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# Dee-Zol Testing – Townsville College of Technical and Further Education

## Introduction

This test was undertaken in the Engine Laboratory of the Townsville College of T.A.F.E. to provide an accurate comparison of the performance of a Diesel Engine before and after the fuel was treated with the Dee-Zol additive formulation.

The formulation was developed in Orlando, Florida, U.S.A., by Bell Additives (then Bell Laboratories) in 1953.

The series of tests was carried out by T.A.F.E instructors Mssrs. Roebuck, Atkinson, and Morecom, and were verified by the Officer in charge of Technology, John Wensley, Ass. Dip. E.E., (Strathclyde), Grad. I.E. (Aust) M.R.I.P.A.

## Test Equipment

The T.A.F.E. Laboratory is ideally equipped for this test as it has a Detroit Diesel 3-71 Engine coupled to a Heenan & Froude Hydraulic Dynamometer as a permanent installation.

Fuel and Exhaust lines, as well as water cooling to the engine and dynamometer are built into the floor and wall of the building.

## Engine Specifications

The engine used for the testing was a General Motors School Engine No. 414, Model 3-71, 3045C. The engine was a 3-cylinder, 2-stroke engine, naturally aspirated and fitted with a Rootes-type gear driven blowers in the Air Induction system.

The engine was fitted with a tachometer, a Tachhour meter, oil pressure and water temperature gauges, a blower pressure gauge, and a gauge to measure injector rail pressure. Refer photographs 1 and 2.

Specifications of the engine were as follows (measured at 25 deg C and 99 kPA environmental conditions):

| | | |
|---|---|---|
| Bore and Stroke | 108 x 127mm | (4.25" x 5") |
| Displacement | 3.49 litres | 213 Cu In |
| Rated Gross Power | 81 kW | 109 bhp @ 2100 rpm |
| Continuous Gross Power | 63 kW | 85 bhp @ 1800 rpm |
| Compression Ratio | 18.7:1 | 291 ft lb. @ 1400 rpm |

Results quoted in our test are at Standard Temperature and Pressure, 15.5 deg C (60 deg F) and 101 kPa (29.97 in Hg) dry.

**Engine Oil**

The engine oil and oil filter were changed before the test and the engine was refilled with B.P. Vanellus M 30 Oil.

**Test Fuel**

The fuel used for the testing was B.P. Distillate with a specific gravity of 0.8318 and a cetane rating of 52.

Fuel Metering was conducted both by electronic flow meters registering to 1/100$^{th}$ of a litre and a glass cylinder calibrated in litres. Both flow rate and total loss methods were used to determine the actual quantity of fuel consumed during testing.

Test No. 1 was carried out using untreated fuel.
Test No. 2 was carried out using the same fuel, but which had also been treated with the Dee-Zol formulation at a treat ratio of 40 ml. to 25 L. of fuel (1 gallon to 625 gallons).

Injector Gallery Pressure was 462 kPa (67 psi) @ 1800 rpm and a blower pressure of 16.5 kPa (2.4 psi).

**Exhaust Smoke Analysis**

The exhaust smoke density was sampled using a B.P. Hartridge Smoke-Meter. This machine contains a photo-electric cell which is calibrated to zero while sampling clean air. The Reference Exhaust Gas is then passed through the filters and rear chambers of the machine, and the photo-electric cell compares the density of the smoke with clean air and registers the result in Hartridge Smoke Units. Refer Engine Analysis Data Sheet for the result and photograph No. 4 which shows the Meter.

**Dynamometer**

The dynamometer used was a Heenan and Froude Size DPX4, with a maximum capacity of 250 bhp and a water pressure of 358 kPa (58 psi). The radius of the torque arm was 0.67M (2.198 feet).

Photograph No. 1 shows the right side view of the test rig. The 100 lb weights, the torque scale, and the tachometer are clearly visible. The water circuits and colored blue and the exhaust sampliong tube colored black. Photograph No. 2 shows the left side view with the handwheel to control the dynamometer load. Bryan Roebuck is standing behind the tailshaft guard.

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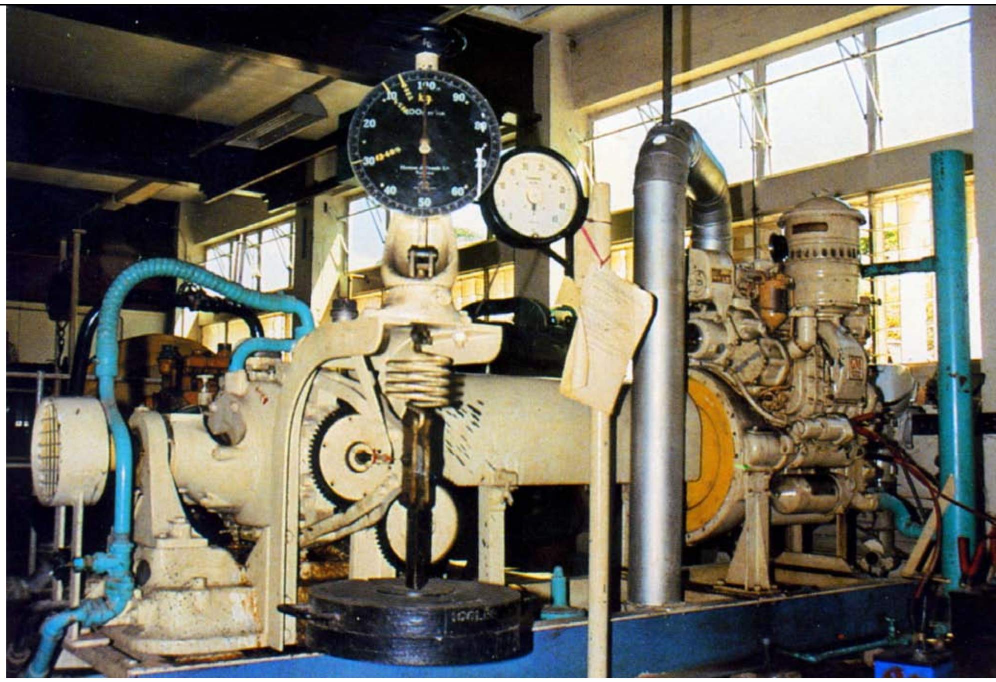
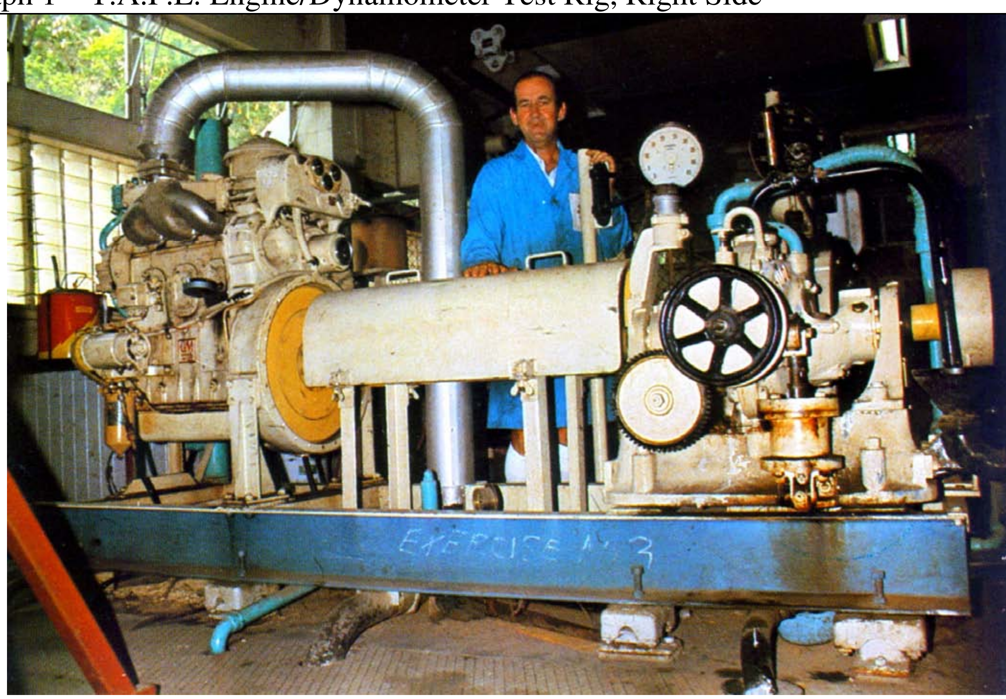


Photograph 1 – T.A.F.E. Engine/Dynamometer Test Rig, Right Side




Photograph 2 – Test Rig, Left Side, Bryan Roebuck Pictured

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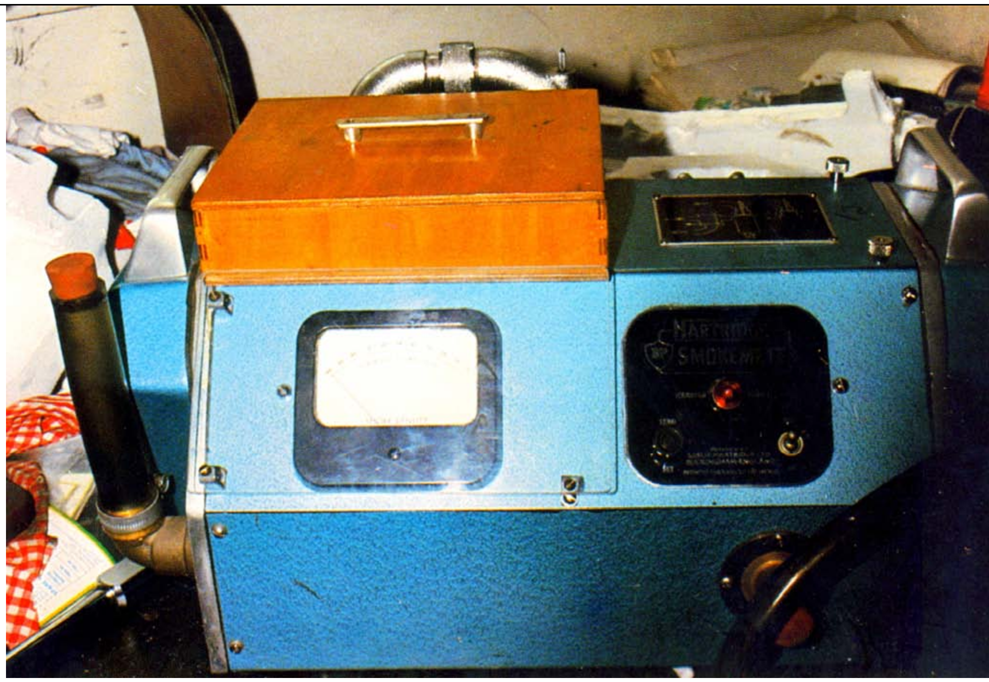


Photograph 3 – B.P. Hartridge Smokemeter

Photograph 4 – Engine Laboratory Exhaust Stack – Engine @ 1500 RPM Under Load

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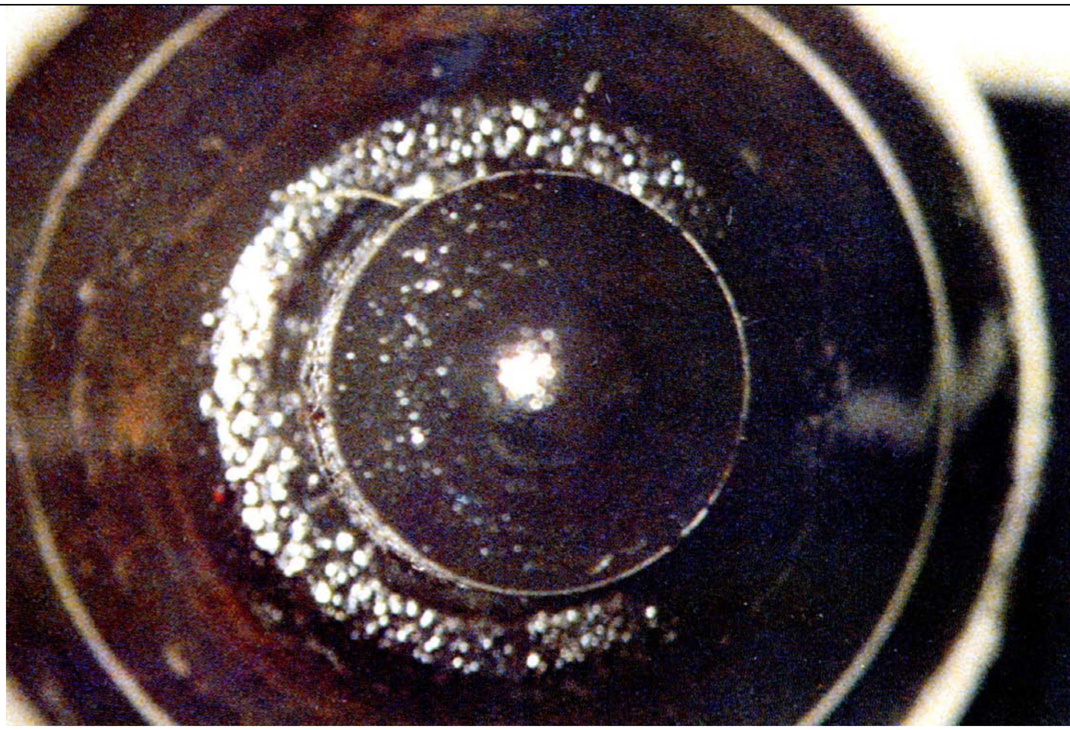

Photograph 5 – No. 1 Injector At Start of Test

Photograph 6 – No. 1 Injector At Completion of Test No. 2

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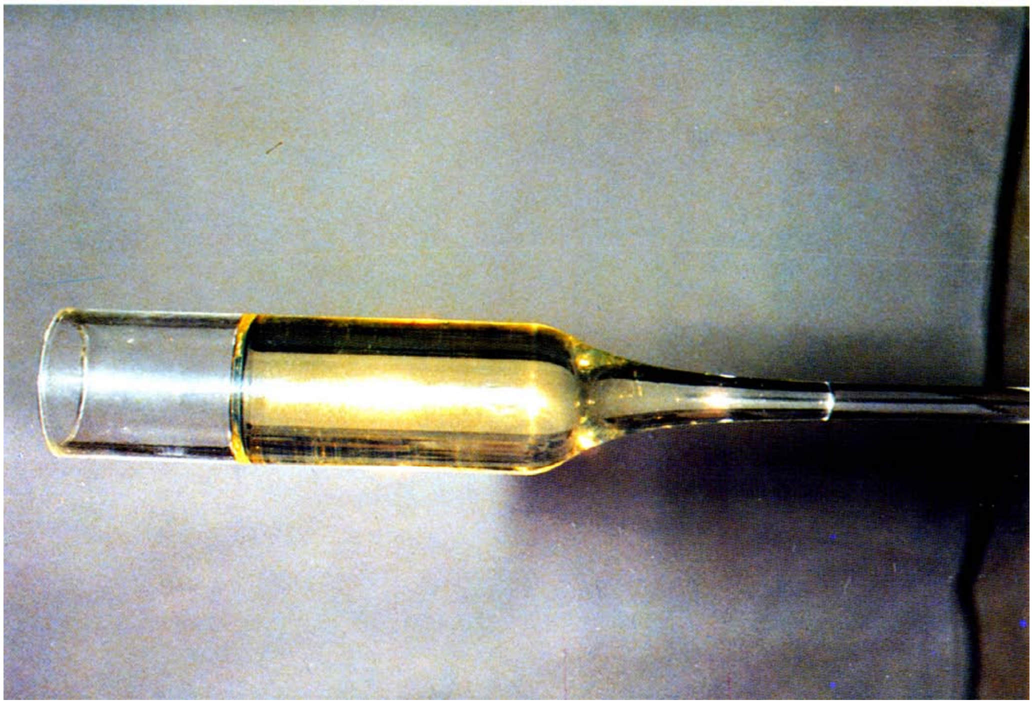
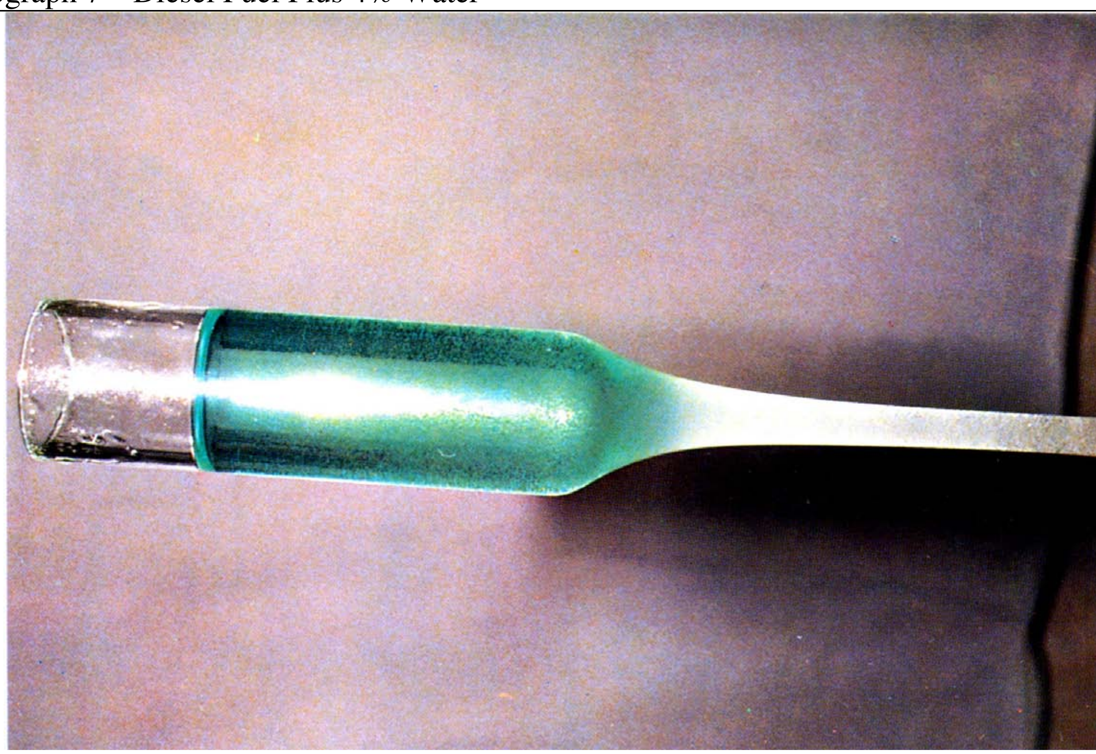


Photograph 7 – Diesel Fuel Plus 4% Water



Photograph 8 – Diesel Fuel Plus 4% Water Showing Surfactant Action of Dee-Zol

**Test Procedure**

The engine and all instruments were set to factory specifications and calibrated before commencement of testing.

The test procedure started with the #1 injector being removed and photographed, then replaced without cleaning. The engine was brought to operating temperature and all engine functions checked for correct function.

The tests were carried out at the Engine Manufacturers' Gross Continuous Horsepower at 1800 rpm and the maximum torque rating at 1400 rpm.

The engine was operated at wide open throttle and the dynamometer load increased until the engine could just maintain 1800 rpm. All gauges were read and the results listed under Test No. 1 on the Engine Analysis Data Sheet.

**Engine Cleaning Phase**

The engine was then placed on the fuel system and the engine cleaning phase commenced. A double dose of the Dee-Zol formulation (80 ml. to 25 L of fuel) was added to the fuel and mixed thoroughly. The engine was then run under varying load at 1500 rpm for a period of 5 hours.

Photograph No. 3 shows the clean exhaust stack during this process. Not even a haze is evident at this stage.

**Test No. 2**

Following this, a single dose of the additive was added to fresh untreated distillate fuel (40 ml. to 25 L). This test was conducted at wide open throttle at both 1800 rpm and 1400 rpm as in test No. 1, and the Instrument readings were again recorded.

At the completion of Test No. 2, the same injector as before was removed and photographed. Refer photograph No. 6.

**Analysis of Test Results**

The manufacturers of Dee-Zol claim that when it is used as directed within a diesel compression-ignition engine, it will promote:

- Improved engine performance
- Increased fuel economy
- Clean injectors and removal of carbon buildup
- Reduction in exhaust smoke
- Prevention of rust and sludge within the fuel tank

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- Reduction of problems associated with water within the fuel system
- Prolonging of fuel filter life
- Reduction of maintenance and down-time

Test results were analyzed and interpreted in light of these claims.

## I. Improved Engine Performance

When horse power results were corrected to standard temperature and pressure, the facility obtained a Manufacturers' Gross Continuous Horsepower reading of **85.98 bhp** at 1800 rpm. IN Test No. 2 with the added Dee-Zol additive, horsepower was increased to **94.19 bhp** at 1800 rpm, an increase of **9.5%** above new engine specification.

At maximum torque, there was **an increase from 70.49 bhp to 74.48 bhp, an increase of 5.5%**. These are significant increases in horsepower and torque and are a result of the Combustion Modifier within the formula converting more of the heat energy in the fuel into useful work by the engine.

The Thermal Efficiency also increased **17%** at 1400 RPM, and **22.5%** at 1800 RPM on the same basis.

## II. Increased Fuel Economy

Fuel economy improved **10.11%** at 1800 rpm, **from 17.8 L per hour to 16** L per hour, and improved 10.8% at 1400 rpm – from **18.46 to 16.6** L per hour from Test #1 to Test #2.

Both the horsepower and economy improvements are very significant considering the total operating hours of 18.5 at the commencement of the test program.

## III. Clean Injectors and Removal of Carbon Buildup

The #1 injector was removed and photographed before the commencement of Test #1 (photograph No. 5). It was then reassembled untouched and removed and re-photographed at the completion of Test #2 (photograph No. 6).

Despite the low number of hours of operation on the test engine before the test cycle, there was already a considerable layer of carbon buildup on the injector nozzle, with a corresponding amount in the combustion chambers.

After five hours of operation under load using a double dosage of the Dee-Zol additive (80ml per L), close examination of the N-65 injector nozzle showed that the solvent action had completely cleaned the nozzle tip including the stamped identification numbers (8-0055-165). The first numeral indicates the number of spray holes, the second section shows the diameter of the holes, and the third section the angle of the spray holes to the vertical.

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The photographs were taken looking straight at the nozzle. The bright ring around the nozzle is the objector seat.

The combustion chambers and pistons are subject to the same cleaning action. Continuous usage would maintain this level of cleanliness in a normal engine.

## IV. Reduction of Exhaust Smoke

The engine analysis data showed **an improvement from 20 smoke units to 18 smoke units** at 1400 rpm, **and from 13 units down to 10 units** at 1800 rpm.

The reduction in smoke density means that more of the fuel is being converted into useful work and less is being lost to waste through the exhaust system. Black smoke from a diesel exhaust is simply unburned or wasted fuel. It can be the result of more fuel being injected into the engine than it can burn at that time overloading the engine, or a result of fouled or worn injectors.

## V – VII. Rust, Sludge and Water in the Fuel, and Blocked Fuel Filters

Water in the fuel system is a major cause of breakdown and expense. The water causes rust and sludge, and can contain microorganisms which can live in the water and feed on the diesel/water interface. These organisms multiply rapidly in fuel filters, and soon block fuel flow with brown to black sludge.

The Dee-Zol formulation breaks down the surface tension of any water in the fuel system to approximately 1 micron in size, allowing the water to pass through filters, pumps and injectors, to be disposed of as steam.

The Dee-Zol formulation contains no ethanol, methanol or other alcohols which can absorb water from the atmosphere and can cause damage to delicate areas of the fuel system.

Photograph No. 7 shows a glass cylinder to which 4% water by volume had been added. The water sank to the bottom due to its greater density. When agitated, the water surged around in large globules due to its natural surface tension.

Photograph No. 8 shows same fuel and water sample to which a double dose of Dee-Zol additive has been added. When agitated, the water was able to be suspended within the distillate fuel in microscopic form. This agitation occurs in many diesel engines as a result of most of the fuel fed to the engine being returned to the fuel tank for injector cooling, pressure regulation and vehicle motion.

In this state, the minute particles of water pass through the fuel system without component damage and are disposed of as steam. During shut down, most of the water will settle to the bottom of the tank.

The Dee-Zol formulation is normally able to dispose of an equivalent volume of water. It is important to note that the manufacturer recommends that if a significant amount of water is present, the system should be drained, cleaned and refilled with fresh fuel. Water is continually being accumulated in fuel systems from condensation resulting from temperature changes and fuel circulation past hot injectors.

## VIII. Reduction of Maintenance and Downtime

It is not possible to demonstrate this claim in the duration of this test. Improve engine efficiency, fuel system and engine cleanliness, easier starting and reduction of exhaust smoke all play a part in extending engine life and maintaining peak operating efficiency.

## Conclusion

The testing by T.A.M.E. supported the manufacturers' claims regarding the effective results of adding Dee-Zol to distillate diesel fuel when used in a diesel engine.

Test results verified by John Wensley, M.I.E. AUST.

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# ENGINE ANALYSIS DATA SHEET

Engine Manufacturer: Detroit Diesel Model: 3-71 Serial No.: 414
Engine Type: 3 cyl. 2 stroke/Blower Bore: 4.25" Stroke: 5"
Engine Displacement: 213 in.$^3$, 3.49 l Ignition Advance: Specification
Fuel Type: BP Distillate Specific Gravity: .8318 52 Cetane
Oil Type: BP Vanellus M30/CLM Fuel/Oil Ratio (2Cycle): N/A
Air Temperature: 86°F Barometric Pressure: 30.05 Inches of Mercury
Wet Bulb Air Temperature: 80.06°F
Correction Factor for Horsepower: 1.0328 for Standard Temperature and Pressure*
Test Observers: T. Atkinson and B. Roebuck, College of T.A.F.E., Townsville; Philip Morcom, Consulting Engineer, Pro-Ma Systems (Aust) Pty. Ltd.

## TEST NO. 1 USING UNTREATED BP DISTILLATE ON 5.12.85 AT 18.5 HOURS OF OPERATION

| ENGINE RPM | 1400 | 1800 |
|---|---|---|
| Maximum Torque | 190.31 nM (257 ft lbs) | 183.52 nM (248 ft lbs) |
| Maximum Brake Horsepower | 50.91 kW (68.25 bhp) | 62.10 kW (83.25 bhp) |
| Corrected Horsepower STP* | 52.58 kW (70.49 bhp) | 64.14 kW (85.98 bhp) |
| Fuel Consumption per hour | 18.46 l (4.06 galls) | 17.80 l (3.92 galls) |
| Specific Fuel Consumption | .48 | .38 |
| Thermal Efficiency | 27.29% | 34.47% |
| Brake Mean Effect. Press. | 1324.00 kPa (192 psi) | 1275.00 kPa (185 psi) |
| Hartridge Smoke Units | 20.00 | 13.00 |
| Oil Pressure | 310.00 kPa ( 45 psi) | 331.00 kPa ( 48 psi) |
| Water Temperature | 76.60°C (170°F) | 76.60°C (170°F) |

### 10.12.85: ENGINE AND FUEL SYSTEM CLEANING PHASE

The fuel was then treated with a double dose of Super DEEZOL MAXIMISER in the ratio of 80 ml of concentrate to 25 litres of distillate.

The engine was then run under varying load for a period of 5 hours at 1500 rpm.
Photograph No. 3 shows the clean exhaust stack from the laboratory during this phase.

## TEST NO. 2 FUEL TREATED WITH A SINGLE DOSE OF SUPER DEEZOL MAXIMISER, 40ml TO 25 LITRES OF DISTILLATE ON 30.1.86 AT 25 HOURS OF OPERATION

| ENGINE RPM | 1400 | 1800 |
|---|---|---|
| Maximum Torque | 198.32 nM (268 ft lbs) | 195.36. nM (264 ft lbs) |
| Maximum Brake Horsepower | 53.35 kW (71.51 bhp) | 67.46 kW (90.43 bhp) |
| Corrected Horsepower STP* | 55.50 kW (74.48 bhp) | 70.27 kW (94.19 bhp) |
| Fuel Consumption per hour | 16.60 l (3.65 galls) | 16.00 l (3.52 galls) |
| Specific Fuel Consumption | .41 | .31 |
| Thermal Efficiency | 31.95% | 42.25% |
| Brake Mean Effect. Press. | 1379.00 kPa (200 psi) | 1358.00 kPa (197 psi) |
| Hartridge Smoke Units | 18.00 | 10.00 |
| Oil Pressure | 345.00 kPa ( 50 psi) | 365.00 kPa ( 53 psi) |
| Water Temperature | 76.6°C (170°F) | 76.60°C (170°F) |

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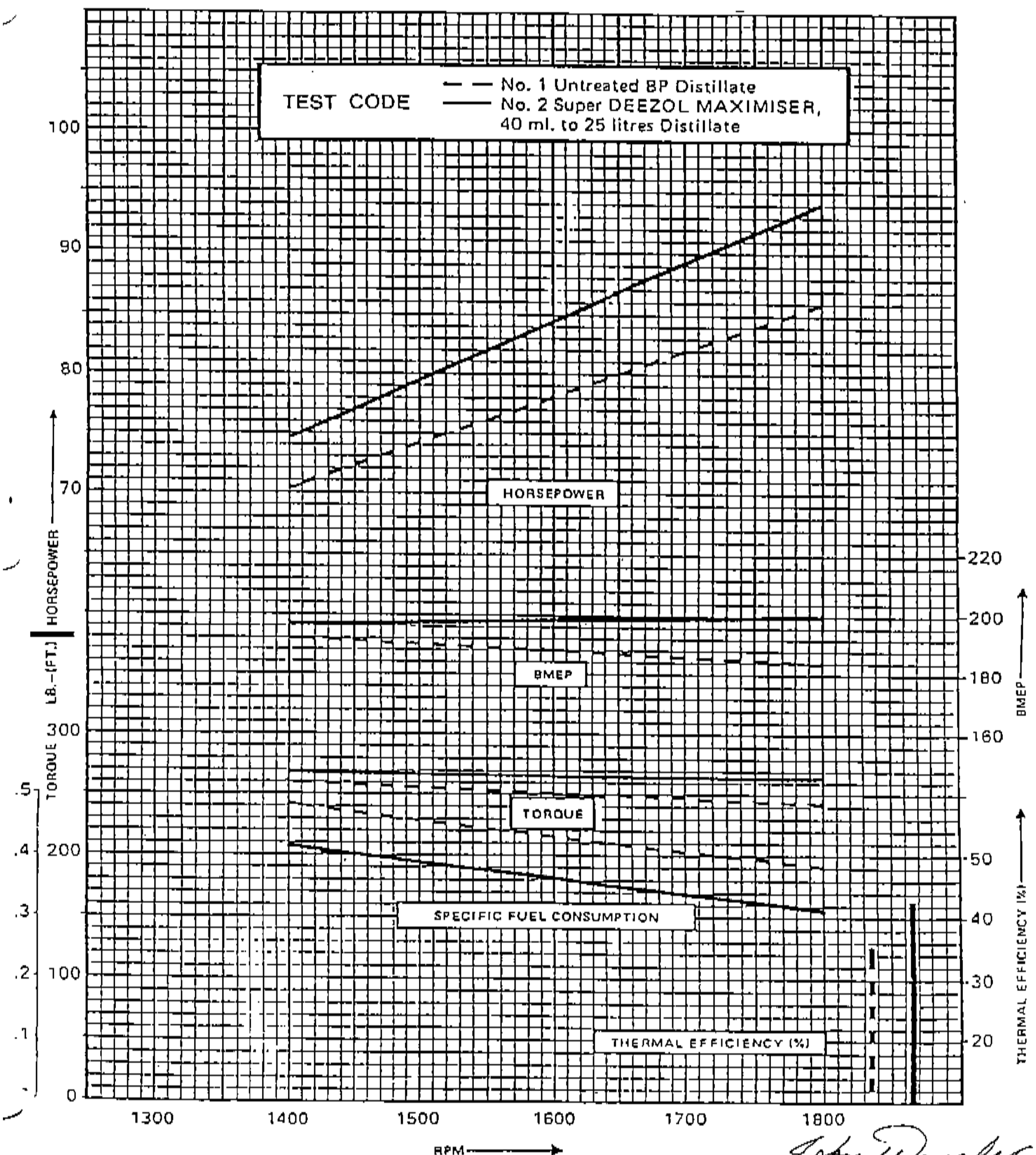
# ENGINE TEST DATA GRAPH

ENGINE TYPE: DETROIT DIESEL 371.G.M. SCHOOL ENGINE No. 414
ENGINE DISPLACEMENT: 3.491 FUEL: Distillate DATE:

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