Technical Bulletin

The following technical bulletin discusses various causes and problems associated with formation of sludge, varnish, soot, rust etc. in oil and how X-1R Engine Treatment may help in reducing these problems.

Introduction:

Manufacturing modern engine oil is a precision operation. From the time that the crude oil goes into processing, until the finished lubricating oil is stored, careful control of temperatures, pressures and process time is exercised. Elaborate equipment takes undesirable components from the oil. Small, precise amounts of desired compounds are added at certain stages. Throughout the entire operation, extreme care is taken to keep contamination out of the product. Painstaking work is required to produce oils that will give first rate lubrication to engines of all types, under all conditions of operation and service. Such wide performance standards require that the oil be refined to meet exacting specifications such as viscosity, viscosity index, pour point, cloud point, flash point, fire point, ash, carbon residue, color and resistance to oxidation and corrosion.

When new oil is poured from its sealed container into an engine, it goes from the controlled environment of the oil refinery into a completely uncontrolled chemical factory - the engine. There is little control of temperature, pressure, time or contamination in the engine. The oil is subjected to temperatures from below zero to perhaps 816°C (1500°F) on the cylinder walls and to pressures from atmospheric up to thousands of pounds per square inch in the bearings. The length of time the oil is exposed to this uncontrolled environment depends simply on the whim of the operator with regard to operating conditions and drain intervals.

In addition to the variations in time, temperature and pressure, the oil now becomes exposed to a great variety of contaminants. The burning of the gasoline or diesel fuel itself yields a host of chemicals which find their way into the crankcase oil. When a pound of gasoline is burned, about a pound of water is produced. Combustion also creates oxides of nitrogen from the air, and these oxides may form acids. Small amounts of carbonic acid, sulfuric and sulfurous acids, lead sulfate, and other complex compounds may be formed. If combustion is incomplete, aldehydes are formed, and when knock or detonation occurs, even more complex reactions take place. During combustion, unburned or partially burned carbon or soot also forms, and it forms more heavily when the air fuel mixture is rich.

Most of these compounds leave the engine through the exhaust, but a small amount goes into the crankcase from blow-by. Some fuels also form other undesirable decomposition products. These products are not only oil contaminants, but may interfere with the action of piston rings and affect engine cleanliness.

Further contamination occurs from the heavy ends of the fuel which reach the crankcase during cold engine operation. Dust and dirt find their way into the oil. The water, chemicals, heavy fuel ends, dirt , dust and the air in the crankcase are then completely mixed with the oil by the motion of the internal parts of the engine. The oil itself will tend to deteriorate because of oxidation. Even though it is well inhibited, high temperatures will speed its oxidation. This chemical union produces oil oxidation products which in themselves can be harmful. With these processes continuing over wide ranges of speed and temperatures between oil drain intervals, it is no wonder that the oil may eventually deteriorate as a lubricant. Let us examine the various types of engine operating conditions and the effects of some of these contaminants so that they can be brought under some degree of control. It is not possible to eliminate oil contamination or to avoid the influence of temperature and time. However, it is possible to minimize their effects to some extent and thus prolong oil life.

In the next few paragraphs, types and causes for sludge formation in oil and possible solutions to control sludge are discussed

Low Temperature Operation: In some parts of world, wintertime operation of engines in stop-and-go service with considerable idling and very short runs, impose low temperature conditions on the crankcase oil. Under these conditions, the cooling water temperature may not exceed 49°C (120°F), and the crankcase oil temperature may not even be this warm. When the engine is started in cold weather, heavy fuel fractions enter the combustion chamber in liquid form and wash down the walls. Combustion is liable to be erratic. Contamination from water and other products of combustion is also higher during low temperature operation because of the condensing effect of cold cylinder walls. It might be pointed out here that low temperature operation is not specifically limited to extreme cold weather. Many times, even in warm weather in some countries, the same problems exist with light duty engines that never get sufficiently warmed up.

Under low temperature operation the oil essentially deteriorates by contamination rather than by oxidation. The mixture of water, oil and contaminants forms a mayonnaise-like sludge which tends to settle out of the oil on the bottom of the oil pan and in other areas of the engine not sufficiently washed by the oil. After about 1500 miles in an average gasoline engine crankcase, the major contaminants may include abrasives, sand, dirt, unburnt gasoline, soot, carbon, metals, water, glycol, tars, gums and resins.

These low temperature effects can be reduced by any number of steps that increase the temperature of the cylinder walls and the crankcase oil. Water temperature can be increased by using higher temperature thermostats, blocking off a portion of the radiator and/or using a fan which is thermostatically controlled. A direct method of increasing oil temperature levels is to insulate the outside surface of the crankcase.

In addition to good oil filtering, adequate crankcase ventilation is helpful. Care should be taken to keep any breather openings clean, and if equipped with positive crankcase ventilation, the valves and tubes should be checked regularly to see that they are clean and free. One of the best answers to the problems of oil contamination under low temperature conditions is to drain the crankcase at more frequent intervals than usual. Historically oil manufacturers use anti-wear and friction modifier additives in motor oil to minimize engine wear and tear which helps in reducing metal contaminants (small particles) getting into oil, but sometimes quantities of these additives are not enough in some types/qualities of motor oils. X-1R Engine treatment contains extreme pressure, anti-wear and friction reducing agents which treat metal parts in an engine improving load bearing capabilities of the metals surfaces and also make these surfaces smoother causing less friction and reduce excessive wear during cold starts. This results in reduction in "wear and tear" particles/metallic contaminants contributing to sludge quantity. X-1R Engine Treatment also contains corrosion inhibitor which takes care of any acids formed in oil in presence water (as contaminant). This helps in reducing corrosion of metal surfaces in an engine, which results in less contribution of ingredients, which are caused by metal corrosion, to the sludge.

High Temperature Operation: Hot weather operation at sustained high speed and heavy loads will result in high crankcase oil temperature. It is not uncommon to find crankcase temperatures over 135°C (275°F). Under these conditions, oil deterioration is mostly the result of oxidation at high temperatures rather than by contamination. When thoroughly mixed with air, oils tend to oxidize faster and this rate of oxidation doubles with every 10°C increase in temperature. Oxidation tendencies are also increased by metallic contaminants which act as catalysts. The minute particles of iron that are scraped from cylinder walls accelerate oil oxidation at high temperatures.

Oxidation of the oil forms many compounds such as oil soluble acids, resins and varnish like materials. Some of these materials also occur from fuel decomposition. These compounds tend to adhere to hot metal surfaces producing the stain, varnish or lacquer coatings frequently seen on piston skirts. Under higher temperatures, they may completely plug oil control rings and piston ring grooves.

Another class of products is the materials formed when oil strikes metal, which is hot enough to "crack" the oil. These materials are not oil soluble, and form the "coffee grounds" type sludge. The amount of oil deterioration through oxidation and the formation of undesirable compounds depends on the total combination of oil type, fuel type, operating temperature, engine design and oil drain interval. Under adverse conditions, even a slight reduction in operating temperature may relieve the situation, as well as the change to better quality motor oils which have good quality base oils or have optimal dosages of additives.

To control oil degradation issue, oil manufacturers typically use Anti-wear/EP additives (Zinc Dialkyldithiophosphates, Organic Phosphates, Moly, Sulfur compounds, other metallic compounds etc.), Oxidation Inhibitors (ZDDP, Aromatic Amines, Hindered Phenols etc.), detergent-dispersants (Succinimides, Amines, Polymeric Detergents, Neutral Metallic Sulfonates, Phenates etc.), corrosion/ rust inhibitors (High Base Additives, Overbased Sulfonates, Phosphates, Organic Acids/Esters, Amines etc) and metal deactivators.

Detergents are cleaning agents that adhere to dirt particles, preventing them from attaching to critical surfaces. Detergents also adhere to the metal surface itself to keep it clean and prevent corrosion from occurring. To provide additional protection, over-based detergents neutralize acidic combustion and oxidation products, helping to control rust, corrosion, and resinous build-up in the engine. Some detergents can also act as oxidation inhibitors. The rate of oxidation doubles with every 10º C rise in temperature. If not controlled, the lubricant decomposition will lead to oil thickening and the formation of sludge, varnish, resin, and corrosive acids. This vicious cycle leads to an increase in rust and corrosion, resulting in metal damage from oxygen and acid attack. Water and polar impurities increase the speed of attack, and internal combustion engines contain plenty of these elements. Rust and corrosion inhibitors provide a barrier between the metal surface and harmful elements. Some inhibitors neutralize acids, others form protective films. Some detergents are excellent rust and corrosion inhibitors, because they protect in both ways.

Dispersants are used in engine oils to keep sludge, soot, oxidation products, and other deposit precursors dispersed in engine oil so that these by-products of heat and combustion do not deposit onto and harm key engine parts. Thus dispersants keep vital engine parts clean, prolonging engine life and helping to maintain proper emissions and good fuel economy.

X-1R Engine Treatment primarily contains extreme pressure, anti-wear and friction reducing agent. Due to its extreme pressure and friction reducing properties, it helps in running engine cooler during heavy load and/or during adverse driving conditions (i.e. reducing operating temperature in an engine). This helps considerably in preventing formation of undesirable compounds in oil, which contributes to the sludge (as discussed above). Anti-wear properties of X-1R Engine Treatment help in reducing metal-wear particles in oil which could act as catalysts for oxidation at higher temperatures. Also metal deactivator present in Engine Treatment forms surface films, so metal surfaces do not catalyzes oil oxidation process.

X-1R Engine Treatment is also fortified with same industry proven antioxidant (oxidation inhibitor), corrosion inhibitor, and detergent-dispersant which are used by oil manufactures as additive package while formulating good quality engine oils. Thus X-1R Engine Treatment helps in controlling sludge and extending engine oil life during high temperature operation.

Discoloration: Generally when crankcase oils are subjected to the extreme conditions of service, as mentioned above, they will definitely change color. They have probably become opaque and may range in color from a dark chocolate brown to a light gray. Because of the contamination and gradual deterioration, the oil be-comes discolored.

First of all, the detergent additives used in oil are designed to keep the engine clean by holding the contaminants and deterioration products as finely divided particles in the oil itself. This keeps the engine clean, but it does make the oil look dirty. If the oil is dark brown or wine colored, it is usually due to the oil oxidation products and varnish-like materials already mentioned. Actually, it is much better to keep this debris in suspension in the oil than to have it drop out of the oil as varnish on the pistons, rings and grooves.

The gray discoloration which is seen frequently is due, in part, to road dust and dirt, and in the past due to the decomposition of lead compounds from fuels containing tetraethyl lead. Generally this gray discoloration is not seen in diesel engines. When oil is black and opaque, this may be attributed to slightly rich air-fuel mixture and to the formation of soot and carbon. While it is due to a rich air-fuel mixture, quite often you will find this type of discoloration in heavily loaded or overloaded engines.

Fuel Dilution - Ambient temperatures, air-fuel ratios, fuel volatility and mechanical condition of the engine are factors that directly influence the amount of crankcase oil dilution. Low temperature operation and worn cylinder bores and rings will also produce a high amount of dilution.

Five or six percent fuel dilution in gasoline engine crankcase oil is the maximum that should be allowed. This will reduce the SAE grade of the crankcase oil by one number. With improper engine operation, it is possible to dilute the crankcase oil sufficiently so that there may be metal-to-metal contact in the bearings. Excessive dilution in the crankcase should never be disregarded, as it means that something is wrong, either with the engine or the manner in which it is being operated.

Dust And Dirt - The air in metropolitan areas may contain as much as four or five tons of dust and dirt per cubic mile. On unimproved roads, in dry weather, or on farms, this figure is greatly exceeded. Road and field dust is very abrasive and will cause very rapid wear of cylinder bores, rings and ultimately the bearings.

Air and oil filters are remarkably efficient when maintained according to manufacturers' recommendations. The average operator is prone to neglect these accessories and, consequently, they become less effective as mileage is accumulated. Both oil and air filters should be serviced regularly.

Soot - Soot is generally formed by incomplete combustion of the fuel. This occurs when there are rich air-fuel ratios during starting in cold weather and also during intermittent operation at low temperatures. The soot is picked up by the oil on the cylinder walls and washed down into the piston ring belt and the crankcase. Oil ring plugging is due to soot mixing with other combustion products and oil deterioration products to form a soft mass in the ring area.

The accumulation in the oil ring slots is then baked hard by higher temperatures, and plugs the oil ring. Oil ring plugging means severely increased oil consumption because of the lack of control on the cylinder walls. Soot formation is difficult to control because of rich air-fuel ratios needed for cold starting and idling. Engines used in stop-and-go service at low temperature seem to be particularly susceptible to plugging. Under these conditions, the best answer is good crankcase ventilation, high operating temperatures and more frequent oil drain intervals.

A Different Problem: The causes of sludge formation and associated problems mentioned in this article to this point have been with us for many years, and they have only been growing more severe. However, over the years, another problem has been en-countered. Under severe conditions, the oil in the crankcase is turning to a grease-like sludge. The reason for this sludge formation is primarily extremely high temperatures - sometimes over 149°C (300°F). Some of the reasons for this higher temperature are: 1) emission control systems; 2) air conditioners; 3) high pressure cooling systems; 4) factory recommended long oil drain periods; 5) cramped engine compartments with restricted air flow; and, 6) the rapid growth of recreational vehicles being towed.

The problem is more or less in passenger cars, but it is likely to show up in truck engines also. The trouble first appeared several years ago when there were scattered complaints of severe oil thickening in some engines. In the beginning, the problem seemed concentrated in one or two makes of cars, but since then, all manufacturers have experienced it to some extent. This does not appear to be a straightforward case of oxidation, because when the sludge is heated it will melt and become oil and this is not typical oxidation.

Engine break-in procedures seem to have some significance. There is less likelihood of thickening in an engine that is carefully broken in. It is believed that new and rebuilt engines generate more bearing heat, and their clean metal surfaces also have a catalytic effect on the process.

Conclusion: The problems of oil contamination and sludge formation have been subjected to a great deal of research by everyone involved with engines. Answers to the problems are being provided by improved motor oils and by engines designed to reduce contamination. The ideal combination of oil that will not deteriorate and an engine that will not contaminate will probably never be reached. Automotive aftermarket products like X-1R Engine Treatment can help to a certain extent in controlling sludge, but may not solve all problems associated with oils in all types of engines. Therefore, the best and most economical procedure is to drain the crankcase at reasonable intervals and to refill it with fresh oil which may be fortified with proven aftermarket product like X-1R Engine Treatment for superior performance. The reasonable oil change interval is not easy to establish for a wide variety of operating conditions, but the industry has worked out recommendations for various types of oil, operating conditions and engine designs based on a great deal of experience. Oil analysis can also be used to establish reasonable, safe drain intervals.