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THE SIGNIFICANCE OF GENERAL LABORATORY TESTS ON FUELS AND LUBRICANTS

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The purpose of this publication is to inform those interested that there is a provincial government laboratory at Edmonton where they can have samples of fuel and lubricating oils tested. Some of the tests which this laboratory is prepared to perform and the meaning of these tests are discussed in the pages which follow. Also, at the end of the discussion there is a schedule of the charges which are made for the various tests.

The operators of small stationary and portable gasoline and diesel engines have been in mind particularly in writing this pamphlet. There may be times when an engine fails to run or does not give the performance of which it is capable. Considerable time may be spent in diagnosing the trouble and the conclusion may finally be reached that the trouble lies with the fuel or lubricating oil. Laboratory testing of the fuel or oil may then be necessary.

Fuel or oil may be tested to see if it conforms to certain standards. If it does and it is used for the purpose for which it is intended, one can be reasonably assured that no trouble will arise from its use. If there is difficulty in choosing a fuel or an oil it is wise to select from standard brands. Generally speaking these can be relied upon to meet rigid specifications. Above all however, care must be taken to follow the directions given by the makers for the operation and maintenance of the engine.

The laboratory testing of fuels and lubricating oils can only be carried out satisfactorily using costly apparatus and chemicals. Consequently, relative to the information obtained, testing may appear to be an expensive matter. Before a sample is submitted for analysis it is worth while to seek authoritative advice as to whether a test is likely to throw light on the cause of the trouble. A clear and concise account of the nature of the trouble should be stated. Suitable tests can then be selected and an indication given of their significance relative to the trouble which is experienced.

Any sample submitted for test should truly represent the fuel or oil which has been used or which it is intended to use. The satisfactory sampling of any liquid is not too difficult a matter. Care must be taken to see that the sample is placed in a perfectly clean dry container. A sample which is contaminated with water or foreign matter is likely to lead to erroneous conclusions even with the most careful testing. A one half to one gallon sample is necessary for fuels while one quart is sufficient for lubricating oils. If the sample is not dispatched to the laboratory by hand it must be placed in a tight container and well packed to prevent damage in transit. Special regulations apply to the carriage of inflammable liquids so appropriate authorities should be consulted before the sample is dispatched.

The following notes have been compiled to describe briefly the tests used and the character of the information which is obtained from them.

FUEL OILS

To be satisfactory fuel oils must be non-corrosive, that is they must not contain substances which would be likely to damage fuel tanks, feed lines or carburettor parts. Moreover, they must not produce corrosive materials when burned. They must be reasonably safe to handle, transport, and store. The fuels must be volatile enough to permit easy starting and yet not so volatile as to cause vapour lock. They should give reasonably good acceleration and burn completely without detonation or knocking.

Laboratory tests devised to evaluate the above mentioned qualities are as follows:

1. Corrosion.

Most petroleum products contain small amounts of sulphur compounds and occasionally free sulphur. Many but not all of the sulphur compounds are corrosive and if these are present even in small amounts corrosion will probably result. The test is therefore designed to determine whether the fuel contains substances of a corrosive nature.

2. Sulphur Content.

When the fuel is burned, sulphur compounds present produce a gas which, if it combines with any moisture present, forms sulphuric acid. Sulphuric acid is highly corrosive. Since moisture is invariably present when the engine and particularly the exhaust is cold, it is important that the sulphur content of the fuel should be as low as possible.

3. Gumming Tendencies.

Gum is the name given to sticky resinous deposits which may form in fuels during periods of storage. If only a small amount of gum is present it may remain in solution but when the fuel evaporates the gum remains as an

insoluble residue. If the gum forms in large amounts it coats the walls of the container and the fuel takes on an objectionable odor. Excessive gum formation is followed by stickiness of the valve stems and carburettor parts, the clogging of screens and filters in the fuel lines and in the formation of deposits on the intake manifold. All these occurrences give rise to uncertain engine performance.

4. Vapour Pressure.

The vapour pressure of a fuel is important from the standpoint of safety during transportation and storage of the fuel. It also influences the ease of starting the engine especially in cold weather, and the occurrence of vapour lock. In the test for vapour pressure which is actually used, the pressure developed in a closed container under certain standard conditions of temperature is measured, and the result is expressed in pounds per square inch. If the vapour pressure of the fuel is found to be too low, then an engine in which the fuel is used may be difficult to start. If the vapour pressure is too high it is likely that vapour lock will occur.

5. Distillation Range.

The distillation test determines whether the fuel contains sufficient volatile substances to give good acceleration. The test also serves to show if the fuel is likely to burn completely in the engine and to leave no residue to dilute the oil in the crankcase. The test is made by distilling a sample of the fuel and noting the temperatures at which certain percentages distil over and can be condensed and collected.

6. Octane Number.

The more a mixture of air and fuel vapour is compressed in the engine cylinders before it is ignited, the greater is the power generated when the mixture is burned. If however, the compression exceeds a certain amount which

is critical for any fuel, either ignition will occur before sparking, or when the mixture is ignited by the spark, combustion may develop in an irregular manner. Such irregular combustion, identified by an audible metallic sound is called detonation or knocking. When it occurs it may severely limit the power developed by the engine.

The tendency of a fuel to knock is largely dependent on the character of the fuel and only to a smaller extent on the construction of the engine. This tendency of a fuel to knock is measured by what is termed the Octane Number. Octane Numbers range from nil to one hundred. The higher the Octane Number the less tendency the fuel has to knock or the higher the compression ratio of the engine in which it can be used. Severe knocking may result not only in loss of power, but in injury to the engine. Occasional trace knock however has little measurable effect.

The knock-rating of a fuel is related to the kind of engine in which it is used. Since high anti-knock fuels in general are higher in price than fuels of lower knock rating, it is not economical to use fuels with a higher knock rating than that required by the particular type of engine. Any increase in power which might be gained is not commensurate with the increased expenditure.

7. Tetraethyl lead content.

Tetraethyl lead is added to fuels to increase their Octane Number. The quantity of tetraethyl lead added to fuels must be limited for reasons of health and public safety, to ensure that no mechanical defects develop in the engine, and for reasons of economy. Precautions are taken to see that only safe quantities of this material are used. If the amount present must be known it may be determined by chemical analysis of the fuel and is expressed as the amount in one gallon of fuel.

8. Freezing Point.

A fuel must not partially or totally solidify at the very low temperatures which occur in winter. In the laboratory test samples of fuel are cooled to 75 degrees Fahrenheit below zero, and if they pass this test it is considered that they will be satisfactory in use under winter conditions.

9. Specific Gravity.

The specific gravity of a petroleum product relates the volume occupied to its weight. In the petroleum industry, specific gravities are generally stated as Degrees A.P.I., that is to say specific gravity according to standards established by the American Petroleum Institute. The lighter the product the higher its specific gravity in Degrees A.P.I. Consequently one often hears the term "high test" or "high gravity" used. These are descriptive terms only and they define a light or volatile product.

LUBRICATING OILS

Lubricating oils are used in internal combustion engines for four main purposes: to reduce friction between rubbing surfaces; to provide good compression by sealing piston rings; to act as a cooling agent in removing heat from the engine; and to act as a scavaging agent in carrying to the filter, particles of carbon, metal chips, dust or other foreign material.

To be satisfactory in use a lubricant must be free from acids or corrosive material. It must be fluid enough at low temperatures to permit easy starting and yet not so fluid at high or operating temperatures as to lose its lubricating quality. It must be stable enough to remain in good condition for long periods without deterioration and free from any materials which tend to form carbon deposits.

Whilst actual service performance must be the final criterion of the worth of any lubricant, laboratory tests serve as a means of selection.

Laboratory tests devised to evaluate the above mentioned qualities are as follows:

1. Corrosion.

The corrosion test has the same significance as that for fuels.

2. Viscosity.

Viscosity is probably the most important characteristic of a lubricating oil. It is a measure of its resistance to flow or of its internal friction. It indicates also the ability of an oil to support loads.

The viscosity of an oil is measured as the length of time in seconds required for a measured quantity of the oil to flow through a standard sized opening. The result is expressed either by Saybolt seconds or by centistokes. Since oils change in viscosity with temperature the viscosity test is made at certain selected temperatures. Temperatures commonly employed are 100 degrees, 130 degrees, and 210 degrees Fahrenheit. The result is always reported with the particular test temperature.

Lubricating oils covering a wide range of viscosity are needed in order to provide for all lubrication requirements. As an aid to the buyer in choosing an oil which will suit his particular need, a viscosity scale has been adopted. The scale was devised by the Society of Automotive Engineers and consists of a series of numbers - S.A.E. 10, S.A.E. 20, etc. The S.A.E. number for an oil is a fair indication of its viscosity. That is to say, all oils with an S.A.E. 30 number, for instance, are of about the same viscosity no matter what company manufactures them. There is an allowable range of viscosity for oils that may be given a certain number but this

range is fixed by maximum and minimum limits of viscosity. It is possible for an oil properly called S.A.E. 20 but high in the allowable range to have almost the same viscosity as an S.A.E. 30 oil, properly named but low in its range. However, each company keeps the viscosity of its oil of a given S.A.E. number quite constant and in general the oils of different companies but of the same S.A.E. number are comparable in viscosity.

On heating, oils change in viscosity although not all of them to the same degree. An oil must be sufficiently viscous to keep moving parts separated at the highest operating temperatures and yet not be so viscous at low temperatures as to cause starting difficulty. In order to compare the viscosity-temperature characteristics of a series of oils the Viscosity Index is calculated. For this calculation it is necessary to know the viscosity at 100 degrees Fahrenheit and 210 degrees Fahrenheit and to compare these with the corresponding values for oils of standard viscosity. The higher the viscosity index the less the oil will change in viscosity with change in temperature. A high viscosity index is considered to be a good quality in an oil.

3. Carbon Residue.

The carbon residue test is designed to measure the tendency of an oil to deposit carbon in an engine. While other factors such as engine condition and adjustment have a marked influence on the serviceability of an oil, the test does give a good measure of what may reasonably be expected of an oil in actual service. Accordingly determination of the carbon residue is probably next in importance to a determination of the viscosity and viscosity index of the oil.

4. Oxidation.

During use, oxidation products are formed in the lubricating oil in a somewhat similar manner to the formation of gum in gasoline. As the oxidation products accumulate the viscosity of the oil increases and there is a greater tendency for carbon deposition to occur. The oxidation test is designed to measure the stability of any particular lubricating oil to oxidation. In this test air is passed through the oil at a high temperature for long periods of time, and the viscosity and carbon residue of the oil then determined. The lower the increase in viscosity and carbon residue, the greater the resistance of the oil to oxidation, and the longer will it remain in good condition in service.

5. Acidity.

During refining, many lubricating oils have to be treated with strong mineral acids and alkalies. If the refining process is not properly carried out, small quantities of acids or alkalies may remain in the oil to its detriment. An oil sample may therefore be examined for the presence of such harmful impurities.

6. Cloud and Pour Point.

Petroleum oils solidify if cooled to a sufficiently low temperature, due either to the partial separation of wax or to a congealing of the oil itself. The temperature at which wax first separates is known as the cloud point. The temperature at which the oil will just flow under certain standard test conditions is known as the pour point. The cloud point is of value when the oil is to be used for wick-feed application. The pour point gives an indication as to what may be expected under low temperature operation. It also represents the temperature below which it would be dangerous to use the oil in gravity lubrication systems.

7. Flash Point.

For safety purposes, fuels such as kerosene, diesel oil, and certain other petroleum distillates are tested to determine the temperature at which they will give rise to highly inflammable vapours. For lubricating oils, the flash point has little general bearing on its usefulness, although on a used oil the flash point may indicate dilution. The flash point is mainly used by refiners for control of their refining process. The value is especially important in connection with the transport of petroleum products from one location to another when stringent regulations apply which specifically relate to the flash point of a petroleum product.

CONCLUSION

The complete analysis of a fuel or an oil is not frequently required. If trouble is experienced, often one or two tests will suffice to assist in the diagnosis of the cause, or one or two special tests not mentioned above may be required for used oils. Advice should be sought before any samples are submitted for analysis and all samples should be accompanied with a clear and concise account of the trouble which is being experienced.

Determinations of the corrosive nature or otherwise of a fuel, its gumming tendency and its distillation range are probably the most important tests for fuels. With lubricating oils the viscosity at 100 degrees and 210 degrees Fahrenheit, a calculation of the viscosity index and the determination of the carbon residue are the most important tests.

Samples of oil for testing may be brought to the testing laboratory personally or they may be dispatched by express prepaid. If expressed, they should be properly packaged and addressed as shown below.

Express Prepaid

Gasoline and Oil Testing Laboratory

Research Council of Alberta

University of Alberta

Edmonton, Alberta.

SCHEDULE OF TEST CHARGES

Test	Standard Test Method	Charge
Entry and report		$1.00
Acidity	A.S.T.M.* D663	2.00
Carbon residue	A.S.T.M. D189 or D524	2.00
Cloud and pour point	A.S.T.M. D97	3.00
Corrosion	A.S.T.M. D130	1.00
Distillation range	A.S.T.M. D86 or D158	2.00
Flash and fire point	A.S.T.M. D56 or D92 or D93	2.00
Freezing point	C.G.P.S.C.**	2.00
Gravity	A.S.T.M. D287	1.00
Gum	A.S.T.M. D381	2.00
Octane number	A.S.T.M. D357	10.00
Oxidation***	C.G.P.S.C.	15.00
Oxidation & viscosity index		18.00
Sulphur	A.S.T.M. D90 or D129 or D894	3.00
Tetraethyl lead	A.S.T.M. D526	3.25
Vapour pressure	A.S.T.M. D323	2.00
Viscosity 1st temperature	A.S.T.M. D445	2.50
2nd or more temperatures	A.S.T.M. D445	2.00
Viscosity Index	A.S.T.M. D445 and D567	5.00

*American Society for Testing Materials
**Canadian Government Purchasing Standards Committee
***Includes carbon residue test and viscosity at 100°F.

Note 1. One account will be rendered from each lot of samples received from any source.

2. A charge of $1.00 is made for entry and report for all samples.

3. A discount of 20 per cent will be given on everything over $10 on any account.

4. Prices for tests not listed above together with estimates for special tests will be given on request.