should be noted that data was also included from oil samples at the 450-hour filter change interval, so that the overall effectiveness of the AMSOIL program could be measured. Four fleet classifications were evaluated and water levels were measured using standard ASTM testing procedures. The results are listed in the chart below:

Vehicle Type	Condemnation Limit* Any Hour Level	Average AMSOIL Water (at 900 hours service)	Q: Any Corresponding Engine Wear Above Limits @ 3-X Longer?
International DT-466	>0.1% by Volume	0.05%	NO
Volvo 230 & 290	>0.1% by Volume	0.05%	NO
Mack E-300 and E-350	>0.1% by Volume	0.06%	NO
Caterpillar (Mixed fleet)	>0.1% by Volume	0.05%	NO
<b>FLEET AVERAGE</b>	<b>&gt;0.1% by Volume</b>	<b>0.0525%</b>	<b>NO</b>

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise.

**Conclusions:**

1. Water contamination had no negative impact on any vehicles in the account fleet when the AMSOIL AME engine oil was in service.
2. Two (2) Mack engines with high water values due to leaking water jackets were detected by oil analysis and repaired under warranty or policy before serious engine damage could occur. Mack has a technical service bulletin on water leaks which states that Mack will repair water problems under warranty if a leak is proven to exist. This is another example of the benefits of an oil analysis program.
3. The AMSOIL-3X Program, and high-performance AMSOIL engine oil protected engines from water damage, even with 3-X extended oil drain intervals.

## Calcium (Ca)

**Oil Analysis  
Category:**

Additive Metal

**Source:**

Engine oil additive of an alkaline nature used as a detergent to neutralize acids formed by products of combustion in engine oil. AMSOIL AME employs Calcium as the primary reserve alkalinity agent, employing approximately 3,700 parts per million per milliliter of oil. This is typically three to four times the treat levels of competitive oils.

**Analysis  
Results:**

- AMSOIL AME 15W-40 engine oil employs calcium as the primary reserve alkalinity and detergent/dispersant agent.
- New oil is additized with approximately 3700 ppm (parts per million per milliliter of oil), which is roughly 3-4 times the treat level of conventional, or other "so-called" performance engine oils.
- Data demonstrates that the AMSOIL Ca add-pack provides unprecedented levels of performance. At the end of the 3-X extended engine oil drain interval (900 hours), calcium averaged 4,400 ppm. There is more Ca at the end of the 3-X extended oil drain interval than when it was started for three reasons:
  - 1) The extremely robust Ca treat levels and the nature of the Ca add-pack.
  - 2) The sweetening of the engine oil when the oil filters are changed at 450 hours and make-up oil is added.
  - 3) Ca associates and bonds with soot. Ca is the detergent/dispersant mechanism used to carry the contaminants to the oil filter. Some extremely small soot particles, with bound up Ca, pass through the oil filter and oil analysis notices this bound-up calcium.
- In summary, the performance of the AMSOIL Ca additive demonstrates the oils ability to keep the engine clean, minimize oil oxidation, and provide a platform for stabilized TBN performance - all of which correlates to safe, 3-X extended engine oil drain intervals.

### Oil Performance - Additive Chemistry

This section includes testing results found during oil analysis that support the additive chemistry present in AMSOIL motor oils. The following additive components were highlighted in the analysis report:

- Calcium
- Phosphorus
- Zinc

## Phosphorus (P)

### **Oil Analysis**

**Category:** Additive Metal

### **Source:**

Phosphorus is utilized as an anti-wear/extreme pressure additive designed to retard oxidation. This is a very important component of AMSOIL AME. AMSOIL AME contains approximately 1,250 PPM of this additive per milliliter of product.

### **Analysis**

#### **Results:**

- Phosphorus is utilized as an anti-wear/extreme pressure additive designed to reduce wear and minimize frictional heat, which subsequently helps to minimize oil oxidation. This is a very important component of AMSOIL AME.
- The AME engine oil contains approximately 1,250 ppm of phosphorus when new.
- Data demonstrate that at the end of the 900-hour (3-X) engine oil drain interval, phosphorus levels averaged between 1,200 and 1,250 ppm.
- This level of anti-wear and extreme-pressure performance is necessary for safe extended engine oil drain intervals, and delivers the maintenance staff the peace of mind that their costly fleet engine investment is receiving maximum wear protection.
- With this level of wear protection occurring, the fleet is assured of receiving the longest possible engine service life available from any engine oil available in the world. This is very important for the maintenance staffs' peace of mind.

## Zinc (Zn)

### Oil Analysis

#### Category:

Additive Metal, and also wear material as plating or alloy

#### Source:

Zinc is the third portion of the AMSOIL proprietary chemistry and is utilized as an anti-wear/extreme pressure additive. This additive is designed to retard oxidation. This is a very important component of AMSOIL AME, which contains approximately 1,370 PPM of this additive per milliliter of product.

### Analysis

#### Results:

- Zinc is the third portion of the proprietary AMSOIL AME add-pack chemistry and is utilized as the primary anti-oxidation agent. It also contributes some anti-wear performance as well.
- Minimizing oil oxidation is a key component for the safe extension of engine oil drain intervals and long oil service life.
- New AMSOIL AME engine oil starts of with 1,370 ppm of Zn. At the end of the 3-X extended engine oil drain interval, Zn levels were virtually equivalent to new oil specification levels.
- Once again, it is easy to see how the fleet benefits from the use of AMSOIL premium quality AME 15W-40 synthetic engine oil. AMSOIL utilizes this proprietary additive chemistry technology to deliver safe 3-X extended engine oil drain intervals.

## Primary Wear Metals

Analyzing engine oil for primary wear metals in an oil analysis program is very revealing. It is a great tool that can differentiate superior quality engine oil from mediocre engine oil. The primary wear metals analyzed in the AMSOIL-3X Program included:

- Iron (Fe)
- Copper (Cu)
- Lead (Pb)
- Tin (Sn)
- Aluminum (Al)
- Chromium (Cr)
- Nickel (Ni)

## Iron (Fe)

### Oil Analysis Category:

Wear Metals

### Source:

Iron is the predominant wear metal found in piston cylinder, bearing, crankshaft and camshaft wear.

### Analysis Results:

Average AMSOIL iron (Fe) wear rates based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet. These were then averaged to give an overall fleet profile on iron wear. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis, so the overall effectiveness of the AMSOIL motor oil could be measured throughout the 900 hour extended oil drain interval.

Vehicle Type	Condemning Limit Wear Rate* (At 300 Hours Service)	Average AMSOIL Wear Rate (at 900 hours service)	% Wear Reduction With AMSOIL Running 3-X Longer
International DT-466	0.500 ppm/hour	0.083 ppm/hour	83% lower Fe wear rate
Volvo 230 & 290	0.500 ppm/hour	0.054 ppm/hour	89% lower Fe wear rate
Mack E-300 and E-350	0.500 ppm/hour	0.049 ppm/hour	92% lower Fe wear rate
Caterpillar (Mixed fleet)	0.500 ppm/hour	0.049 ppm/hour	90% lower Fe wear rate
<b>FLEET AVERAGE</b>	<b>0.500 ppm/hour</b>	<b>0.056 ppm/hour</b>	<b>89% lower Fe wear rate</b>

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise.

### Conclusions:

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a fantastic job controlling iron wear, which translates directly to long engine life and maximum resale/trade-in value.
2. Overall iron wear was reduced an average of 89% below condemnation levels.
3. The 3-X extension in motor oil drain intervals from 300 to 900 hours did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and absolutely minimize iron wear.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.
5. The overall reduction of iron wear was so significant that this fleet could give serious consideration to further extending engine oil drain intervals.

## Copper (Cu)

**Oil Analysis**

**Category:** Wear Metals

**Source:** Copper (Cu) is typically a wear metal or additive that is alloyed with lead, tin or aluminum in bushings. It also leaches from gaskets, sealants and oil coolers.

**Analysis**

**Results:** Average AMSOIL Copper (Cu) wear rates based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on copper wear. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis so that the overall effectiveness of the AMSOIL motor oil could

Vehicle Type	Condemning Limit Wear Rate* (At 300 Hours Service)	Average AMSOIL Wear Rate (at 900 hours service)	% Wear Reduction With AMSOIL Running 3-X Longer
International DT-466	0.1667	0.00884	95%
Volvo 230 & 290	0.1667	0.03695	78%
Mack E-300 and E-350	0.1667	0.04922	71%
Caterpillar(Mixed fleet)	0.1667	0.00420	98%
<b>FLEET AVERAGE</b>	<b>0.1667</b>	<b>0.0248</b>	<b>85%</b>

be measured throughout the 900 hour extended oil drain interval.

**Conclusions:**

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a fantastic job controlling bushing wear, which translates directly to long engine life and maximum resale/trade-in value.
2. Overall, copper wear was 85% lower than condemnation levels. In most cases, increased copper wear could be attributed to oil coolers. In fact, MACK makes this same statement in their oil analysis handbook. The Mack engines experienced the highest copper levels in the overall fleet analysis.
3. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and minimize copper wear.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.
5. The overall reduction of copper wear was so significant that this fleet could give serious consideration to further extending engine oil drain intervals.

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise.

## Lead (Pb)

**Oil Analysis Category:**

Wear Metals

**Source:**

Lead is a wear metal that is usually alloyed with copper, tin or aluminum in plain bearings and bushings.

**Analysis Results:**

Average AMSOIL lead (Pb) wear rates based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on lead wear. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis, so the overall effectiveness of the AMSOIL motor oil could be

Vehicle Type	Condemning Limit Wear Rate* (At 300 Hours Service)	Average AMSOIL Wear Rate (at 900 hours service)	% Wear Reduction With AMSOIL Running 3-X Longer
International DT-466	0.1667 ppm/hour	0.00619 ppm/hour	96%
Volvo 230 & 290	0.1667 ppm/hour	0.00790 ppm/hour	95%
Mack E-300 and E-350	0.1667 ppm/hour	0.01684 ppm/hour	90%
Caterpillar (Mixed fleet)	0.1667 ppm/hour	0.00331 ppm/hour	98%
<b>FLEET AVERAGE</b>	<b>0.1667 ppm/hour</b>	<b>0.00856 ppm/hour</b>	<b>95%</b>

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measured throughout the 900 hour extended oil drain interval.

**Conclusions:**

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a fantastic job controlling lead wear, which translates directly to long engine life and maximum resale/trade-in value.
2. Overall, lead wear was an average of 95% below condemnation levels.
3. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and absolutely minimize lead wear.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.

## Tin (Sn)

**Oil Analysis**

**Category:** Wear Metals

**Source:** Tin (Sn) is typically a wear metal that is alloyed with lead, copper or aluminum.

**Analysis Results:**

Average AMSOIL Tin (Sn) wear rates, based upon 900 hour service intervals (three times the normal service intervals), were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on tin wear. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis so the overall effectiveness of the AMSOIL motor oil could be

Vehicle Type	Condemning Limit Wear Rate* (At 300 Hours Service)	Average AMSOIL Wear Rate (at 900 hours service)	% Wear Reduction With AMSOIL Running 3-X Longer
International DT-466	0.0833	0.00247	97%
Volvo 230 & 290	0.0833	0.00241	97%
Mack E-300 and E-350	0.0833	0.00288	97%
Caterpillar(Mixed fleet)	0.0833	0.00277	97%
<b>FLEET AVERAGE</b>	<b>0.0833</b>	<b>0.00258</b>	<b>97%</b>

measured throughout the 900 hour extended oil drain interval.

**Conclusions:**

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a fantastic job controlling tin wear, which translates directly to long engine life and maximum resale/trade-in value.
2. Overall, tin wear was 97% lower then condemnation levels. In most cases, increased tin levels in oil may be attributed to keeping the oil cooler surfaces clean.
3. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and minimize tin wear.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.
5. The overall reduction of tin wear was so significant that this fleet could give serious consideration to further extending oil drain intervals.

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## Aluminum (Al)

**Oil Analysis**

**Category:** Wear Metals

**Source:** Aluminum is a wear metal that may be found alone or in alloys.

**Analysis**

**Results:** Average AMSOIL aluminum (Al) wear rates, based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on aluminum wear. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis, so the overall effectiveness of the AMSOIL motor oil could be measured throughout the 900 hour extended

Vehicle Type	Condemning Limit Wear Rate* (At 300 Hours Service)	Average AMSOIL Wear Rate (at 900 hours service)	% Wear Reduction With AMSOIL Running 3-X Longer
International DT-466	0.0600 ppm/hour	0.01541 ppm/hour	74%
Volvo 230 & 290	0.0600 ppm/hour	0.01337 ppm/hour	78%
Mack E-300 and E-350	0.0600 ppm/hour	0.01237 ppm/hour	79%
Caterpillar (Mixed fleet)	0.0600 ppm/hour	0.01852 ppm/hour	69%
<b>FLEET AVERAGE</b>	<b>0.0600 ppm/hour</b>	<b>0.0149 ppm/hour</b>	<b>75%</b>

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oil drain interval.

**Conclusions:**

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a fantastic job controlling aluminum wear, which translates directly to long engine life and maximum resale/trade-in value.
2. Overall, aluminum wear was an average of 75% below condemnation levels.
3. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and absolutely minimize aluminum wear.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.
5. The overall reduction of aluminum wear was so significant that this fleet could give serious consideration to further extending oil drain intervals.

## Chromium (Cr)

**Oil Analysis**

**Category:** Wear Metals

**Source:** Chromium (Cr) is typically a wear metal, representing chrome components. It may also be present as an alloy or as a coolant additive.

**Analysis Results:**

Average AMSOIL chromium (Cr) wear rates, based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on chromium wear. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis, so the overall effectiveness of the AMSOIL motor oil could be measured throughout the 900 hour extended

Vehicle Type	Condemning Limit Wear Rate* (At 300 Hours Service)	Average AMSOIL Wear Rate (at 900 hours service)	% Wear Reduction With AMSOIL Running 3-X Longer
International DT-466	0.08333 ppm/hour	0.00148 ppm/hour	98%
Volvo 230 & 290	0.08333 ppm/hour	0.00097 ppm/hour	99%
Mack E-300 and E-350	0.08333 ppm/hour	0.00073 ppm/hour	99%
Caterpillar (Mixed fleet)	0.08333 ppm/hour	0.00239 ppm/hour	97%
<b>FLEET AVERAGE</b>	<b>0.08333 ppm/hour</b>	<b>0.00139 ppm/hour</b>	<b>98%</b>

oil drain interval.

**Conclusions:**

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a fantastic job controlling chromium wear, which translates directly to long cylinder and piston ring service life - which translates to long engine life and maximum resale/trade-in value.
2. Overall, chromium wear was 98% lower then condemnation levels.
3. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and minimize chromium wear.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.
5. The overall reduction of chromium wear was so significant that this fleet could give serious consideration to further extending oil drain intervals.

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise.

## Nickel (Ni)

**Oil Analysis Category:**

Wear Metals

**Source:**

Nickel is a wear metal that is found in steel alloys in some engine components.

**Analysis Results:**

Average AMSOIL nickel (ni) wear rates, based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on aluminum wear. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis, so the overall effectiveness of the AMSOIL motor oil could

Vehicle Type	Condemning Limit Wear Rate* (At 300 Hours Service)	Average AMSOIL Wear Rate (at 900 hours service)	% Wear Reduction With AMSOIL Running 3-X Longer
International DT-466	0.02667 ppm/hour	0.00105 ppm/hour	96%
Volvo 230 & 290	0.02667 ppm/hour	0.00086 ppm/hour	99%
Mack E-300 and E-350	0.02667 ppm/hour	0.00037 ppm/hour	99%
Caterpillar(Mixed fleet)	0.02667 ppm/hour	0.00034 ppm/hour	99%
<b>FLEET AVERAGE</b>	<b>0.02667 ppm/hour</b>	<b>0.000655 ppm/hour</b>	<b>98%</b>

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**Conclusions:**

be measured throughout the 900 hour extended oil drain interval.

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil did a fantastic job controlling nickel wear, which translates directly to long engine life and maximum resale/trade-in value.
2. Overall, nickel wear was an average of **98% below** condemnation levels.
3. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and absolutely minimize nickel wear.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.

## Silicon (Si)

### Oil Performance Contaminants

This section includes testing results found during oil analysis that revealed the presence of contaminants in the oil samples. The following contaminants were discovered and analyzed:

- Silicon
- Boron
- Sodium

**Oil Analysis Category:**

Contaminant

**Source:**

Silicon is in some cases found as an antifoam additive or as leachate from gaskets or seal materials. However, the predominant source of silicon is dirt particles. High silicon levels indicate a need for maintenance practice improvements. Silicon levels may vary by fleet and environment.

**Analysis Results:**

Average AMSOIL silicon (Si) incidence rates, based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on silicon contamination. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis, so the overall effectiveness of the AMSOIL motor oil could be measured throughout the 900 hour

Vehicle Type	Condemning Limit Silicon Levels* (At 300 Hours Service)	Average AMSOIL Silicon Levels (at 900 hours service)	% Below Alarm Levels With AMSOIL Running 3-X Longer
International DT-466	25 ppm	5 ppm	80%
Volvo 230 & 290	25 ppm	8 ppm	68%
Mack E-300 and E-350	25 ppm	5 ppm	80%
Caterpillar(Mixed fleet)	25 ppm	7 ppm	81%
<b>FLEET AVERAGE</b>	<b>25 ppm</b>	<b>6 ppm</b>	<b>76%</b>

extended oil drain interval.

**Conclusions:**

1. The account maintenance team did a fantastic job controlling silicon contamination, primarily as a function of properly scheduled oil and air filter change interval maintenance.
2. The proper handling of silicon contamination correlates directly to reduced engine wear, resulting in long engine life and maximum resale/trade-in value.
3. AMSOIL AME SAE 15W-40 Synthetic Motor Oil does an outstanding job of handling silicon (dirt) contamination with silicon levels averaging 76% below condemnation limits.
4. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and absolutely deal with contaminants.
5. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.

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## Boron (B)

**Oil Analysis Category:**

Contaminant

**Source:**

Boron is an additive in coolants and in some engine oils. The presence of Boron in amounts above base line engine oil samples typically indicates a coolant leak. Normally, Boron is present with Sodium (NA), an increase in wear metals and a possible increase in viscosity under these circumstances.

**Analysis Results:**

Average AMSOIL boron (B) incidence rates, based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on boron contamination. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis, so the overall effectiveness of the AMSOIL motor oil could be measured throughout the 900 hour extended

Vehicle Type	Condemning Limit Boron Levels* (At 300 Hours Service)	Average AMSOIL Boron Levels (at 900 hours service)	% Below Alarm Levels With AMSOIL Running 3-X Longer
International DT-466	80 ppm*	5 ppm	94%
Volvo 230 & 290	80 ppm*	3 ppm	96%
Mack E-300 and E-350	80 ppm*	25 ppm	69% **
Caterpillar(Mixed fleet)	80 ppm*	6 ppm	93%
<b>FLEET AVERAGE</b>	<b>80 ppm*</b>	<b>10 ppm</b>	<b>88%</b>

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise. Sodium levels above 80 ppm coupled with water contamination or excessive wear are indicators of coolant contamination. This is confirmed by the use of tests to confirm glycol contamination.

\*\* Using oil analysis, several coolant leaks were discovered before catastrophic failure - saving tens of thousands of dollars in repair costs.

oil drain interval.

**Conclusions:**

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil as well as fleet management did a fantastic job controlling boron contamination, which translates directly to long engine life and maximum resale/trade-in value.
2. Overall, boron contamination averaged **88% below** condemnation levels.
3. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and absolutely deal with contaminants.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.

## Sodium (Na)

**Oil Analysis**

**Category:** Contaminant

**Source:** Sodium is a contaminant that is usually an additive found in engine coolant. Sodium is an indicator of engine coolant leakage and can warn of an expensive imminent engine failure.

**Analysis**

**Results:** Average AMSOIL sodium (Na) incidence rates, based upon 900 hour service intervals (three times the normal service intervals) were established for each of four classes of vehicles within this fleet, then averaged to give an overall fleet profile on sodium contamination. It should be noted that data from oil samples at the 450-hour filter change interval were also included in this analysis, so the overall effectiveness of the AMSOIL motor oil could be measured throughout the 900 hour

Vehicle Type	Condemning Limit Sodium Levels* (At 300 Hours Service)	Average AMSOIL Sodium Levels (at 900 hours service)	% Below Alarm Levels With AMSOIL Running 3-X Longer
International DT-466	80 ppm**	5 ppm	94%
Volvo 230 & 290	80 ppm**	3 ppm	96%
Mack E-300 and E-350	80 ppm**	25 ppm	69% **
Caterpillar(Mixed fleet)	80 ppm**	6 ppm	93%
<b>FLEET AVERAGE</b>	<b>80 ppm**</b>	<b>10 ppm</b>	<b>88%</b>

extended oil drain interval.

**Conclusions:**

1. AMSOIL AME SAE 15W-40 Synthetic Motor Oil as well as fleet management did a fantastic job controlling silicon contamination, which translates directly to long engine life and maximum resale/trade-in value.
2. Overall, sodium contamination averaged **88% below** condemnation levels.
3. The 3-X extension in motor oil drain intervals (from 300 to 900 hours) did not affect the ability of the AMSOIL synthetic motor oil to provide engine protection and absolutely deal with contaminants.
4. A 900-hour engine oil drain interval is a safe and effective engine oil drain interval as scientifically established through oil analysis.

\* The condemning limits were provided by CTC Analytical, a third party oil analysis laboratory. CTC Analytical is the largest oil analysis service organization in the country and adheres to generally accepted industry standards. The condemnation limits are based upon direct recommendations from OEM's and CTC's vast experience and expertise. Sodium levels above 80 ppm coupled with water contamination or excessive wear are indicators of coolant contamination. This is confirmed by the use of tests to confirm glycol contamination.

\*\* Using oil analysis, several coolant leaks were discovered before catastrophic failure - saving tens of thousands of dollars in repair costs.