THE MODERN DIESEL ENGINE:

A DEPENDABLE EFFICIENT WORK HORSE, BUT WITH AN APPETITE FOR CLEAN GOOD QUALITY FUEL

Authors: AJ von Wielligh Pr Eng BSc Eng (Mech)
NDL Burger Pr Eng M.Eng (Mech) GCC
TL Wilcocks B.Eng (Mech)

Staff of Department Mechanical and Aeronautical Engineering, University of Pretoria

1. Abstract

The modern diesel engine is developed from the older generations to satisfy the requirements of modern day operation. These developments took place in the injection system, combustion, piston design, breathing, lubrication, etc.

These engines are mostly developed in Europe and in North America and are based on fuels available in these countries. To satisfy air pollution requirements, the sulphur content of the fuel was lowered and in order to achieve the higher output etc., the operating temperatures were greatly increased. This necessitated development of new lubricating oil and higher demands are now placed on cleanliness and quality of the fuel for these machines.

A large number of engine failures have recently occurred on these modern diesel engines, which can be directly blamed on the quality of the fuel used. Due to poor lubricity of the fuel as well as some particle contamination, injectors failed prematurely, leading to poor combustion and the subsequent damage of the engine. Several failures were investigated and eventually tests were conducted on the lubricity of the fuels use in the engines. These tests proved that whenever the lubricity of the fuel is lower than an accepted norm, injector failures occur and engine failures follow. A study is presently under way to develop a new monitoring technique to warn operators whenever injectors fail. The aim of this project is to have monitoring systems installed on big diesel engines so that whenever an injector fails, the operator is warned and remedial steps can be taken before real engine damage occurs.

Due to the fuel supply situation in South Africa, it is very often difficult to pinpoint the source of the poor quality of fuel. Furthermore, the South African Specification for diesel SABS 342 does not specify lubricity and/or contamination levels and it is proposed that either the European or North American specification, which does include these aspects, be adopted in South Africa.

1. Introduction

In order to meet the demands of industries, the manufacturers of diesel engine had to drastically redevelope the modern diesel engine. These demands covered a wide range of aspects. The most important of these are the following.

1. Higher output

   From the same volumetric capacity, operators now demand higher outputs in order to make machines smaller, lighter, etc.

2. Smaller size

   In order to make machines more compact, the demands are that machines should be smaller and lighter for the same output.

3. Higher efficiency

   In order to cut cost and make the operation more profitable, the demands are that engines should be more efficient, that is having a lower fuel consumption for the same output.

4. Lower air pollution

   In order to protect the environment, both moral and legal requirements were imposed on engines, to reduce air pollution from diesel engine exhaust.

5. Longer engine life

   Due to economic pressures, engines had to be developed to have a longer service life before overhaul. In the distant past, an engine life of 8 to 10 000 hours was considered acceptable. For the same operation the demands are now in the region of 20 000 to 25 000 hours. This necessitated the redesign of the engine, very often making use of sophisticated systems and materials.

6. Longer services intervals

   In order not to interfere with production programs as before, the demands were that the intervals between services are stretched longer. In older generation engines, service intervals of 200 to 250 hours were accepted as a norm. Today the requirements are 300 to 500 hours. This placed an enormous demand on the lubricant used in the engine, as well as on filtration etc.

2. The modern diesel engine

The modern diesel engine differs significantly from its predecessors in the following areas.

1. The injection system is controlled electronically to ensure more exact control over the amount and point of injection.

2. The injectors, although electronically controlled are nowadays operating at substantially higher pressures and with a bigger number of orifices, discharging the fuel into the combustion chamber. This is done in order to make the fuel droplets smaller, which result in more complete and efficient combustion as well as speeding up the rate of combustion.

3. The valve timing is adjusted according to the speed and load of the engine.

4. The breathing of the engine is improved by adding turbo chargers as well as intercoolers. On the bigger engines two turbo chargers in series are often used with inter cooling and after cooling being applied to the inlet air. This means that more air is fed into the engine, allowing more fuel to be added to improve the output of the engine.

5. The pistons of the engine are changed, placing the top piston ring very high up, often as little as 3mm from the top of the piston. This is done in order to reduce the volume of unburnt gasses, which normally exist in the space between the top piston ring and the top of the piston. This is done in order to reduce air pollution.

6. The volume of water in the engine block is reduced, in order to make the block smaller but the velocity of flow is increased in order to increase heat transfer.

The result of these developments are the following:

1. The engines now run at significantly higher combustion and exhaust gas temperatures. Positive piston cooling now becomes essential.

2. The top piston ring now experiences significantly higher operating temperatures and in order to prevent excessive wear in the upper cylinder area, lubricating oil with a much higher specification is required.

3. Due to the high temperatures above the piston, one of the inlet valves may be open when the engine is stopped. The high heat chem-carborizes the lubricating oil on the stem of the inlet valve.

The result is a build-up of carbon and oil additive residue around the stem of the inlet valve.

4. Due to the retarded timing for the lower air pollution, as well as the smaller droplets size of the fuel, the soot loading on the engine increases. The lubricating oil must therefore also cater for a higher soot loading and the additives must be adapted accordingly.

5. Due to the higher operating temperature as well as higher load factors, the bearings have to withstand significantly higher loading than before. This also places a bigger demand on the lubricating oil.

6. In order achieve the higher injection pressures the clearances on all the components of the injection system have to be significantly decreased in order to ensure exact injection quantities and pressures.

In view of the above, the modern diesel engine therefore places significantly higher demands on lubricating oil and fuel. If these demands are not met, the engine will not perform as designed and premature failure will result.

3. Engine failures caused by fuel of poor quality

During the regular investigation of engine failures, it was found at a large portion of engine failed, due to the seizing of the piston in the cylinder liner. Very often this happened soon after overhaul. The nature of these failures are that the piston start seizing on the piston crown and this then gradually work its way down to the skirt of the piston. Several cases were also encountered were the piston crown started melting and in some cases holes were melted through the crown of the piston. Figures 1 and 2 shows the typically type of damage that piston sustain.

Figure 1: Holed piston.

Figure 2: Damage to piston crown.

The damage to these pistons are typical of that of a combustion related failure.

In the majority of these cases the injectors were carefully taken out and tested. When gently pumped on the test rig, the injectors emitted streams of fuel instead of the normal fine misty vapour. In a lot of cases, the injector still emitted a spray but the droplets sizes were significantly bigger than the normal very fine mist. This phenom is not readily noticed by the usual pump mechanic. This poor spray pattern is a result the of needle becoming sticky in its movements. A typical test where jets of fuel are delivered is shown in figure 3.

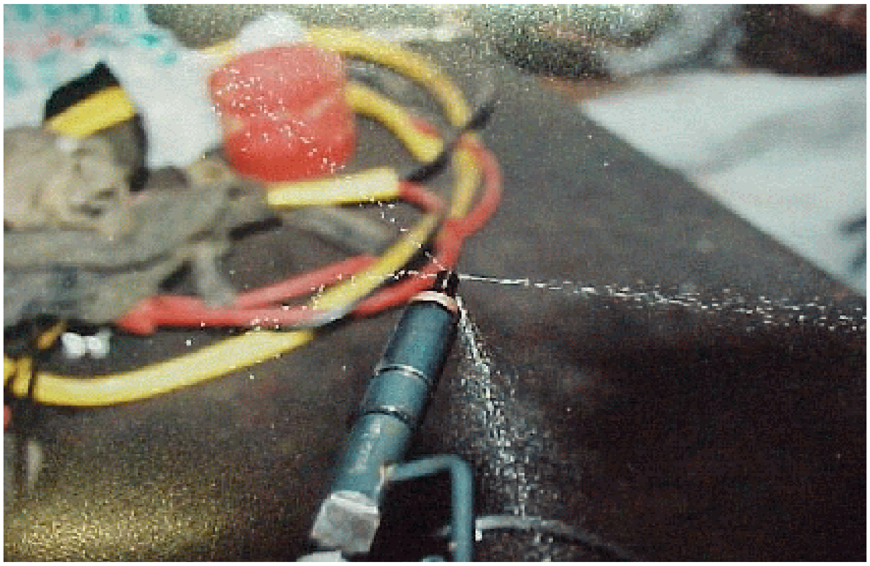


Figure 3: Poor injector spray pattern.

When pumped hard and quickly by hand, the needle tend to loosen up and the spray pattern improves slightly. This led to the problem encountered that on the failed engine, some pump rooms normally commented that the spray pattern of the injectors were not 100% but that they were “reasonable”. The injectors would then soon afterwards fail again if they were put back into the engine.

When these injectors were stripped, the needle points were discoloured and black and in quite a few cases damage to the shank of the injector could be seen under the microscope. Examples of this discolouration and damage to the shank are shown in figures 4, 5 and 6.

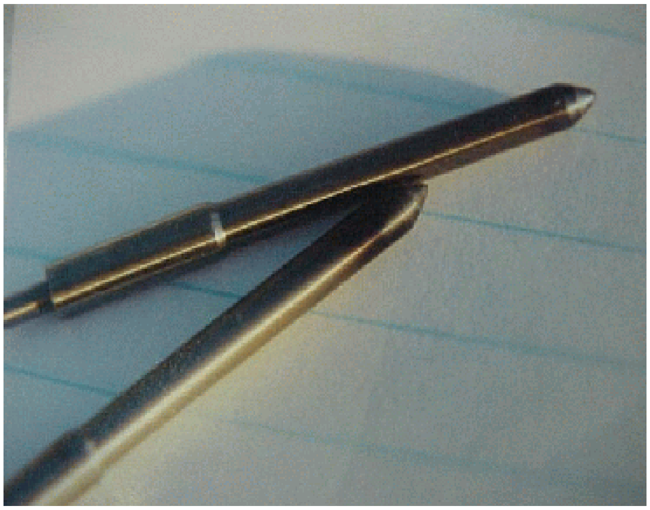


Figure 4: Discolouring of injector needle surface.

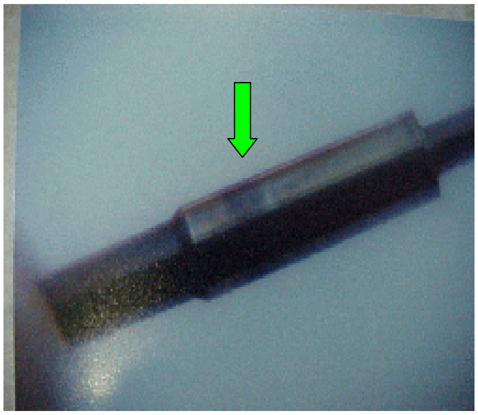


Figure 5: Arrow indicates scratches on needle shank.

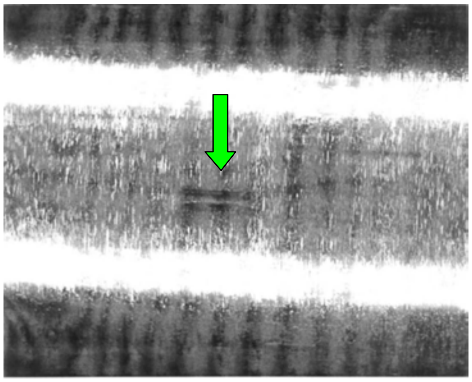


Figure 6:Scratch marks under microscope.

The dark and discoloured end of the needles of the injector is an indication that the needle did not seal properly on the seat on the bottom of the injector tip. The combustion gasses were therefore allowed to blow back through the orifices into the needle chamber, causing excessively high temperatures and discolouration of the needle tip. This scuffing that could be seen under microscope is an indication that seizing occurred between the injector needle and the injector tip body. Scuffing is an indication of poor lubrication conditions, or jamming of the needle due to contaminating particles. It must be kept in mind that all these moving parts has to be lubricated by the fuel. This is therefore an indication of a fuel lubricity problem. Dirt particles in the fuel aggravates this situation.

4. Background of combustion in a diesel engine.

In order to understand the problems around poor combustion it is necessary to understand the combustion process in a diesel engine.

4.1 Diesel engine principles and operation

The piston of a diesel engine fit tightly in the cylinder to provide high compression in order to cause ignition of the injected fuel. The fuel is delivered in quantities metered exactly by the injection system. This fuel is delivered to the cylinders at very high pressure and is broken up in to a very fine spray with droplets usually smaller than 20 microns. This is done by forcing the fuel through small orifices at very high pressures. In the modern diesel engine the tendency is to increase the number of the orifices as well as the pressure. In some of the more modern diesel engines the injection pressure is 10 times higher than the older generation of engines.

In the hot air caused by compression, the fuel starts burning and due to the heat release, the pressure rises and the piston is forced down to produce the power of the engine. It must be kept in mind that the injection is not an insultaneous happening. The injection process has a certain duration, and the more fuel that has to be injected, the longer the process takes. Some injection processes consist of an initial pilot injection to start the flame burning, with a secondary higher volume injection where the majority of the fuel is delivered.

The injection process starts between 10 and 25º before Top Dead Centre and continues, while combustion takes place and the piston is forced downwards. The power output of the engine is controlled by the amount of fuel injected, while the amount of breathing air to the engine is not changed.

4.2 Spray pattern requirements

The injected fuel is broken up into a spray consisting of micro fine droplets. The combustion process starts by the oxidising of the fuel droplets from the surface of these droplets. It must furthermore be kept in mind that the smaller the droplets the bigger the specific area. This means that the combustion take place faster and more efficiently the smaller the size of the droplets. There is therefore a tendency to use smaller droplets and finer spray in the higher pressure modern diesel engine. The spray is obtained by supplying the fuel to the needle, which is in the closed position and held down on the seat by a spring. When the pressure has built-up sufficiently, the spring force is overcome and the needle is lifted from the seat. At this point in time very high pressure exists around the needle. This high pressure then forces diesel through the orifices of the injector tip and a very fine spray is obtained. The layout of a basic injector is shown in figure 7. (The more modern injectors are slightly different, but operate on the same principle. They are actuated either hydraulically or electronically or with a combination of both).

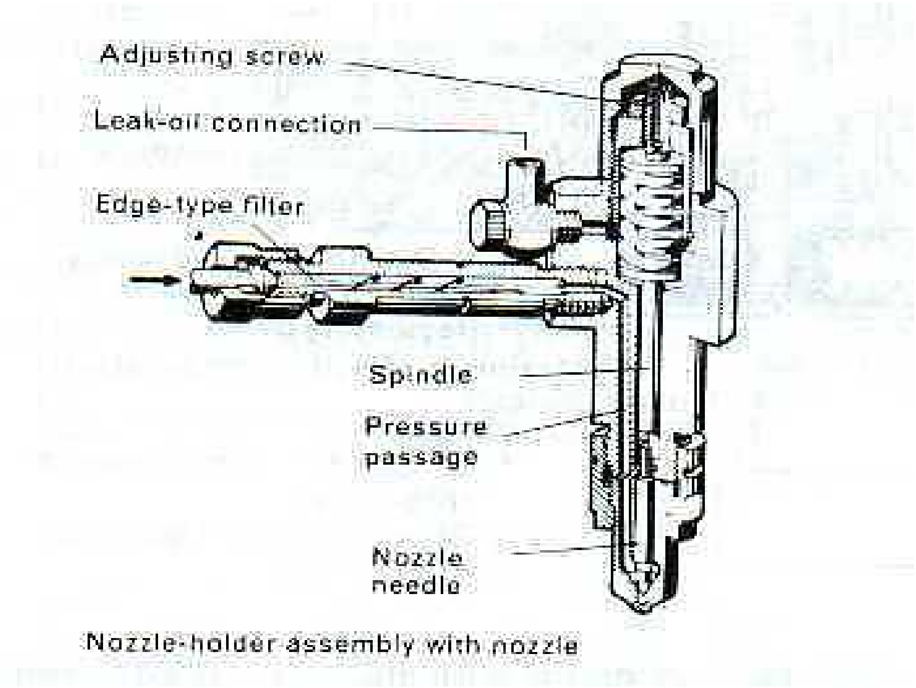


Figure 7: Injector layout.

4.3 Causes of poor spray patterns.

The most important cause of a poor spray pattern is a low pressure in the injector tip area before injection starts. This low pressure can be caused by amongst others the following reasons:

1. Leaking of the needle on the seat of the injector tip:

   When the needle does not seal properly on the seat and fuel pressure is applied, the fuel starts leaking out through the orifices before a high pressure is able to build-up. This causes large droplets and can also cause dripping of the fuel from the injector tip.

2. Sticking needle:

   When the needle is not free to move in the injector tip, the spring force is usually insufficient to ensure proper sealing of the needle tip on the seat. When pressure is applied to the injector tip, leaking starts and usually jets of fuel are emitted from the orifices, instead of the normal fine spray.

4.4 Consequences of poor spray patterns:

When a poor spray pattern exist as describe above, the following actions usually takes place:

1. Washing away of the oil film on the cylinder wall:

   Whenever a jet of diesel, fuel is directed onto the cylinder wall the thin film of lubricating oil is washed away. This leads to dry rubbing of the piston and piston ring material on the cylinder wall. Due to the absence of the lubricating film, the friction coefficient rises and excessive heat is developed. Damage to the surface, leading to eventual seizing of the piston, usually results. In some cases accelerated wear can also take place.

   In several cases where the spray pattern was reported to be “reasonable”, the bigger droplets emitted by the injector did not burn properly in time and these drops of liquid fuel also reaches the cylinder walls with the same resultant washing away of the lubricant film. Due to the fact that this now occurs over a wider area, immediate seizing of the pistons does not occur. The wear pattern on the piston ring and on the cylinder liner however changes drastically. Rapid wear of the piston rings takes place. Several cases were investigated where the wear pattern on the ring almost resembled the same situation where dust is inhaled by the engine. The ring corners are as sharp as razor edges and spectro graphic oil analysis indicate high iron content in the lubricating oil. The silicon content of the oil is however normal. This rapid wear process then leads to improper sealing of the piston ring and the blow-by of exhaust gasses past the piston rings increase.

2. Melting of the piston crown material.

   Whenever jets of fuel or drops of fuel falls onto the piston crown, it normally starts burning on the material of the piston and overheat this material. In the case of aluminium pistons, melting temperature of aluminium is soon reached and the material is blown out through the exhaust valve. In severe cases holes can also be blown through the crown of the piston. Examples of this type of damage is shown in figures 1 and 2. In engines where the common rail system of injection is used, continuous emitting of fuel can take place, causing a torch, burning away the piston material. Cases were investigated where even a steel piston was burnt away.

5. Lubricity of diesel fuel

In these days of high fuel prices, virtually any fuel that can burn in a compression ignition engine is tried out by some people. It must furthermore be kept in mind, that the fuel as it is manufactured at the refineries does not necessarily have enough inherent lubricity. In the past, diesel was refined from crude oil in refineries and an inherent percentage of sulphur was present in the fuel. Up to December 2001 the allowable sulphur content of South African fuels was 0,5%. This sulphur with its associated compounds, was a good enough lubricant and therefore it was usually not necessary to add additional lubricity additives to crude oil refined diesel. From January 2002, the maximum allowable sulphur in South African diesel will be 0,3%. It is commonly accepted that this percentage of sulphur with its associated compounds, still have enough lubricity to lubricate the parts of the injection system of the diesel engine.

In the case of synthetically produced diesel and other fuels like Kerosene, the sulphur content is very low and the fuel does not have lubricity properties as such. It is therefore necessary to add additives to the fuel to render the fuel acceptable in a diesel engine. The purpose of these additives is to provide lubricity properties as well as cleaning the nozzle etc.

5.1 The purpose of fuel additives

As mentioned above the base fuel does not necessarily have enough lubricity properties to be able to use this fuel in a diesel engine. Additives are therefore added to provide proper lubrication between moving parts in the injection system. It must be kept in mind, that the components of the injector system are operating at high temperatures and high pressures and must be lubricated by the fuel. The equipment therefore usually operates in the elastro hydro dynamic or even mixed and boundary lubrication regimes. The fuel must therefore be able to prevent sticking of the moving parts and to prevent excessive wear.

A careful balance must be maintained in regard to the concentration of additives added as well as the type of additives. Cases are known where some of the additives reacted with the additives in the lubricating oil, causing problems in the injection system. If the quantity of additives are to small, seizing of the components can occur. The economical of these additives must also be kept in mind as these additives packages are usually fairly expensive.

5.2 Typical tests for lubricity

Several tests are presently in use to test particular aspects of lubrication. It is therefore important to determine exactly the conditions under which certain components operate, before deciding on a particular lubrication test. The author and his assistants have investigated and tried some of the following tests for diesel lubricity properties.

1. The Timken test

   The normal Timken test was modified in such a way that the friction forces could be measured directly and the friction coefficient could be determined from the test. This testing methods was not persued for long, because the condition under which the needle in the injector operates is not really comparable to the conditions of the Timken test unit.

2. The Shell four ball tester in the Laboratories of the South African Bureau of Standards was used to determine the friction coefficient of the diesel fuel. Reasonable results were obtained from these tests, but as the operating conditions of these tests methods are also not really comparable with the operation of the injector, these tests were terminated.

3. The Bosch Fuel pump test where a blue printed fuel injection pump is used and run for 1000 hours to determine the wear characteristics of the pump components was investigated but not used. In the first instance a large quantity of fuel (typically a 1000 litres) is required to do this test and the duration of the test is a 1000 hours. This test is therefore very expensive to carry out. Another draw back of this particularly test is that the sump is tested for wear but the injectors are not attended to at all. The

operating conditions of the injectors are not nearly the same as that of a normal engine. This test does however provides long term result on the wear properties of fuels, but does not necessarily provide the necessary information in regard to injector failures.

4. Other test methods:

When a test method for an injector is selected it must be kept in mind that the injector operates at a reasonably high temperature usually in the region of 110 to 120°C. Furthermore, the injector operates in a liniar mode of small amplitude. The needle is moving up and down in the barrel of the injector tip at a high frequency and the moment damage to the needle occurs, the injector has failed. The clearances are extremely small, usually in the order of fractions of a micron.

Several methods of testing like the SLBOCLE (Scuffing Load Ball on Cylinder Evaluator) and the HFRR (High Frequency Resiprotating Rig) were developed. It would seem that the HFRR is gaining preference over the world, for the testing of diesel fuel. In this test a ball is rubbed on a polished disc emerged in the fuel to be tested. After a period of typically 2 hours the wear scar on the ball is measured and from this the lubricity is determined. In normal operation of an engine, failure of the injector would have taken place long before the amount of damage is achieved, as is achieved in the HFRR. Although there are short comings in the operation of the HFRR, it is at least a step in the right direction as it is a quick method of determining the quality of the fuel.

Another method of testing lubricity is the Optimol Resiprocating Rig (SRV). One of these instruments is available in the Tribology Laboratory of the University of Pretoria. This machine has a 10mm diameter steel ball that vibrates under load on a 25 mm polished disc. The contact surface is emerged in the fuel to be tested and the amplitude of vibration as well as the frequency and the load and temperature can be controlled from a computer. Due to the fact that the friction force on the disc can be measured directly, and the fact that the load is known, the friction coefficient can be determined in real time and can be plotted against the load on the ball. The output of this process, is therefore a graph of friction vs time, coupled to the load against time for the particular fuel. The friction coefficient against load can therefore be easily determined. The moment the film strength is not able to sustain the load, penetration of the film occurs and the friction coefficient increase dramatically. At this point the machine is set to switch off automatically. This machine resembles the injector situation in a diesel engine very closely.

6. Contamination

Although it is generally accepted that contamination can lead to premature failure of injection equipment, the research into the type of contamination, the amount of contamination and the real mechanisms are not yet fully researched. In the test carried out by the authors, a direct relation was determined between contamination and the allowable load on the ball of the SRV machine. As indicated in the graphs, the nature of the friction of the friction coefficient vs load graph becomes very stickly whenever contamination is present. This contamination can therefore also lead to premature failure of the injection equipment. This research is presently still under way and only preliminarily results will be discussed later in this paper.

7. Test done on the SRV machine at the University of Pretoria

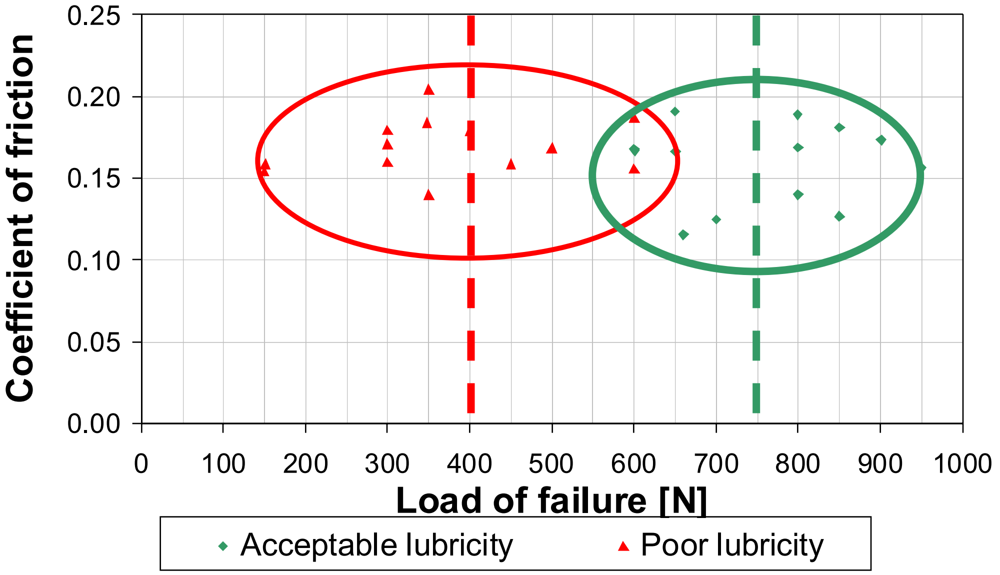
After running a large number of tests on fuels that produced failure in engines, as well as fuels that did not produce failures, the following parameters were chosen for the evaluation of fuel:

Stoke	1 mm
Frequency of vibration	50Hz
Operating temperature	110°C
Load	Initial load 50N with an increase of 50N every minute
Break through friction co-efficient	0,3

During the test it was furthermore realized that under initial light loads the process showed very erratic results. A second test was therefore run, using similar operating parameters with a load increase of only 10N per minute from an initial 50N starting load. These tests were run at a separate test at the varying load condition. Various samples were tested and it was eventually decided to use diesel fuel which was refined from crude as crude oil as reference. This was done as it was established that vehicles running on this fuel did not exhibit many of the above mentioned problems.

8. Result of tests carried out and failure analysis case studies

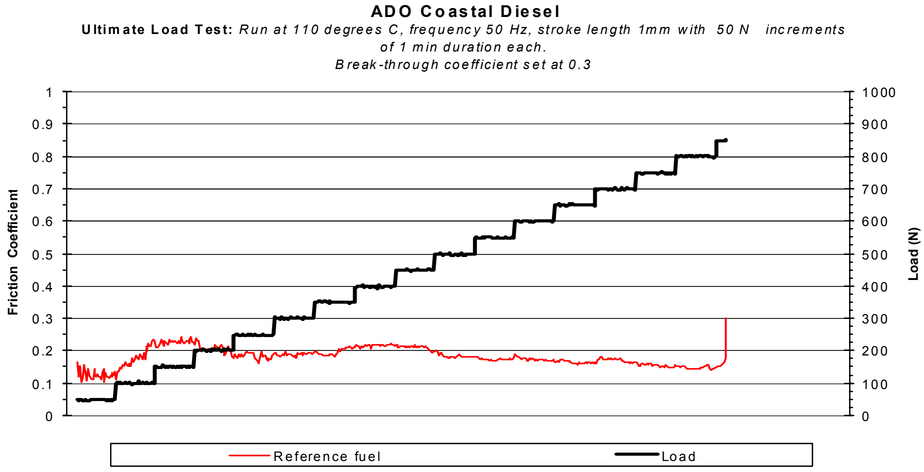
As mentioned above it was necessary to establish a base line for reference purposes. The author operate as a failure analysis consultant over the whole country and an area was selected where this type of combustion related failures are not very frequent. The fuel used in this instance was crude oil refined diesel. A sample of this fuel was obtained, it was tested and it was decided to use this as a reference. From failure analysis of several engines fuel samples were taken and these were tested on the SRV machine. It was establish that typically a minimum load of 700N on the ball is required to prevent injector failures. This is not an exact figure, but as indicated by graph A the value seems to be a typical nominal value.



Graph A

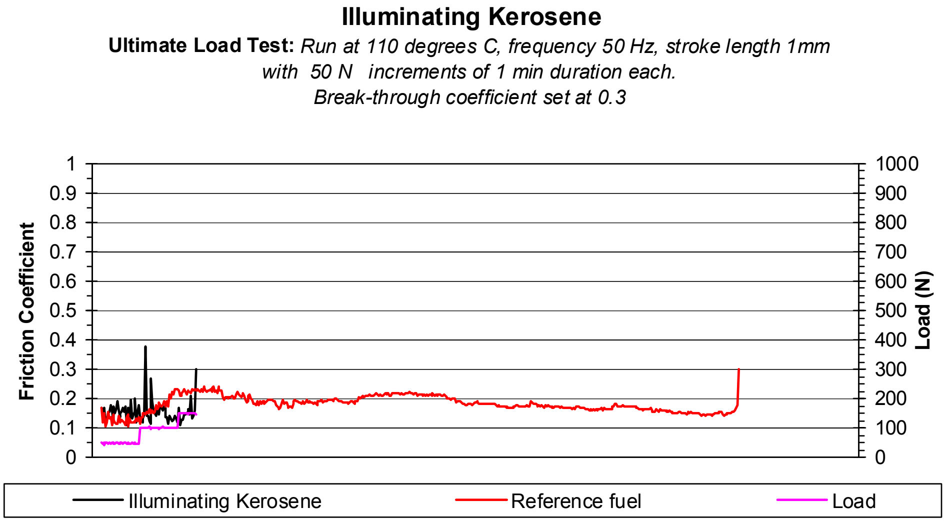
Some of the results of various fuels as well as the fuel which caused engine failure are attached in the annexure. The result of the reference fuel (crude oil refined diesel) as well as the different fuels are quoted on individual graphs.

8.1 In graph 1, the results of the test on the reference fuel is quoted. As can be seen, the fuel was able to withstand a load of 850N before the break through friction coefficient of 0,3 was reached.



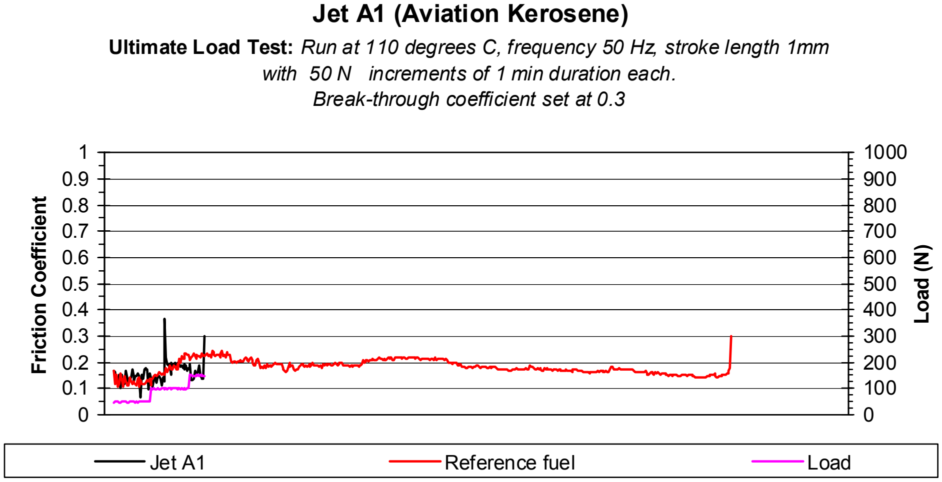
Graph 1

8.2 In graph 2, the results of the test on illuminating paraffin are shown. It can be seen from the graph, that a load of only 150N could be reached before break through occurs.



Graph 2

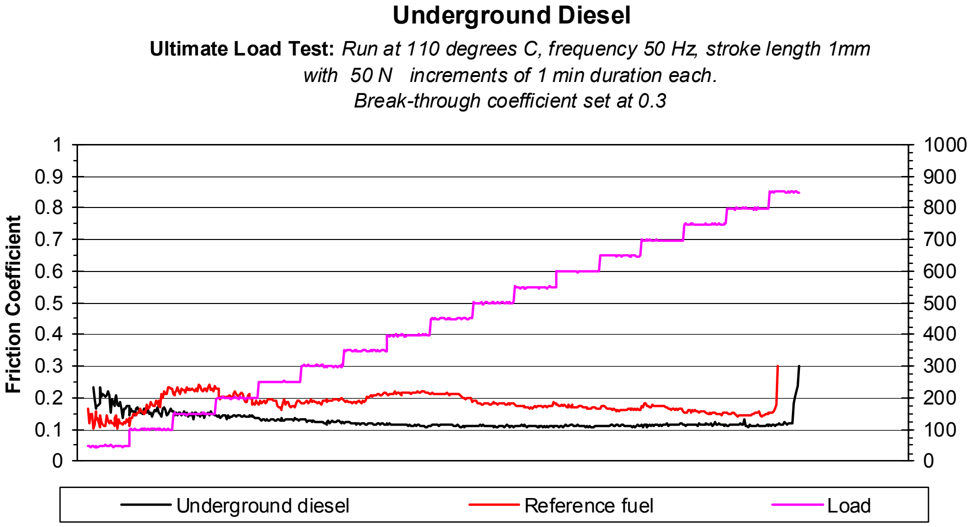
8.3 Graph 3, shows the result on jet A1, (aviation kerosene). This fuel is basically similar to I.P. and therefore a load of only 150N could also be reached.



Graph 3

It must be noted that the above two fuels are the most common blending ingredients when diesel fuel is “spiked” in order to avoid taxation. It can therefore easily be understood that when this fuel is mixed with proper diesel that very poor lubricity will result.

8.4 A sample of underground diesel which is used in Gold Mines was obtained and tested. The result of these tests are shown in graph 4. This fuel is basically a kerosene type fuel, with the proper additive to insure proper lubricity and cleanliness etc. It can be seen from the graph that the fuel could easily withstand a load 850N which is well above the thresh hold of 700N.

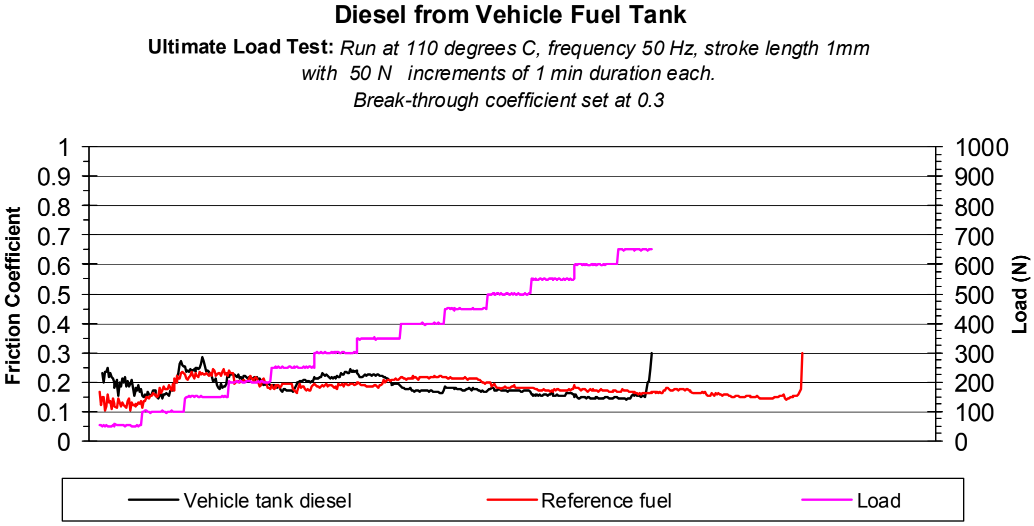

Underground Diesel

Ultimate Load Test: *Run at 110 degrees C, frequency 50 Hz, stroke length 1mm with 50 N increments of 1 min duration each. Break-through coefficient set at 0.3*

Graph 4

The effect of the lubricity additives in this fuel can therefore be clearly seen.

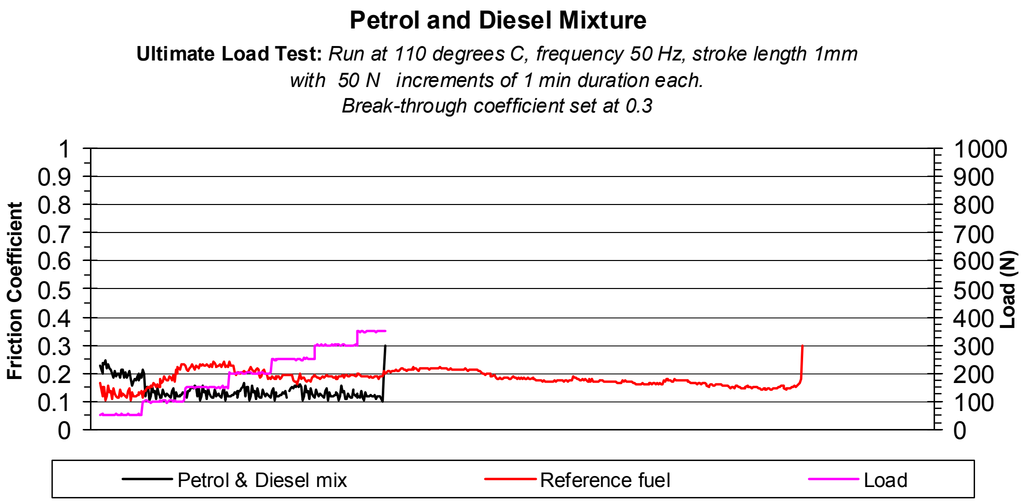
8.5 One of the failures that were investigated was a 5 cylinder European diesel engine, which twisted off the plunger in the diesel pump when the front section of the plunder seized in the head of the diesel pump. A sample of this fuel was obtained from the tank and the results are shown in graph 5. As can be seen from the graph, the fuel could only withstand a load of 650 N.


Diesel from Vehicle Fuel Tank

Ultimate Load Test: *Run at 110 degrees C, frequency 50 Hz, stroke length 1mm with 50 N increments of 1 min duration each. Break-through coefficient set at 0.3*

Graph 5

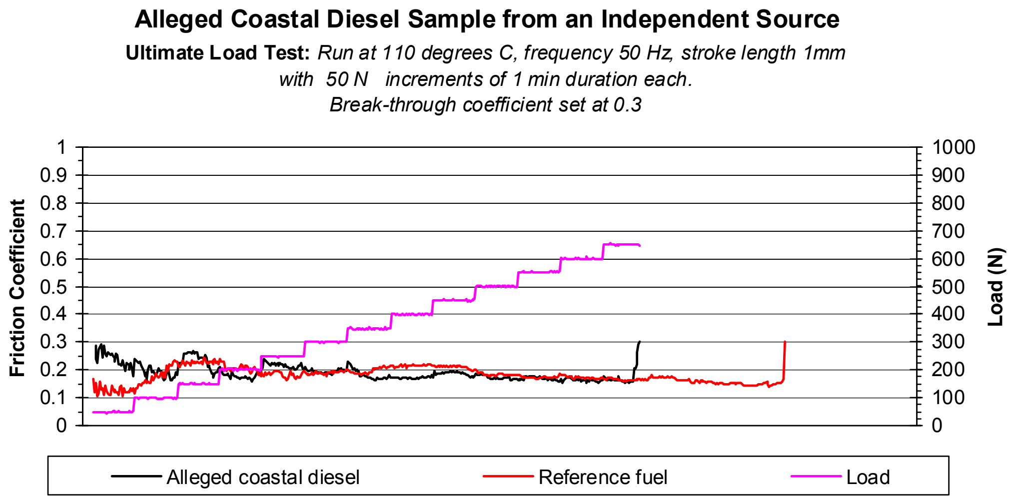
8.6 A civil contracting company operating front end loaders and excavators etc., ordered fuel from their regular supplier. When the fuel was delivered, by mistake 20% petrol was first poured into the tanks and then it was filled up with diesel. The mixture of 20% petrol and 80% diesel caused substantial problems in the machines, and when a sample of this fuel was tested on the SRV machine, the result indicated that the fuel could only withstand a load 350N. As shown in graph 6.


Petrol and Diesel Mixture

Ultimate Load Test: *Run at 110 degrees C, frequency 50 Hz, stroke length 1mm with 50 N increments of 1 min duration each. Break-through coefficient set at 0.3*

Graph 6

8.7 A small 4 cylinder diesel engine was completely rebuilt and failed 140 km after overhaul. The failure was a typical injector failure that led to damage of a piston. The vehicle's fuel was obtained from a local supplier who alleges that he only sold coastally refined petroleum diesel. A sample of this fuel was tested on the SRV machine and the results are given graph 7. It can be seen that the fuel could only withstand a load of 650N and it is therefore clear that this is not the coastal diesel that the supplier alleges.


Alleged Coastal Diesel Sample from an Independent Source

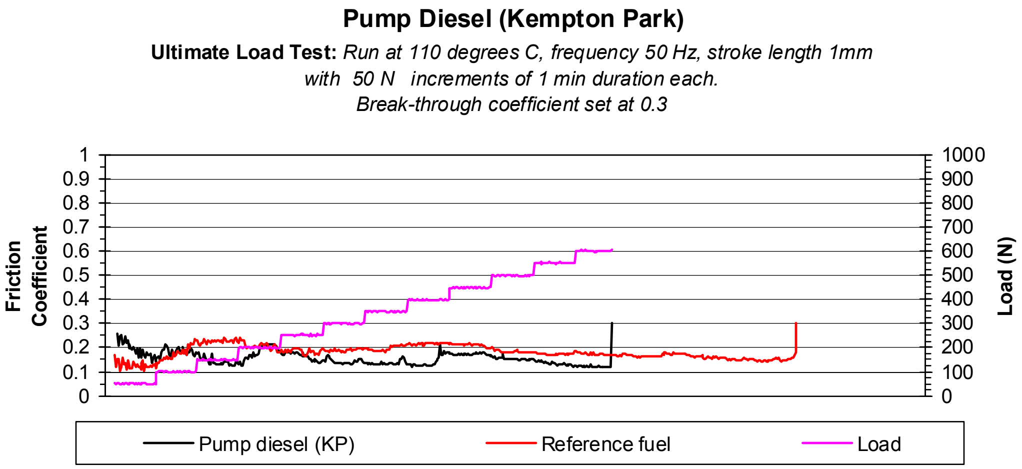
Ultimate Load Test: *Run at 110 degrees C, frequency 50 Hz, stroke length 1mm with 50 N increments of 1 min duration each. Break-through coefficient set at 0.3*

Graph 7

8.8 Samples of fuel were obtained from the forecourts of different filling stations and tests on the SRV machine. In Durban a sample was taken from a filling station selling the same product as the reference fuel.

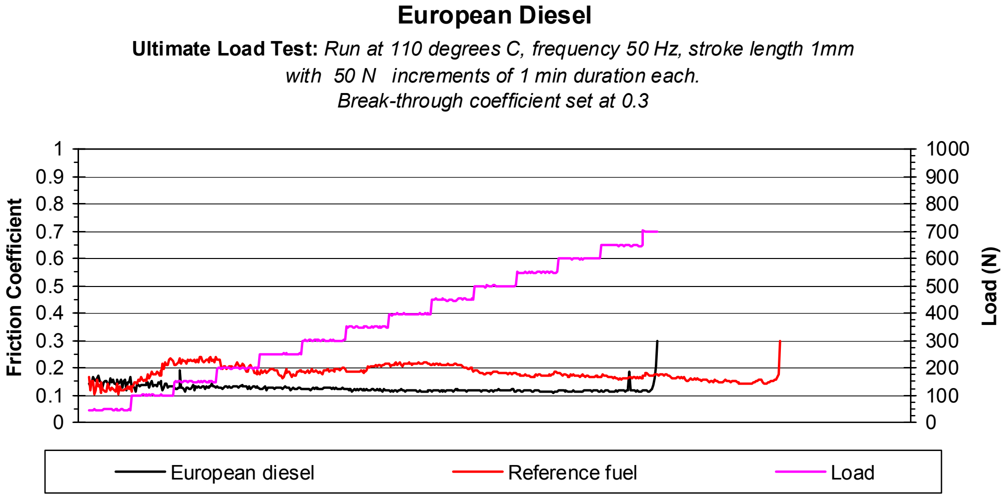
The fuel displayed exactly the same graph as the reference fuel graph 1.

A few other filling stations were also tried in various towns in the country with mixed results. In graph 8, a fuel bought at a filling station in Kempton Park is shown. It can be seen from the graph, that the fuel could only withstand a load of 600N. This value is considered too low for the safe operation of a modern diesel engine.



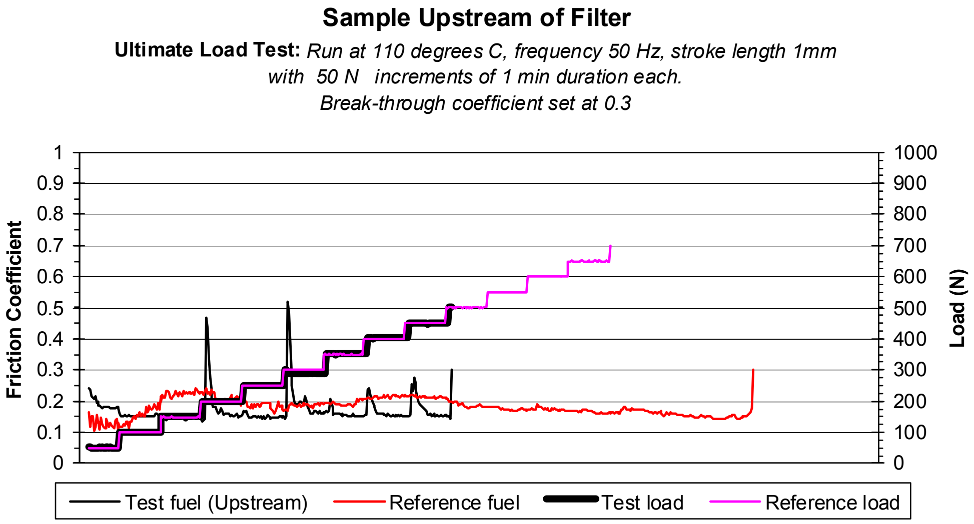
Graph 8

8.9 A sample of diesel from Belguim was obtained and tested. The result of these tests are shown in graph 9. Although the fuel withstood only slightly more than 700N, the smoothness of the graph is noticeable in comparison with the reference fuel.

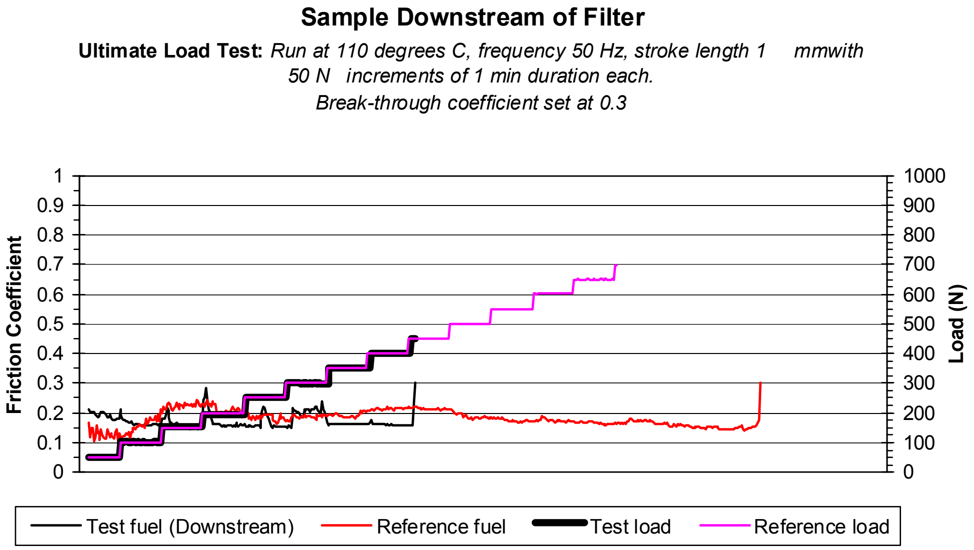


Graph 9

8.10 In order to determine the effectiveness of the two micron filter in the fuel lines of some modern diesel engines, fuel was deliberately contaminated with fine dust and then put through the two micron filter. Samples were obtained before the filter and after the filter. The results of these tests are shown in graphs 10 and 11.



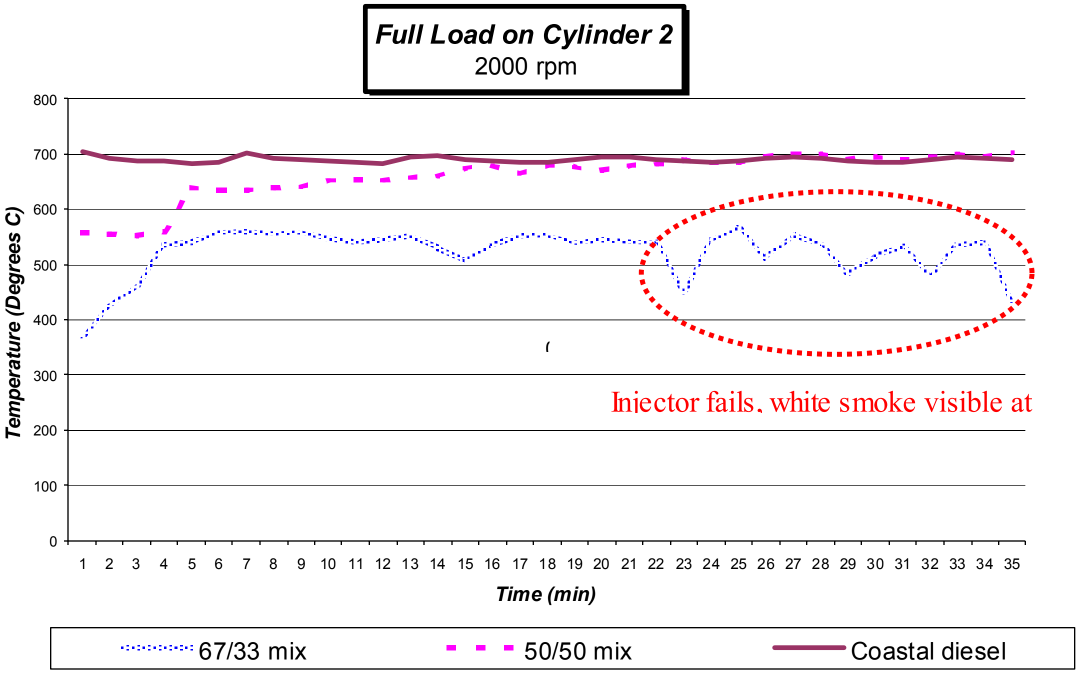
Graph 10



Graph 11

It can be seen from these graphs, that the friction coefficient is not as smooth as the reference fuel or other fuels, but tend to be very "spiky". It is assumed that whenever a particle comes between the ball and the disc that the friction coefficient shoots up for a split second and when this particle is crushed the friction coefficient reduces again. The effect of the filter can clearly be seen as the "spikes" are considerably less after the filter. It can therefore be considered that the filter was doing is work.

8.11 During the research to develop a new technique to safe guard engines from fuel related fuelliers, tests were done on a 3 cylinder air cooled engine in the laboratories of the University of Pretoria. The engine was first run on the reference fuel and temperatures, engine torque, etc. was recorded. As can be seen in graph 12, the engine ran consistently at around 700°C for more than half an hour. In fact the engine was run for about an 1 ½ at 700° without any change.



Graph 12

The fuel to the engine was then changed to a 50% diesel and 50% kerosene mixture. The result of this is also shown in graph 12 and it can be seen that the temperature dropped and that the temperature was not as smooth as with the pure diesel.

A mixture of 67% kerosene and 33% diesel was then made and the engine was again tested on this fuel. The result of this tests is also shown on graph 12. It can be seen that the exhaust gas temperature was lower and that the graph was erratic until about 21 minute into the test. At this stage the engine started running slightly uneven, white smoke appeared in the exhaust gas and the temperature fluctuated with a wide variation. At this stage the fuel caused the new injector to start malfunctioning.

9. The South African Specification for diesel fuel

From the above fuels, several caused engine failures, as reported in the discussion above. It must be noted that in these cases where engines failed, and the fuel was not of sufficient lubricity, these fuels all satisfied the present SABS 342 specification.

The SABS specification deals primarily with boiling points, viscosity, etc. No mention is made in the specification of lubricity.

Contamination as such is also not specified, although the specification says that the fuel must be clean.

The unfortunate situation therefore exist, that fuel complying with SABS 342 specification is supplied to consumers, and that new and recently repaired engines very often failed because of the lack of lubricity of this fuel. Due to the fact that lubricity is not addressed in the specification, the fuel supplier can not be taken to task as he is supplying fuel according to the specification. The company that repaired the engine can also not be taken to task for bad workmanship, because the engine did not fail because of their bad workmanship. The unfortunate operator of the engine, who also did not do anything wrong, unfortunately has to pay the repair cost.

It is therefore strongly suggested that the present SABS specification be amended to include limits for contamination and for lubricity. These aspects are already covered in European and American specifications. If the fact is taken into account that most of these engine were developed in those countries, it is only logic that we adopt similar specifications to those countries.

10. Conclusion

The modern diesel engine is supplying a much higher output from a smaller unit at a higher efficiency than its predecessors. The air pollution of this engine is also considerably less than the predecessors. If provided with proper fuel and lubrication, the engine will also give a substantially longer engine life than before.

Due to the higher pressures, temperatures, clearances, etc., the engine however demand very clean fuel with proper lubricity properties. The engine oil is also under much higher stresses than before and therefore only the best available oil (typically at least API-CH 4), should be used.

From several failure analysis case studies, it was determine that engine failure are occurring on these engines when fuel with insufficient lubricity or excessive contamination is used. It was found that when fuel still satisfied the normal requirements of SABS 342, the fuel lacking in lubricity and cleanliness caused engine failures.

It can therefore be rightly said that the modern diesel engine is an efficient, dependable work horse, but that it has an appetite for good, clean fuel and proper lubricant.