Fuel Systems Testing

Determinations of the effect of (electro-) magnetic installations, a fuel additive and a lubricant additive on diesel fuel consumption

prepared for:

The Sea Fish Industry Authority

with support from:

by

Thomas Clifford

Dean Millar

David Parish

Camborne School of Mines,
School of Geography, Archaeology and Earth Resources,
University of Exeter,
Tremough Campus,
Penryn,
Cornwall,
TR10 9EZ

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Executive Summary

On 6th March 2008 representatives from SeaFISH and the University of Exeter met to discuss testing of fuel economy enhancement technologies at the CSM dynamometer test cell facility. These discussions resulted in an order for testing of various technologies to determine their effectiveness. The proposed technologies were varied in nature, ranging from the use of permanent and electromagnets installed on fuel lines to performance exhaust systems and engine lubricant conditioners.

For each of these technologies, engine performance and fuel consumption tests were undertaken once without the technology deployed, then once with the technology installed. The results from the two tests were compared.

The central findings of the test work are as follows:

- The FuelVantage Digital Fuel Treatment system, marketed by Vaughan Industries Ltd (http://www.magyk.com/) brought about a **1.00%** improvement in specific fuel consumption for the CSM dynamometer test cell diesel engine.
- The Ethos Max-power large permanent magnet fuel conditioner system, marketed by Ethosworld.com Ltd (http://www.max-power.org.uk/index.php) brought about a **0.47%** improvement in specific fuel consumption for the CSM dynamometer test cell diesel engine.
- Belesta LC2, a lubricating oil additive marketed by Belesta (http://www.belesta.com/), a subsidiary of Belzona Polymerics Limited (http://www.belzona.com/) brought about specific fuel consumption savings of between **0.36%** and **0.56%**.
- Further testing of both large and small Max-power permanent magnets, marketed by Ethosworld.com Ltd (http://www.max-power.org.uk/index.php), and the latter being applied with opposing poles on the fuel lines leading to individual injectors, brought about specific fuel consumption savings of **0.43%**.
- MPG-CAPS fuel combustion catalyst tablets, marketed by Fuel Freedom International, FFi Europe Ltd, (http://www.myffi.biz/t-MPG-CAPS.aspx) brought about specific fuel consumption savings of **1.08%**
- It is possible that combinations of technologies could produce further enhancements. For example, providing an engine treatment dose of MPG-CAPS and following this with a sequence of oil changes (with and without Belesta LC2) brought about a **3.18%** improvement in specific fuel consumption.

The report closes by identifying three avenues for further work. The first of these involves conducting similar tests under a more dynamic, but fully controlled testing regime. The second concerns the utilisation of heat recovered from exhaust and engine cooling systems. The third concerns further investigations of (electro-)magnetic fuel conditioning technologies.

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Introduction

This document reports methodology and results of comparative testing a series of commercially available products each of which is designed to improve the fuel economy of diesel engines. The tests were untaken at the University of Exeter's CSM engine dynamometer test cell.

Initial scope of work – Comparative Testing

On 6th March 2008 representatives from SeaFISH and the University of Exeter met to discuss testing of various fuel economy enhancement technologies. These discussions resulted in an order for testing of the following during the period March to June 2008:

A. The FuelVantage Digital Fuel Treatment system, marketed by Vaughan Industries Ltd (http://www.magyk.com/)
B. An exhaust system, marketed by Vortex Performance Exhausts Ltd (http://www.vortex-performance-exhausts.co.uk/index.php)
C. The Calorific Value Enhancer (CVE) system, marketed by Enersol Ltd (http://www.enersolcorp.com/motive/index.cfm)
D. The Ethos Maxpower permanent magnet fuel conditioner system, marketed by Ethosworld.com Ltd (http://www.max-power.org.uk/index.php)
E. Belester LC2, a lubricating oil additive marketed by Belesta (http://www.belesta.com/), a subsidiary of Belzona Polymerics Limited (http://www.belzona.com/).

For each of these technologies, engine performance and fuel consumption testing would be undertaken once without the technology deployed, then once with the technology installed and the results from the two tests would be compared. Tests of this nature are referred to as Comparative Tests in this report.

Developmental Testing

The testing schedule agreed allowed for Developmental Tests of each of the technologies, as required, at the expense of the company marketing the product tested. Such work was outside of the scope of work agreed with SeaFISH and outside the scope of work reported herein. However, in each such instance, the developmental testing would be undertaken under separate contract with the product provider to the satisfaction of the product provider, prior to Comparative Tests undertaken within the scope of the work reported herein.

Variations in the scope of work, agreed over the duration of the test schedule

2 weeks within the schedule was allocated to developmental testing of the Enersol CVE system, funded by Enersol in order that they could undertake developmental testing to tune their device to the test cell engine, prior to comparative testing conducted under this SeaFISH programme. In

practice, over the duration of the test schedule, Enersol were committed to a testing programme elsewhere and were not available to participate in the SeaFISH programme.

Approximately one week of the schedule was allocated exclusively to Vortex Performance Exhausts Ltd, in order that they could identify the most appropriate exhaust dimensions under a separate developmental testing contract, prior to comparative testing conducted under this SeaFISH programme. At the time of writing, developmental testing for Vortex Performance Exhausts Ltd has been undertaken and is ongoing but, with the agreement of SeaFISH, comparative testing of this technology has been deferred.

Within the Comparative Test schedule, and with the agreement of SeaFISH, the work planned for Enersol Ltd and Vortex Performance Exhausts Ltd was substituted by:

F. Further testing of Max-power permanent magnets, marketed by Ethosworld.com Ltd (http://www.max-power.org.uk/index.php)
G. MPG-CAPS fuel combustion catalyst tablets, marketed by Fuel Freedom International, FFi Europe Ltd, (http://www.myffi.biz/t-MPG-CAPS.aspx)

In practice, the final test schedule, including developmental testing phases within, was completed at the end of June 2008.

Test cycles adopted

Two distinct test cycles were adopted in the comparative test work reported herein. The first was termed the Baseline test cycle. This comprises running the engine at the maximum rack position, while using the dynamometer to control the load on the engine such that the engine speed is steady. The test cycle starts by defining an engine speed set point of (a maximum of) 2500 rpm and then follows a series of engine speed set points where the engine speed is progressively reduced by 100 rpm, to a minimum engine speed of 1000 rpm. The test cycle proceeds by ramping the engine speed back up to 2500 rpm through a series of set points where the engine speed is increased by 100 rpm at each point. While the test is underway, engine temperatures (at various locations), pressures, environmental conditions (humidity, atmospheric pressure, etc.) and fuel consumption are monitored. Including warm up and warm down phases of the cycle, this test cycle takes around 1 ½ hours to complete. The Baseline test cycle is primarily used as a diagnostic test sequence to determine whether or not the test engine has sustained damage or an irreversible physical change during the more prolonged DayTrawl test cycle has occurred. The DayTrawl test cycle is outlined next.

The second test cycle adopted was called the DayTrawl test cycle. This engine duty cycle defines engine set points where the engine torque and engine rotational speed are specified and controlled to simulate a typical summer season day excursion of a ~10m class trawler fishing vessel. The cycle simulates 2 ½ hours steaming to the trawling location, then 3 x 4 hour long trawls, then a 2 ½ hour journey from the trawling location back to harbour and a 1 hour ‘warm down’ while idling. While the test is underway, engine temperatures (at various locations), pressures, environmental conditions (humidity, atmospheric pressure, etc.) and fuel consumption are monitored. Including warm up and warm down phases of the cycle, this test cycle takes around 21 hours to complete and is the main test used to determine differences in fuel economy.

Full details of both of the test cycles are provided in the report entitled: *“Diesel Fuel Additives Testing; An abstracted report from the Biofuels for the Fishing Industry project”*, prepared for SeaFISH in February 2008.

Comparative Testing – Rationale and general procedures

The engine dynamometer test cell is not operated manually during testing but is operated by computer using a supervisory control and data acquisition (SCADA) system. During a DayTrawl test, the SCADA system guarantees that the uncorrected work done by the engine at each set point and over the whole test cycle is identical to that of earlier or later DayTrawl tests.

For each technology assessed, an initial DayTrawl test cycle is performed with the engine unmodified. Then, the technology assessed is then either i) installed on the engine, ii) added to the fuel or iii) added to the lubricant – as required by the technology being assessed. Then the engine undergoes the DayTrawl test cycle again. When both DayTrawl test cycles have been completed, the fuel consumption figures are compared between these tests.

Some of the technologies investigated may have effects that last longer than the duration of one test. For example, FFi Europe Ltd state that their MPG-CAPS product works partly by depositing a “thermally derived oxidation” film on the surfaces of the engine cylinders. To try to reduce the effect of this and other possible effects relating to the order in which the technologies were assessed in the determinations, each technology has its own ‘technology free’ benchmark DayTrawl test, conducted either immediately before or immediately after the DayTrawl test designed to test the technology. These tactics for comparative testing also aim to reduce/eliminate variance between DayTrawl test results due to other factors, such as:

- use of different fuel batches between tests compared (same fuel used)
- long term drift in dynamometer or other sensor calibration (minimum engine hours between comparative tests)
- changes in exhaust systems (engine fitted with 3 inch exhaust system after Vortex testing)

In comparison to field trials, the SCADA system allows comparison between tests free from effects due to:

- weather
- tidal currents
- operator usage variance

While the SCADA system ensures that the uncorrected work done by the test engine is the same for each DayTrawl test, installation of the dynamometer test cell in the sub-surface of a mine aims to reduce variance in test results due to:

- diurnal effects on the temperature and humidity of intake air
- seasonal effects on the temperature and humidity of intake air

as ambient temperature and humidity of the mine air is relatively constant.

Variations in atmospheric pressure are unavoidable and consequently an ISO1585 correction factor is applied to calibrated torque observations, using real-time measurements of intake air temperature, humidity and absolute pressure.

The engine is subjected to the Baseline test diagnostic, typically between testing of each technology, and each of the DayTrawl tests, in order to verify that the engine has not suffered any serious malfunction or sudden deterioration of performance through the test schedule.

Dynamometer test cell – Construction and specification

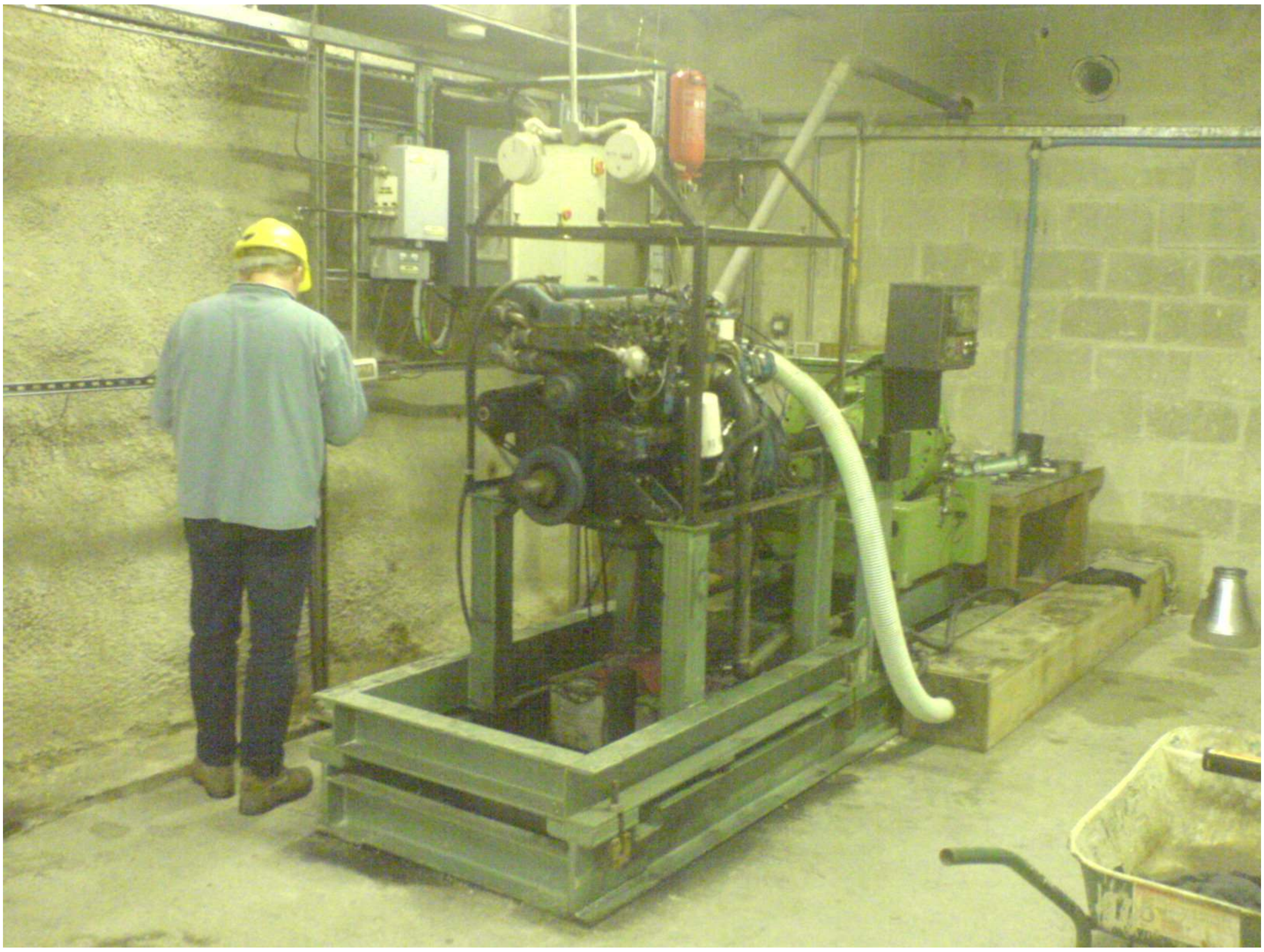


Figure 01: CSM engine dynamometer test cell – before modifications to exhaust system

The test cell is located in an underground chamber about 50 metres from the entrance to the mine in which it is located. This is a secure location with a relatively stable environment. The major equipment is based around a 6 cylinder, normally aspirated Perkins marine diesel engine with a nominal rating of 120hp. A dynamometer (Figure 02) is used to apply a load to the engine and to measure the torque. A computer-controlled system is used to run the engine through pre-defined tests in which two of i) rack position, ii) engine speed and iii) torque are specified. A set of instruments accurately records a wide range of data such as fuel consumption, engine oil pressure and temperature, coolant temperature, exhaust temperature, and environmental conditions.

Table 01: Test cell engine specification

Parameter:	Specification:
Manufacturer:	Perkins
Type:	6.3544M
Cylinders	6
Cubic capacity	5.8 litres
Compression ratio:	16:1
Bore:	98.4mm
Stroke:	127mm
Firing order:	1-5-3-6-2-4
Combustion system:	Direct injection
Cycle:	4 stroke
Output power:	89.5kW
@ Rotational speed	2800rpm

Table 02: Summary of dynamometer features

Parameter:	Specification:
Manufacturer:	Schenk
Type:	W230
Serial number:	LWH 0994
Date of manufacture:	1986
Resistance:	Eddy current
Torque transducer:	Load cell
Speed transducer:	60 tooth wheel / inductive cell
Calibration:	Dead weight arm

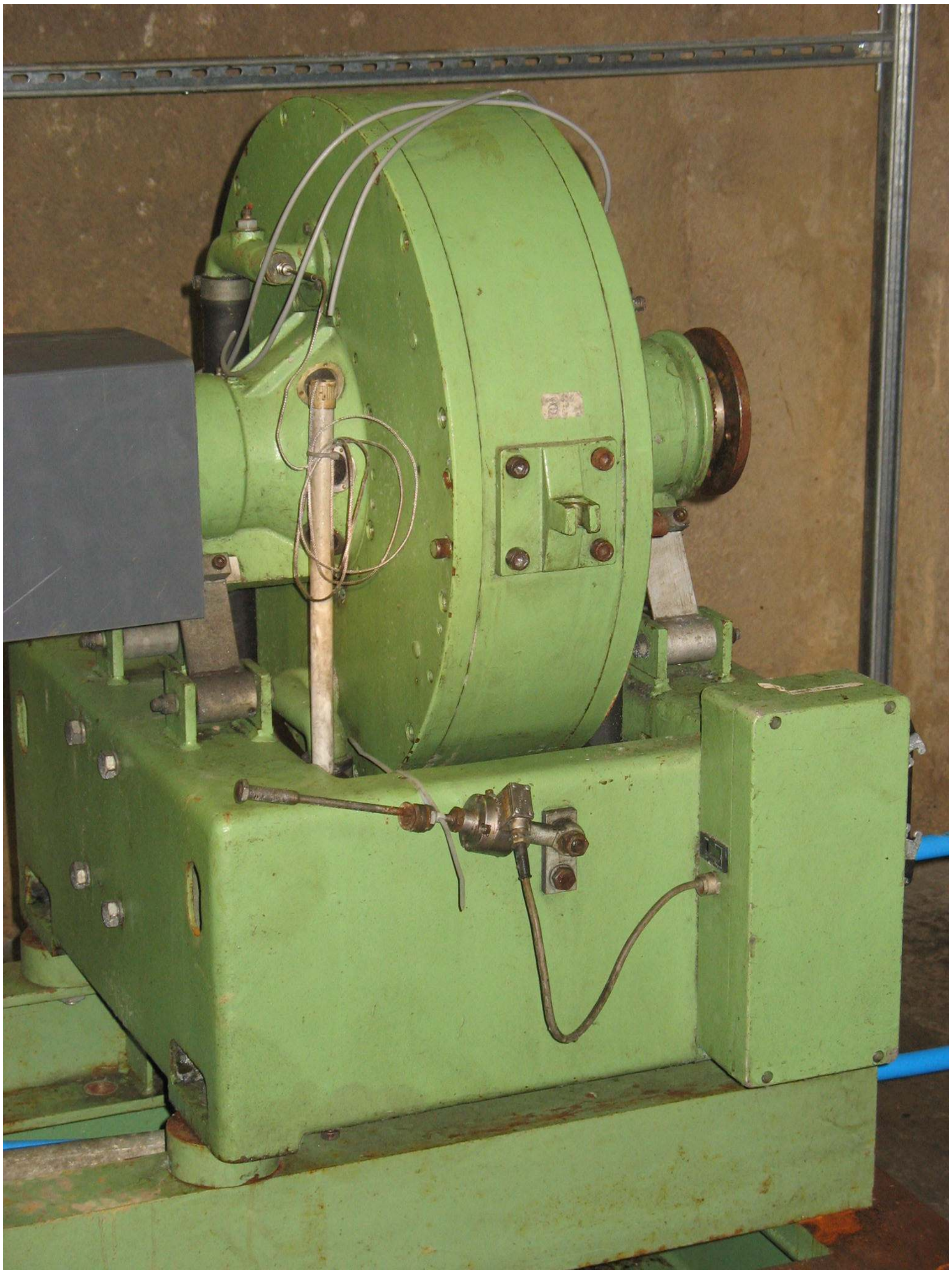


Figure 02: Dynamometer detail (N.B. Load cell unattached)

The construction of this facility and a full specification of the components and instrumentation can be reviewed the report entitled: *"Diesel Fuel Additives Testing; An abstracted report from the Biofuels for the Fishing Industry project"*, prepared for SeaFISH in February 2008.

Modifications to the dynamometer test facility since December 2007

In comparison to the test work previously reported to SeaFISH in the December 2007 report: *"Bio-Fuels for the Fishing Industry"*, the dynamometer test facility has been subjected to the following modifications:

- The rigid, twin universal joint (UJ) and solid shaft coupling between the test engine and the dynamometer has been replaced by twin rubber coupling with hollow shaft. This was done to reduce wear and possible damage to the engine, as well as UJ bearings. Universal joints had to be replaced twice during the earlier reported testing due to damaged bearings. It is thought that this damage occurred due to instantaneous excessive loading during engine starting and stopping with the earlier rigid coupling.

- Prior to the start of this phase of testing, the engine head was removed and broken piston rings were replaced and a new head gasket was installed. The engine was run in for around 85 hours before a new set of Baseline tests was undertaken to establish repeatability of results from the engine.

- After testing of the Vaughan Industries FuelVantage system, but before testing of Vortex performance exhaust systems, the exhaust line carrying combustion products out of the test cell chamber was terminated closer to the engine. An exhaust extract cone was installed such that the end of the exhaust pipe overlapped by 5-10 cm with the outer edge of the exhaust extract cone. This was done to ensure that the pressure at the end of the exhaust pipe was close to atmospheric during testing, as Vortex representatives has expressed concern that the exhaust fan could influence test results. In practice under the maximum load observed during the Day-trawl cycle, the static gauge pressure in the gap between the end of the exhaust pipe and the extract cone was measured less than 30 Pa (0.03 kPa). This is one order of magnitude lower than the typical variation of atmospheric pressure during a DayTrawl test and thus was deemed to have an insignificant effect on the test results.

Figure 03: Exhaust extraction arrangements after comparative testing with Vaughan Industries FuelVantage electromagnetic system but before developmental testing for Vortex Performance Exhausts Ltd

Use of electromagnets on fuel feed lines

Experimental set up

Figures 04 to 07 inclusive provide views of the FuelVantage Digital Fuel Treatment unit installation. The installation was approved by representatives of Vaughan Industries Ltd during a site visit prior to testing. Installation involved wrapping copper wire around the fuel feed line to the engine, then the unit was connected to the mains electricity supply, although the unit itself is supplied with a 9V DC supply adapter.

Figure 04: General arrangements for the FuelVantage Digital Fuel Treatment system (N.B. Yellow Transformer disconnected from supply for 'before' DayTrawl test)

Figure 05: Detail photograph showing the FuelVantage Digital Fuel Treatment unit (Disconnected)

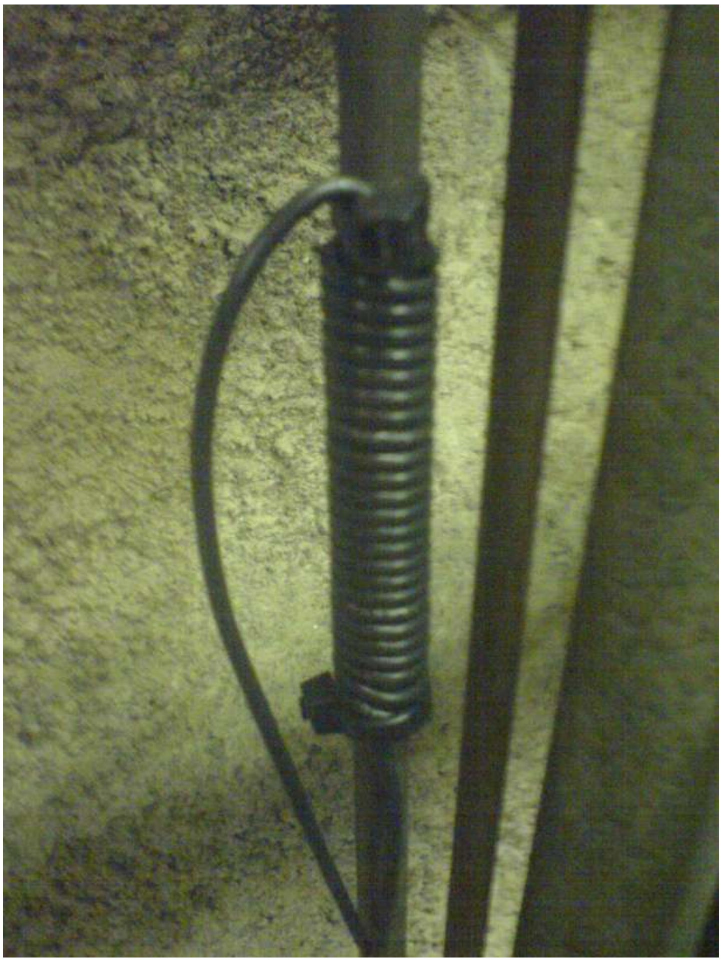


Figure 06: Detail photograph showing the electromagnetic coil wrapped around the fuel supply line to the test engine.

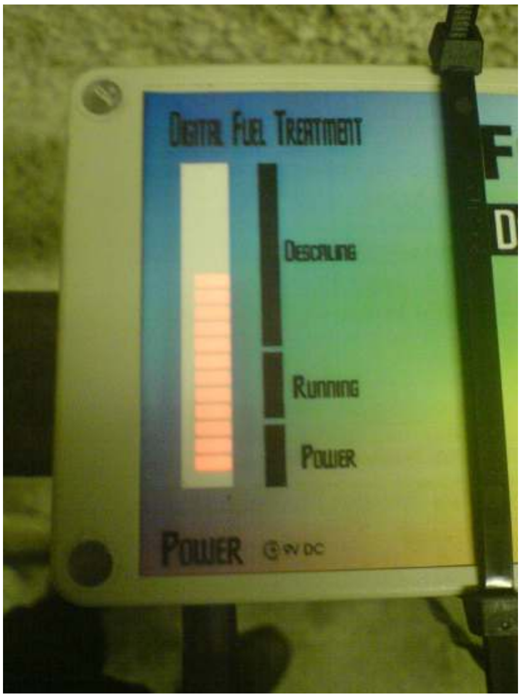


Figure 07: Detail photograph showing the FuelVantage Digital Fuel Treatment unit in operation.

Experimental method

- Six Baseline tests were conducted to establish engine performance following engine reassembly following repair (Baseline_003_201 to Baseline_003_206)
- DayTrawl test was attempted but failed due cut out of cooling water pump at mine sump, forcing test abort on three occasions. Eventually diagnosed as an earth fault with the cooling water pump switch.
- Benchmark DayTrawl test undertaken (DayTrawl_002_201) with digital fuel treatment unit disconnected
- Intermediate Baseline test undertaken as check diagnostic (Baseline_003_207)
- DayTrawl test undertaken (DayTrawl_002_202_VEMC) with digital fuel treatment unit operating
- Closing Baseline test undertaken as check diagnostic (Baseline_003_208_AVEMC)

Use of permanent magnets on fuel feed lines

Experimental set up – Large magnets only

Two phases of testing were undertaken (D and F in the Introduction section presented earlier). For the first of these phases, three of the larger Ethos Max-power permanent magnets were clipped around the test engine fuel supply line (Figure 08). The magnets were then secured with cable ties. The installation was approved by a representative of Ethosworld.com Ltd during a site visit after the first phase of testing, but before the second phase of testing.

Figure 08: Three 'large' Ethos Max-power magnets installed around the fuel supply line leading to the test engine.

Experimental set up – Large and small magnets

During the second phase of testing of the Ethos Max-power permanent magnets, the three large magnets were installed around the common fuel supply line leading to the test engine (Figure 08) and an additional 6 smaller magnets were installed around the fuel supply lines leading to each injector (Figure 09). Under the instruction of the Ethosworld.com Ltd representative who visited the site, the small magnets were installed by holding repelling poles of the permanent magnets together around the injector fuel lines with a cable tie (Not shown in Figure 09; photo taken when installation scheme was approved by Ahmed Yoozooph on 8th May 2008).

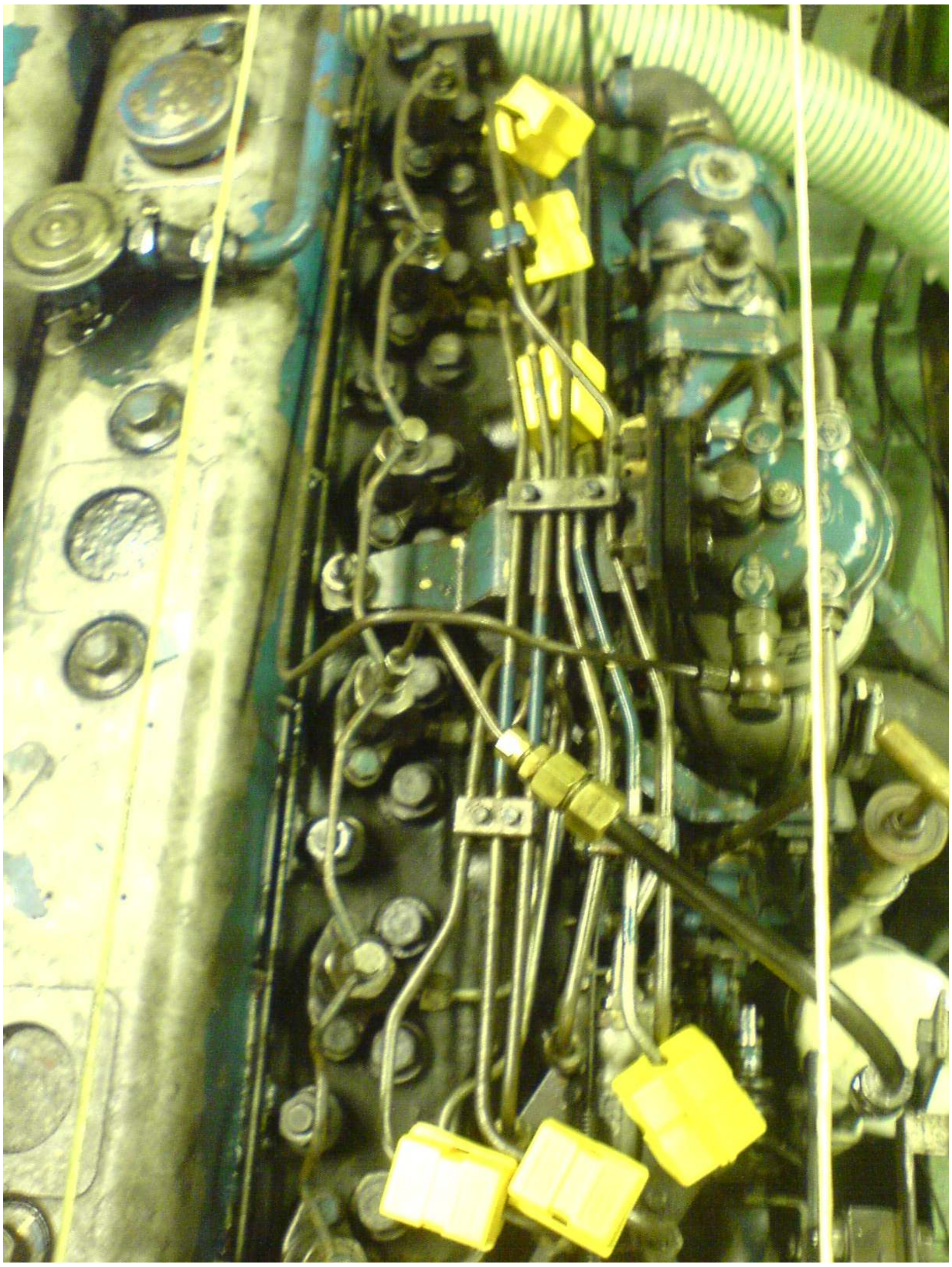


Figure 09: Six 'small' Ethos Max-power magnets installed on the fuel supply lines leading to the injectors of the test engine.

Experimental method – Large magnets only

- Benchmark DayTrawl test undertaken (DayTrawl_002_290), no magnets installed.
- Baseline test undertaken as check diagnostic (Baseline_003_214)
- DayTrawl test undertaken with large magnets installed (DayTrawl_003_291_MP)
- Baseline test undertaken with large magnets installed (Baseline_003_215_MP)
- Baseline test undertaken without large magnets installed (Baseline_003_216)

Experimental method – Large and small magnets

- Baseline test undertaken as check diagnostic (BL003_130508)
- DayTrawl test undertaken (DT002_140508) with large Max-power magnets installed.
- Intermediate Baseline test undertaken as check diagnostic (BL003_200508). Large Max-power magnets were removed.
- DayTrawl test undertaken (DT002_200508) with large Max-power magnets removed.
- Closing Baseline test undertaken as check diagnostic (BL003_210508)

Between the phase of testing dealing with the large Max-power magnets only and the second involving the large and small magnets, developmental tests were undertaken for Vortex Performance Exhausts Ltd. These ultimately required increasing the diameter of the exhaust pipe from the exhaust manifold to the exhaust silencer tail pipe from 2 ½ inches to 3 inches. Results from the large magnets only testing and the large and small magnets testing are thus not directly comparable. However, benchmark DayTrawl tests in each of the two phases of testing allow the improvements in fuel economy to be identified for both cases, and the improvements compared.

Use of engine conditioner

Fuel Freedom International state (http://www.myffi.biz/t-MPG-CAPS.aspx) that their MPG-CAPS fuel combustion catalyst tablets improve fuel economy in two ways. Firstly in conditioning doses of 3 capsules per 109 – 130 litres, their effect is to create film on the cylinder surfaces that alters the heat transfer characteristics leading to higher combustion temperatures and more even distribution of fuel within the combustion chamber. FFI also state that their tablets contain a catalyst that promotes better dissociation of the fuel leading to improved fuel burn characteristics.

Figure 10: MPG-CAPS engine conditioning tablets (Source: http://www.myffi.biz/t-MPG-CAPS.aspx)

Experimental method

- Baseline test undertaken as check diagnostic (BL003_210508)
- Benchmark DayTrawl test undertaken (DT002_130608) running on red diesel without FFi tablets added to fuel.
- Intermediate Baseline test undertaken as check diagnostic (BL003_140608).
- DayTrawl test undertaken (DT002_140608) running on red diesel with FFi tablets added to the fuel according to manufacturers dosing specifications.
- Closing Baseline test undertaken as check diagnostic (BL003_150608)

Use of engine lubricant additive

Belesta Ltd, a subsidiary of Belzona Polymerics Ltd, market a product called Belesta LC2. According to the manufacturers, LC2 is a friction reducing supplement. It is added to existing lubricants at 5% by volume. The manufacturers claim: wear resisting properties, fuel savings, reduced engine noise, reduced engine temperature and lower CO_2 emissions (by virtue of reduced fuel consumption).

Figure 11: Belesta lubricant additive promotional materials (source: http://www.belesta.com/)

Experimental method

The following experimental procedure was agreed with Belesta representatives following their site inspection of the dynamometer test cell on 4th June 2008.

Phase A

- Drain existing oil, renew engine oil filter and engine oil.
- Baseline test undertaken as a check diagnostic (BL003_160608)
- Benchmark DayTrawl test undertaken (DT002_160608).
- Baseline test undertaken as check diagnostic (BL003_170608).

Phase B

- Drain 10% by volume of engine oil (including oil in filter).
- Mix half of this volume with an equal volume of LC2, stir well and use to top up engine oil to normal level. Reserve remaining 5% of oil used in Phase A

- Baseline test undertaken as a check diagnostic (BL003_180608)
- DayTrawl test undertaken (DT002_180608).
- Baseline test undertaken as check diagnostic (BL003_200608).

Phase C

- Drain all oil, renew engine oil filter and engine oil, the latter blended at 5% by volume with LC2.
- Baseline test undertaken as a check diagnostic (BL003_010708)
- Benchmark DayTrawl test undertaken (DT002_010708).
- Baseline test undertaken as check diagnostic (BL003_030708).

Phase D

- Drain all oil, renew engine oil filter and engine oil; engine oil should be the same as used in Phase A.
- Baseline test undertaken as a check diagnostic (BL003_040708)
- Benchmark DayTrawl test undertaken (DT002_040708).
- Baseline test undertaken as check diagnostic (BL003_070708).

Summary of Overall Test Sequence

A complete listing of test and diagnostic running of the CSM engine test cell is provided below for completeness. Entries highlighted in light blue are developmental tests undertaken for Vortex Performance Exhausts Ltd, not reported herein.

Table 03: Schedule of all testing undertaken since 4th March to 7th July 2008.

Test start time	Test Reference	Duration (hh:mm:ss)	Dyno days	Notes
16/12/07 12:00:00	Torque calibration check	00:00:00	16.12	
04/03/08 12:00:00	Running in	05:00:00	16.32	New rubber coupling between engine and dyno
04/03/08 18:00:00	Running in	14:00:00	16.91	
10/03/08 12:00:00	Running in	16:00:00	17.57	
14/03/08 12:00:00	Running in	14:00:00	18.16	
15/03/08 12:00:00	Running in	14:00:00	18.74	
16/03/08 12:00:00	Running in	14:00:00	19.32	
16/03/08 12:00:00	Running in	08:00:00	19.66	
17/03/08 15:14:08	BASELINE_003_201_c	01:32:33	19.72	Baseline run to assess repeatability
18/03/08 08:37:55	BASELINE_003_202_c	01:36:38	19.79	Baseline run to assess repeatability
18/03/08 10:32:21	BASELINE_003_203_c	01:28:25	19.85	Baseline run to assess repeatability
18/03/08 13:26:19	BASELINE_003_204_c	01:33:52	19.91	Baseline run to assess repeatability
18/03/08 15:33:02	BASELINE_003_205_c	01:30:29	19.98	Baseline run to assess repeatability
19/03/08 07:33:07	BASELINE_003_206_c	01:38:20	20.05	Baseline run to assess repeatability
19/03/08 12:00:00	Aborted DayTrawl	04:00:00	20.21	
20/03/08 12:00:00	Aborted DayTrawl	04:00:00	20.38	
21/03/08 12:00:00	Aborted DayTrawl	04:00:00	20.55	
25/03/08 12:39:33	DAYTRAWL_002_201_c	20:46:12	21.41	DayTrawl test without Vaughan EM coil testing
26/03/08 11:43:00	BASELINE_003_207_c	01:32:57	21.48	
26/03/08 14:53:04	DAYTRAWL_002_202_VEMC_c	20:43:54	22.34	Comparative DayTrawl test with Vaughan EM coil
27/03/08 12:02:30	BASELINE_003_208_AVEMC_c	01:29:02	22.40	Conducted after 21 hour DayTrawl on fossil after Vaughan testing
28/03/08 11:00:00	Trials to test new exhaust system	00:30:00	22.42	
28/03/08 12:00:00	Torque calibration check	00:00:00	22.42	
28/03/08 13:05:38	BASELINE_003_209_ANE_c	01:35:33	22.49	Baseline test after new exhaust extract system installed
28/03/08 15:38:39	DAYTRAWL_002_203_NE_c	20:47:02	23.35	DayTrawl benchmark after new exhaust extractor system installed
29/03/08 12:59:17	Aborted Baseline	00:15:00	23.37	Exhaust fell off during Baseline test - significant repairs needed
31/03/08 14:52:20	BASELINE_003_211_c	01:26:51	23.43	Baseline after exhaust failure and repairs
31/03/08 18:26:06	DAYTRAWL_002_204_NE_c	20:48:19	24.29	DayTrawl after exhaust failure and repairs
01/04/08 16:38:15	BASELINE_003_212_c	02:00:08	24.38	Baseline after Daytrawl with new exhaust extractor & 2.5 inch CSM silence
01/04/08 21:02:28	BASELINE_003_213_c	01:30:30	24.44	Baseline with Vortex Performance Exhaust silencer No. 1
04/04/08 11:40:25	SHORTDAYTRAWL_001_001_VE_c	01:57:04	24.52	Short DayTrawl with Vortex narrow silencer (No. 1)
04/04/08 14:16:19	SHORTDAYTRAWL_001_002_c	01:48:08	24.60	Short DayTrawl with HTM silencer
05/04/08 13:54:05	SHORTDAYTRAWL_001_003_VE_c	01:50:54	24.67	Short DayTrawl with Vortex broad silencer (No. 2)
08/04/08 10:39:37	DAYTRAWL_002_290_c	20:59:00	25.55	Daytrawl on 2.5 inch CSM silencer, providing datum for fixed magnets wor
09/04/08 10:28:29	BASELINE_003_214_c	01:35:47	25.61	Diagnostic after DayTrawl test above
09/04/08 15:04:10	DAYTRAWL_002_291_MP_c	20:59:00	26.49	Daytrawl on 2.5 inch CSM silencer , with large permanent magnets installe
10/04/08 12:52:39	BASELINE_003_215_MP_c	01:32:16	26.55	Baseline on 2.5 inch CSM silencer, with large permanent magnets installe
11/04/08 08:44:23	BASELINE_003_216_c	01:35:50	26.62	Baseline on 2.5 inch CSM silencer, without permanent magnets
25/04/08 11:05:25	SDT01_250408_01_c	01:48:08	26.69	ShortDayTrawl with 2.5 inch CSM silencer
01/05/08 08:42:56	BL003_010508_001_c	01:38:14	26.76	Baseline with 3 inch CSM silencer
01/05/08 10:35:26	SDT01_010508_001_c	01:48:08	26.84	Short DayTrawl 3 inch CSM silencer
01/05/08 12:43:07	SDT01_010508_002_c	01:48:08	26.91	Short DayTrawl 3 inch CSM silencer
01/05/08 14:50:19	SDT01_010508_003_c	01:48:08	26.99	Short DayTrawl 3 inch CSM silencer
02/05/08 15:13:28	BL003_020508_001_c	01:35:55	27.05	Baseline with 3 inch CSM silencer
08/05/08 12:10:58	SDT01_080508_001_c	01:48:08	27.13	ShortDayTrawl with 3 inch Vortex silencer (No 3) - mistake in progression
13/05/08 08:49:11	SDT01_130508_001VE_c	01:48:08	27.20	ShortDayTrawl with 3 inch Vortex silencer (No 3) - repeat of 08/05/08
13/05/08 11:54:39	BL003_130508_001VE_c	01:32:38	27.27	Baseline with 3 inch Vortex silencer
13/05/08 14:10:57	BL003_130508_002_c	01:32:24	27.33	Baseline with 3 inch CSM silencer / Opening Baseline for fixed magnets
14/05/08 10:58:21	DT002_140508_001EM_c	20:52:43	28.20	DayTrawl with fixed magnets 140508
20/05/08 09:21:32	BL003_200508_001_c	01:34:57	28.27	Baseline between Magnets DT and Red Diesel DT 200508
20/05/08 19:02:40	DT002_200508_001_c	20:51:27	29.14	DayTrawl without Magnets 200508
21/05/08 16:30:51	BL003_210508_001_c	01:31:38	29.20	Closing Baseline for Fixed Magnets 210508 / Opening baseline for Ffi table
13/06/08 10:02:34	DT002_130608_001_c	20:57:42	30.07	DayTrawl on red diesel only 130608
14/06/08 07:44:08	BL003_140608_001_c	01:31:20	30.14	Baseline between Red DT and Ffi tablets DT 130608
14/06/08 09:29:10	DT002_140608_001_c	20:43:06	31.00	DayTrawl with Ffi tablets 140608
15/06/08 08:15:58	BL003_150608_001_c	01:34:17	31.07	Closing baseline for Ffi tablets 150608
16/06/08 13:59:54	BL003_160608_001_c	01:27:07	31.13	Opening baseline on Belesta work (no Belesta installed) 160608
16/06/08 15:56:19	DT002_160608_001_c	20:42:52	31.99	DayTrawl on red (no Belesta installed) 160608
17/06/08 13:47:09	BL003_170608_001_c	01:31:38	32.05	Baseline after red (no Belesta installed) 170608
18/06/08 10:26:33	BL003_180608_001_c	01:35:23	32.12	Opening baseline on Red (5% Belesta) 180608
18/06/08 12:20:54	DT002_180608_001_c	20:43:05	32.98	DayTrawl on Red (5% Belesta) 180608
20/06/08 08:37:20	BL003_200608_001_c	01:36:04	33.05	Closing baseline on Red (5% Belesta) 200608
01/07/08 10:02:11	BL003_010708_001_c	01:35:19	33.12	Opening baseline on Red (5% Belesta, 2nd rinse), 010708
01/07/08 14:35:29	DT002_010708_001_c	20:49:39	33.98	DayTrawl on Red (5% Belesta, 2nd rinse), 010708
03/07/08 08:47:10	BL003_030708_001_c	01:37:05	34.05	Closing baseline on Red (5% Belesta, 2nd rinse), 030708
04/07/08 10:33:02	BL003_040708_001_c	01:38:42	34.12	Opening baseline for closing daytrawl on red, 040708
04/07/08 12:40:32	DT002_040708_001_c	20:44:42	34.98	DayTrawl on Red (closing DayTrawl), 040708
07/07/08 08:03:58	BL003_070708_001_c	01:40:29	35.05	Closing baseline on Red, 050708
08/07/08 10:00:00	Torque calibration check	00:00:00	35.05	

Dynamometer Calibration

Signals from the load cell on the test cell dynamometer pass to a signal conditioning box and then subsequently to a PCB card in a rack of analogue to digital converters. During testing the digital values are recorded and displayed on the screen of the SCADA software. These are also the values that the SCADA system uses to control the torque - when it is (operator) defined that it is appropriate to do so.

The SCADA software has an off-line procedure that guides the process of dynamometer calibration. A deadweight cantilever arm is placed across the dynamometer and a known load is placed on a hanger at the end of the arm, providing known torque. The magnitude of the known load is provided to the system and recorded, while it senses the torque through the instrumentation. The process is repeated with different known loads. The SCADA system then computes the calibration parameters and these are stored within the system, ready for operations.

As a part of routine testing operations, the dynamometer calibration is periodically checked using a similar procedure to that described above. Known loads are placed on the hanger at the end of the cantilever arm and the resulting known torque is compared with the torque displayed on the SCADA system screen (the value which would be recorded during operations). This process is repeated with known loads. These data are used to post process torque data recovered from the system during testing in a process that is termed *compensation*.

Dynamometer calibration checks have demonstrated that it has remained stable throughout the current period of testing.

Table 04: Torque compensation parameter values

Dyno days	Gain (Nm/Nm)	Offset (Nm)
16.12	1.010	-1.1
22.42	1.013	-2.5
35.05	1.008	-2.0

Observed, compensated and corrected torque

In DayTrawl test results that are presented, three values for torque are reported: observed torque, compensated torque and corrected torque. The observed torque figures are those recorded by the SCADA system. The compensated torque figures are those found after post processing using the compensation parameters. The corrected torque figures are those found after applying an ISO1585 procedure to allow for variations in atmospheric conditions during testing. The latter procedure determines the so-called *engine correction factor* and full details of this process are provided in the report prepared for SeaFISH entitled: *“Diesel Fuel Additives Testing; An abstracted report from the Biofuels for the Fishing Industry project”*, February 2008.

Experimental Results

A. Vaughan FuelVantage Digital Fuel Treatment System

The experimental results are presented using both graphical and tabular formats.

Firstly the results of Baseline diagnostic tests are presented graphically, before, during and after the main DayTrawl tests. These results are presented in confirmation that the test engine did not suffer any major malfunction throughout the test sequence. With exceptions where indicated, all Baseline tests are conducted on straight red diesel, without any of the technologies being examined being deployed. Thus, there should be excellent agreement between Baseline diagnostic tests, presuming the technology tested does not provide an effect beyond its deployments.

The main results of comparative testing are then presented using a tabular format. Firstly, the results of the Benchmark DayTrawl test are presented. Then the results of the DayTrawl test with the technology deployed are presented. Finally, a table of percentage differences in quantities found for each stage of the test cycle (presented in the first two tables) are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

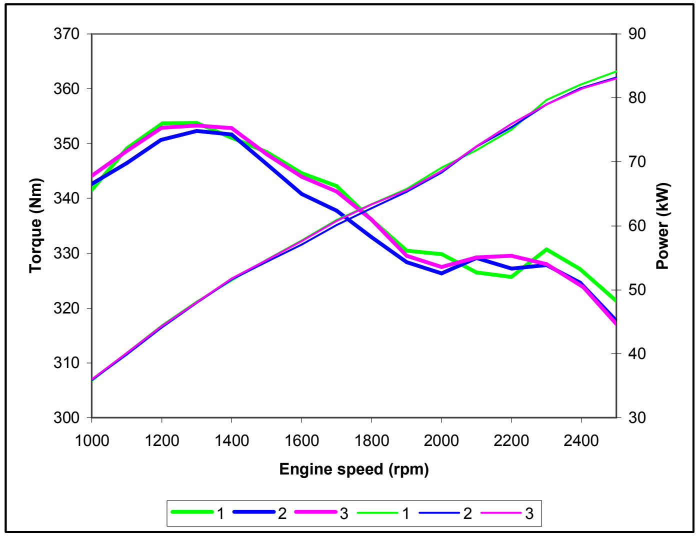
This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

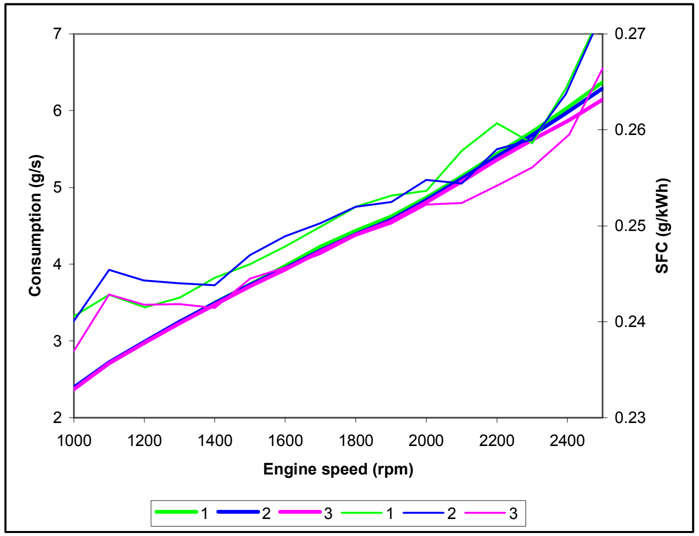
The main results of comparative testing are then presented using a graphical format. Firstly the time series of the Benchmark DayTrawl test are presented. Then the time series of the DayTrawl test with the technology deployed are presented. Finally, time series of the percentage differences in engine performance and fuel consumption parameters are presented. The percentage differences are calculated as:

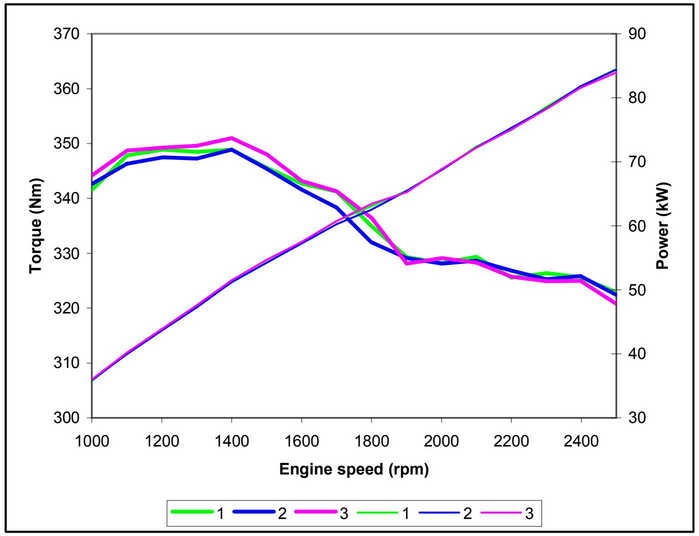
((Value with technology – Benchmark value) / Benchmark value) x 100

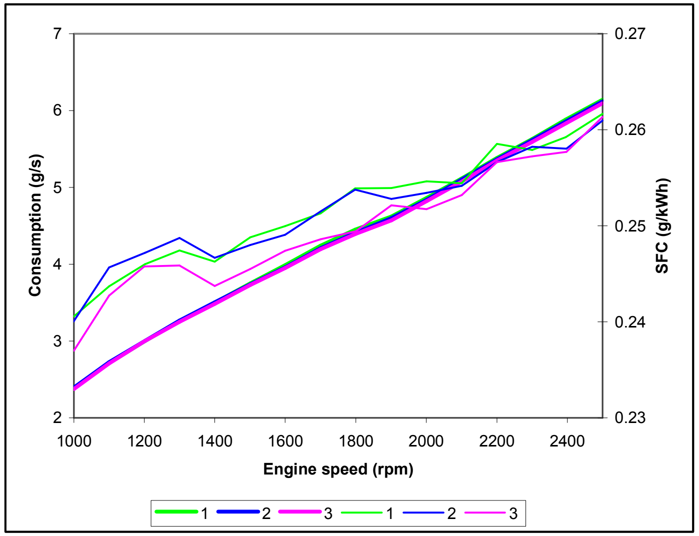
This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.
For brevity, table and figure numbering are suspended until the Summary Results section below.

Comparison of Baseline diagnostic tests









1 - BASELINE_003_206 (Before), 2 - BASELINE_003_207 (Between DayTrawls), 3 - BASELINE_003_208_AVEMC (After)

Narrative:

Curves in upper boxes are for the ramping down stages of the test cycle. Curves in the lower boxes are for the ramping up (later) stages of the test cycle.

Curves indicate no significant malfunction occurred with the test engine.

Good consistency between maximum torque and maximum power curves between tests.

SFC for test 3 lower than others suggesting that effect of the technology persisted beyond deployment but this could be experimental variance.

DayTrawl test results

Day trawl test cycle results

Test date	25/03/2008	Description	
Warm-up duration	00:06:12		Fossil DayTrawl Test - without use of Vaughan EM coil
Test duration	20:40:00		DAYTRAWL_002_201_c
Total engine hour:	20:46:12		

Stage	Description	Start time	End time	Duration	Engine Speed		Torque						Total Work done in stage						Stage fuel consumption				Total fuel consumed				Specific fuel consumption in stage						Engine Efficiency	
							Observed		Compensated		Reduced		Observed		Compensated		Reduced										Instantaneous		Aggregate over stage					
					Ave.	Stdev.	Ave.	Stdev.	Ave.	Stdev.	Ave.	Stdev.	Sum	Stdev.	Sum	Stdev.	Sum	Stdev.	Initial	Final	Ave.	Stdev.	Mass	Stdev.	Volume	Energy	Ave.	Stdev.	Mass	Stdev	Volume	Energy	Ave.	Agg.
		hh:mm:ss	hh:mm:ss	hh:mm:ss	(RPM)	(RPM)	(Nm)	(Nm)	(Nm)	(Nm)	(Nm)	(Nm)	(kWh)	(kWh)	(kWh)	(kWh)	(kWh)	(kWh)	(g/s)	(g/s)	(g/s)	(g/s)	(kg)	(kg)	(litres)	(kWh)	(kg/kWh)	(kg/kWh)	(kg/kWh)	(kg/kWh)	(L/kWh)	(kWh/kWh)	(%)	(%)
Stage Start TP00	15 minute tick over under zero load	12:45:45	13:00:45	00:15:00	1184.79	4.84	-1.24	0.05	1.05	0.05	1.04	0.05	-0.05	0.000	0.04	0.000	0.04	0.000	0.52	0.50	0.51	0.008	0.4596	0.0000	0.54	5.78	14.256	0.860	12.354	0.009	14.449	155.410	0.559	0.643
Stage Start TP01	15 minute gentle cruise from port	13:00:45	13:15:45	00:15:00	1300.00	0.00	36.70	0.00	39.45	0.00	39.28	0.00	1.25	0.000	1.34	0.000	1.34	0.000	0.80	0.79	0.79	0.004	0.7128	0.0000	0.83	8.97	0.533	0.002	0.533	0.000	0.624	6.708	14.920	14.909
Stage Start TP02	2.5 hr steaming to trawl site	13:15:45	15:45:45	02:30:00	2000.00	0.20	47.00	0.00	49.88	0.00	49.68	0.01	24.61	0.000	26.12	0.000	26.01	0.000	1.47	1.41	1.42	0.012	12.7932	0.0000	14.96	160.94	0.492	0.004	0.492	0.000	0.575	6.187	16.168	16.163
Stage Start TP03	5 min gentle cruise while shooting	15:45:45	15:50:45	00:05:00	1500.00	0.00	38.20	0.00	40.97	0.00	40.83	0.00	0.50	0.000	0.54	0.000	0.53	0.000	0.90	0.91	0.90	0.005	0.2706	0.0000	0.32	3.40	0.507	0.003	0.506	0.000	0.592	6.370	15.691	15.699
Stage Start TP04	4 hour trawl	15:50:45	19:50:45	04:00:00	1750.00	0.06	278.10	0.01	283.80	0.01	282.96	0.11	203.86	0.000	208.04	0.000	207.42	0.000	3.48	3.44	3.45	0.007	49.6566	0.0000	58.08	624.68	0.239	0.000	0.239	0.000	0.280	3.012	33.206	33.204
Stage Start TP05	20 min haul in of nets	19:50:45	20:10:45	00:20:00	1400.00	0.00	82.50	0.00	85.81	0.00	85.61	0.01	4.03	0.000	4.19	0.000	4.18	0.000	1.10	1.13	1.12	0.010	1.3434	0.0000	1.57	16.90	0.321	0.003	0.321	0.000	0.376	4.039	24.735	24.756
Stage Start TP06	20 min tickover: net handling & unload	20:10:45	20:30:45	00:20:00	1165.21	2.15	-0.89	0.03	1.40	0.03	1.40	0.03	-0.04	0.000	0.06	0.000	0.06	0.000	0.45	0.47	0.46	0.007	0.5526	0.0000	0.65	6.95	9.723	0.264	9.709	0.003	11.355	122.134	0.818	0.819
Stage Start TP07	5 min gentle cruise while shooting	20:30:45	20:35:45	00:05:00	1500.00	0.00	38.20	0.00	40.97	0.00	40.87	0.00	0.50	0.000	0.54	0.000	0.53	0.000	0.93	0.92	0.93	0.006	0.2778	0.0000	0.32	3.49	0.519	0.003	0.519	0.000	0.607	6.532	15.325	15.308
Stage Start TP08	4 hour trawl	20:35:45	00:35:45	04:00:00	1750.00	0.06	278.10	0.01	283.80	0.01	283.29	0.16	203.86	0.000	208.04	0.000	207.66	0.000	3.51	3.43	3.44	0.012	49.4886	0.0000	57.88	622.57	0.238	0.001	0.238	0.000	0.279	2.998	33.359	33.356
Stage Start TP09	20 min haul in of nets	00:35:45	00:55:45	00:20:00	1400.05	0.23	82.50	0.00	85.81	0.00	85.76	0.00	4.03	0.000	4.19	0.000	4.19	0.000	1.10	1.13	1.12	0.012	1.3410	0.0000	1.57	16.87	0.320	0.003	0.320	0.000	0.374	4.025	24.825	24.843
Stage Start TP10	20 min tickover: net handling & unload	00:55:45	01:15:45	00:20:00	1163.47	2.22	-0.66	0.08	1.64	0.08	1.64	0.08	-0.03	0.000	0.07	0.000	0.07	0.000	0.45	0.46	0.46	0.004	0.5496	0.0000	0.64	6.91	8.296	0.384	8.306	0.004	9.714	104.486	0.960	0.957
Stage Start TP11	5 min gentle cruise while shooting	01:15:45	01:20:45	00:05:00	1500.00	0.00	38.20	0.00	40.97	0.00	40.95	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.92	0.92	0.92	0.000	0.2760	0.0000	0.32	3.47	0.515	0.000	0.515	0.000	0.602	6.478	15.437	15.437
Stage Start TP12	4 hour trawl	01:20:45	05:20:45	04:00:00	1750.01	0.11	278.10	0.01	283.80	0.01	283.84	0.10	203.86	0.000	208.04	0.000	208.07	0.000	3.49	3.42	3.43	0.011	49.3488	0.0000	57.72	620.81	0.237	0.001	0.237	0.000	0.277	2.984	33.519	33.516
Stage Start TP13	20 min haul in of nets	05:20:45	05:40:45	00:20:00	1400.00	0.00	82.50	0.00	85.81	0.00	85.83	0.00	4.03	0.000	4.19	0.000	4.19	0.000	1.10	1.13	1.12	0.010	1.3392	0.0000	1.57	16.85	0.320	0.003	0.319	0.000	0.373	4.016	24.881	24.898
Stage Start TP14	2.5 hr steaming to trawl site	05:40:45	08:10:45	02:30:00	2000.00	0.28	47.00	0.00	49.88	0.00	49.86	0.01	24.61	0.000	26.12	0.000	26.11	0.000	1.40	1.39	1.39	0.005	12.5484	0.0000	14.68	157.86	0.481	0.002	0.481	0.000	0.562	6.047	16.538	16.537
Stage Start TP15	15 minute gentle cruise to port	08:10:45	08:25:45	00:15:00	1300.00	0.00	36.70	0.00	39.45	0.00	39.43	0.00	1.25	0.000	1.34	0.000	1.34	0.000	0.73	0.76	0.75	0.011	0.6732	0.0000	0.79	8.47	0.503	0.007	0.502	0.000	0.587	6.311	15.820	15.844
Stage Start TP16	Tick over for 1 hour	08:25:45	09:25:45	01:00:00	1159.59	1.05	-0.51	0.05	1.79	0.05	1.79	0.05	-0.06	0.000	0.22	0.000	0.22	0.000	0.45	0.47	0.47	0.005	1.6800	0.0000	1.96	21.13	7.741	0.189	7.739	0.000	9.051	97.351	1.027	1.027
End Test	End of test	09:25:45																																

Fuel	M&W Batch 3 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.29	MJ/kg
	12.580	kWh/kg
	10.756	kWh/litre

	Work Observed Sum	Work Compensated Sum	Work Reduced Sum	Fuel Mass	Fuel Volume	Fuel Energy	Aggregate Mass	Aggregate Volume	Aggregate Energy	Efficiency Agg.
Total over whole test	676.71	693.60	692.50	183.31	214.40	2306.06	0.265	0.310	3.330	30.030
Total over whole test (check)	676.72	693.59	692.49	183.31	214.40	2306.06	0.265	0.310	3.330	30.029
Total over census stages	676.89	693.22	692.12	180.07	210.61	2265.28	0.260	0.304	3.273	30.554
Total over census stage 1	234.25	240.23	239.49	64.78	75.76	814.89	0.270	0.316	3.403	29.389
Total over census stage 2	208.39	212.77	212.39	51.11	59.77	642.93	0.241	0.281	3.027	33.034
Total over census stage 3	234.25	240.23	240.25	64.19	75.07	807.45	0.267	0.312	3.361	29.753

Day trawl test cycle results

Test date	26/03/2008	Description	
Warm-up duration	00:03:55		Fossil DayTrawl Test - with use of Vaughan EM coil
Test duration	20:39:59		DAYTRAWL_002_202_VEMC_c
Total engine hour:	20:43:54		

Stage	Description	Start time	End time	Duration	Engine Speed		Torque						Total Work done in stage						Stage fuel consumption				Total fuel consumed				Specific fuel consumption in stage						Engine Efficiency	
							Observed		Compensated		Reduced		Observed		Compensated		Reduced										Instantaneous		Aggregate over stage					
					Ave.	Stdev.	Ave.	Stdev.	Ave.	Stdev.	Ave.	Stdev.	Sum	Stdev.	Sum	Stdev.	Sum	Stdev.	Initial	Final	Ave.	Stdev.	Mass	Stdev.	Volume	Energy	Ave.	Stdev.	Mass	Stdev	Volume	Energy	Ave.	Agg.
		hh:mm:ss	hh:mm:ss	hh:mm:ss	(RPM)	(RPM)	(Nm)	(Nm)	(Nm)	(Nm)	(Nm)	(Nm)	(kWh)	(kWh)	(kWh)	(kWh)	(kWh)	(kWh)	(g/s)	(g/s)	(g/s)	(g/s)	(kg)	(kg)	(litres)	(kWh)	(kg/kWh)	(kg/kWh)	(kg/kWh)	(kg/kWh)	(L/kWh)	(kWh/kWh)	(%)	(%)
Stage Start TP00	15 minute tick over under zero load	14:56:59	15:11:59	00:15:00	1173.71	2.16	-0.45	0.05	2.06	0.05	2.06	0.05	-0.02	0.000	0.07	0.000	0.07	0.000	0.47	0.47	0.47	0.000	0.4230	0.0000	0.49	5.32	6.692	0.159	5.742	0.002	6.716	72.232	1.188	1.384
Stage Start TP01	15 minute gentle cruise from port	15:11:59	15:26:59	00:15:00	1300.00	0.00	36.70	0.00	39.68	0.00	39.66	0.00	1.25	0.000	1.35	0.000	1.35	0.000	0.77	0.76	0.76	0.004	0.6858	0.0000	0.80	8.63	0.508	0.002	0.508	0.000	0.594	6.392	15.656	15.644
Stage Start TP02	2.5 hr steaming to trawl site	15:26:59	17:56:59	02:30:00	1999.95	0.28	47.00	0.00	50.11	0.00	50.06	0.01	24.61	0.000	26.24	0.000	26.21	0.000	1.43	1.40	1.40	0.005	12.6054	0.0000	14.74	158.58	0.481	0.002	0.481	0.000	0.562	6.050	16.533	16.530
Stage Start TP03	5 min gentle cruise while shooting	17:56:59	18:01:59	00:05:00	1500.00	0.00	38.20	0.00	41.20	0.00	41.16	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.89	0.90	0.90	0.006	0.2682	0.0000	0.31	3.37	0.498	0.003	0.498	0.000	0.582	6.262	15.952	15.969
Stage Start TP04	4 hour trawl	18:01:59	22:01:59	04:00:00	1750.00	0.00	278.10	0.01	284.14	0.01	283.93	0.03	203.86	0.000	208.29	0.000	208.13	0.000	3.46	3.41	3.42	0.010	49.2930	0.0000	57.65	620.11	0.237	0.001	0.237	0.000	0.277	2.979	33.565	33.563
Stage Start TP05	20 min haul in of nets	22:01:59	22:21:59	00:20:00	1400.00	0.00	82.50	0.00	86.06	0.00	86.00	0.00	4.03	0.000	4.21	0.000	4.20	0.000	1.09	1.12	1.11	0.010	1.3314	0.0000	1.56	16.75	0.317	0.003	0.317	0.000	0.371	3.985	25.070	25.091
Stage Start TP06	20 min tickover: net handling & unload	22:21:59	22:41:59	00:20:00	1160.84	1.92	-0.54	0.05	1.97	0.05	1.96	0.05	-0.02	0.000	0.08	0.000	0.08	0.000	0.45	0.46	0.46	0.005	0.5478	0.0000	0.64	6.89	6.891	0.124	6.893	0.002	8.061	86.708	1.154	1.153
Stage Start TP07	5 min gentle cruise while shooting	22:41:59	22:46:59	00:05:00	1500.00	0.00	38.20	0.00	41.20	0.00	41.17	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.92	0.92	0.92	0.000	0.2760	0.0000	0.32	3.47	0.512	0.000	0.512	0.000	0.599	6.443	15.521	15.521
Stage Start TP08	4 hour trawl	22:46:59	02:46:59	04:00:00	1750.00	0.00	278.10	0.01	284.14	0.01	284.08	0.06	203.86	0.000	208.29	0.000	208.24	0.000	3.48	3.41	3.41	0.011	49.1490	0.0000	57.48	618.29	0.236	0.001	0.236	0.000	0.276	2.969	33.683	33.679
Stage Start TP09	20 min haul in of nets	02:46:59	03:06:59	00:20:00	1400.00	0.00	82.50	0.00	86.06	0.00	86.06	0.00	4.03	0.000	4.21	0.000	4.21	0.000	1.09	1.12	1.11	0.010	1.3296	0.0000	1.56	16.73	0.316	0.003	0.316	0.000	0.370	3.977	25.125	25.145
Stage Start TP10	20 min tickover: net handling & unload	03:06:59	03:26:59	00:20:00	1161.95	1.99	-0.60	0.00	1.91	0.00	1.91	0.00	-0.02	0.000	0.08	0.000	0.08	0.000	0.45	0.46	0.46	0.005	0.5466	0.0000	0.64	6.88	7.072	0.090	7.066	0.000	8.265	88.894	1.124	1.125
Stage Start TP11	5 min gentle cruise while shooting	03:26:59	03:31:59	00:05:00	1500.00	0.00	38.20	0.00	41.20	0.00	41.20	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.92	0.91	0.92	0.005	0.2754	0.0000	0.32	3.46	0.510	0.003	0.511	0.000	0.597	6.424	15.575	15.567
Stage Start TP12	4 hour trawl	03:31:59	07:31:59	04:00:00	1750.00	0.00	278.10	0.01	284.14	0.01	284.10	0.04	203.86	0.000	208.29	0.000	208.25	0.000	3.47	3.40	3.40	0.013	49.0242	0.0000	57.34	616.72	0.235	0.001	0.235	0.000	0.275	2.961	33.771	33.768
Stage Start TP13	20 min haul in of nets	07:31:59	07:51:59	00:20:00	1400.00	0.00	82.50	0.00	86.06	0.00	86.04	0.01	4.03	0.000	4.21	0.000	4.20	0.000	1.09	1.12	1.11	0.010	1.3278	0.0000	1.55	16.70	0.316	0.003	0.316	0.000	0.369	3.973	25.154	25.172
Stage Start TP14	2.5 hr steaming to trawl site	07:51:59	10:21:58	02:29:59	2000.01	0.37	47.00	0.00	50.11	0.00	50.08	0.00	24.61	0.001	26.24	0.001	26.22	0.001	1.40	1.39	1.39	0.003	12.5164	0.0000	14.64	157.46	0.477	0.001	0.477	0.000	0.558	6.005	16.653	16.652
Stage Start TP15	15 minute gentle cruise to port	10:21:58	10:36:58	00:15:00	1300.00	0.00	36.70	0.00	39.68	0.00	39.66	0.00	1.25	0.000	1.35	0.000	1.35	0.000	0.74	0.76	0.75	0.007	0.6732	0.0000	0.79	8.47	0.499	0.004	0.499	0.000	0.583	6.275	15.927	15.937
Stage Start TP16	Tick over for 1 hour	10:36:58	11:36:58	01:00:00	1156.47	1.24	-0.32	0.04	2.20	0.04	2.19	0.04	-0.04	0.000	0.27	0.000	0.27	0.000	0.45	0.47	0.47	0.006	1.6746	0.0000	1.96	21.07	6.307	0.102	6.307	0.000	7.376	79.338	1.261	1.260
End Test	End of test	11:36:58																																

Fuel	M&W Batch 3 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.29	MJ/kg
	12.580	kWh/kg
	10.756	kWh/litre

	Work Observed Sum	Work Compensated Sum	Work Reduced Sum	Fuel Mass	Fuel Volume	Fuel Energy	Aggregate Mass	Aggregate Volume	Aggregate Energy	Efficiency Agg.
Total over whole test	676.78	694.77	694.48	181.95	212.80	2288.90	0.262	0.306	3.296	30.341
Total over whole test (check)	676.78	694.76	694.47	181.95	212.80	2288.90	0.262	0.306	3.296	30.341
Total over census stages	676.88	694.27	693.98	178.76	209.07	2248.74	0.258	0.301	3.240	30.861
Total over census stage 1	234.25	240.62	240.43	64.18	75.07	807.43	0.267	0.312	3.358	29.777
Total over census stage 2	208.39	213.03	212.98	50.75	59.36	638.49	0.238	0.279	2.998	33.357
Total over census stage 3	234.24	240.62	240.57	63.82	74.64	802.82	0.265	0.310	3.337	29.965

Percentage differences of DayTrawl tests

Percentage difference between 2 DayTrawl tests (Positive values mean the benchmark was lower, negative values mean the technology tested was lower)

Benchmark: Fossil DayTrawl Test - without use of Vaughan EM coil
Technology tested: Fossil DayTrawl Test - with use of Vaughan EM coil

Stage	Description	Start time	End time	Duration	Engine Speed	Torque			Total Work done in stag			Stage fuel consumpr			Total fuel consumed			Specific fuel consumption in stage				Engine Efficiency	
																		Instantan.	Aggregate over stage				
					Ave.	Obs. Ave.	Comp. Ave.	Red. Ave.	Obs. Sum	Comp. Sum	Red. Sum	Initial	Final	Ave.	Mass	Volume	Energy	Ave.	Mass	Volume	Energy	Ave.	Agg.
		hh:mm:ss	hh:mm:ss	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	(%)	(%)
Stage Start TP00	15 minute tick over under zero load																						
Stage Start TP01	15 minute gentle cruise from port			0.00	0.00	0.00	0.58	0.95	0.00	0.58	0.96	-3.75	-3.80	-3.79	-3.7879	-3.79	-3.79	-4.700	-4.698	-4.698	-4.698	4.932	4.930
Stage Start TP02	2.5 hr steaming to trawl site			0.00	0.00	0.00	0.47	0.77	0.00	0.47	0.77	-2.72	-0.71	-1.46	-1.4680	-1.47	-1.47	-2.213	-2.222	-2.222	-2.222	2.258	2.273
Stage Start TP03	5 min gentle cruise while shooting			0.00	0.00	0.00	0.56	0.82	0.00	0.56	0.82	-1.11	-1.10	-0.83	-0.8869	-0.89	-0.89	-1.635	-1.691	-1.691	-1.691	1.663	1.720
Stage Start TP04	4 hour trawl			0.00	0.00	0.00	0.12	0.34	0.00	0.12	0.34	-0.57	-0.87	-0.73	-0.7322	-0.73	-0.73	-1.070	-1.070	-1.070	-1.070	1.082	1.082
Stage Start TP05	20 min haul in of nets			0.00	0.00	0.00	0.29	0.45	0.00	0.29	0.45	-0.91	-0.88	-0.89	-0.8933	-0.89	-0.89	-1.335	-1.336	-1.336	-1.336	1.353	1.354
Stage Start TP06	20 min tickover: net handling & unload																						
Stage Start TP07	5 min gentle cruise while shooting			0.00	0.00	0.00	0.56	0.73	0.00	0.56	0.73	-1.08	0.00	-0.54	-0.6479	-0.65	-0.65	-1.263	-1.370	-1.370	-1.370	1.276	1.389
Stage Start TP08	4 hour trawl			0.00	0.00	0.00	0.12	0.28	0.00	0.12	0.28	-0.85	-0.58	-0.69	-0.6862	-0.69	-0.69	-0.960	-0.961	-0.961	-0.961	0.969	0.970
Stage Start TP09	20 min haul in of nets			0.00	0.00	0.00	0.29	0.36	0.00	0.29	0.35	-0.91	-0.88	-0.85	-0.8501	-0.85	-0.85	-1.196	-1.200	-1.200	-1.200	1.208	1.215
Stage Start TP10	20 min tickover: net handling & unload																						
Stage Start TP11	5 min gentle cruise while shooting			0.00	0.00	0.00	0.56	0.62	0.00	0.56	0.62	0.00	-1.09	-0.27	-0.2174	-0.22	-0.22	-0.885	-0.831	-0.831	-0.831	0.895	0.837
Stage Start TP12	4 hour trawl			0.00	0.00	0.00	0.12	0.09	0.00	0.12	0.09	-0.57	-0.58	-0.66	-0.6578	-0.66	-0.66	-0.746	-0.746	-0.746	-0.746	0.752	0.752
Stage Start TP13	20 min haul in of nets			0.00	0.00	0.00	0.29	0.24	0.00	0.29	0.24	-0.91	-0.88	-0.85	-0.8513	-0.85	-0.85	-1.084	-1.087	-1.087	-1.087	1.097	1.099
Stage Start TP14	2.5 hr steaming to trawl site			-0.01	0.00	0.00	0.47	0.45	-0.01	0.46	0.44	0.00	0.00	-0.25	-0.2549	-0.25	-0.25	-0.692	-0.690	-0.690	-0.690	0.696	0.695
Stage Start TP15	15 minute gentle cruise to port			0.00	0.00	0.00	0.58	0.59	0.00	0.58	0.59	1.37	0.00	-0.10	0.0000	0.00	0.00	-0.681	-0.586	-0.586	-0.586	0.673	0.589
Stage Start TP16	Tick over for 1 hour																						
End Test	End of test																						

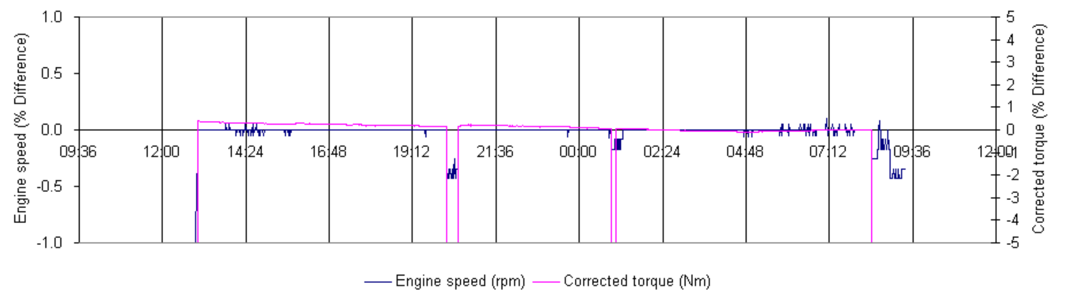
			Obs. Sum	Comp. Sum	Red. Sum	Mass	Volume	Energy	SFC Mass	SFC Volume	SFC Energy	Eff. Agg.
Fuel	M&W Batch 3 BS590 diesel	Total over whole test	0.01	0.17	0.29	-0.74	-0.74	-0.74	-1.027	-1.027	-1.027	1.038
Specific gravity	0.855 kg/litre	Total over whole test (check)	0.01	0.17	0.28	-0.74	-0.74	-0.74	-1.026	-1.026	-1.026	1.037
Calorific value	45.29 MJ/kg	Total over census stages	0.00	0.15	0.27	-0.73	-0.73	-0.73	-0.996	-0.996	-0.996	1.006
	12.580 kWh/kg	Total over census stage 1	0.00	0.16	0.39	-0.92	-0.92	-0.92	-1.305	-1.305	-1.305	1.322
	10.756 kWh/litre	Total over census stage 2	0.00	0.13	0.28	-0.69	-0.69	-0.69	-0.967	-0.967	-0.967	0.977
		Total over census stage 3	0.00	0.16	0.13	-0.57	-0.57	-0.57	-0.707	-0.707	-0.707	0.712

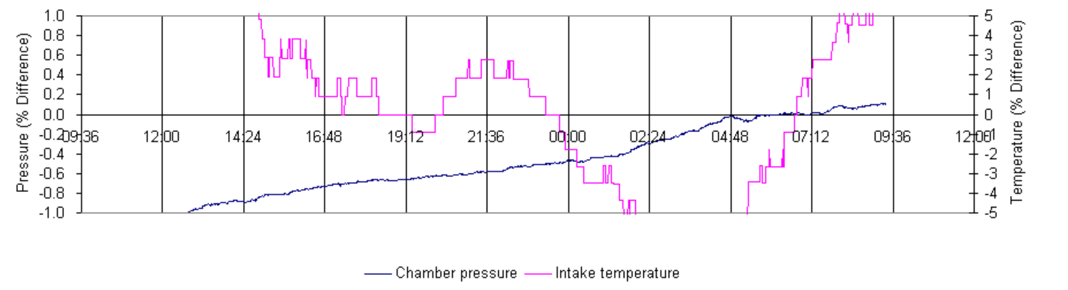
Narrative / Comment:

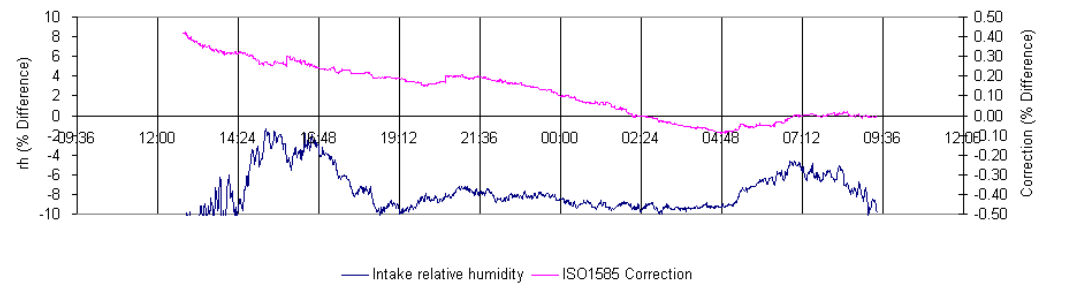
Specific fuel consumption is reduced for all stages in the test with the Vaughan electromagnetic coil by between 4.698% in initial stages to 0.586% in last stage. Over all the census stages (i.e. excluding idle stages), the specific fuel consumption is reduced by 0.996%.

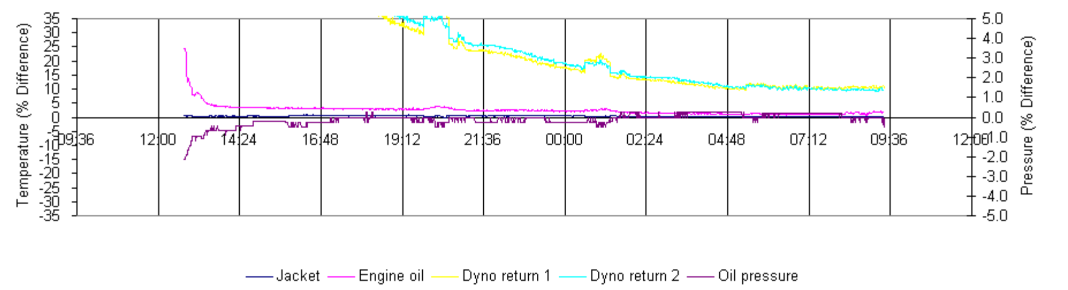
Given the progressive fall in improvement between the two tests, a question is raised regarding whether the improvement is sustained in the longer term.

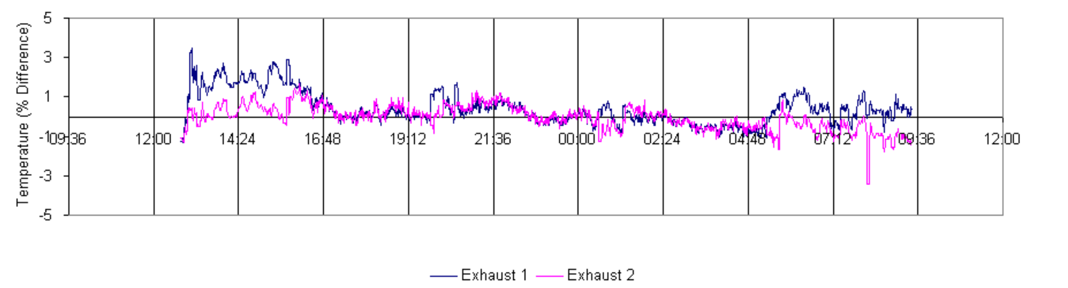
Percentage differences between DayTrawl tests - time series

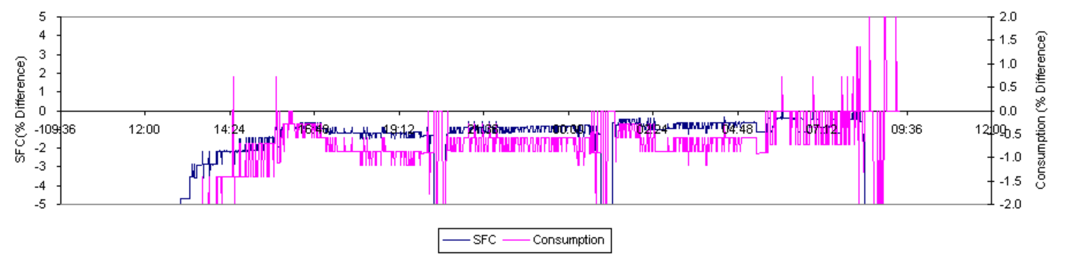












D. Ethos MaxPower Large Permanent Magnets

The experimental results are presented using both graphical and tabular formats.

Firstly the results of Baseline diagnostic tests are presented graphically, before, during and after the main DayTrawl tests. These results are presented in confirmation that the test engine did not suffer any major malfunction throughout the test sequence. With exceptions where indicated, all Baseline tests are conducted on straight red diesel, without any of the technologies being examined being deployed. Thus, there should be excellent agreement between Baseline diagnostic tests, presuming the technology tested does not provide a effect beyond its deployments.

The main results of comparative testing are then presented using a tabular format. Firstly, the results of the Benchmark DayTrawl test are presented. Then the results of the DayTrawl test with the technology deployed are presented. Finally, a table of percentage differences in quantities found for each stage of the test cycle (presented in the first two tables) are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

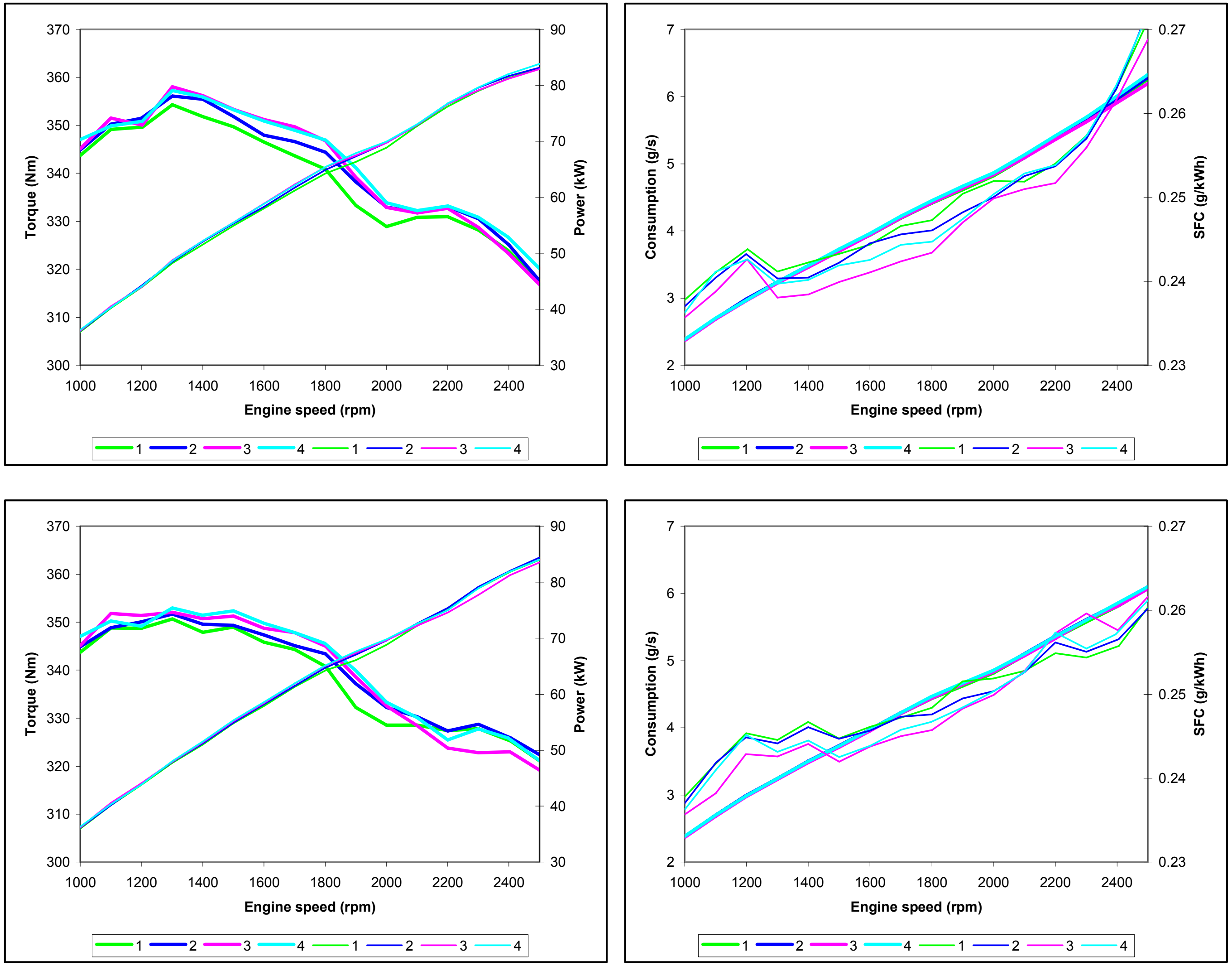
The main results of comparative testing are then presented using a graphical format. Firstly the time series of the Benchmark DayTrawl test are presented. Then the time series of the DayTrawl test with the technology deployed are presented. Finally, time series of the percentage differences in engine performance and fuel consumption parameters are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

For brevity, table and figure numbering are suspended until the Summary Results section below.

Comparison of Baseline diagnostic tests



1 - BASELINE_003_212 (Before), 2 - BASELINE_003_214 (Between DayTrawls), 3 - BASELINE_003_215_AVEMC (After, with magnets), 4 BASELINE_003_216 (After, without magnets)

Narrative:

Curves in upper boxes are for the ramping down stages of the test cycle. Curves in the lower boxes are for the ramping up (later) stages of the test cycle.

Curves indicate no significant malfunction occurred with the test engine.

Good consistency between maximum torque and maximum power curves between tests.

Test 1 (Baseline 003_212) suggests lower torque between 1300 and 2200 rpm than in subsequent tests. Several exhaust system changes were effected between Test 1 and the sequence 2 to 4 (Vortex developmental testing). For this reason an additional Baseline test was added to the sequence, one with the technology installed (Test 3). Comparison of Test 3 and Test 4 reveals close agreement in torque, power and SFC figures with and without the magnets installed.

DayTrawl test results

Test date	08/04/2008	Description	
Warm-up duration	00:27:56		Fossil DayTrawl - DayTrawl without perm. Magnets
Test duration	20:39:59		DAYTRAWL_002_290_c
Total engine hour:	21:07:55		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)	Total Work done in stage Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel consumption Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)	Total fuel consumed Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	Specific fuel consumption in stage Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate over stage Mass (kg/kWh)	Aggregate Stdev (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Engine Efficiency Agg. (%)
Stage Start TP00	15 minute tick over under zero load	11:07:33	11:22:33	00:15:00	1169.79	3.09	-1.05	0.11	1.34	0.11	1.34	0.11	-0.04	0.000	0.05	0.000	0.05	0.000	0.49	0.49	0.49	0.000	0.4410	0.0000	0.52	5.55	10.829	0.858	9.466	0.011	11.071	119.082	0.738	0.840
Stage Start TP01	15 minute gentle cruise from port	11:22:33	11:37:33	00:15:00	1300.00	0.00	36.70	0.00	39.53	0.00	39.41	0.00	1.25	0.000	1.35	0.000	1.34	0.000	0.80	0.79	0.79	0.004	0.7128	0.0000	0.83	8.97	0.531	0.002	0.531	0.000	0.622	6.686	14.969	14.958
Stage Start TP02	2.5 hr steaming to trawl site	11:37:33	14:07:33	02:30:00	2000.00	0.31	47.00	0.00	49.95	0.00	49.80	0.01	24.61	0.000	26.16	0.000	26.08	0.000	1.47	1.42	1.43	0.010	12.8514	0.0000	15.03	161.67	0.493	0.003	0.493	0.000	0.576	6.200	16.133	16.129
Stage Start TP03	5 min gentle cruise while shooting	14:07:33	14:12:33	00:05:00	1500.00	0.00	38.20	0.00	41.05	0.00	40.94	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.91	0.91	0.91	0.000	0.2730	0.0000	0.32	3.43	0.509	0.000	0.509	0.000	0.596	6.409	15.603	15.603
Stage Start TP04	4 hour trawl	14:12:33	18:12:33	04:00:00	1750.01	0.11	278.10	0.00	283.75	0.00	283.09	0.07	203.86	0.000	208.00	0.000	207.51	0.000	3.41	3.37	3.38	0.010	48.6444	0.0000	56.89	611.95	0.234	0.001	0.234	0.000	0.274	2.949	33.912	33.910
Stage Start TP05	20 min haul in of nets	18:12:33	18:32:33	00:20:00	1399.95	0.23	82.50	0.00	85.87	0.00	85.70	0.01	4.03	0.000	4.20	0.000	4.19	0.000	1.09	1.13	1.12	0.013	1.3368	0.0000	1.56	16.82	0.320	0.004	0.319	0.000	0.373	4.015	24.879	24.904
Stage Start TP06	20 min tickover: net handling & unload	18:32:33	18:52:33	00:20:00	1150.42	2.34	-0.44	0.07	1.96	0.07	1.95	0.07	-0.02	0.000	0.08	0.000	0.08	0.000	0.45	0.46	0.46	0.005	0.5466	0.0000	0.64	6.88	6.980	0.199	6.997	0.002	8.183	88.017	1.140	1.136
Stage Start TP07	5 min gentle cruise while shooting	18:52:33	18:57:33	00:05:00	1500.00	0.00	38.20	0.00	41.05	0.00	40.97	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.93	0.93	0.93	0.000	0.2790	0.0000	0.33	3.51	0.520	0.000	0.520	0.000	0.609	6.545	15.278	15.278
Stage Start TP08	4 hour trawl	18:57:33	22:57:32	03:59:59	1750.00	0.06	278.10	0.01	283.75	0.01	283.11	0.05	203.84	0.004	207.99	0.004	207.52	0.004	3.43	3.37	3.37	0.011	48.5492	0.0000	56.78	610.75	0.234	0.001	0.234	0.000	0.274	2.943	33.981	33.978
Stage Start TP09	20 min haul in of nets	22:57:32	23:17:32	00:20:00	1400.00	0.00	82.50	0.00	85.87	0.00	85.66	0.01	4.03	0.000	4.20	0.000	4.19	0.000	1.10	1.13	1.12	0.011	1.3410	0.0000	1.57	16.87	0.321	0.003	0.320	0.000	0.375	4.030	24.796	24.814
Stage Start TP10	20 min tickover: net handling & unload	23:17:32	23:37:32	00:20:00	1149.00	2.73	-0.33	0.05	2.07	0.05	2.06	0.05	-0.01	0.000	0.08	0.000	0.08	0.000	0.44	0.46	0.45	0.007	0.5436	0.0000	0.64	6.84	6.584	0.232	6.562	0.002	7.675	82.551	1.209	1.211
Stage Start TP11	5 min gentle cruise while shooting	23:37:32	23:42:32	00:05:00	1500.00	0.00	38.20	0.00	41.05	0.00	40.94	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.93	0.93	0.93	0.000	0.2790	0.0000	0.33	3.51	0.521	0.000	0.521	0.000	0.609	6.549	15.269	15.269
Stage Start TP12	4 hour trawl	23:42:32	03:42:32	04:00:00	1750.00	0.06	278.10	0.00	283.75	0.00	283.09	0.07	203.86	0.000	208.00	0.000	207.52	0.000	3.41	3.36	3.36	0.009	48.3978	0.0000	56.61	608.84	0.233	0.001	0.233	0.000	0.273	2.934	34.086	34.084
Stage Start TP13	20 min haul in of nets	03:42:32	04:02:32	00:20:00	1400.00	0.00	82.50	0.00	85.87	0.00	85.67	0.00	4.03	0.000	4.20	0.000	4.19	0.000	1.09	1.12	1.11	0.010	1.3290	0.0000	1.55	16.72	0.318	0.003	0.317	0.000	0.371	3.993	25.023	25.043
Stage Start TP14	2.5 hr steaming to trawl site	04:02:32	06:32:32	02:30:00	2000.03	0.18	47.00	0.00	49.95	0.00	49.84	0.01	24.61	0.000	26.16	0.000	26.10	0.000	1.41	1.40	1.40	0.004	12.5934	0.0000	14.73	158.42	0.483	0.001	0.483	0.000	0.564	6.070	16.474	16.473
Stage Start TP15	15 minute gentle cruise to port	06:32:32	06:47:32	00:15:00	1300.00	0.00	36.70	0.00	39.53	0.00	39.45	0.00	1.25	0.000	1.35	0.000	1.34	0.000	0.74	0.76	0.76	0.008	0.6786	0.0000	0.79	8.54	0.506	0.005	0.505	0.000	0.591	6.358	15.708	15.727
Stage Start TP16	Tick over for 1 hour	06:47:32	07:47:32	01:00:00	1141.32	0.80	-0.19	0.03	2.21	0.03	2.20	0.03	-0.02	0.000	0.26	0.000	0.26	0.000	0.45	0.47	0.46	0.005	1.6584	0.0000	1.94	20.86	6.299	0.122	6.291	0.000	7.358	79.138	1.262	1.264
End Test	End of test	07:47:32																																

Fuel	M&W Batch 3 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.29	MJ/kg
	12.580	kWh/kg
	10.756	kWh/litre

	Work Observed Sum (kWh)	Work Compensated Sum (kWh)	Work Reduced Sum (kWh)	Fuel Mass (kg)	Fuel Volume (litres)	Fuel Energy (kWh)	Aggregate Mass (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Engine Efficiency Agg. (%)
Total over whole test	676.78	693.67	692.05	180.46	211.06	2270.12	0.261	0.305	3.280	30.485
Total over whole test (check)	676.79	693.66	692.04	180.46	211.06	2270.12	0.261	0.305	3.280	30.485
Total over census stages	676.87	693.19	691.58	177.27	207.33	2230.00	0.256	0.300	3.225	31.012
Total over census stage 1	234.25	240.24	239.66	63.82	74.64	802.84	0.266	0.311	3.350	29.851
Total over census stage 2	208.38	212.72	212.24	50.17	58.68	631.13	0.236	0.276	2.974	33.629
Total over census stage 3	234.25	240.24	239.68	63.28	74.01	796.03	0.264	0.309	3.321	30.109

Test date	09/04/2008	Description	
Warm-up duration	00:09:06		Fossil DayTrawl - DayTrawl with perm. Magnets
Test duration	20:40:00		DAYTRAWL_002_291_MP_c
Total engine hour:	20:49:06		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)	Total Work done in stage Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel consumption Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)	Total fuel consumed Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	Specific fuel consumption in stage Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate over stage Mass (kg/kWh)	Aggregate Stdev (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Engine Efficiency Agg. (%)
Stage Start TP00	15 minute tick over under zero load	15:13:16	15:28:16	00:15:00	1168.57	2.53	0.16	0.06	2.52	0.07	2.52	0.07	0.01	0.000	0.09	0.000	0.09	0.000	0.47	0.47	0.47	0.000	0.4230	0.0000	0.49	5.32	5.480	0.149	4.697	0.002	5.494	59.090	1.451	1.692
Stage Start TP01	15 minute gentle cruise from port	15:28:16	15:43:16	00:15:00	1300.00	0.00	36.70	0.00	39.48	0.00	39.47	0.00	1.25	0.000	1.34	0.000	1.34	0.000	0.77	0.77	0.77	0.005	0.6906	0.0000	0.81	8.69	0.514	0.003	0.514	0.000	0.601	6.467	15.467	15.463
Stage Start TP02	2.5 hr steaming to trawl site	15:43:16	18:13:16	02:30:00	1999.97	0.37	47.00	0.00	49.90	0.00	49.87	0.01	24.61	0.000	26.13	0.000	26.11	0.000	1.44	1.40	1.41	0.007	12.6738	0.0000	14.82	159.44	0.485	0.002	0.485	0.000	0.568	6.105	16.382	16.379
Stage Start TP03	5 min gentle cruise while shooting	18:13:16	18:18:16	00:05:00	1500.00	0.00	38.20	0.00	41.00	0.00	40.97	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.89	0.90	0.90	0.006	0.2682	0.0000	0.31	3.37	0.501	0.003	0.500	0.000	0.585	6.291	15.878	15.895
Stage Start TP04	4 hour trawl	18:18:16	22:18:16	04:00:00	1750.00	0.00	278.10	0.02	283.62	0.02	283.43	0.04	203.86	0.000	207.91	0.000	207.76	0.000	3.40	3.36	3.37	0.009	48.4992	0.0000	56.72	610.12	0.233	0.001	0.233	0.000	0.273	2.937	34.055	34.053
Stage Start TP05	20 min haul in of nets	22:18:16	22:38:16	00:20:00	1400.00	0.00	82.50	0.00	85.80	0.00	85.71	0.00	4.03	0.000	4.19	0.000	4.19	0.000	1.09	1.12	1.11	0.010	1.3284	0.0000	1.55	16.71	0.317	0.003	0.317	0.000	0.371	3.990	25.047	25.066
Stage Start TP06	20 min tickover: net handling & unload	22:38:16	22:58:16	00:20:00	1151.16	2.95	-0.05	0.05	2.32	0.05	2.32	0.05	0.00	0.000	0.09	0.000	0.09	0.000	0.45	0.46	0.45	0.005	0.5430	0.0000	0.64	6.83	5.841	0.118	5.843	0.001	6.833	73.499	1.361	1.361
Stage Start TP07	5 min gentle cruise while shooting	22:58:16	23:03:16	00:05:00	1500.00	0.00	38.20	0.00	41.00	0.00	40.95	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.92	0.92	0.92	0.000	0.2760	0.0000	0.32	3.47	0.515	0.000	0.515	0.000	0.602	6.477	15.439	15.439
Stage Start TP08	4 hour trawl	23:03:16	03:03:16	04:00:00	1750.00	0.00	278.10	0.01	283.62	0.01	283.35	0.04	203.86	0.000	207.91	0.000	207.70	0.000	3.42	3.35	3.36	0.011	48.3564	0.0000	56.56	608.32	0.233	0.001	0.233	0.000	0.272	2.929	34.147	34.144
Stage Start TP09	20 min haul in of nets	03:03:16	03:23:16	00:20:00	1400.00	0.00	82.50	0.00	85.80	0.00	85.73	0.00	4.03	0.000	4.19	0.000	4.19	0.000	1.09	1.12	1.11	0.010	1.3308	0.0000	1.56	16.74	0.318	0.003	0.318	0.000	0.372	3.996	25.004	25.024
Stage Start TP10	20 min tickover: net handling & unload	03:23:16	03:43:16	00:20:00	1149.74	2.60	-0.24	0.05	2.12	0.05	2.12	0.05	-0.01	0.000	0.09	0.000	0.09	0.000	0.44	0.45	0.45	0.004	0.5376	0.0000	0.63	6.76	6.333	0.189	6.315	0.002	7.386	79.442	1.256	1.259
Stage Start TP11	5 min gentle cruise while shooting	03:43:16	03:48:16	00:05:00	1500.00	0.00	38.20	0.00	41.00	0.00	40.96	0.00	0.50	0.000	0.54	0.000	0.54	0.000	0.92	0.92	0.92	0.000	0.2760	0.0000	0.32	3.47	0.515	0.000	0.515	0.000	0.602	6.476	15.441	15.441
Stage Start TP12	4 hour trawl	03:48:16	07:48:16	04:00:00	1750.00	0.00	278.10	0.01	283.62	0.01	283.49	0.09	203.86	0.000	207.91	0.000	207.80	0.000	3.41	3.35	3.36	0.010	48.3348	0.0000	56.53	608.05	0.233	0.001	0.233	0.000	0.272	2.926	34.178	34.176
Stage Start TP13	20 min haul in of nets	07:48:16	08:08:16	00:20:00	1400.00	0.00	82.50	0.00	85.80	0.00	85.81	0.00	4.03	0.000	4.19	0.000	4.19	0.000	1.09	1.12	1.11	0.010	1.3260	0.0000	1.55	16.68	0.316	0.003	0.316	0.000	0.370	3.978	25.123	25.138
Stage Start TP14	2.5 hr steaming to trawl site	08:08:16	10:38:16	02:30:00	2000.02	0.22	47.00	0.00	49.90	0.00	49.91	0.01	24.61	0.000	26.13	0.000	26.13	0.000	1.40	1.39	1.40	0.002	12.5994	0.0000	14.74	158.50	0.482	0.001	0.482	0.000	0.564	6.065	16.487	16.487
Stage Start TP15	15 minute gentle cruise to port	10:38:16	10:53:16	00:15:00	1300.00	0.00	36.70	0.00	39.48	0.00	39.50	0.00	1.25	0.000	1.34	0.000	1.34	0.000	0.74	0.76	0.75	0.009	0.6756	0.0000	0.79	8.50	0.503	0.006	0.502	0.000	0.588	6.321	15.805	15.819
Stage Start TP16	Tick over for 1 hour	10:53:16	11:53:16	01:00:00	1140.80	1.68	-0.11	0.04	2.26	0.04	2.26	0.04	-0.01	0.000	0.27	0.000	0.27	0.000	0.45	0.46	0.46	0.004	1.6482	0.0000	1.93	20.73	6.105	0.099	6.101	0.000	7.136	76.749	1.302	1.303
End Test	End of test	11:53:16																																

Fuel	M&W Batch 3 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.29	MJ/kg
	12.580	kWh/kg
	10.756	kWh/litre

	Work Observed Sum (kWh)	Work Compensated Sum (kWh)	Work Reduced Sum (kWh)	Fuel Mass (kg)	Fuel Volume (litres)	Fuel Energy (kWh)	Aggregate Mass (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Engine Efficiency Agg. (%)
Total over whole test	676.86	693.39	692.93	179.79	210.28	2261.72	0.259	0.303	3.264	30.637
Total over whole test (check)	676.86	693.38	692.91	179.79	210.28	2261.72	0.259	0.303	3.264	30.637
Total over census stages	676.88	692.85	692.39	176.64	206.59	2222.07	0.255	0.298	3.209	31.160
Total over census stage 1	234.25	240.11	239.95	63.46	74.22	798.33	0.264	0.309	3.327	30.056
Total over census stage 2	208.39	212.64	212.43	49.96	58.44	628.54	0.235	0.275	2.959	33.798
Total over census stage 3	234.25	240.11	240.01	63.21	73.93	795.20	0.263	0.308	3.313	30.182

Percentage differences of DayTrawl tests

Percentage difference between 2 DayTrawl tests (Positive values mean the benchmark was lower, negative values mean the technology tested was lower)

Benchmark: Fossil DayTrawl - DayTrawl without perm. Magnets
Technology tested: Fossil DayTrawl - DayTrawl with perm. Magnets

Stage	Description	Start time	End time	Duration	Engine	Torque			Total Work done in stag			Stage fuel consumpr			Total fuel consumed			Specific fuel consumption in stage				Engine Efficiency	
					Speed	Obs.	Comp.	Red.	Obs.	Comp.	Red.							Instantan.	Aggregate over stage				
					Ave.	Ave.	Ave.	Ave.	Sum	Sum	Sum	Initial	Final	Ave.	Mass	Volume	Energy	Ave.	Mass	Volume	Energy	Ave.	Agg.
		hh:mm:ss	hh:mm:ss	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	(%)	(%)
Stage Start TP00	15 minute tick over under zero load																						
Stage Start TP01	15 minute gentle cruise from port			0.00	0.00	0.00	-0.13	0.16	0.00	-0.13	0.16	-3.75	-2.53	-3.07	-3.1145	-3.11	-3.11	-3.223	-3.269	-3.269	-3.269	3.332	3.379
Stage Start TP02	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.11	0.15	0.00	-0.11	0.15	-2.04	-1.41	-1.38	-1.3820	-1.38	-1.38	-1.520	-1.525	-1.525	-1.525	1.541	1.548
Stage Start TP03	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.12	0.08	0.00	-0.12	0.08	-2.20	-1.10	-1.65	-1.7582	-1.76	-1.76	-1.727	-1.837	-1.837	-1.837	1.761	1.871
Stage Start TP04	4 hour trawl			0.00	0.00	0.00	-0.05	0.12	0.00	-0.05	0.12	-0.29	-0.30	-0.30	-0.2985	-0.30	-0.30	-0.419	-0.419	-0.419	-0.419	0.420	0.421
Stage Start TP05	20 min haul in of nets			0.00	0.00	0.00	-0.08	0.01	0.00	-0.07	0.02	0.00	-0.88	-0.66	-0.6284	-0.63	-0.63	-0.678	-0.646	-0.646	-0.646	0.678	0.650
Stage Start TP06	20 min tickover: net handling & unload																						
Stage Start TP07	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.12	-0.04	0.00	-0.12	-0.04	-1.08	-1.08	-1.08	-1.0753	-1.08	-1.08	-1.039	-1.039	-1.039	-1.039	1.050	1.050
Stage Start TP08	4 hour trawl			0.01	0.00	0.00	-0.04	0.08	0.01	-0.04	0.09	-0.29	-0.59	-0.40	-0.3972	-0.40	-0.40	-0.487	-0.486	-0.486	-0.486	0.489	0.489
Stage Start TP09	20 min haul in of nets			0.00	0.00	0.00	-0.08	0.08	0.00	-0.08	0.08	-0.91	-0.88	-0.75	-0.7606	-0.76	-0.76	-0.833	-0.840	-0.840	-0.840	0.839	0.847
Stage Start TP10	20 min tickover: net handling & unload																						
Stage Start TP11	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.12	0.04	0.00	-0.12	0.04	-1.08	-1.08	-1.08	-1.0753	-1.08	-1.08	-1.115	-1.115	-1.115	-1.115	1.127	1.127
Stage Start TP12	4 hour trawl			0.00	0.00	0.00	-0.05	0.14	0.00	-0.05	0.14	0.00	-0.30	-0.13	-0.1302	-0.13	-0.13	-0.269	-0.269	-0.269	-0.269	0.270	0.269
Stage Start TP13	20 min haul in of nets			0.00	0.00	0.00	-0.08	0.16	0.00	-0.08	0.16	0.00	0.00	-0.24	-0.2257	-0.23	-0.23	-0.394	-0.382	-0.382	-0.382	0.396	0.383
Stage Start TP14	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.11	0.13	0.00	-0.11	0.13	-0.71	-0.71	0.05	0.0476	0.05	0.05	-0.077	-0.082	-0.082	-0.082	0.076	0.082
Stage Start TP15	15 minute gentle cruise to port			0.00	0.00	0.00	-0.13	0.14	0.00	-0.13	0.14	0.00	0.00	-0.47	-0.4421	-0.44	-0.44	-0.613	-0.583	-0.583	-0.583	0.620	0.586
Stage Start TP16	Tick over for 1 hour																						
End Test	End of test																						

Fuel	M&W Batch 3 BS590 diesel
Specific gravity	0.855 kg/litre
Calorific value	45.29 MJ/kg
	12.580 kWh/kg
	10.756 kWh/litre

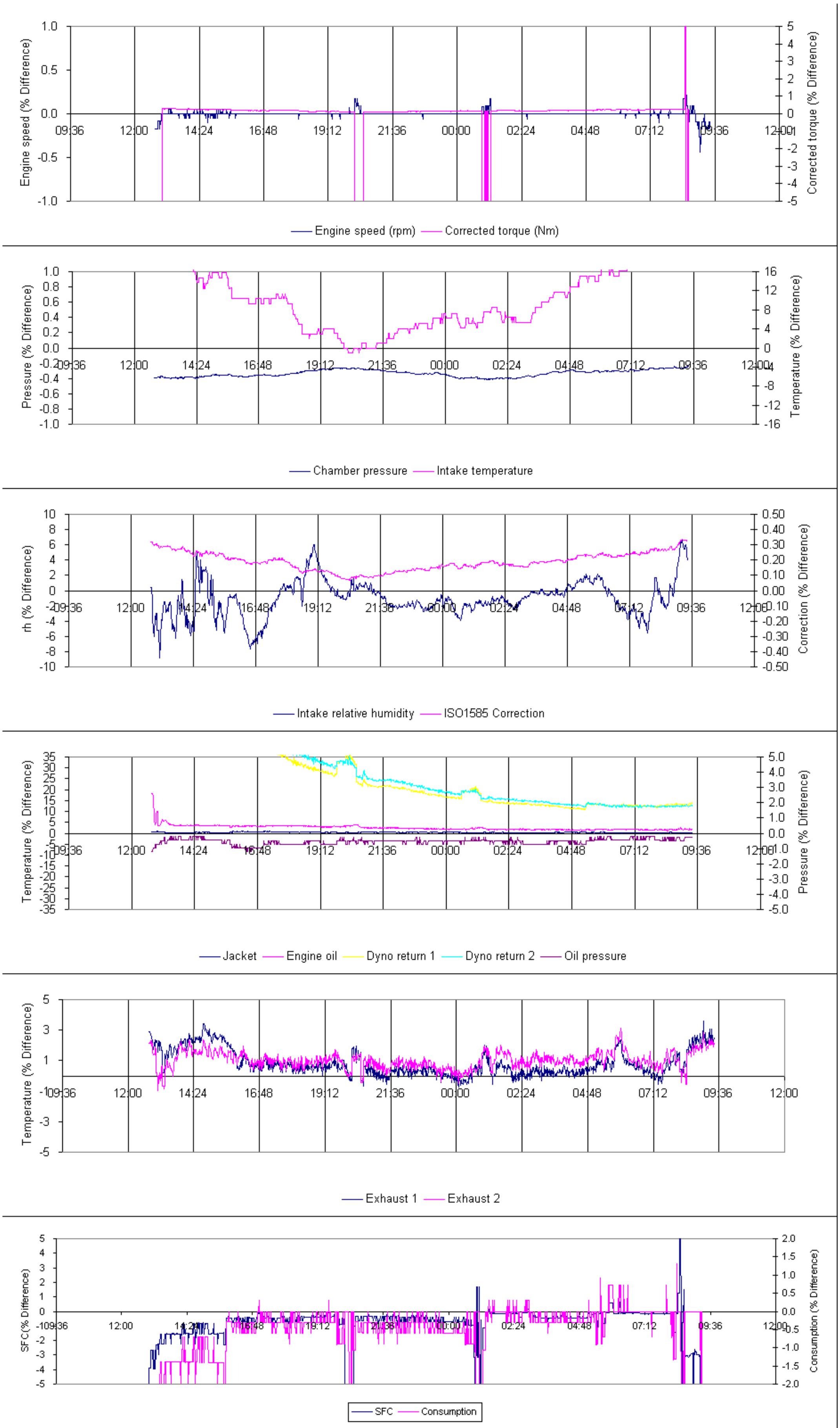
	Work Obs. Sum	Work Comp. Sum	Work Red. Sum	Fuel Mass	Fuel Volume	Fuel Energy	SFC Mass	SFC Volume	SFC Energy	Eff. Agg.
Total over whole test	0.01	-0.04	0.13	-0.37	-0.37	-0.37	-0.497	-0.497	-0.497	0.499
Total over whole test (check)	0.01	-0.04	0.13	-0.37	-0.37	-0.37	-0.496	-0.496	-0.496	0.498
Total over census stages	0.00	-0.05	0.12	-0.36	-0.36	-0.36	-0.472	-0.472	-0.472	0.475
Total over census stage 1	0.00	-0.05	0.12	-0.56	-0.56	-0.56	-0.682	-0.682	-0.682	0.687
Total over census stage 2	0.01	-0.04	0.09	-0.41	-0.41	-0.41	-0.499	-0.499	-0.499	0.502
Total over census stage 3	0.00	-0.05	0.14	-0.10	-0.10	-0.10	-0.242	-0.242	-0.242	0.242

Narrative / Comment:

Specific fuel consumption is reduced for all stages in the test with the large Max-power permanent magnets by between 3.269% in initial stages to 0.269% in the last four hour trawl stage. Over all the census stages (i.e. excluding idle stages), the specific fuel consumption is reduced by 0.472%.

Given the progressive fall in improvement between the two tests, a question is raised regarding whether the improvement is sustained in the longer term. This is a similar outcome to the testing with the Vaughan electromagnetic coil.

Percentage differences between DayTrawl tests - time series



F. Ethos MaxPower Large & Small Permanent Magnets

The experimental results are presented using both graphical and tabular formats.

Firstly the results of Baseline diagnostic tests are presented graphically, before, during and after the main DayTrawl tests. These results are presented in confirmation that the test engine did not suffer any major malfunction throughout the test sequence. With exceptions where indicated, all Baseline tests are conducted on straight red diesel, without any of the technologies being examined being deployed. Thus, there should be excellent agreement between Baseline diagnostic tests, presuming the technology tested does not provide a effect beyond its deployments.

The main results of comparative testing are then presented using a tabular format. Firstly, the results of the Benchmark DayTrawl test are presented. Then the results of the DayTrawl test with the technology deployed are presented. Finally, a table of percentage differences in quantities found for each stage of the test cycle (presented in the first two tables) are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to ‘work’, the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

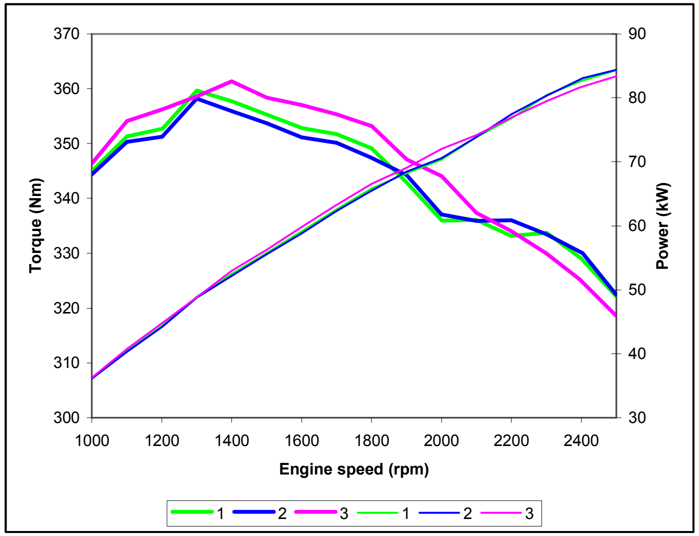
The main results of comparative testing are then presented using a graphical format. Firstly the time series of the Benchmark DayTrawl test are presented. Then the time series of the DayTrawl test with the technology deployed are presented. Finally, time series of the percentage differences in engine performance and fuel consumption parameters are presented. The percentage differences are calculated as:

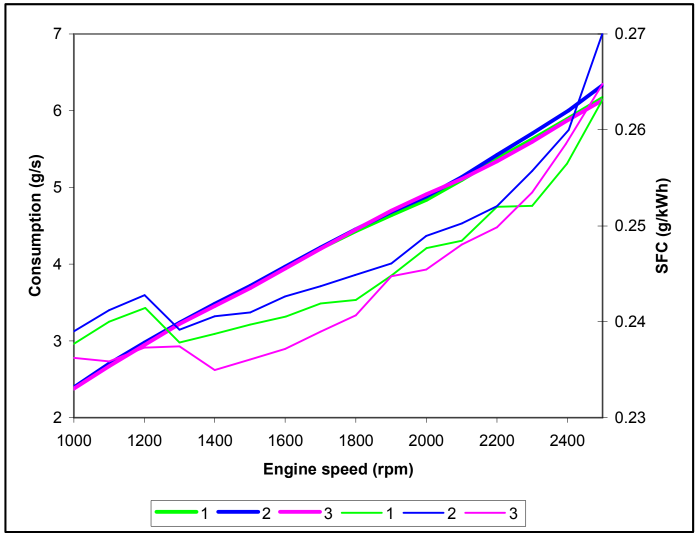
((Value with technology – Benchmark value) / Benchmark value) x 100

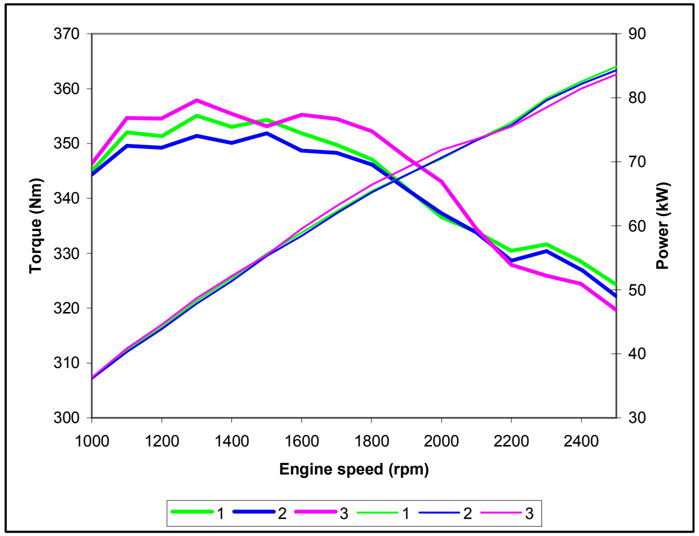
This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to ‘work’, the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

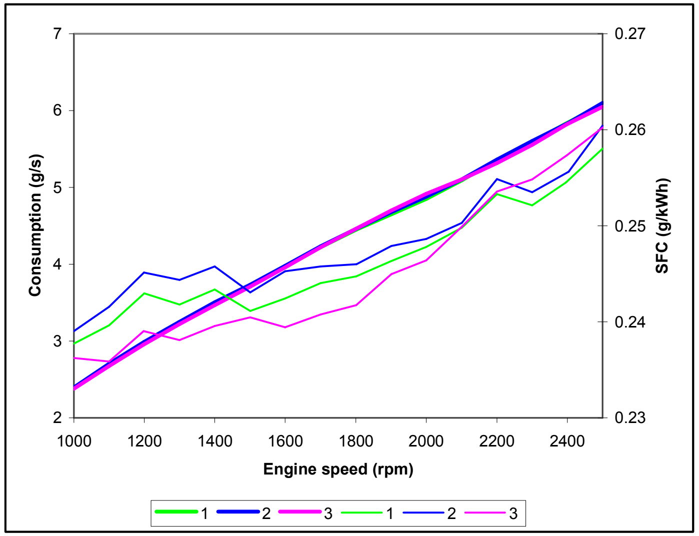
For brevity, table and figure numbering are suspended until the Summary Results section below.

Comparison of Baseline diagnostic tests









Narrative:

Curves in upper boxes are for the ramping down stages of the test cycle. Curves in the lower boxes are for the ramping up (later) stages of the test cycle.

Curves indicate no significant malfunction occurred with the test engine.

Good consistency between maximum torque, maximum power curves and fuel consumption curves between Tests 1 and 2. Suggests no significant difference in performance after ~21 hours running with permanent magnets installed.

Results for Test 3 suggest that the engine is developing higher torque in the range 1000-2200 rpm after ~21 hours running without magnets. Consequently there is lower SFC (consumption ~same over this range).

Note that all three tests shown were conducted without any permanent magnets installed. Test 3 suggests they may have a residual after effect.

1 – BL003_130508 (Before), 2 – BL003_200508 (Between DayTrawls, after DayTrawl with magnets), 3 – BL003_210508 (After; after DayTrawl without magnets)

DayTrawl test results

Test date	20/05/2008	Description	
Warm-up duration	00:11:27		DayTrawl with maxpower magnets removed
Test duration	20:40:00		DT002_200508_001_c
Total engine hour:	20:51:27		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)
Stage Start TP00	15 minute tick over under zero load	19:14:07	19:29:07	00:15:00	1164.71	4.60	-1.22	0.07	1.02	0.07	1.02	0.07
Stage Start TP01	15 minute gentle cruise from port	19:29:07	19:44:07	00:15:00	1300.07	0.27	36.70	0.00	39.34	0.00	39.20	0.00
Stage Start TP02	2.5 hr steaming to trawl site	19:44:07	22:14:07	02:30:00	1999.95	0.31	47.00	0.00	49.75	0.00	49.57	0.00
Stage Start TP03	5 min gentle cruise while shooting	22:14:07	22:19:07	00:05:00	1500.00	0.00	38.20	0.00	40.86	0.00	40.71	0.00
Stage Start TP04	4 hour trawl	22:19:07	02:19:07	04:00:00	1750.00	0.00	278.10	0.01	283.27	0.01	282.41	0.07
Stage Start TP05	20 min haul in of nets	02:19:07	02:39:07	00:20:00	1400.00	0.00	82.50	0.00	85.62	0.00	85.40	0.00
Stage Start TP06	20 min tickover: net handling & unload	02:39:07	02:59:07	00:20:00	1133.53	1.90	-0.48	0.08	1.77	0.08	1.76	0.08
Stage Start TP07	5 min gentle cruise while shooting	02:59:07	03:04:07	00:05:00	1500.00	0.00	38.20	0.00	40.86	0.00	40.75	0.00
Stage Start TP08	4 hour trawl	03:04:07	07:04:07	04:00:00	1750.00	0.00	278.10	0.00	283.27	0.00	282.66	0.07
Stage Start TP09	20 min haul in of nets	07:04:07	07:24:07	00:20:00	1400.05	0.23	82.50	0.00	85.62	0.00	85.46	0.00
Stage Start TP10	20 min tickover: net handling & unload	07:24:07	07:44:07	00:20:00	1133.84	3.02	-0.31	0.03	1.94	0.03	1.94	0.03
Stage Start TP11	5 min gentle cruise while shooting	07:44:07	07:49:07	00:05:00	1499.75	0.50	38.20	0.00	40.86	0.00	40.78	0.00
Stage Start TP12	4 hour trawl	07:49:07	11:49:07	04:00:00	1750.01	0.09	278.10	0.02	283.27	0.02	282.77	0.04
Stage Start TP13	20 min haul in of nets	11:49:07	12:09:07	00:20:00	1400.00	0.00	82.50	0.00	85.62	0.00	85.49	0.00
Stage Start TP14	2.5 hr steaming to trawl site	12:09:07	14:39:07	02:30:00	2000.02	0.22	47.00	0.00	49.75	0.00	49.67	0.00
Stage Start TP15	15 minute gentle cruise to port	14:39:07	14:54:07	00:15:00	1300.00	0.00	36.70	0.00	39.34	0.00	39.28	0.00
Stage Start TP16	Tick over for 1 hour	14:54:07	15:54:07	01:00:00	1127.10	0.71	-0.02	0.04	2.23	0.04	2.23	0.04
End Test	End of test	15:54:07										

Stage	Total Work done in stage Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel consumption Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)
Stage Start TP00	-0.04	0.000	0.04	0.000	0.04	0.000	0.48	0.48	0.48	0.005
Stage Start TP01	1.25	0.000	1.34	0.000	1.33	0.000	0.79	0.78	0.78	0.004
Stage Start TP02	24.61	0.000	26.05	0.000	25.95	0.000	1.46	1.40	1.41	0.010
Stage Start TP03	0.50	0.000	0.53	0.000	0.53	0.000	0.91	0.91	0.91	0.000
Stage Start TP04	203.86	0.000	207.65	0.000	207.01	0.000	3.39	3.34	3.35	0.011
Stage Start TP05	4.03	0.000	4.18	0.000	4.17	0.000	1.09	1.12	1.11	0.010
Stage Start TP06	-0.02	0.000	0.07	0.000	0.07	0.000	0.44	0.45	0.45	0.004
Stage Start TP07	0.50	0.000	0.53	0.000	0.53	0.000	0.93	0.93	0.93	0.000
Stage Start TP08	203.86	0.000	207.65	0.000	207.20	0.000	3.40	3.32	3.33	0.012
Stage Start TP09	4.03	0.000	4.18	0.000	4.18	0.000	1.09	1.12	1.11	0.010
Stage Start TP10	-0.01	0.000	0.08	0.000	0.08	0.000	0.44	0.45	0.45	0.005
Stage Start TP11	0.50	0.000	0.53	0.000	0.53	0.000	0.92	0.92	0.92	0.000
Stage Start TP12	203.86	0.000	207.65	0.000	207.28	0.000	3.38	3.32	3.33	0.010
Stage Start TP13	4.03	0.000	4.18	0.000	4.18	0.000	1.09	1.12	1.11	0.011
Stage Start TP14	24.61	0.000	26.05	0.000	26.01	0.000	1.40	1.38	1.38	0.005
Stage Start TP15	1.25	0.000	1.34	0.000	1.34	0.000	0.74	0.76	0.75	0.007
Stage Start TP16	0.00	0.000	0.26	0.000	0.26	0.000	0.45	0.46	0.46	0.005

Stage	Total fuel consumed Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	Specific fuel consumption in stage Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate over stage Mass (kg/kWh)	Aggregate Stdev (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Engine Efficiency Agg. (%)
Stage Start TP00	0.4344	0.0000	0.51	5.46	14.036	0.992	12.184	0.012	14.250	153.270	0.569	0.652
Stage Start TP01	0.7038	0.0000	0.82	8.85	0.527	0.002	0.527	0.000	0.617	6.636	15.081	15.070
Stage Start TP02	12.7320	0.0000	14.89	160.17	0.490	0.003	0.491	0.000	0.574	6.171	16.208	16.204
Stage Start TP03	0.2730	0.0000	0.32	3.43	0.512	0.000	0.512	0.000	0.599	6.444	15.518	15.518
Stage Start TP04	48.2262	0.0000	56.40	606.69	0.233	0.001	0.233	0.000	0.272	2.931	34.124	34.122
Stage Start TP05	1.3332	0.0000	1.56	16.77	0.320	0.003	0.319	0.000	0.374	4.019	24.860	24.882
Stage Start TP06	0.5376	0.0000	0.63	6.76	7.725	0.325	7.728	0.004	9.039	97.221	1.031	1.029
Stage Start TP07	0.2790	0.0000	0.33	3.51	0.523	0.000	0.523	0.000	0.612	6.580	15.198	15.198
Stage Start TP08	47.9340	0.0000	56.06	603.01	0.231	0.001	0.231	0.000	0.271	2.910	34.365	34.362
Stage Start TP09	1.3284	0.0000	1.55	16.71	0.318	0.003	0.318	0.000	0.372	4.001	24.975	24.993
Stage Start TP10	0.5358	0.0000	0.63	6.74	6.984	0.108	6.973	0.001	8.156	87.724	1.138	1.140
Stage Start TP11	0.2760	0.0000	0.32	3.47	0.517	0.000	0.517	0.000	0.605	6.505	15.372	15.372
Stage Start TP12	47.9262	0.0000	56.05	602.91	0.231	0.001	0.231	0.000	0.270	2.909	34.383	34.381
Stage Start TP13	1.3266	0.0000	1.55	16.69	0.318	0.003	0.318	0.000	0.371	3.994	25.019	25.035
Stage Start TP14	12.4410	0.0000	14.55	156.51	0.478	0.002	0.478	0.000	0.560	6.018	16.618	16.616
Stage Start TP15	0.6750	0.0000	0.79	8.49	0.505	0.005	0.505	0.000	0.591	6.352	15.730	15.743
Stage Start TP16	1.6410	0.0000	1.92	20.64	6.236	0.105	6.232	0.000	7.289	78.402	1.275	1.275

Fuel	M&W Batch 3 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.29	MJ/kg
	12.580	kWh/kg
	10.756	kWh/litre

	Work Observed Sum	Work Compensated Sum	Work Reduced Sum	Fuel Mass	Fuel Volume	Fuel Energy	SFC Aggregate Mass	SFC Aggregate Volume	SFC Aggregate Energy	Engine Efficiency Agg.
Total over whole test	676.81	692.32	690.71	178.60	208.89	2246.83	0.259	0.302	3.253	30.741
Total over whole test (check)	676.81	692.31	690.70	178.60	208.89	2246.83	0.259	0.302	3.253	30.741
Total over census stages	676.88	691.87	690.26	175.45	205.21	2207.22	0.254	0.297	3.198	31.273
Total over census stage 1	234.25	239.75	239.01	63.27	74.00	795.91	0.265	0.310	3.330	30.029
Total over census stage 2	208.39	212.37	211.91	49.54	57.94	623.23	0.234	0.273	2.941	34.002
Total over census stage 3	234.25	239.75	239.34	62.64	73.27	788.07	0.262	0.306	3.293	30.370

Test date	14/05/2008	Description	
Warm-up duration	00:12:43		DayTrawl with large and small maxpower magnets
Test duration	20:40:00		DT002_140508_001EM_c
Total engine hour:	20:52:43		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)
Stage Start TP00	15 minute tick over under zero load	11:11:04	11:26:04	00:15:00	1170.64	3.59	-1.48	0.04	0.80	0.04	0.80	0.04
Stage Start TP01	15 minute gentle cruise from port	11:26:04	11:41:04	00:15:00	1300.00	0.00	36.70	0.00	39.39	0.00	39.30	0.00
Stage Start TP02	2.5 hr steaming to trawl site	11:41:04	14:11:04	02:30:00	1999.99	0.12	47.00	0.00	49.80	0.00	49.69	0.00
Stage Start TP03	5 min gentle cruise while shooting	14:11:04	14:16:04	00:05:00	1500.00	0.00	38.20	0.00	40.91	0.00	40.82	0.00
Stage Start TP04	4 hour trawl	14:16:04	18:16:04	04:00:00	1750.00	0.00	278.10	0.01	283.39	0.01	282.94	0.07
Stage Start TP05	20 min haul in of nets	18:16:04	18:36:04	00:20:00	1400.00	0.00	82.50	0.00	85.69	0.00	85.58	0.00
Stage Start TP06	20 min tickover: net handling & unload	18:36:04	18:56:04	00:20:00	1144.89	2.88	-0.83	0.05	1.46	0.05	1.46	0.05
Stage Start TP07	5 min gentle cruise while shooting	18:56:04	19:01:04	00:05:00	1500.00	0.00	38.20	0.00	40.91	0.00	40.85	0.00
Stage Start TP08	4 hour trawl	19:01:04	23:01:04	04:00:00	1750.01	0.09	278.10	0.01	283.39	0.01	283.11	0.05
Stage Start TP09	20 min haul in of nets	23:01:04	23:21:04	00:20:00	1400.05	0.23	82.50	0.00	85.69	0.00	85.63	0.00
Stage Start TP10	20 min tickover: net handling & unload	23:21:04	23:41:04	00:20:00	1143.74	1.88	-0.61	0.05	1.68	0.05	1.68	0.05
Stage Start TP11	5 min gentle cruise while shooting	23:41:04	23:46:04	00:05:00	1500.00	0.00	38.20	0.00	40.91	0.00	40.88	0.00
Stage Start TP12	4 hour trawl	23:46:04	03:46:04	04:00:00	1750.00	0.06	278.10	0.01	283.39	0.01	283.26	0.06
Stage Start TP13	20 min haul in of nets	03:46:04	04:06:04	00:20:00	1400.00	0.00	82.50	0.00	85.69	0.00	85.68	0.00
Stage Start TP14	2.5 hr steaming to trawl site	04:06:04	06:36:04	02:30:00	2000.04	0.30	47.00	0.00	49.80	0.00	49.79	0.00
Stage Start TP15	15 minute gentle cruise to port	06:36:04	06:51:04	00:15:00	1300.00	0.00	36.70	0.00	39.39	0.00	39.38	0.00
Stage Start TP16	Tick over for 1 hour	06:51:04	07:51:04	01:00:00	1136.03	2.06	-0.14	0.07	2.15	0.07	2.15	0.07
End Test	End of test	07:51:04										

Stage	Total Work done in stage Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel consumption Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)
Stage Start TP00	-0.05	0.000	0.03	0.000	0.03	0.000	0.48	0.48	0.48	0.005
Stage Start TP01	1.25	0.000	1.34	0.000	1.34	0.000	0.79	0.78	0.78	0.004
Stage Start TP02	24.61	0.000	26.08	0.000	26.02	0.000	1.46	1.40	1.41	0.010
Stage Start TP03	0.50	0.000	0.54	0.000	0.53	0.000	0.90	0.91	0.91	0.006
Stage Start TP04	203.86	0.000	207.74	0.000	207.40	0.000	3.39	3.33	3.34	0.013
Stage Start TP05	4.03	0.000	4.19	0.000	4.18	0.000	1.09	1.12	1.11	0.010
Stage Start TP06	-0.03	0.000	0.06	0.000	0.06	0.000	0.45	0.46	0.45	0.005
Stage Start TP07	0.50	0.000	0.54	0.000	0.53	0.000	0.92	0.92	0.92	0.000
Stage Start TP08	203.86	0.000	207.74	0.000	207.53	0.000	3.40	3.31	3.33	0.013
Stage Start TP09	4.03	0.000	4.19	0.000	4.18	0.000	1.08	1.12	1.10	0.012
Stage Start TP10	-0.02	0.000	0.07	0.000	0.07	0.000	0.44	0.45	0.45	0.004
Stage Start TP11	0.50	0.000	0.54	0.000	0.54	0.000	0.92	0.91	0.92	0.005
Stage Start TP12	203.86	0.000	207.74	0.000	207.64	0.000	3.38	3.31	3.32	0.012
Stage Start TP13	4.03	0.000	4.19	0.000	4.19	0.000	1.08	1.11	1.10	0.010
Stage Start TP14	24.61	0.000	26.08	0.000	26.07	0.000	1.38	1.38	1.37	0.005
Stage Start TP15	1.25	0.000	1.34	0.000	1.34	0.000	0.74	0.76	0.75	0.006
Stage Start TP16	-0.02	0.000	0.26	0.000	0.26	0.000	0.44	0.46	0.45	0.007

Stage	Total fuel consumed Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	Specific fuel consumption in stage Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate over stage Mass (kg/kWh)	Aggregate Stdev (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Engine Efficiency Agg. (%)
Stage Start TP00	0.4344	0.0000	0.51	5.46	17.782	0.923	15.324	0.013	17.923	192.781	0.448	0.519
Stage Start TP01	0.7038	0.0000	0.82	8.85	0.526	0.002	0.526	0.000	0.615	6.619	15.119	15.108
Stage Start TP02	12.7116	0.0000	14.87	159.91	0.488	0.004	0.489	0.000	0.571	6.146	16.275	16.270
Stage Start TP03	0.2712	0.0000	0.32	3.41	0.508	0.003	0.508	0.000	0.594	6.385	15.646	15.663
Stage Start TP04	48.1140	0.0000	56.27	605.27	0.232	0.001	0.232	0.000	0.271	2.918	34.269	34.266
Stage Start TP05	1.3326	0.0000	1.56	16.76	0.319	0.003	0.319	0.000	0.373	4.009	24.924	24.946
Stage Start TP06	0.5442	0.0000	0.64	6.85	9.346	0.252	9.358	0.003	10.945	117.719	0.851	0.849
Stage Start TP07	0.2760	0.0000	0.32	3.47	0.516	0.000	0.516	0.000	0.604	6.493	15.402	15.402
Stage Start TP08	47.8866	0.0000	56.01	602.41	0.231	0.001	0.231	0.000	0.270	2.903	34.453	34.449
Stage Start TP09	1.3218	0.0000	1.55	16.63	0.316	0.003	0.316	0.000	0.369	3.973	25.144	25.167
Stage Start TP10	0.5376	0.0000	0.63	6.76	8.039	0.194	8.049	0.002	9.414	101.257	0.989	0.988
Stage Start TP11	0.2754	0.0000	0.32	3.46	0.514	0.003	0.515	0.000	0.602	6.474	15.454	15.446
Stage Start TP12	47.7810	0.0000	55.88	601.08	0.230	0.001	0.230	0.000	0.269	2.895	34.548	34.545
Stage Start TP13	1.3194	0.0000	1.54	16.60	0.315	0.003	0.315	0.000	0.369	3.964	25.205	25.227
Stage Start TP14	12.3474	0.0000	14.44	155.33	0.474	0.002	0.474	0.000	0.554	5.958	16.786	16.785
Stage Start TP15	0.6720	0.0000	0.79	8.45	0.502	0.004	0.501	0.000	0.586	6.307	15.846	15.855
Stage Start TP16	1.6242	0.0000	1.90	20.43	6.357	0.140	6.359	0.000	7.437	79.991	1.251	1.250

Fuel	M&W Batch 3 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.29	MJ/kg
	12.580	kWh/kg
	10.756	kWh/litre

	Work Observed Sum	Work Compensated Sum	Work Reduced Sum	Fuel Mass	Fuel Volume	Fuel Energy	SFC Aggregate Mass	SFC Aggregate Volume	SFC Aggregate Energy	Engine Efficiency Agg.
Total over whole test	676.76	692.63	691.91	178.15	208.37	2241.17	0.257	0.301	3.239	30.873
Total over whole test (check)	676.76	692.62	691.91	178.15	208.37	2241.17	0.257	0.301	3.239	30.873
Total over census stages	676.88	692.22	691.50	175.01	204.69	2201.66	0.253	0.296	3.184	31.408
Total over census stage 1	234.25	239.88	239.48	63.13	73.84	794.22	0.264	0.308	3.316	30.152
Total over census stage 2	208.39	212.46	212.25	49.48	57.88	622.51	0.233	0.273	2.933	34.095
Total over census stage 3	234.25	239.88	239.78	62.40	72.98	784.93	0.260	0.304	3.274	30.548

Percentage differences of DayTrawl tests

Percentage difference between 2 DayTrawl tests (Positive values mean the benchmark was lower, negative values mean the technology tested was lower)

Benchmark: DayTrawl with maxpower magnets removed
Technology tested: DayTrawl with large and small maxpower magnets

Stage	Description	Start time	End time	Duration	Engine Speed	Torque Obs.	Torque Comp.	Torque Red.	Total Work done in stage Obs.	Total Work Comp.	Total Work Red.	Stage fuel consumption Initial	Stage fuel Final	Stage fuel Ave.	Total fuel consumed Mass	Total fuel Volume	Total fuel Energy	Specific fuel consumption in stage Instantan. Ave.	SFC Aggregate over stage Mass	SFC Aggregate Volume	SFC Aggregate Energy	Engine Efficiency Ave.	Engine Efficiency Agg.
		hh:mm:ss	hh:mm:ss	%	Ave. %	Ave. %	Ave. %	Ave. %	Sum %	Sum %	Sum %	%	%	%	%	%	%	Ave. %	%	%	%	(%)	(%)
Stage Start TP00	15 minute tick over under zero load																						
Stage Start TP01	15 minute gentle cruise from port			0.00	-0.01	0.00	0.13	0.25	-0.01	0.12	0.25	0.00	0.00	0.00	0.0000	0.00	0.00	-0.248	-0.248	-0.248	-0.248	0.249	0.249
Stage Start TP02	2.5 hr steaming to trawl site			0.00	0.00	0.00	0.11	0.25	0.00	0.11	0.25	0.00	0.00	-0.16	-0.1602	-0.16	-0.16	-0.409	-0.407	-0.407	-0.407	0.411	0.409
Stage Start TP03	5 min gentle cruise while shooting			0.00	0.00	0.00	0.12	0.27	0.00	0.12	0.27	-1.10	0.00	-0.55	-0.6593	-0.66	-0.66	-0.817	-0.925	-0.925	-0.925	0.827	0.934
Stage Start TP04	4 hour trawl			0.00	0.00	0.00	0.04	0.19	0.00	0.04	0.19	0.00	-0.30	-0.23	-0.2327	-0.23	-0.23	-0.422	-0.421	-0.421	-0.421	0.424	0.422
Stage Start TP05	20 min haul in of nets			0.00	0.00	0.00	0.07	0.21	0.00	0.07	0.21	0.00	0.00	-0.05	-0.0450	-0.05	-0.05	-0.258	-0.255	-0.255	-0.255	0.258	0.256
Stage Start TP06	20 min tickover: net handling & unload																						
Stage Start TP07	5 min gentle cruise while shooting			0.00	0.00	0.00	0.12	0.25	0.00	0.12	0.25	-1.08	-1.08	-1.08	-1.0753	-1.08	-1.08	-1.326	-1.326	-1.326	-1.326	1.344	1.344
Stage Start TP08	4 hour trawl			0.00	0.00	0.00	0.04	0.16	0.00	0.04	0.16	0.00	-0.30	-0.10	-0.0989	-0.10	-0.10	-0.256	-0.255	-0.255	-0.255	0.256	0.256
Stage Start TP09	20 min haul in of nets			0.00	0.00	0.00	0.07	0.20	0.00	0.07	0.20	-0.92	0.00	-0.48	-0.4968	-0.50	-0.50	-0.671	-0.692	-0.692	-0.692	0.679	0.697
Stage Start TP10	20 min tickover: net handling & unload																						
Stage Start TP11	5 min gentle cruise while shooting			0.00	0.02	0.00	0.12	0.25	0.01	0.14	0.26	0.00	-1.09	-0.27	-0.2174	-0.22	-0.22	-0.533	-0.474	-0.474	-0.474	0.538	0.476
Stage Start TP12	4 hour trawl			0.00	0.00	0.00	0.05	0.17	0.00	0.04	0.17	0.00	-0.30	-0.30	-0.3030	-0.30	-0.30	-0.476	-0.475	-0.475	-0.475	0.479	0.477
Stage Start TP13	20 min haul in of nets			0.00	0.00	0.00	0.07	0.22	0.00	0.07	0.22	-0.92	-0.89	-0.52	-0.5427	-0.54	-0.54	-0.740	-0.760	-0.760	-0.760	0.745	0.766
Stage Start TP14	2.5 hr steaming to trawl site			0.00	0.00	0.00	0.11	0.25	0.00	0.11	0.25	-1.43	0.00	-0.75	-0.7524	-0.75	-0.75	-0.998	-1.002	-1.002	-1.002	1.008	1.012
Stage Start TP15	15 minute gentle cruise to port			0.00	0.00	0.00	0.13	0.26	0.00	0.13	0.26	0.00	0.00	-0.48	-0.4444	-0.44	-0.44	-0.736	-0.704	-0.704	-0.704	0.739	0.709
Stage Start TP16	Tick over for 1 hour																						
End Test	End of test																						

Fuel	M&W Batch 3 BS590 diesel
Specific gravity	0.855 kg/litre
Calorific value	45.29 MJ/kg
	12.580 kWh/kg
	10.756 kWh/litre

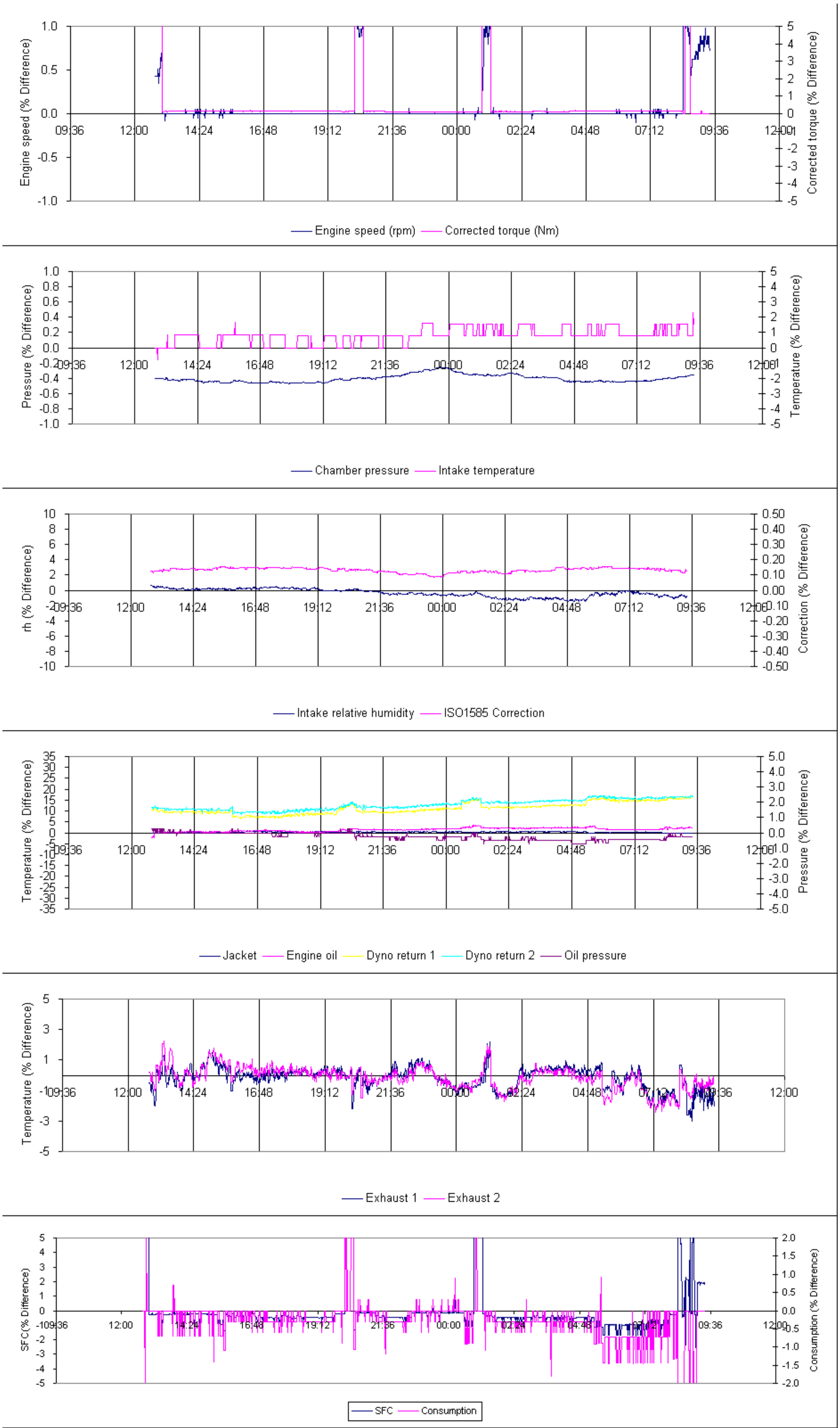
	Work Obs. Sum	Work Comp. Sum	Work Red. Sum	Total fuel Mass	Total fuel Volume	Total fuel Energy	SFC Mass	SFC Volume	SFC Energy	Engine Efficiency Agg.
Total over whole test	-0.01	0.04	0.17	-0.25	-0.25	-0.25	-0.426	-0.426	-0.426	0.427
Total over whole test (check)	-0.01	0.04	0.17	-0.25	-0.25	-0.25	-0.426	-0.426	-0.426	0.428
Total over census stages	0.00	0.05	0.18	-0.25	-0.25	-0.25	-0.431	-0.431	-0.431	0.433
Total over census stage 1	0.00	0.05	0.20	-0.21	-0.21	-0.21	-0.409	-0.409	-0.409	0.410
Total over census stage 2	0.00	0.05	0.16	-0.12	-0.12	-0.12	-0.272	-0.272	-0.272	0.273
Total over census stage 3	0.00	0.05	0.18	-0.40	-0.40	-0.40	-0.580	-0.580	-0.580	0.584

Narrative / Comment:

Specific fuel consumption is reduced for all stages in the test with the large and small Maxpower permanent magnets by between 1.326% and 0.255%. Over all the census stages (i.e. excluding idle stages), the specific fuel consumption is reduced by 0.431%.

This figure is comparable with the 0.472% improvement in specific fuel consumption obtained with the large permanent magnets alone. In contrast with the tests with the large magnets alone, there does not appear to be any discernable falling trend across the stages of the tests. Whether this is due to the presence of the small magnets, or the fact that these were installed with opposing polarity (in accordance with manufacturers instruction on site), or some other factor, is inconclusive.

Percentage differences between DayTrawl tests - time series



G. MPG-CAPS Fuel combustion catalyst tablets

The experimental results are presented using both graphical and tabular formats.

Firstly the results of Baseline diagnostic tests are presented graphically, before, during and after the main DayTrawl tests. These results are presented in confirmation that the test engine did not suffer any major malfunction throughout the test sequence. With exceptions where indicated, all Baseline tests are conducted on straight red diesel, without any of the technologies being examined being deployed. Thus, there should be excellent agreement between Baseline diagnostic tests, presuming the technology tested does not provide a effect beyond its deployments.

The main results of comparative testing are then presented using a tabular format. Firstly, the results of the Benchmark DayTrawl test are presented. Then the results of the DayTrawl test with the technology deployed are presented. Finally, a table of percentage differences in quantities found for each stage of the test cycle (presented in the first two tables) are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

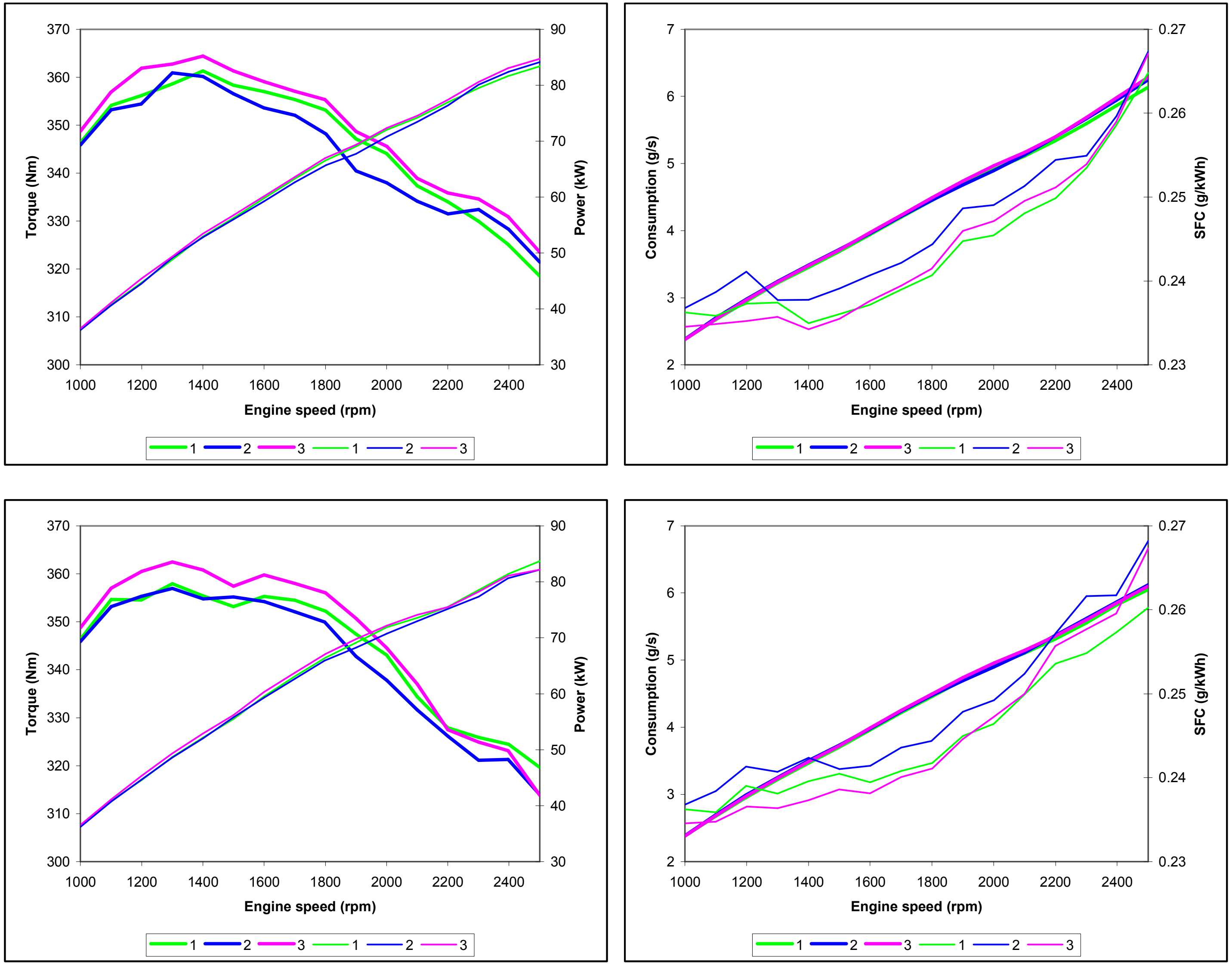
The main results of comparative testing are then presented using a graphical format. Firstly the time series of the Benchmark DayTrawl test are presented. Then the time series of the DayTrawl test with the technology deployed are presented. Finally, time series of the percentage differences in engine performance and fuel consumption parameters are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

For brevity, table and figure numbering are suspended until the Summary Results section below.

Comparison of Baseline diagnostic tests



1 – BL003_210508 (Before), 2 – BL003_140608 (Between DayTrawls – straight Red Diesel), 3 – BL003_150608 (After treatment with MPG-CAPS)

Narrative:

Curves in upper boxes are for the ramping down stages of the test cycle. Curves in the lower boxes are for the ramping up (later) stages of the test cycle.

Curves indicate no significant malfunction occurred with the test engine.

Good consistency between maximum torque, maximum power curves and fuel consumption curves between Tests 1 and 3. Tests 1 and 3 appear to deliver higher torque, with consequent superiority in SFC, in comparison to Test 2.

Test 2 is a diagnostic test undertaken after around 45 hours running 'free' from contemporaneous effect of any technological enhancement tested. The performance curves should thus compare well with BL003_130508_002 (the Baseline test conducted to open the large and small permanent magnets work) – which it does. Test 1 may still be influenced by effects of the permanent magnets – as noted previously. The consequence is that Tests 1 & 3 may reflect after effects of 2 different technologies.

DayTrawl test results

Test date	13/06/2008	Description	
Warm-up duration	00:17:42		DayTrawl for Ffi additive testing - no tablets
Test duration	20:40:00		DT002_130608_001_c
Total engine hour:	20:57:42		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)
Stage Start TP00	15 minute tick over under zero load	10:20:16	10:35:16	00:15:00	1157.43	3.52	-1.05	0.18	1.16	0.18	1.15	0.18
Stage Start TP01	15 minute gentle cruise from port	10:35:16	10:50:16	00:15:00	1300.00	0.00	36.70	0.00	39.29	0.00	39.11	0.00
Stage Start TP02	2.5 hr steaming to trawl site	10:50:16	13:20:16	02:30:00	1999.99	0.08	47.00	0.00	49.70	0.00	49.46	0.00
Stage Start TP03	5 min gentle cruise while shooting	13:20:16	13:25:16	00:05:00	1500.00	0.00	38.20	0.00	40.81	0.00	40.62	0.00
Stage Start TP04	4 hour trawl	13:25:16	17:25:16	04:00:00	1750.00	0.00	278.10	0.01	283.14	0.01	282.01	0.08
Stage Start TP05	20 min haul in of nets	17:25:16	17:45:16	00:20:00	1399.95	0.23	82.50	0.00	85.56	0.00	85.25	0.00
Stage Start TP06	20 min tickover: net handling & unload	17:45:16	18:05:16	00:20:00	1143.74	3.30	-0.76	0.17	1.45	0.18	1.44	0.18
Stage Start TP07	5 min gentle cruise while shooting	18:05:16	18:10:16	00:05:00	1500.00	0.00	38.20	0.00	40.81	0.00	40.66	0.00
Stage Start TP08	4 hour trawl	18:10:16	22:10:16	04:00:00	1750.00	0.00	278.10	0.01	283.14	0.01	282.15	0.03
Stage Start TP09	20 min haul in of nets	22:10:16	22:30:16	00:20:00	1400.00	0.00	82.50	0.00	85.56	0.00	85.26	0.00
Stage Start TP10	20 min tickover: net handling & unload	22:30:16	22:50:16	00:20:00	1143.11	2.85	-0.73	0.07	1.49	0.07	1.48	0.07
Stage Start TP11	5 min gentle cruise while shooting	22:50:16	22:55:16	00:05:00	1500.00	0.00	38.20	0.00	40.81	0.00	40.66	0.00
Stage Start TP12	4 hour trawl	22:55:16	02:55:16	04:00:00	1750.00	0.00	278.10	0.02	283.14	0.02	282.24	0.08
Stage Start TP13	20 min haul in of nets	02:55:16	03:15:16	00:20:00	1400.00	0.00	82.50	0.00	85.56	0.00	85.33	0.00
Stage Start TP14	2.5 hr steaming to trawl site	03:15:16	05:45:16	02:30:00	2000.01	0.18	47.00	0.00	49.70	0.00	49.56	0.00
Stage Start TP15	15 minute gentle cruise to port	05:45:16	06:00:16	00:15:00	1300.00	0.00	36.70	0.00	39.29	0.00	39.19	0.00
Stage Start TP16	Tick over for 1 hour	06:00:16	07:00:16	01:00:00	1131.80	2.07	-0.01	0.10	2.21	0.10	2.21	0.10
End Test	End of test	07:00:16										

Stage	Total Work Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)	Total fuel Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	SFC Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate Mass (kg/kWh)	Aggregate Stdev (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Engine Efficiency Agg. (%)
Stage Start TP00	-0.04	0.000	0.04	0.000	0.04	0.000	0.50	0.49	0.50	0.005	0.4470	0.0000	0.52	5.60	13.085	2.050	10.572	0.022	12.365	132.508	0.624	0.755
Stage Start TP01	1.25	0.000	1.34	0.000	1.33	0.000	0.81	0.80	0.80	0.005	0.7230	0.0000	0.85	9.06	0.543	0.003	0.543	0.000	0.635	6.809	14.697	14.687
Stage Start TP02	24.61	0.000	26.02	0.000	25.90	0.000	1.48	1.42	1.43	0.011	12.9054	0.0000	15.09	161.75	0.498	0.004	0.498	0.000	0.583	6.246	16.015	16.011
Stage Start TP03	0.50	0.000	0.53	0.000	0.53	0.000	0.92	0.93	0.93	0.006	0.2772	0.0000	0.32	3.47	0.522	0.003	0.521	0.000	0.610	6.534	15.288	15.304
Stage Start TP04	203.86	0.000	207.55	0.000	206.72	0.000	3.41	3.37	3.37	0.008	48.5430	0.0000	56.78	608.43	0.235	0.001	0.235	0.000	0.275	2.943	33.978	33.976
Stage Start TP05	4.03	0.000	4.18	0.000	4.17	0.000	1.11	1.14	1.13	0.011	1.3542	0.0000	1.58	16.97	0.325	0.003	0.325	0.000	0.380	4.074	24.524	24.543
Stage Start TP06	-0.03	0.000	0.06	0.000	0.06	0.000	0.45	0.46	0.46	0.005	0.5466	0.0000	0.64	6.85	9.616	1.081	9.565	0.012	11.187	119.890	0.839	0.834
Stage Start TP07	0.50	0.000	0.53	0.000	0.53	0.000	0.93	0.93	0.93	0.000	0.2790	0.0000	0.33	3.50	0.524	0.000	0.524	0.000	0.613	6.571	15.219	15.219
Stage Start TP08	203.86	0.000	207.55	0.000	206.82	0.000	3.43	3.35	3.37	0.012	48.4620	0.0000	56.68	607.42	0.234	0.001	0.234	0.000	0.274	2.937	34.053	34.050
Stage Start TP09	4.03	0.000	4.18	0.000	4.17	0.000	1.10	1.13	1.12	0.010	1.3404	0.0000	1.57	16.80	0.322	0.003	0.322	0.000	0.376	4.032	24.782	24.800
Stage Start TP10	-0.03	0.000	0.06	0.000	0.06	0.000	0.44	0.46	0.45	0.006	0.5418	0.0000	0.63	6.79	9.196	0.317	9.193	0.004	10.752	115.220	0.869	0.868
Stage Start TP11	0.50	0.000	0.53	0.000	0.53	0.000	0.93	0.92	0.93	0.005	0.2784	0.0000	0.33	3.49	0.523	0.003	0.523	0.000	0.612	6.555	15.263	15.255
Stage Start TP12	203.86	0.000	207.55	0.000	206.89	0.000	3.41	3.34	3.35	0.011	48.2460	0.0000	56.43	604.71	0.233	0.001	0.233	0.000	0.273	2.923	34.217	34.214
Stage Start TP13	4.03	0.000	4.18	0.000	4.17	0.000	1.09	1.12	1.11	0.010	1.3326	0.0000	1.56	16.70	0.320	0.003	0.320	0.000	0.374	4.005	24.944	24.966
Stage Start TP14	24.61	0.000	26.02	0.000	25.95	0.000	1.39	1.38	1.39	0.005	12.4716	0.0000	14.59	156.32	0.481	0.002	0.481	0.000	0.562	6.024	16.601	16.600
Stage Start TP15	1.25	0.000	1.34	0.000	1.33	0.000	0.74	0.76	0.75	0.005	0.6732	0.0000	0.79	8.44	0.505	0.004	0.505	0.000	0.590	6.327	15.794	15.805
Stage Start TP16	0.00	0.000	0.26	0.000	0.26	0.000	0.45	0.45	0.45	0.003	1.6170	0.0000	1.89	20.27	6.199	0.267	6.196	0.001	7.247	77.665	1.289	1.288
End Test																						

Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

	Work Observed Sum (kWh)	Work Compensated Sum (kWh)	Work Reduced Sum (kWh)	Fuel Mass (kg)	Volume (litres)	Energy (kWh)	Aggregate Mass (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Efficiency Agg. (%)
Total over whole test	676.78	691.94	689.47	180.04	210.57	2256.58	0.261	0.305	3.273	30.554
Total over whole test (check)	676.79	691.94	689.46	180.04	210.57	2256.58	0.261	0.305	3.273	30.553
Total over census stages	676.88	691.52	689.05	176.89	206.88	2217.07	0.257	0.300	3.218	31.079
Total over census stage 1	234.25	239.63	238.65	63.80	74.62	799.70	0.267	0.313	3.351	29.842
Total over census stage 2	208.39	212.27	211.52	50.08	58.57	627.71	0.237	0.277	2.968	33.697
Total over census stage 3	234.25	239.63	238.88	63.00	73.69	789.66	0.264	0.308	3.306	30.251

Test date	14/06/2008	Description	
Warm-up duration	00:03:06		DayTrawl with Ffi additive
Test duration	20:40:00		DT002_140608_001_c
Total engine hour:	20:43:06		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)
Stage Start TP00	15 minute tick over under zero load	09:32:16	09:47:16	00:15:00	1146.86	3.32	0.26	0.05	2.44	0.05	2.44	0.05
Stage Start TP01	15 minute gentle cruise from port	09:47:16	10:02:16	00:15:00	1300.00	0.00	36.70	0.00	39.24	0.00	39.15	0.00
Stage Start TP02	2.5 hr steaming to trawl site	10:02:16	12:32:16	02:30:00	2000.01	0.18	47.00	0.00	49.64	0.00	49.51	0.00
Stage Start TP03	5 min gentle cruise while shooting	12:32:16	12:37:16	00:05:00	1500.00	0.00	38.20	0.00	40.76	0.00	40.65	0.00
Stage Start TP04	4 hour trawl	12:37:16	16:37:16	04:00:00	1750.00	0.00	278.10	0.01	283.02	0.01	282.39	0.06
Stage Start TP05	20 min haul in of nets	16:37:16	16:57:16	00:20:00	1400.05	0.23	82.50	0.00	85.49	0.00	85.33	0.00
Stage Start TP06	20 min tickover: net handling & unload	16:57:16	17:17:16	00:20:00	1139.00	3.09	-0.16	0.08	2.02	0.08	2.01	0.08
Stage Start TP07	5 min gentle cruise while shooting	17:17:16	17:22:16	00:05:00	1500.00	0.00	38.20	0.00	40.76	0.00	40.68	0.00
Stage Start TP08	4 hour trawl	17:22:16	21:22:16	04:00:00	1750.00	0.00	278.10	0.01	283.02	0.01	282.56	0.05
Stage Start TP09	20 min haul in of nets	21:22:16	21:42:16	00:20:00	1400.00	0.00	82.50	0.00	85.49	0.00	85.37	0.00
Stage Start TP10	20 min tickover: net handling & unload	21:42:16	22:02:16	00:20:00	1136.11	3.05	-0.14	0.05	2.04	0.05	2.04	0.05
Stage Start TP11	5 min gentle cruise while shooting	22:02:16	22:07:16	00:05:00	1500.00	0.00	38.20	0.00	40.76	0.00	40.70	0.00
Stage Start TP12	4 hour trawl	22:07:16	02:07:16	04:00:00	1750.00	0.06	278.10	0.01	283.02	0.01	282.67	0.07
Stage Start TP13	20 min haul in of nets	02:07:16	02:27:16	00:20:00	1400.00	0.00	82.50	0.00	85.49	0.00	85.42	0.00
Stage Start TP14	2.5 hr steaming to trawl site	02:27:16	04:57:16	02:30:00	2000.03	0.20	47.00	0.00	49.64	0.00	49.60	0.00
Stage Start TP15	15 minute gentle cruise to port	04:57:16	05:12:16	00:15:00	1300.00	0.00	36.70	0.00	39.24	0.00	39.22	0.00
Stage Start TP16	Tick over for 1 hour	05:12:16	06:12:16	01:00:00	1120.71	3.03	0.15	0.05	2.33	0.05	2.33	0.05
End Test	End of test	06:12:16										

Stage	Total Work Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)	Total fuel Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	SFC Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate Mass (kg/kWh)	Aggregate Stdev (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Engine Efficiency Agg. (%)
Stage Start TP00	0.01	0.000	0.08	0.000	0.08	0.000	0.44	0.45	0.44	0.005	0.3984	0.0000	0.47	4.99	5.449	0.090	4.848	0.001	5.671	60.768	1.465	1.646
Stage Start TP01	1.25	0.000	1.34	0.000	1.33	0.000	0.76	0.76	0.75	0.005	0.6792	0.0000	0.79	8.51	0.509	0.003	0.510	0.000	0.596	6.389	15.661	15.653
Stage Start TP02	24.61	0.000	25.99	0.000	25.93	0.000	1.42	1.39	1.39	0.005	12.5232	0.0000	14.65	156.96	0.483	0.002	0.483	0.000	0.565	6.054	16.520	16.517
Stage Start TP03	0.50	0.000	0.53	0.000	0.53	0.000	0.89	0.89	0.89	0.000	0.2670	0.0000	0.31	3.35	0.502	0.000	0.502	0.000	0.587	6.289	15.901	15.901
Stage Start TP04	203.86	0.000	207.46	0.000	207.00	0.000	3.37	3.33	3.34	0.006	48.1152	0.0000	56.28	603.07	0.232	0.000	0.232	0.000	0.272	2.913	34.326	34.325
Stage Start TP05	4.03	0.000	4.18	0.000	4.17	0.000	1.09	1.12	1.11	0.010	1.3308	0.0000	1.56	16.68	0.319	0.003	0.319	0.000	0.373	4.000	24.981	25.001
Stage Start TP06	-0.01	0.000	0.08	0.000	0.08	0.000	0.44	0.45	0.45	0.005	0.5358	0.0000	0.63	6.72	6.706	0.212	6.714	0.003	7.853	84.158	1.191	1.188
Stage Start TP07	0.50	0.000	0.53	0.000	0.53	0.000	0.92	0.92	0.92	0.000	0.2760	0.0000	0.32	3.46	0.518	0.000	0.518	0.000	0.606	6.496	15.394	15.394
Stage Start TP08	203.86	0.000	207.46	0.000	207.13	0.000	3.40	3.33	3.34	0.012	48.0612	0.0000	56.21	602.39	0.232	0.001	0.232	0.000	0.271	2.908	34.388	34.384
Stage Start TP09	4.03	0.000	4.18	0.000	4.17	0.000	1.09	1.12	1.11	0.010	1.3290	0.0000	1.55	16.66	0.319	0.003	0.319	0.000	0.373	3.993	25.027	25.046
Stage Start TP10	-0.01	0.000	0.08	0.000	0.08	0.000	0.44	0.45	0.45	0.005	0.5358	0.0000	0.63	6.72	6.627	0.095	6.629	0.002	7.753	83.087	1.204	1.204
Stage Start TP11	0.50	0.000	0.53	0.000	0.53	0.000	0.92	0.92	0.92	0.000	0.2760	0.0000	0.32	3.46	0.518	0.000	0.518	0.000	0.606	6.494	15.399	15.399
Stage Start TP12	203.86	0.000	207.46	0.000	207.21	0.000	3.40	3.32	3.33	0.012	47.9100	0.0000	56.04	600.50	0.231	0.001	0.231	0.000	0.270	2.898	34.510	34.506
Stage Start TP13	4.03	0.000	4.18	0.000	4.17	0.000	1.09	1.11	1.11	0.010	1.3266	0.0000	1.55	16.63	0.318	0.003	0.318	0.000	0.372	3.983	25.089	25.106
Stage Start TP14	24.61	0.000	25.99	0.000	25.97	0.000	1.39	1.39	1.38	0.005	12.4650	0.0000	14.58	156.23	0.480	0.002	0.480	0.000	0.561	6.015	16.625	16.624
Stage Start TP15	1.25	0.000	1.34	0.000	1.33	0.000	0.74	0.76	0.75	0.007	0.6732	0.0000	0.79	8.44	0.505	0.004	0.504	0.000	0.590	6.322	15.806	15.817
Stage Start TP16	0.02	0.000	0.27	0.000	0.27	0.000	0.44	0.46	0.45	0.007	1.6290	0.0000	1.91	20.42	5.963	0.114	5.960	0.000	6.971	74.708	1.338	1.339
End Test																						

Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

	Work Observed Sum (kWh)	Work Compensated Sum (kWh)	Work Reduced Sum (kWh)	Fuel Mass (kg)	Volume (litres)	Energy (kWh)	Aggregate Mass (kg/kWh)	Aggregate Volume (L/kWh)	Aggregate Energy (kWh/kWh)	Efficiency Agg. (%)
Total over whole test	676.90	691.70	690.54	178.33	208.57	2235.19	0.258	0.302	3.237	30.894
Total over whole test (check)	676.90	691.69	690.53	178.33	208.57	2235.19	0.258	0.302	3.237	30.894
Total over census stages	676.88	691.18	690.02	175.23	204.95	2196.34	0.254	0.297	3.183	31.417
Total over census stage 1	234.25	239.50	238.96	62.92	73.59	788.57	0.263	0.308	3.300	30.303
Total over census stage 2	208.39	212.17	211.83	49.67	58.09	622.51	0.234	0.274	2.939	34.029
Total over census stage 3	234.25	239.51	239.22	62.65	73.28	785.26	0.262	0.306	3.283	30.464

Percentage differences of DayTrawl tests

Percentage difference between 2 DayTrawl tests (Positive values mean the benchmark was lower, negative values mean the technology tested was lower)

	Benchmark	DayTrawl for Ffi additive testing - no tablets
	Technology tested	DayTrawl with Ffi additive

Stage	Description	Start time	End time	Duration	Engine Speed Ave.	Torque Obs. Ave.	Torque Comp. Ave.	Torque Red. Ave.	Total Work done in stage Obs. Sum	Total Work done in stage Comp. Sum	Total Work done in stage Red. Sum	Stage fuel consumption Initial	Stage fuel consumption Final	Stage fuel consumption Ave.	Total fuel consumed Mass	Total fuel consumed Volume	Total fuel consumed Energy	Specific fuel consumption in stage Instantan. Ave.	Specific fuel consumption Aggregate over stage Mass	Aggregate over stage Volume	Aggregate over stage Energy	Engine Efficiency Ave.	Engine Efficiency Agg.
		hh:mm:ss	hh:mm:ss	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	(%)	(%)
Stage Start TP00	15 minute tick over under zero load																						
Stage Start TP01	15 minute gentle cruise from port			0.00	0.00	0.00	-0.12	0.12	0.00	-0.12	0.12	-6.17	-5.00	-6.05	-6.0581	-6.06	-6.06	-6.159	-6.167	-6.167	-6.167	6.564	6.572
Stage Start TP02	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.10	0.11	0.00	-0.10	0.11	-4.05	-2.11	-2.95	-2.9616	-2.96	-2.96	-3.058	-3.065	-3.065	-3.065	3.150	3.162
Stage Start TP03	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.12	0.08	0.00	-0.12	0.08	-3.26	-4.30	-3.78	-3.6797	-3.68	-3.68	-3.859	-3.755	-3.755	-3.755	4.011	3.902
Stage Start TP04	4 hour trawl			0.00	0.00	0.00	-0.04	0.14	0.00	-0.04	0.14	-1.17	-1.19	-0.88	-0.8813	-0.88	-0.88	-1.015	-1.017	-1.017	-1.017	1.025	1.027
Stage Start TP05	20 min haul in of nets			0.00	0.01	0.00	-0.07	0.10	0.01	-0.07	0.11	-1.80	-1.75	-1.72	-1.7280	-1.73	-1.73	-1.828	-1.831	-1.831	-1.831	1.861	1.866
Stage Start TP06	20 min tickover: net handling & unload																						
Stage Start TP07	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.12	0.06	0.00	-0.12	0.06	-1.08	-1.08	-1.08	-1.0753	-1.08	-1.08	-1.137	-1.137	-1.137	-1.137	1.150	1.150
Stage Start TP08	4 hour trawl			0.00	0.00	0.00	-0.04	0.15	0.00	-0.04	0.15	-0.87	-0.60	-0.83	-0.8270	-0.83	-0.83	-0.974	-0.974	-0.974	-0.974	0.983	0.983
Stage Start TP09	20 min haul in of nets			0.00	0.00	0.00	-0.07	0.13	0.00	-0.07	0.13	-0.91	-0.88	-0.85	-0.8505	-0.85	-0.85	-0.979	-0.981	-0.981	-0.981	0.988	0.991
Stage Start TP10	20 min tickover: net handling & unload																						
Stage Start TP11	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.12	0.08	0.00	-0.12	0.08	-1.08	0.00	-0.81	-0.8621	-0.86	-0.86	-0.886	-0.939	-0.939	-0.939	0.892	0.947
Stage Start TP12	4 hour trawl			0.00	0.00	0.00	-0.04	0.15	0.00	-0.04	0.15	-0.29	-0.60	-0.70	-0.6964	-0.70	-0.70	-0.849	-0.848	-0.848	-0.848	0.857	0.855
Stage Start TP13	20 min haul in of nets			0.00	0.00	0.00	-0.07	0.10	0.00	-0.07	0.11	0.00	-0.89	-0.47	-0.4502	-0.45	-0.45	-0.578	-0.555	-0.555	-0.555	0.580	0.558
Stage Start TP14	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.10	0.09	0.00	-0.10	0.09	0.00	0.72	-0.05	-0.0529	-0.05	-0.05	-0.142	-0.142	-0.142	-0.142	0.142	0.142
Stage Start TP15	15 minute gentle cruise to port			0.00	0.00	0.00	-0.12	0.08	0.00	-0.12	0.08	0.00	0.00	0.00	0.0000	0.00	0.00	-0.076	-0.076	-0.076	-0.076	0.078	0.076
Stage Start TP16	Tick over for 1 hour																						
End Test	End of test																						

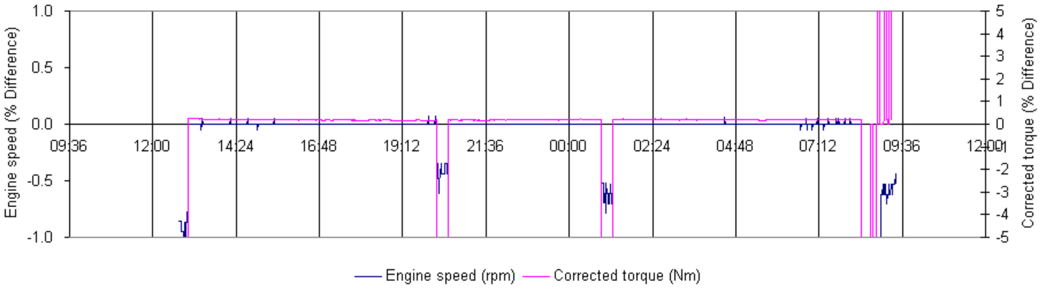
Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

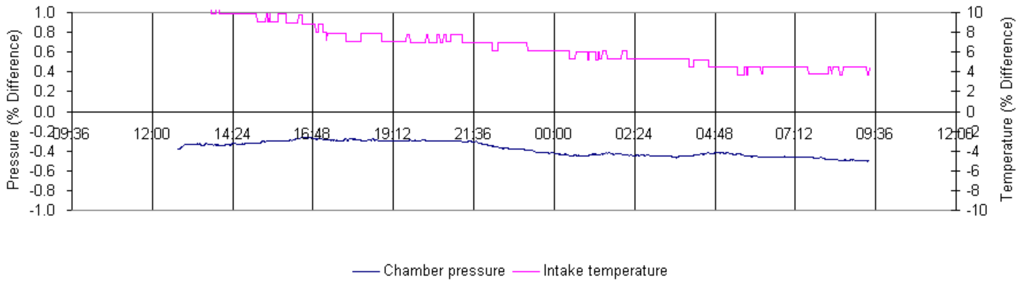
	Work Obs. Sum	Work Comp. Sum	Work Red. Sum	Fuel Mass	Fuel Volume	Fuel Energy	SFC Mass	SFC Volume	SFC Energy	Efficiency Agg.
Total over whole test	0.02	-0.03	0.16	-0.95	-0.95	-0.95	-1.102	-1.102	-1.102	1.114
Total over whole test (check)	0.02	-0.04	0.15	-0.95	-0.95	-0.95	-1.101	-1.101	-1.101	1.114
Total over census stages	0.00	-0.05	0.14	-0.93	-0.93	-0.93	-1.075	-1.075	-1.075	1.086
Total over census stage 1	0.00	-0.05	0.13	-1.39	-1.39	-1.39	-1.522	-1.522	-1.522	1.545
Total over census stage 2	0.00	-0.04	0.15	-0.83	-0.83	-0.83	-0.975	-0.975	-0.975	0.985
Total over census stage 3	0.00	-0.05	0.14	-0.56	-0.56	-0.56	-0.700	-0.700	-0.700	0.705

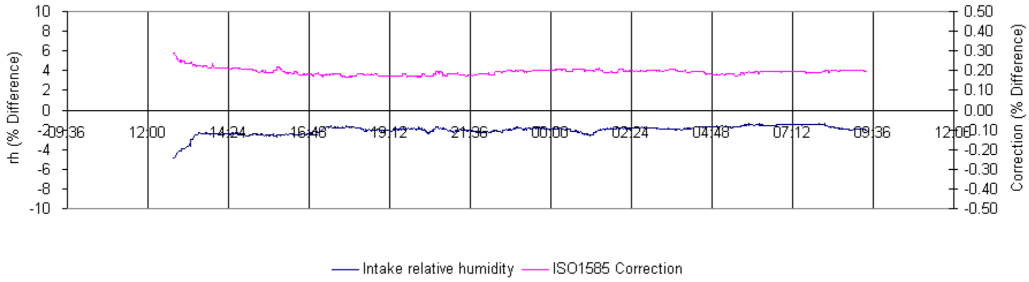
Narrative / Comment:

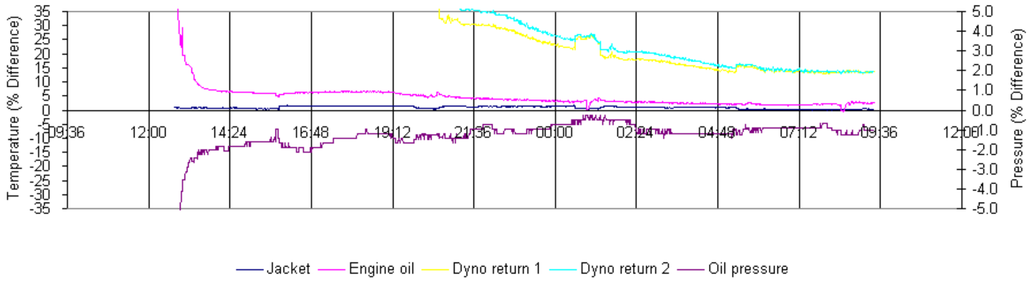
Specific fuel consumption is reduced for all stages in the test where the fuel is treated with MPG-CAPS by between 6.167% and 0.076%. Over all the census stages (i.e. excluding idle stages), the specific fuel consumption is reduced by 1.075%. It is also worth noting that specific fuel consumption figures during the 4 hour trawl stages are 1.017%, 0.974% and 0.848%, that is, they are broadly maintained through these stages where by far the most load is put on the test engine. This is despite the evident reduction in fuel savings as the test progresses from stage to stage.

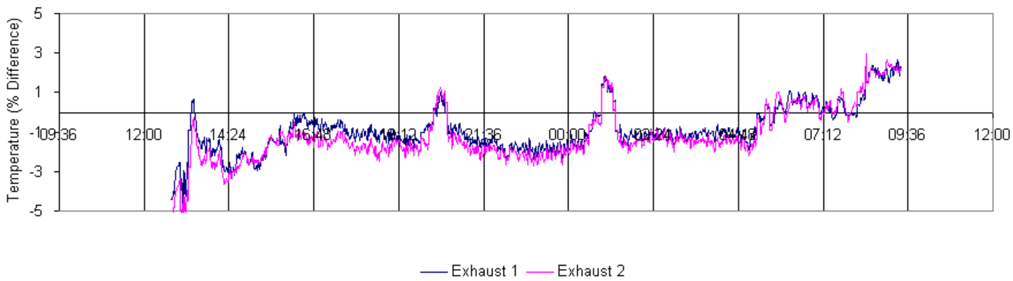
Percentage differences between DayTrawl tests - time series

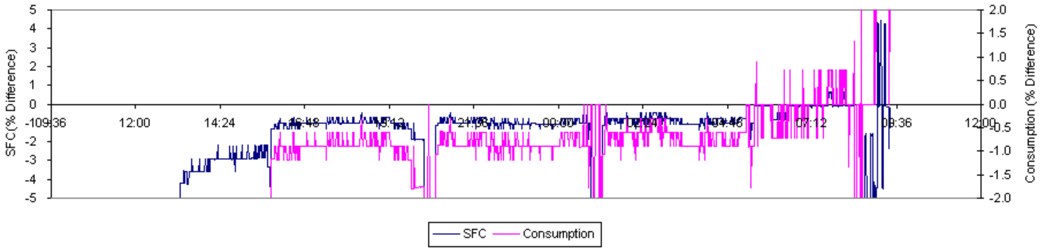












E. Belesta LC2 Lubricating oil additive – Phases A and B

The experimental results are presented using both graphical and tabular formats.

Firstly the results of Baseline diagnostic tests are presented graphically, before, during and after the main DayTrawl tests. These results are presented in confirmation that the test engine did not suffer any major malfunction throughout the test sequence. With exceptions where indicated, all Baseline tests are conducted on straight red diesel, without any of the technologies being examined being deployed. Thus, there should be excellent agreement between Baseline diagnostic tests, presuming the technology tested does not provide a effect beyond its deployments.

The main results of comparative testing are then presented using a tabular format. Firstly, the results of the Benchmark DayTrawl test are presented. Then the results of the DayTrawl test with the technology deployed are presented. Finally, a table of percentage differences in quantities found for each stage of the test cycle (presented in the first two tables) are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

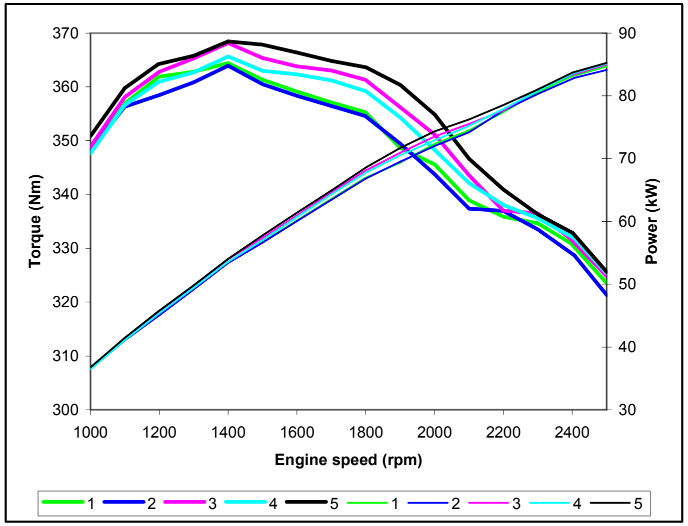
The main results of comparative testing are then presented using a graphical format. Firstly the time series of the Benchmark DayTrawl test are presented. Then the time series of the DayTrawl test with the technology deployed are presented. Finally, time series of the percentage differences in engine performance and fuel consumption parameters are presented. The percentage differences are calculated as:

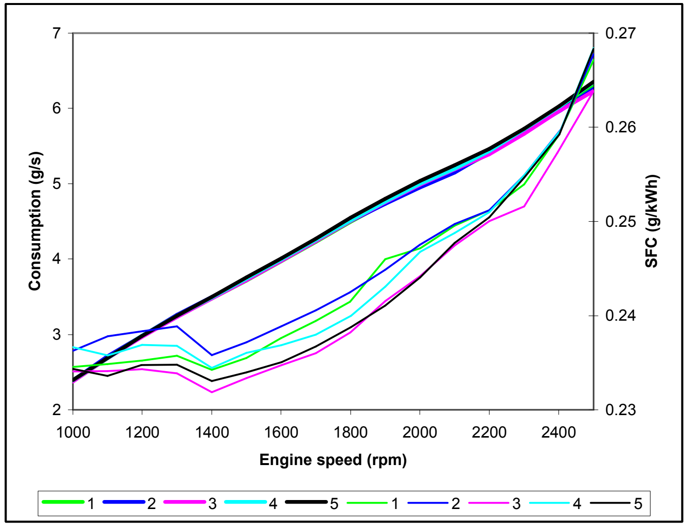
((Value with technology – Benchmark value) / Benchmark value) x 100

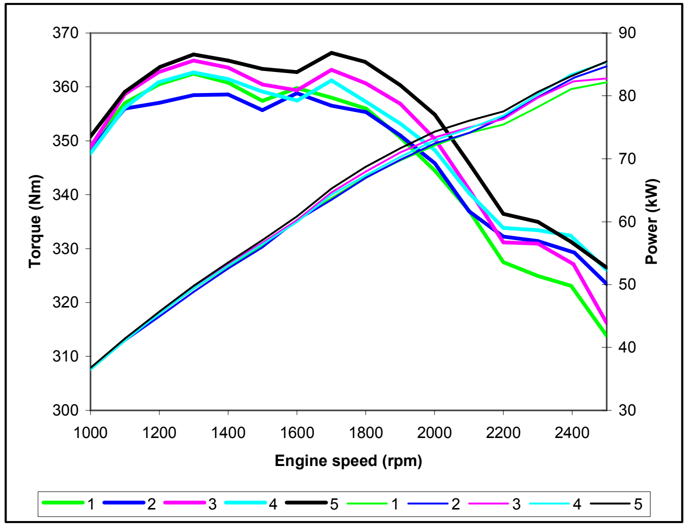
This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

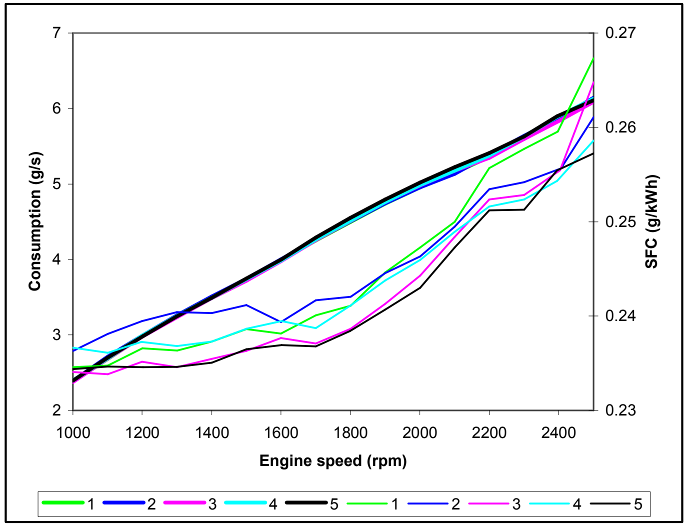
For brevity, table and figure numbering are suspended until the Summary Results section below.

Comparison of Baseline diagnostic tests









Narrative:

Curves in upper boxes are for the ramping down stages of the test cycle. Curves in the lower boxes are for the ramping up (later) stages of the test cycle.

Curves indicate no significant malfunction occurred with the test engine.

Good consistency between Tests 1 and 2. Indicates similar engine condition from end of MPG-CAPS work and start of Belesta work. Much higher torque and much lower SFC when comparing Test 2 and Test 3. Suggests that new lubricating oil may need a 'run in' before it becomes really effective. Lower torque and higher SFC when comparing Test 3 and Test 4 or Test 2 and Test 4. Comparing Test 4 with Test 5 or Test 2 with Test 5 reveals another leap in torque and further reduction in SFC. This suggests that after adding the LC2 lubricant, the oil and additive may require a 'run in' before becoming really effective.

Through this sequence of testing (including 2 intermediate DayTrawl cycles) at 1700 rpm torque has increased by 2.1% at full throttle and SFC has improved by 1.1% when ramping down and 2.3% and 1.3% when ramping up.

N.B. These tests were conducted with MPG-CAPS remnant concentrations at 30% of FFI recommended levels. This was done to ensure all tests in the Belesta sequence could be conducted on the same batch of fuel.

1 – BL003_150608 (After treatment with MPG-CAPS, old oil), 2 – BL003_160608 (new oil), 3 – BL003_170608 (same oil, after DayTrawl), 4 – BL003_180608 (same oil with 5% LC5), 5 – BL003_200608 (same oil with 5% LC5, after DayTrawl)

DayTrawl test results

Test date	16/06/2008	Description	
Warm-up duration	00:02:52		DayTrawl benchmark with new oil & filter
Test duration	20:40:00		DT002_160608_001_c
Total engine hour:	20:42:52		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)	Total Work done in stage Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel consumption Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)	Total fuel consumed Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	Specific fuel consumption in stage Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate over stage Mass (kg/kWh)	Stdev (kg/kWh)	Volume (L/kWh)	Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Agg. (%)
Stage Start TP00	15 minute tick over under zero load	15:59:11	16:14:11	00:15:00	1150.29	0.83	0.31	0.09	2.45	0.09	2.45	0.09	0.01	0.000	0.08	0.000	0.08	0.000	0.45	0.45	0.45	0.000	0.4050	0.0000	0.47	5.08	5.497	0.212	4.895	0.003	5.725	61.353	1.453	1.630
Stage Start TP01	15 minute gentle cruise from port	16:14:11	16:29:11	00:15:00	1300.00	0.00	36.70	0.00	39.19	0.00	39.15	0.00	1.25	0.000	1.33	0.000	1.33	0.000	0.76	0.75	0.75	0.004	0.6774	0.0000	0.79	8.49	0.508	0.003	0.508	0.000	0.595	6.372	15.705	15.693
Stage Start TP02	2.5 hr steaming to trawl site	16:29:11	18:59:11	02:30:00	2000.03	0.43	47.00	0.00	49.59	0.00	49.53	0.00	24.61	0.000	25.96	0.000	25.93	0.000	1.41	1.38	1.38	0.007	12.4518	0.0000	14.56	156.07	0.480	0.002	0.480	0.000	0.562	6.018	16.619	16.616
Stage Start TP03	5 min gentle cruise while shooting	18:59:11	19:04:11	00:05:00	1499.75	0.50	38.20	0.00	40.70	0.00	40.65	0.00	0.50	0.000	0.53	0.000	0.53	0.000	0.88	0.89	0.89	0.006	0.2652	0.0000	0.31	3.32	0.499	0.003	0.498	0.000	0.583	6.247	15.990	16.008
Stage Start TP04	4 hour trawl	19:04:11	23:04:11	04:00:00	1750.02	0.13	278.10	0.02	282.88	0.02	282.58	0.03	203.86	0.000	207.36	0.000	207.14	0.000	3.35	3.31	3.32	0.009	47.8530	0.0000	55.97	599.78	0.231	0.001	0.231	0.000	0.270	2.896	34.538	34.536
Stage Start TP05	20 min haul in of nets	23:04:11	23:24:11	00:20:00	1400.05	0.23	82.50	0.00	85.43	0.00	85.32	0.00	4.03	0.000	4.17	0.000	4.17	0.000	1.07	1.11	1.09	0.012	1.3092	0.0000	1.53	16.41	0.314	0.004	0.314	0.000	0.367	3.935	25.389	25.411
Stage Start TP06	20 min tickover: net handling & unload	23:24:11	23:44:11	00:20:00	1138.89	2.21	-0.03	0.07	2.11	0.07	2.11	0.07	0.00	0.000	0.08	0.000	0.08	0.000	0.43	0.44	0.44	0.005	0.5238	0.0000	0.61	6.57	6.248	0.176	6.263	0.001	7.325	78.497	1.278	1.274
Stage Start TP07	5 min gentle cruise while shooting	23:44:11	23:49:11	00:05:00	1500.00	0.00	38.20	0.00	40.70	0.00	40.64	0.00	0.50	0.000	0.53	0.000	0.53	0.000	0.91	0.90	0.91	0.005	0.2724	0.0000	0.32	3.41	0.512	0.003	0.512	0.000	0.599	6.417	15.592	15.583
Stage Start TP08	4 hour trawl	23:49:11	03:49:11	04:00:00	1750.00	0.06	278.10	0.01	282.88	0.01	282.51	0.03	203.86	0.000	207.37	0.000	207.09	0.000	3.36	3.30	3.31	0.012	47.6244	0.0000	55.70	596.92	0.230	0.001	0.230	0.000	0.269	2.882	34.696	34.693
Stage Start TP09	20 min haul in of nets	03:49:11	04:09:11	00:20:00	1400.00	0.00	82.50	0.00	85.43	0.00	85.32	0.00	4.03	0.000	4.17	0.000	4.17	0.000	1.07	1.10	1.09	0.011	1.3086	0.0000	1.53	16.40	0.314	0.003	0.314	0.000	0.367	3.934	25.397	25.420
Stage Start TP10	20 min tickover: net handling & unload	04:09:11	04:29:11	00:20:00	1135.16	2.59	-0.04	0.05	2.10	0.05	2.10	0.05	0.00	0.000	0.08	0.000	0.08	0.000	0.43	0.44	0.44	0.005	0.5232	0.0000	0.61	6.56	6.306	0.114	6.307	0.002	7.377	79.051	1.265	1.265
Stage Start TP11	5 min gentle cruise while shooting	04:29:11	04:34:11	00:05:00	1500.00	0.00	38.20	0.00	40.70	0.00	40.65	0.00	0.50	0.000	0.53	0.000	0.53	0.000	0.90	0.90	0.90	0.000	0.2700	0.0000	0.32	3.38	0.507	0.000	0.507	0.000	0.594	6.360	15.722	15.722
Stage Start TP12	4 hour trawl	04:34:11	08:34:11	04:00:00	1750.00	0.06	278.10	0.01	282.88	0.01	282.61	0.09	203.86	0.000	207.37	0.000	207.17	0.000	3.35	3.29	3.29	0.012	47.4504	0.0000	55.50	594.74	0.229	0.001	0.229	0.000	0.268	2.871	34.836	34.833
Stage Start TP13	20 min haul in of nets	08:34:11	08:54:11	00:20:00	1400.00	0.00	82.50	0.00	85.43	0.00	85.38	0.00	4.03	0.000	4.17	0.000	4.17	0.000	1.07	1.10	1.09	0.009	1.3020	0.0000	1.52	16.32	0.312	0.003	0.312	0.000	0.365	3.911	25.552	25.569
Stage Start TP14	2.5 hr steaming to trawl site	08:54:11	11:24:11	02:30:00	2000.03	0.27	47.00	0.00	49.59	0.00	49.55	0.00	24.61	0.000	25.96	0.000	25.95	0.000	1.36	1.37	1.37	0.007	12.2880	0.0000	14.37	154.02	0.474	0.002	0.474	0.000	0.554	5.936	16.846	16.846
Stage Start TP15	15 minute gentle cruise to port	11:24:11	11:39:11	00:15:00	1300.00	0.00	36.70	0.00	39.19	0.00	39.16	0.00	1.25	0.000	1.33	0.000	1.33	0.000	0.72	0.74	0.73	0.008	0.6600	0.0000	0.77	8.27	0.496	0.005	0.495	0.000	0.579	6.207	16.092	16.112
Stage Start TP16	Tick over for 1 hour	11:39:11	12:39:11	01:00:00	1117.10	2.81	0.19	0.06	2.33	0.06	2.33	0.06	0.02	0.000	0.27	0.000	0.27	0.000	0.43	0.45	0.44	0.007	1.5924	0.0000	1.86	19.96	5.848	0.123	5.846	0.000	6.838	73.275	1.365	1.365
End Test	End of test	12:39:11																																

Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

	Work Observed Sum (kWh)	Work Compensated Sum (kWh)	Work Reduced Sum (kWh)	Fuel Mass (kg)	Fuel Volume (litres)	Fuel Energy (kWh)	SFC Mass (kg/kWh)	SFC Volume (L/kWh)	SFC Energy (kWh/kWh)	Efficiency Agg. (%)
Total over whole test	676.91	691.34	690.57	176.78	206.76	2215.70	0.256	0.299	3.208	31.167
Total over whole test (check)	676.91	691.33	690.56	176.78	206.76	2215.70	0.256	0.299	3.209	31.167
Total over census stages	676.88	690.82	690.05	173.73	203.20	2177.54	0.252	0.294	3.156	31.689
Total over census stage 1	234.25	239.37	239.11	62.56	73.17	784.08	0.262	0.306	3.279	30.496
Total over census stage 2	208.39	212.07	211.79	49.21	57.55	616.74	0.232	0.272	2.912	34.341
Total over census stage 3	234.25	239.37	239.15	61.97	72.48	776.73	0.259	0.303	3.248	30.789

Test date	18/06/2008	Description	
Warm-up duration	00:03:05		DayTrawl with new oil & filter, Belesta LC2 (5%)
Test duration	20:40:00		DT002_180608_001_c
Total engine hour:	20:43:05		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)	Total Work done in stage Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel consumption Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)	Total fuel consumed Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	Specific fuel consumption in stage Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate over stage Mass (kg/kWh)	Stdev (kg/kWh)	Volume (L/kWh)	Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Agg. (%)
Stage Start TP00	15 minute tick over under zero load	12:23:59	12:38:59	00:15:00	1142.71	2.02	0.23	0.05	2.33	0.05	2.33	0.05	0.01	0.000	0.08	0.000	0.08	0.000	0.42	0.44	0.43	0.007	0.3876	0.0000	0.45	4.86	5.566	0.069	4.799	0.002	5.612	60.145	1.434	1.663
Stage Start TP01	15 minute gentle cruise from port	12:38:59	12:53:59	00:15:00	1299.93	0.27	36.70	0.00	39.14	0.00	39.14	0.00	1.25	0.000	1.33	0.000	1.33	0.000	0.74	0.74	0.74	0.000	0.6660	0.0000	0.78	8.35	0.500	0.000	0.500	0.000	0.585	6.267	15.956	15.956
Stage Start TP02	2.5 hr steaming to trawl site	12:53:59	15:23:59	02:30:00	2000.07	0.36	47.00	0.00	49.53	0.00	49.53	0.01	24.61	0.000	25.94	0.000	25.93	0.000	1.40	1.38	1.38	0.006	12.3978	0.0000	14.50	155.39	0.478	0.002	0.478	0.000	0.559	5.992	16.690	16.688
Stage Start TP03	5 min gentle cruise while shooting	15:23:59	15:28:59	00:05:00	1500.00	0.00	38.20	0.00	40.65	0.00	40.66	0.00	0.50	0.000	0.53	0.000	0.53	0.000	0.88	0.88	0.88	0.000	0.2640	0.0000	0.31	3.31	0.496	0.000	0.496	0.000	0.580	6.218	16.083	16.083
Stage Start TP04	4 hour trawl	15:28:59	19:28:59	04:00:00	1750.01	0.09	278.10	0.01	282.75	0.01	283.08	0.16	203.86	0.000	207.27	0.000	207.51	0.000	3.33	3.30	3.30	0.009	47.5674	0.0000	55.63	596.20	0.229	0.001	0.229	0.000	0.268	2.873	34.806	34.805
Stage Start TP05	20 min haul in of nets	19:28:59	19:48:59	00:20:00	1400.00	0.00	82.50	0.00	85.36	0.00	85.54	0.01	4.03	0.000	4.17	0.000	4.18	0.000	1.07	1.10	1.09	0.010	1.3086	0.0000	1.53	16.40	0.313	0.003	0.313	0.000	0.366	3.924	25.463	25.486
Stage Start TP06	20 min tickover: net handling & unload	19:48:59	20:08:59	00:20:00	1139.63	3.56	-0.12	0.06	1.98	0.06	1.99	0.06	0.00	0.000	0.08	0.000	0.08	0.000	0.43	0.44	0.44	0.005	0.5226	0.0000	0.61	6.55	6.617	0.150	6.621	0.002	7.744	82.988	1.206	1.205
Stage Start TP07	5 min gentle cruise while shooting	20:08:59	20:13:59	00:05:00	1500.00	0.00	38.20	0.00	40.65	0.00	40.74	0.00	0.50	0.000	0.53	0.000	0.53	0.000	0.91	0.90	0.91	0.006	0.2718	0.0000	0.32	3.41	0.509	0.003	0.510	0.000	0.596	6.389	15.671	15.653
Stage Start TP08	4 hour trawl	20:13:59	00:13:59	04:00:00	1750.00	0.00	278.10	0.02	282.75	0.02	283.45	0.07	203.86	0.000	207.26	0.000	207.78	0.000	3.35	3.31	3.30	0.011	47.5008	0.0000	55.56	595.37	0.229	0.001	0.229	0.000	0.267	2.865	34.902	34.899
Stage Start TP09	20 min haul in of nets	00:13:59	00:33:59	00:20:00	1400.00	0.00	82.50	0.00	85.36	0.00	85.57	0.01	4.03	0.000	4.17	0.000	4.18	0.000	1.07	1.10	1.09	0.010	1.3086	0.0000	1.53	16.40	0.313	0.003	0.313	0.000	0.366	3.922	25.472	25.495
Stage Start TP10	20 min tickover: net handling & unload	00:33:59	00:53:59	00:20:00	1133.53	2.74	-0.10	0.07	2.00	0.07	2.00	0.07	0.00	0.000	0.08	0.000	0.08	0.000	0.43	0.44	0.43	0.005	0.5196	0.0000	0.61	6.51	6.560	0.184	6.567	0.002	7.681	82.312	1.217	1.215
Stage Start TP11	5 min gentle cruise while shooting	00:53:59	00:58:59	00:05:00	1500.00	0.00	38.20	0.00	40.65	0.00	40.74	0.00	0.50	0.000	0.53	0.000	0.53	0.000	0.90	0.90	0.90	0.000	0.2700	0.0000	0.32	3.38	0.506	0.000	0.506	0.000	0.592	6.346	15.758	15.758
Stage Start TP12	4 hour trawl	00:58:59	04:58:59	04:00:00	1750.03	0.16	278.10	0.01	282.75	0.01	283.23	0.05	203.86	0.000	207.27	0.000	207.62	0.000	3.34	3.28	3.29	0.014	47.3262	0.0000	55.35	593.18	0.228	0.001	0.228	0.000	0.267	2.857	35.005	35.002
Stage Start TP13	20 min haul in of nets	04:58:59	05:18:59	00:20:00	1399.95	0.62	82.50	0.00	85.36	0.00	85.48	0.00	4.03	0.000	4.17	0.000	4.18	0.000	1.07	1.10	1.09	0.010	1.3056	0.0000	1.53	16.36	0.313	0.003	0.313	0.000	0.366	3.918	25.505	25.525
Stage Start TP14	2.5 hr steaming to trawl site	05:18:59	07:48:59	02:30:00	2000.00	0.33	47.00	0.00	49.53	0.00	49.57	0.01	24.61	0.000	25.93	0.000	25.96	0.000	1.37	1.37	1.37	0.005	12.2922	0.0000	14.38	154.07	0.474	0.002	0.474	0.000	0.554	5.936	16.848	16.847
Stage Start TP15	15 minute gentle cruise to port	07:48:59	08:03:59	00:15:00	1300.00	0.39	36.70	0.00	39.14	0.00	39.16	0.00	1.25	0.000	1.33	0.000	1.33	0.000	0.72	0.74	0.74	0.008	0.6606	0.0000	0.77	8.28	0.496	0.005	0.496	0.000	0.580	6.213	16.075	16.095
Stage Start TP16	Tick over for 1 hour	08:03:59	09:03:59	01:00:00	1104.29	3.33	0.28	0.04	2.39	0.04	2.39	0.04	0.03	0.000	0.28	0.000	0.28	0.000	0.43	0.44	0.43	0.005	1.5606	0.0000	1.83	19.56	5.651	0.087	5.652	0.000	6.610	70.840	1.412	1.412
End Test	End of test	09:03:59																																

Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

	Work Observed Sum (kWh)	Work Compensated Sum (kWh)	Work Reduced Sum (kWh)	Fuel Mass (kg)	Fuel Volume (litres)	Fuel Energy (kWh)	SFC Mass (kg/kWh)	SFC Volume (L/kWh)	SFC Energy (kWh/kWh)	Efficiency Agg. (%)
Total over whole test	676.92	690.96	692.11	176.13	206.00	2207.59	0.254	0.298	3.190	31.352
Total over whole test (check)	676.92	690.95	692.10	176.13	206.00	2207.59	0.254	0.298	3.190	31.351
Total over census stages	676.89	690.44	691.60	173.14	202.50	2170.11	0.250	0.293	3.138	31.869
Total over census stage 1	234.25	239.24	239.48	62.20	72.75	779.66	0.260	0.304	3.256	30.717
Total over census stage 2	208.39	211.97	212.49	49.08	57.40	615.18	0.231	0.270	2.895	34.542
Total over census stage 3	234.25	239.24	239.62	61.85	72.34	775.28	0.258	0.302	3.235	30.908

Percentage differences of DayTrawl tests

Percentage difference between 2 DayTrawl tests (Positive values mean the benchmark was lower, negative values mean the technology tested was lower)

Benchmark	DayTrawl benchmark with new oil & filter
Technology tested	DayTrawl with new oil & filter, Belesta LC2 (5%)

Stage	Description	Start time	End time	Duration	Engine Speed Ave.	Torque Obs. Ave.	Torque Comp. Ave.	Torque Red. Ave.	Total Work done in stag Obs. Sum	Comp. Sum	Red. Sum	Stage fuel consumpt Initial	Final	Ave.	Total fuel consumed Mass	Volume	Energy	Specific fuel consumption in stage Instantan. Ave.	Aggregate over stage Mass	Volume	Energy	Engine Efficiency Ave.	Agg.
		hh:mm:ss	hh:mm:ss	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	(%)	(%)
Stage Start TP00	15 minute tick over under zero load																						
Stage Start TP01	15 minute gentle cruise from port			0.00	-0.01	0.00	-0.14	-0.03	-0.01	-0.14	-0.04	-2.63	-1.33	-1.61	-1.6829	-1.68	-1.68	-1.578	-1.647	-1.647	-1.647	1.601	1.675
Stage Start TP02	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.11	0.00	0.00	-0.11	0.00	-0.71	0.00	-0.43	-0.4337	-0.43	-0.43	-0.430	-0.432	-0.432	-0.432	0.432	0.434
Stage Start TP03	5 min gentle cruise while shooting			0.00	0.02	0.00	-0.13	0.00	0.01	-0.12	0.01	0.00	-1.12	-0.56	-0.4525	-0.45	-0.45	-0.583	-0.467	-0.467	-0.467	0.583	0.469
Stage Start TP04	4 hour trawl			0.00	0.00	0.00	-0.05	0.18	0.00	-0.05	0.18	-0.60	-0.30	-0.60	-0.5968	-0.60	-0.60	-0.772	-0.772	-0.772	-0.772	0.779	0.778
Stage Start TP05	20 min haul in of nets			0.00	0.00	0.00	-0.08	0.25	0.00	-0.08	0.25	0.00	-0.90	-0.05	-0.0458	-0.05	-0.05	-0.293	-0.291	-0.291	-0.291	0.290	0.292
Stage Start TP06	20 min tickover: net handling & unload																						
Stage Start TP07	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.13	0.23	0.00	-0.13	0.23	0.00	0.00	-0.28	-0.2203	-0.22	-0.22	-0.503	-0.447	-0.447	-0.447	0.506	0.449
Stage Start TP08	4 hour trawl			0.00	0.00	0.00	-0.05	0.33	0.00	-0.05	0.33	-0.30	0.30	-0.26	-0.2595	-0.26	-0.26	-0.589	-0.589	-0.589	-0.589	0.592	0.592
Stage Start TP09	20 min haul in of nets			0.00	0.00	0.00	-0.08	0.30	0.00	-0.08	0.30	0.00	0.00	0.00	0.0000	0.00	0.00	-0.295	-0.295	-0.295	-0.295	0.295	0.296
Stage Start TP10	20 min tickover: net handling & unload																						
Stage Start TP11	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.13	0.23	0.00	-0.13	0.23	0.00	0.00	0.00	0.0000	0.00	0.00	-0.226	-0.225	-0.225	-0.225	0.226	0.226
Stage Start TP12	4 hour trawl			0.00	0.00	0.00	-0.05	0.22	0.00	-0.05	0.22	-0.30	-0.30	-0.26	-0.2617	-0.26	-0.26	-0.481	-0.482	-0.482	-0.482	0.484	0.484
Stage Start TP13	20 min haul in of nets			0.00	0.00	0.00	-0.08	0.11	0.00	-0.08	0.10	0.00	0.00	0.29	0.2765	0.28	0.28	0.187	0.173	0.173	0.173	-0.186	-0.173
Stage Start TP14	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.11	0.04	0.00	-0.12	0.04	0.74	0.00	0.03	0.0342	0.03	0.03	-0.010	-0.005	-0.005	-0.005	0.009	0.005
Stage Start TP15	15 minute gentle cruise to port			0.00	0.00	0.00	-0.14	-0.01	0.00	-0.14	-0.01	0.00	0.00	0.10	0.0909	0.09	0.09	0.107	0.101	0.101	0.101	-0.107	-0.101
Stage Start TP16	Tick over for 1 hour																						
End Test	End of test																						

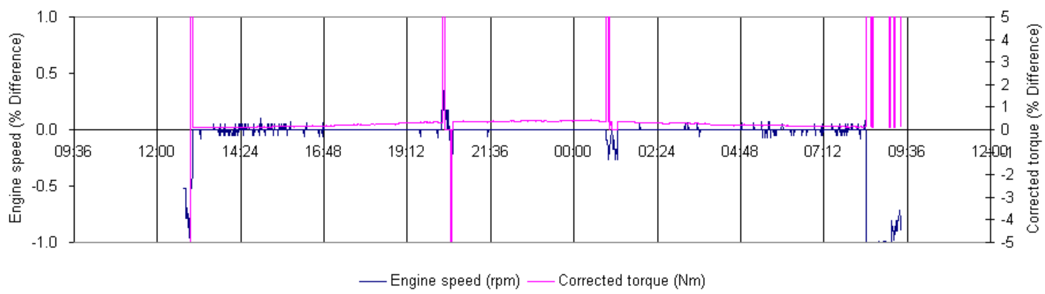
Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

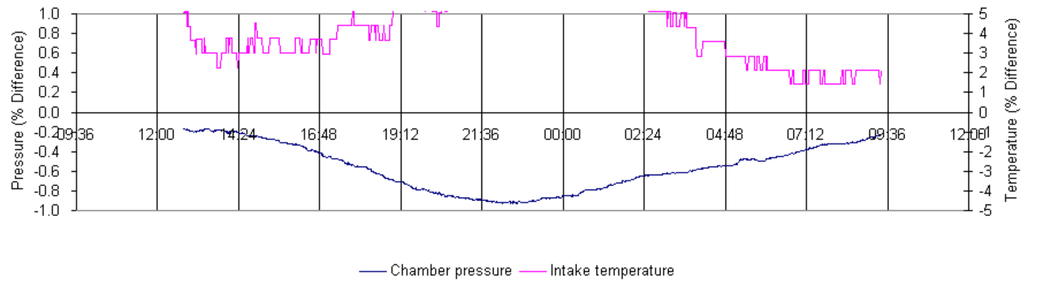
	Work Obs. Sum	Work Comp. Sum	Work Red. Sum	Fuel Mass	Fuel Volume	Fuel Energy	SFC Mass	SFC Volume	SFC Energy	Efficiency Agg.
Total over whole test	0.00	-0.05	0.22	-0.37	-0.37	-0.37	-0.588	-0.588	-0.588	0.591
Total over whole test (check)	0.00	-0.06	0.22	-0.37	-0.37	-0.37	-0.588	-0.588	-0.588	0.591
Total over census stages	0.00	-0.05	0.22	-0.34	-0.34	-0.34	-0.564	-0.564	-0.564	0.568
Total over census stage 1	0.00	-0.06	0.16	-0.56	-0.56	-0.56	-0.720	-0.720	-0.720	0.725
Total over census stage 2	0.00	-0.05	0.33	-0.25	-0.25	-0.25	-0.581	-0.581	-0.581	0.584
Total over census stage 3	0.00	-0.06	0.20	-0.19	-0.19	-0.19	-0.384	-0.384	-0.384	0.386

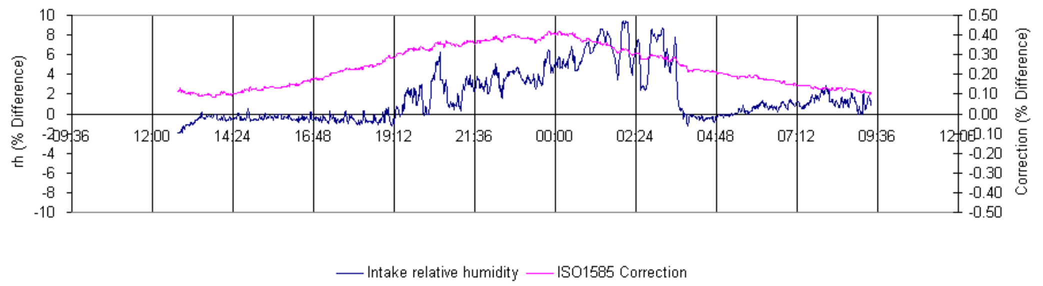
Narrative / Comment:

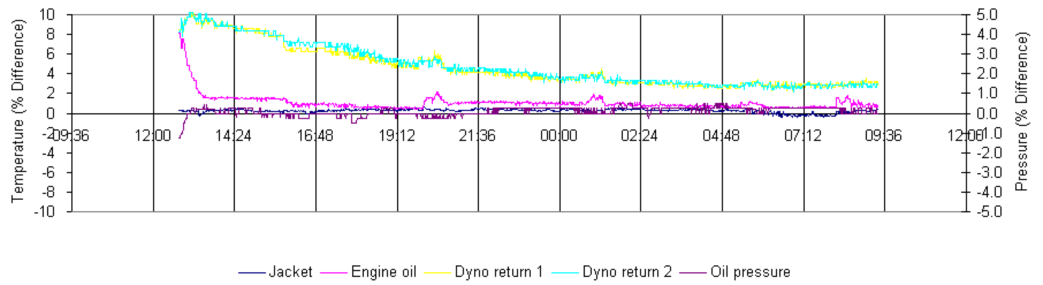
Specific fuel consumption is reduced for almost all stages in the test where the lubricating oil is treated with Belesta LC2 by between 1.647% and 0.005%. Small increases in SFC are observed for Stage 13 and Stage 15. Over all the census stages (i.e. excluding idle stages), the specific fuel consumption is reduced by 0.564%. During the 4 hour trawl stages are SFC improves by 0.772%, 0.589% and 0.482%. There is a trend of reduced improvements in SFC across the progression of the stages of the test.

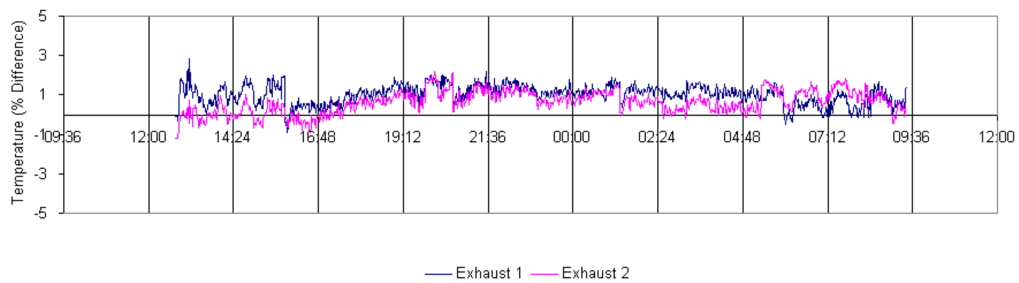
Percentage differences between DayTrawl tests - time series

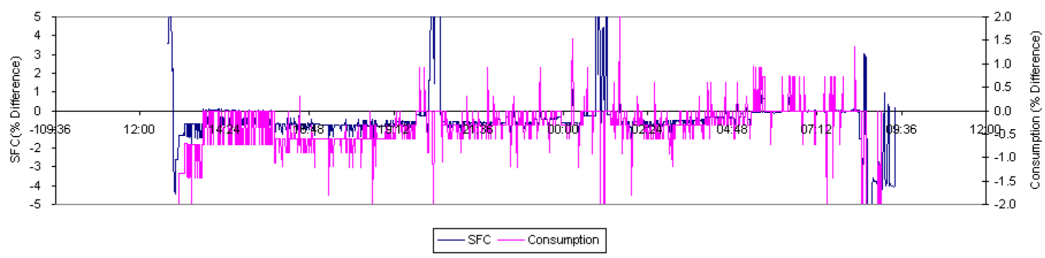












E. Belesta LC2 Lubricating oil additive – Phases C and D

The experimental results are presented using both graphical and tabular formats.

Firstly the results of Baseline diagnostic tests are presented graphically, before, during and after the main DayTrawl tests. These results are presented in confirmation that the test engine did not suffer any major malfunction throughout the test sequence. With exceptions where indicated, all Baseline tests are conducted on straight red diesel, without any of the technologies being examined being deployed. Thus, there should be excellent agreement between Baseline diagnostic tests, presuming the technology tested does not provide an effect beyond its deployments.

The main results of comparative testing are then presented using a tabular format. Firstly, the results of the Benchmark DayTrawl test are presented. Then the results of the DayTrawl test with the technology deployed are presented. Finally, a table of percentage differences in quantities found for each stage of the test cycle (presented in the first two tables) are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

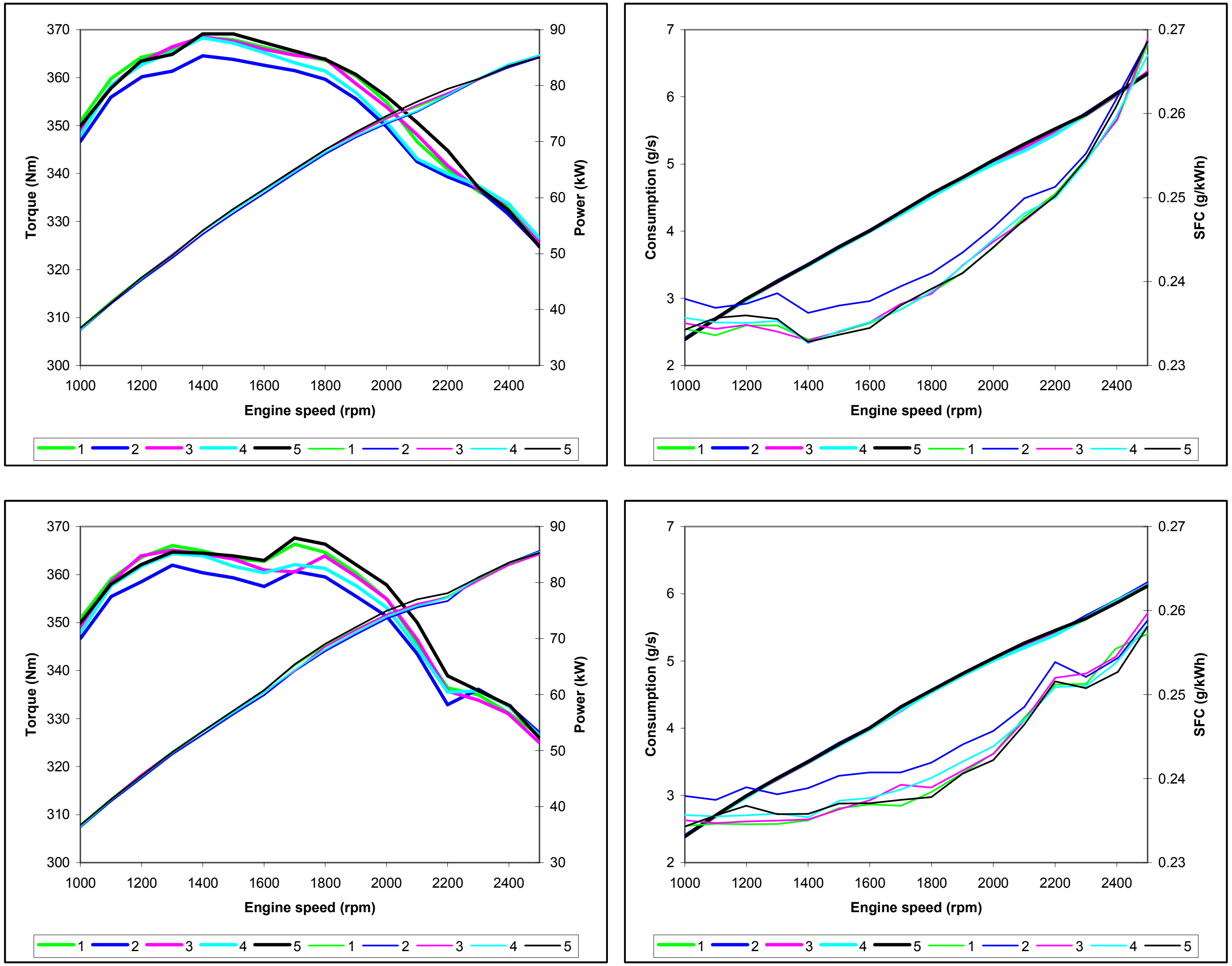
The main results of comparative testing are then presented using a graphical format. Firstly the time series of the Benchmark DayTrawl test are presented. Then the time series of the DayTrawl test with the technology deployed are presented. Finally, time series of the percentage differences in engine performance and fuel consumption parameters are presented. The percentage differences are calculated as:

((Value with technology – Benchmark value) / Benchmark value) x 100

This means that a positive percentage difference means that the value with technology was higher than the benchmark value without the technology. A negative percentage difference means that the value with the technology was lower than the benchmark value without the technology. For example, if the technology tested is found to 'work', the percentage difference in thermal efficiency should be positive and the percentage difference in specific fuel consumption should be negative.

For brevity, table and figure numbering are suspended until the Summary Results section below.

Comparison of Baseline diagnostic tests



Narrative:

Curves in upper boxes are for the ramping down stages of the test cycle. Curves in the lower boxes are for the ramping up (later) stages of the test cycle.

Curves indicate no significant malfunction occurred with the test engine.

Comparison between Tests 1 and 2, and 2 and 3 suggests, again, that when adding a new batch of lubricating oil (with or without lubricant additive), it seems that the new oil needs ‘running in’ before having full effect. There seems little difference between Tests 1 and 3, suggesting that the lubricating oil may have been changed ‘prematurely’ (of course, this occurred simply for the purposes of the tests). Comparing Test 3 and 4 leads to a small reduction in torque across the range and a small increase in SFC. Comparing Test 4 and Test 5 again confirms the idea that new oil (in this case without LC2) needs a run in period. Comparing Test 1 and Test 5 reveals consistent performance in torque, power and SFC. This suggests a possible residual after effect of LC2 on engine performance, even when virtually all of the oil containing LC2 is removed.

N.B. These tests were conducted with MPG-CAPS remnant concentrations at 30% of FFI recommended levels. This was done to ensure all tests in the Belesta sequence could be conducted on the same batch of fuel.

1 – BL003_200608 (same oil with 5% LC2, after DayTrawl), 2 – BL003_010708 (new oil, 5% LC2, 2nd rinse), 3 – BL003_030708 (new oil, 5% LC2, 2nd rinse, after DayTrawl), 4 – BL003_140708 (new oil again, no LC2), 5 – BL003_070708 (new oil again, no LC2, after DayTrawl)

DayTrawl test results

Test date	01/07/2008	Description	
Warm-up duration	00:09:39		DayTrawl with new oil & filter, Belesta LC2 (5%) (2nd rinse)
Test duration	20:40:00		DT002_010708_001_c
Total engine hour:	20:49:39		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)
Stage Start TP00	15 minute tick over under zero load	14:45:08	15:00:08	00:15:00	1162.00	7.97	-0.01	0.07	2.05	0.07	2.05	0.07
Stage Start TP01	15 minute gentle cruise from port	15:00:08	15:15:08	00:15:00	1300.00	0.00	36.70	0.00	39.08	0.00	39.11	0.00
Stage Start TP02	2.5 hr steaming to trawl site	15:15:08	17:45:08	02:30:00	2000.02	0.27	47.00	0.00	49.48	0.00	49.50	0.01
Stage Start TP03	5 min gentle cruise while shooting	17:45:08	17:50:08	00:05:00	1500.00	0.00	38.20	0.00	40.60	0.00	40.61	0.00
Stage Start TP04	4 hour trawl	17:50:08	21:50:08	04:00:00	1750.00	0.06	278.10	0.02	282.61	0.02	282.78	0.05
Stage Start TP05	20 min haul in of nets	21:50:08	22:10:08	00:20:00	1400.26	0.56	82.50	0.00	85.29	0.00	85.36	0.00
Stage Start TP06	20 min tickover: net handling & unload	22:10:08	22:30:08	00:20:00	1131.05	4.27	-0.01	0.14	2.05	0.14	2.06	0.14
Stage Start TP07	5 min gentle cruise while shooting	22:30:08	22:35:08	00:05:00	1500.00	0.00	38.20	0.00	40.60	0.00	40.63	0.00
Stage Start TP08	4 hour trawl	22:35:08	02:35:08	04:00:00	1750.00	0.00	278.10	0.01	282.62	0.01	282.93	0.05
Stage Start TP09	20 min haul in of nets	02:35:08	02:55:08	00:20:00	1400.00	0.00	82.50	0.00	85.29	0.00	85.40	0.00
Stage Start TP10	20 min tickover: net handling & unload	02:55:08	03:15:08	00:20:00	1131.84	4.19	-0.24	0.07	1.82	0.07	1.82	0.07
Stage Start TP11	5 min gentle cruise while shooting	03:15:08	03:20:08	00:05:00	1500.00	0.00	38.20	0.00	40.60	0.00	40.65	0.00
Stage Start TP12	4 hour trawl	03:20:08	07:20:08	04:00:00	1750.00	0.00	278.10	0.02	282.61	0.02	283.10	0.06
Stage Start TP13	20 min haul in of nets	07:20:08	07:40:08	00:20:00	1400.00	0.00	82.50	0.00	85.29	0.00	85.45	0.00
Stage Start TP14	2.5 hr steaming to trawl site	07:40:08	10:10:08	02:30:00	2000.03	0.26	47.00	0.00	49.48	0.00	49.56	0.00
Stage Start TP15	15 minute gentle cruise to port	10:10:08	10:25:08	00:15:00	1300.00	0.00	36.70	0.00	39.08	0.00	39.16	0.00
Stage Start TP16	Tick over for 1 hour	10:25:08	11:25:08	01:00:00	1111.24	2.42	0.20	0.06	2.26	0.06	2.27	0.06
End Test	End of test	11:25:08										

Stage	Total Work done in stage Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel consumption Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)	Total fuel consumed Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	Specific fuel consumption in stage Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate over stage Mass (kg/kWh)	Stdev (kg/kWh)	Volume (L/kWh)	Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Agg. (%)
Stage Start TP00	0.00	0.000	0.07	0.000	0.07	0.000	0.47	0.46	0.47	0.005	0.4194	0.0000	0.49	5.26	6.737	0.236	5.827	0.002	6.816	73.041	1.186	1.369
Stage Start TP01	1.25	0.000	1.33	0.000	1.33	0.000	0.77	0.76	0.76	0.004	0.6864	0.0000	0.80	8.60	0.515	0.003	0.516	0.000	0.603	6.464	15.482	15.471
Stage Start TP02	24.61	0.000	25.91	0.000	25.92	0.000	1.43	1.38	1.39	0.010	12.5190	0.0000	14.64	156.91	0.483	0.003	0.483	0.000	0.565	6.054	16.521	16.517
Stage Start TP03	0.50	0.000	0.53	0.000	0.53	0.000	0.89	0.90	0.89	0.005	0.2676	0.0000	0.31	3.35	0.504	0.003	0.503	0.000	0.589	6.310	15.840	15.849
Stage Start TP04	203.86	0.000	207.17	0.000	207.29	0.000	3.35	3.31	3.31	0.014	47.6820	0.0000	55.77	597.64	0.230	0.001	0.230	0.000	0.269	2.883	34.686	34.684
Stage Start TP05	4.03	0.000	4.17	0.000	4.17	0.000	1.07	1.10	1.09	0.010	1.3074	0.0000	1.53	16.39	0.314	0.003	0.313	0.000	0.366	3.928	25.439	25.461
Stage Start TP06	0.00	0.000	0.08	0.000	0.08	0.000	0.43	0.44	0.43	0.005	0.5208	0.0000	0.61	6.53	6.444	0.418	6.460	0.003	7.556	80.972	1.243	1.235
Stage Start TP07	0.50	0.000	0.53	0.000	0.53	0.000	0.91	0.91	0.91	0.000	0.2730	0.0000	0.32	3.42	0.513	0.000	0.513	0.000	0.600	6.434	15.543	15.543
Stage Start TP08	203.86	0.000	207.17	0.000	207.40	0.000	3.36	3.29	3.30	0.013	47.4672	0.0000	55.52	594.95	0.229	0.001	0.229	0.000	0.268	2.869	34.864	34.860
Stage Start TP09	4.03	0.000	4.17	0.000	4.17	0.000	1.07	1.10	1.09	0.010	1.3038	0.0000	1.52	16.34	0.313	0.003	0.312	0.000	0.365	3.915	25.522	25.540
Stage Start TP10	-0.01	0.000	0.07	0.000	0.07	0.000	0.42	0.43	0.43	0.004	0.5136	0.0000	0.60	6.44	7.143	0.209	7.159	0.002	8.373	89.726	1.118	1.115
Stage Start TP11	0.50	0.000	0.53	0.000	0.53	0.000	0.90	0.90	0.90	0.000	0.2700	0.0000	0.32	3.38	0.507	0.000	0.507	0.000	0.593	6.359	15.725	15.725
Stage Start TP12	203.86	0.000	207.17	0.000	207.53	0.000	3.34	3.28	3.29	0.011	47.3316	0.0000	55.36	593.25	0.228	0.001	0.228	0.000	0.267	2.859	34.984	34.981
Stage Start TP13	4.03	0.000	4.17	0.000	4.18	0.000	1.06	1.10	1.08	0.012	1.2996	0.0000	1.52	16.29	0.312	0.003	0.311	0.000	0.364	3.901	25.609	25.635
Stage Start TP14	24.61	0.000	25.91	0.000	25.95	0.000	1.36	1.36	1.36	0.002	12.2370	0.0000	14.31	153.38	0.472	0.001	0.472	0.000	0.552	5.911	16.918	16.918
Stage Start TP15	1.25	0.000	1.33	0.000	1.33	0.000	0.72	0.74	0.73	0.007	0.6594	0.0000	0.77	8.26	0.495	0.005	0.495	0.000	0.579	6.202	16.105	16.124
Stage Start TP16	0.02	0.000	0.26	0.000	0.26	0.000	0.42	0.44	0.43	0.006	1.5648	0.0000	1.83	19.61	5.936	0.131	5.933	0.000	6.940	74.368	1.345	1.345
End Test																						

Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

	Work Observed Sum (kWh)	Work Compensated Sum (kWh)	Work Reduced Sum (kWh)	Fuel Mass (kg)	Fuel Volume (litres)	Fuel Energy (kWh)	SFC Mass (kg/kWh)	SFC Volume (L/kWh)	SFC Energy (kWh/kWh)	Efficiency Agg. (%)
Total over whole test	676.89	690.56	691.35	176.32	206.23	2210.01	0.255	0.298	3.197	31.283
Total over whole test (check)	676.89	690.55	691.34	176.32	206.23	2210.01	0.255	0.298	3.197	31.282
Total over census stages	676.88	690.07	690.86	173.30	202.69	2172.17	0.251	0.293	3.144	31.805
Total over census stage 1	234.25	239.10	239.24	62.46	73.06	782.90	0.261	0.305	3.272	30.558
Total over census stage 2	208.39	211.87	212.11	49.04	57.36	614.71	0.231	0.270	2.898	34.505
Total over census stage 3	234.25	239.10	239.52	61.80	72.28	774.56	0.258	0.302	3.234	30.923

Test date	04/07/2008	Description	
Warm-up duration	00:04:42		DayTrawl with new oil & filter
Test duration	20:40:00		DT002_040708_001_c
Total engine hour:	20:44:42		

Stage	Description	Start time (hh:mm:ss)	End time (hh:mm:ss)	Duration (hh:mm:ss)	Engine Speed Ave. (RPM)	Engine Speed Stdev. (RPM)	Torque Observed Ave. (Nm)	Torque Observed Stdev. (Nm)	Torque Compensated Ave. (Nm)	Torque Compensated Stdev. (Nm)	Torque Reduced Ave. (Nm)	Torque Reduced Stdev. (Nm)
Stage Start TP00	15 minute tick over under zero load	12:45:14	13:00:14	00:15:00	1150.50	2.85	0.07	0.09	2.09	0.09	2.09	0.09
Stage Start TP01	15 minute gentle cruise from port	13:00:14	13:15:14	00:15:00	1299.93	0.27	36.70	0.00	39.03	0.00	39.04	0.00
Stage Start TP02	2.5 hr steaming to trawl site	13:15:14	15:45:14	02:30:00	2000.01	0.18	47.00	0.00	49.42	0.00	49.44	0.01
Stage Start TP03	5 min gentle cruise while shooting	15:45:14	15:50:14	00:05:00	1500.00	0.00	38.20	0.00	40.54	0.00	40.58	0.00
Stage Start TP04	4 hour trawl	15:50:14	19:50:14	04:00:00	1750.00	0.06	278.10	0.02	282.48	0.02	282.93	0.11
Stage Start TP05	20 min haul in of nets	19:50:14	20:10:14	00:20:00	1400.00	0.00	82.50	0.00	85.22	0.00	85.41	0.00
Stage Start TP06	20 min tickover: net handling & unload	20:10:14	20:30:14	00:20:00	1140.84	2.41	-0.11	0.10	1.91	0.11	1.91	0.11
Stage Start TP07	5 min gentle cruise while shooting	20:30:14	20:35:14	00:05:00	1500.25	0.50	38.20	0.00	40.54	0.00	40.63	0.00
Stage Start TP08	4 hour trawl	20:35:14	00:35:14	04:00:00	1750.01	0.09	278.10	0.01	282.48	0.01	283.27	0.11
Stage Start TP09	20 min haul in of nets	00:35:14	00:55:14	00:20:00	1400.00	0.33	82.50	0.00	85.22	0.00	85.51	0.00
Stage Start TP10	20 min tickover: net handling & unload	00:55:14	01:15:14	00:20:00	1144.89	4.50	-0.17	0.07	1.84	0.07	1.85	0.07
Stage Start TP11	5 min gentle cruise while shooting	01:15:14	01:20:14	00:05:00	1500.00	0.00	38.20	0.00	40.54	0.00	40.68	0.00
Stage Start TP12	4 hour trawl	01:20:14	05:20:14	04:00:00	1750.01	0.09	278.10	0.01	282.48	0.01	283.44	0.03
Stage Start TP13	20 min haul in of nets	05:20:14	05:40:14	00:20:00	1399.84	0.50	82.50	0.00	85.22	0.00	85.50	0.00
Stage Start TP14	2.5 hr steaming to trawl site	05:40:14	08:10:14	02:30:00	2000.02	0.32	47.00	0.00	49.42	0.00	49.57	0.00
Stage Start TP15	15 minute gentle cruise to port	08:10:14	08:25:14	00:15:00	1300.00	0.00	36.70	0.00	39.03	0.00	39.16	0.00
Stage Start TP16	Tick over for 1 hour	08:25:14	09:25:14	01:00:00	1110.02	2.99	0.15	0.05	2.17	0.05	2.17	0.05
End Test	End of test	09:25:14										

Stage	Total Work done in stage Observed Sum (kWh)	Observed Stdev. (kWh)	Compensated Sum (kWh)	Compensated Stdev. (kWh)	Reduced Sum (kWh)	Reduced Stdev. (kWh)	Stage fuel consumption Initial (g/s)	Final (g/s)	Ave. (g/s)	Stdev. (g/s)	Total fuel consumed Mass (kg)	Stdev. (kg)	Volume (litres)	Energy (kWh)	Specific fuel consumption in stage Instantaneous Ave. (kg/kWh)	Instantaneous Stdev. (kg/kWh)	Aggregate over stage Mass (kg/kWh)	Stdev (kg/kWh)	Volume (L/kWh)	Energy (kWh/kWh)	Engine Efficiency Ave. (%)	Agg. (%)
Stage Start TP00	0.00	0.000	0.07	0.000	0.07	0.000	0.43	0.44	0.44	0.005	0.3930	0.0000	0.46	4.93	6.249	0.235	5.370	0.004	6.281	67.306	1.278	1.486
Stage Start TP01	1.25	0.000	1.33	0.000	1.33	0.000	0.75	0.75	0.75	0.005	0.6726	0.0000	0.79	8.43	0.506	0.003	0.506	0.000	0.592	6.345	15.766	15.761
Stage Start TP02	24.61	0.000	25.88	0.000	25.89	0.000	1.39	1.37	1.37	0.005	12.3420	0.0000	14.44	154.69	0.477	0.002	0.477	0.000	0.558	5.976	16.735	16.733
Stage Start TP03	0.50	0.000	0.53	0.000	0.53	0.000	0.88	0.88	0.88	0.000	0.2640	0.0000	0.31	3.31	0.497	0.000	0.497	0.000	0.581	6.230	16.052	16.052
Stage Start TP04	203.86	0.000	207.07	0.000	207.40	0.000	3.32	3.28	3.28	0.012	47.2878	0.0000	55.31	592.70	0.228	0.001	0.228	0.000	0.267	2.858	34.995	34.993
Stage Start TP05	4.03	0.000	4.16	0.000	4.17	0.000	1.06	1.10	1.08	0.011	1.2990	0.0000	1.52	16.28	0.312	0.003	0.311	0.000	0.364	3.901	25.610	25.636
Stage Start TP06	0.00	0.000	0.08	0.000	0.08	0.000	0.43	0.44	0.43	0.005	0.5190	0.0000	0.61	6.51	6.833	0.336	6.847	0.004	8.008	85.818	1.170	1.165
Stage Start TP07	0.50	0.000	0.53	0.000	0.53	0.000	0.90	0.89	0.90	0.006	0.2688	0.0000	0.31	3.37	0.505	0.003	0.505	0.000	0.591	6.333	15.808	15.790
Stage Start TP08	203.86	0.000	207.07	0.000	207.65	0.000	3.33	3.27	3.27	0.014	47.1216	0.0000	55.11	590.62	0.227	0.001	0.227	0.000	0.265	2.844	35.161	35.157
Stage Start TP09	4.03	0.000	4.16	0.000	4.18	0.000	1.06	1.09	1.08	0.012	1.2942	0.0000	1.51	16.22	0.310	0.003	0.310	0.000	0.362	3.882	25.742	25.762
Stage Start TP10	-0.01	0.000	0.07	0.000	0.07	0.000	0.42	0.43	0.43	0.005	0.5124	0.0000	0.60	6.42	6.940	0.216	6.949	0.003	8.128	87.099	1.151	1.148
Stage Start TP11	0.50	0.000	0.53	0.000	0.53	0.000	0.89	0.88	0.89	0.006	0.2658	0.0000	0.31	3.33	0.499	0.003	0.499	0.000	0.584	6.256	16.004	15.985
Stage Start TP12	203.86	0.000	207.07	0.000	207.77	0.000	3.32	3.25	3.26	0.020	46.9902	0.0000	54.96	588.97	0.226	0.001	0.226	0.000	0.265	2.835	35.281	35.277
Stage Start TP13	4.03	0.000	4.16	0.000	4.18	0.000	1.06	1.08	1.07	0.008	1.2870	0.0000	1.51	16.13	0.308	0.002	0.308	0.000	0.360	3.861	25.885	25.899
Stage Start TP14	24.61	0.000	25.88	0.000	25.96	0.000	1.34	1.35	1.35	0.005	12.1110	0.0000	14.16	151.80	0.467	0.002	0.467	0.000	0.546	5.848	17.099	17.099
Stage Start TP15	1.25	0.000	1.33	0.000	1.33	0.000	0.71	0.73	0.73	0.008	0.6516	0.0000	0.76	8.17	0.490	0.005	0.489	0.000	0.572	6.129	16.296	16.317
Stage Start TP16	0.02	0.000	0.25	0.000	0.25	0.000	0.41	0.43	0.43	0.008	1.5312	0.0000	1.79	19.19	6.066	0.169	6.061	0.000	7.089	75.971	1.316	1.316
End Test																						

Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

	Work Observed Sum (kWh)	Work Compensated Sum (kWh)	Work Reduced Sum (kWh)	Fuel Mass (kg)	Fuel Volume (litres)	Fuel Energy (kWh)	SFC Mass (kg/kWh)	SFC Volume (L/kWh)	SFC Energy (kWh/kWh)	Efficiency Agg. (%)
Total over whole test	676.89	690.18	691.92	174.81	204.46	2191.06	0.253	0.295	3.167	31.579
Total over whole test (check)	676.89	690.17	691.91	174.81	204.46	2191.06	0.253	0.295	3.167	31.579
Total over census stages	676.88	689.71	691.45	171.86	201.00	2154.02	0.249	0.291	3.115	32.100
Total over census stage 1	234.25	238.97	239.32	61.87	72.36	775.41	0.259	0.302	3.240	30.864
Total over census stage 2	208.39	211.77	212.36	48.68	56.94	610.21	0.229	0.268	2.873	34.801
Total over census stage 3	234.25	238.97	239.77	61.31	71.70	768.40	0.256	0.299	3.205	31.204

Percentage differences of DayTrawl tests

Percentage difference between 2 DayTrawl tests (Positive values mean the benchmark was lower, negative values mean the technology tested was lower)

Benchmark: DayTrawl with new oil & filter, Belesta LC2 (5%) (2nd rinse)

Technology tested: DayTrawl with new oil & filter

Stage	Description	Start time	End time	Duration	Engine Speed Ave.	Torque Obs. Ave.	Torque Comp. Ave.	Torque Red. Ave.	Total Work done in stage Obs. Sum	Total Work done in stage Comp. Sum	Total Work done in stage Red. Sum	Stage fuel consumption Initial	Stage fuel consumption Final	Stage fuel consumption Ave.	Total fuel consumed Mass	Total fuel consumed Volume	Total fuel consumed Energy	Specific fuel consumption in stage Instantan. Ave.	Specific fuel consumption in stage Aggregate over stage Mass	Specific fuel consumption in stage Aggregate over stage Volume	Specific fuel consumption in stage Aggregate over stage Energy	Engine Efficiency Ave.	Engine Efficiency Agg.
		hh:mm:ss	hh:mm:ss	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	(%)	(%)
Stage Start TP00	15 minute tick over under zero load																						
Stage Start TP01	15 minute gentle cruise from port			0.00	-0.01	0.00	-0.13	-0.16	-0.01	-0.14	-0.17	-2.60	-1.32	-1.97	-2.0105	-2.01	-2.01	-1.802	-1.845	-1.845	-1.845	1.836	1.880
Stage Start TP02	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.11	-0.12	0.00	-0.11	-0.13	-2.80	-0.72	-1.40	-1.4139	-1.41	-1.41	-1.280	-1.290	-1.290	-1.290	1.293	1.307
Stage Start TP03	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.13	-0.08	0.00	-0.13	-0.08	-1.12	-2.22	-1.40	-1.3453	-1.35	-1.35	-1.322	-1.266	-1.266	-1.266	1.337	1.282
Stage Start TP04	4 hour trawl			0.00	0.00	0.00	-0.05	0.06	0.00	-0.05	0.06	-0.90	-0.91	-0.83	-0.8267	-0.83	-0.83	-0.882	-0.882	-0.882	-0.882	0.890	0.890
Stage Start TP05	20 min haul in of nets			0.00	-0.02	0.00	-0.08	0.06	-0.02	-0.10	0.04	-0.93	0.00	-0.63	-0.6425	-0.64	-0.64	-0.668	-0.681	-0.681	-0.681	0.673	0.686
Stage Start TP06	20 min tickover: net handling & unload																						
Stage Start TP07	5 min gentle cruise while shooting			0.00	0.02	0.00	-0.13	0.01	0.01	-0.12	0.02	-1.10	-2.20	-1.65	-1.5385	-1.54	-1.54	-1.675	-1.562	-1.562	-1.562	1.707	1.587
Stage Start TP08	4 hour trawl			0.00	0.00	0.00	-0.05	0.12	0.00	-0.05	0.12	-0.89	-0.61	-0.73	-0.7281	-0.73	-0.73	-0.845	-0.845	-0.845	-0.845	0.852	0.852
Stage Start TP09	20 min haul in of nets			0.00	0.00	0.00	-0.08	0.13	0.00	-0.08	0.13	-0.93	-0.91	-0.73	-0.7363	-0.74	-0.74	-0.852	-0.862	-0.862	-0.862	0.863	0.870
Stage Start TP10	20 min tickover: net handling & unload																						
Stage Start TP11	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.13	0.07	0.00	-0.13	0.07	-1.11	-2.22	-1.67	-1.5556	-1.56	-1.56	-1.736	-1.624	-1.624	-1.624	1.770	1.651
Stage Start TP12	4 hour trawl			0.00	0.00	0.00	-0.05	0.12	0.00	-0.05	0.12	-0.60	-0.91	-0.72	-0.7213	-0.72	-0.72	-0.839	-0.838	-0.838	-0.838	0.848	0.845
Stage Start TP13	20 min haul in of nets			0.00	-0.01	0.00	-0.08	0.06	-0.01	-0.09	0.05	0.00	-1.82	-1.02	-0.9695	-0.97	-0.97	-1.071	-1.021	-1.021	-1.021	1.077	1.032
Stage Start TP14	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.11	0.03	0.00	-0.11	0.03	-1.47	-0.74	-1.03	-1.0297	-1.03	-1.03	-1.053	-1.056	-1.056	-1.056	1.065	1.067
Stage Start TP15	15 minute gentle cruise to port			0.00	0.00	0.00	-0.13	0.00	0.00	-0.13	0.00	-1.39	-1.35	-1.17	-1.1829	-1.18	-1.18	-1.168	-1.183	-1.183	-1.183	1.183	1.197
Stage Start TP16	Tick over for 1 hour																						
End Test	End of test																						

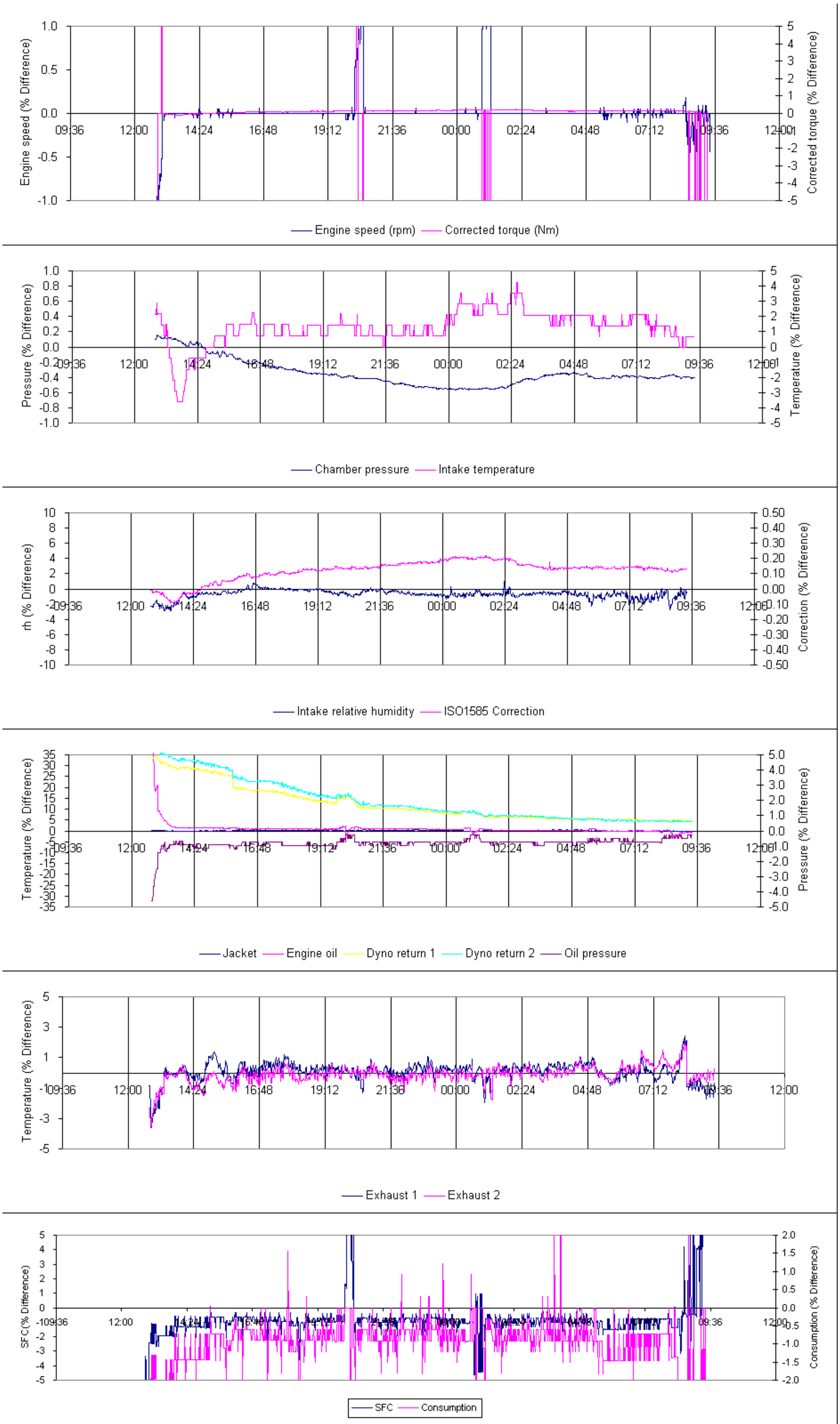
Fuel	M&W Batch 4 BS590 diesel	
Specific gravity	0.855	kg/litre
Calorific value	45.12	MJ/kg
	12.534	kWh/kg
	10.716	kWh/litre

	Total Work Obs. Sum	Total Work Comp. Sum	Total Work Red. Sum	Total fuel Mass	Total fuel Volume	Total fuel Energy	SFC Mass	SFC Volume	SFC Energy	Engine Efficiency Agg.
Total over whole test	0.00	-0.05	0.08	-0.86	-0.86	-0.86	-0.940	-0.940	-0.940	0.948
Total over whole test (check)	0.00	-0.05	0.08	-0.86	-0.86	-0.86	-0.939	-0.939	-0.939	0.948
Total over census stages	0.00	-0.05	0.09	-0.84	-0.84	-0.84	-0.920	-0.920	-0.920	0.929
Total over census stage 1	0.00	-0.06	0.03	-0.96	-0.96	-0.96	-0.990	-0.990	-0.990	1.000
Total over census stage 2	0.00	-0.05	0.12	-0.73	-0.73	-0.73	-0.850	-0.850	-0.850	0.857
Total over census stage 3	0.00	-0.05	0.11	-0.80	-0.80	-0.80	-0.901	-0.901	-0.901	0.909

Narrative / Comment:

This table compares the performance of the test engine at the point where the engine has had a second oil change with oil dosed with Belesta LC2 in a 5% by volume proportion (before) with the performance when the engine has had a third oil change without the oil being conditioned with LC2 (after). Improvements in SFC are obtained across all stages with a third oil change and these improvements are relatively consistent. Across all census stages, the incremental improvement in SFC is 0.920%.

Percentage differences between DayTrawl tests - time series



Further comparison between DayTrawl tests between Phase A and Phase C

Percentage difference between 2 DayTrawl tests (Positive values mean the benchmark was lower, negative values mean the technology tested was lower)

Benchmark: DayTrawl benchmark with new oil & filter

Technology tested: DayTrawl with new oil & filter, Belesta LC2 (5%) (2nd rinse)

Stage	Description	Start time	End time	Duration	Engine Speed	Torque			Total Work done in stag			Stage fuel consumpr			Total fuel consumed			Specific fuel consumption in stage				Engine Efficiency	
																		Instantan.	Aggregate over stage				
					Ave.	Obs. Ave.	Comp. Ave.	Red. Ave.	Obs. Sum	Comp. Sum	Red. Sum	Initial	Final	Ave.	Mass	Volume	Energy	Ave.	Mass	Volume	Energy	Ave.	Agg.
		hh:mm:ss	hh:mm:ss	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	(%)	(%)
Stage Start TP00	15 minute tick over under zero load																						
Stage Start TP01	15 minute gentle cruise from port			0.00	0.00	0.00	-0.27	-0.11	0.00	-0.27	-0.11	1.32	1.33	1.33	1.3286	1.33	1.33	1.441	1.440	1.440	1.440	-1.420	-1.420
Stage Start TP02	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.23	-0.06	0.00	-0.23	-0.06	1.42	0.00	0.53	0.5397	0.54	0.54	0.592	0.598	0.598	0.598	-0.586	-0.594
Stage Start TP03	5 min gentle cruise while shooting			0.00	0.02	0.00	-0.26	-0.11	0.01	-0.25	-0.10	1.14	1.12	0.85	0.9050	0.90	0.90	0.941	1.002	1.002	1.002	-0.934	-0.992
Stage Start TP04	4 hour trawl			0.00	0.00	0.00	-0.10	0.07	0.00	-0.10	0.07	0.00	0.00	-0.36	-0.3573	-0.36	-0.36	-0.428	-0.426	-0.426	-0.426	0.431	0.428
Stage Start TP05	20 min haul in of nets			0.00	0.02	0.00	-0.16	0.04	0.02	-0.14	0.06	0.00	-0.90	-0.14	-0.1375	-0.14	-0.14	-0.199	-0.195	-0.195	-0.195	0.196	0.195
Stage Start TP06	20 min tickover: net handling & unload																						
Stage Start TP07	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.26	-0.04	0.00	-0.26	-0.04	0.00	1.11	0.28	0.2203	0.22	0.22	0.312	0.257	0.257	0.257	-0.313	-0.257
Stage Start TP08	4 hour trawl			0.00	0.00	0.00	-0.09	0.15	0.00	-0.10	0.15	0.00	-0.30	-0.33	-0.3301	-0.33	-0.33	-0.480	-0.479	-0.479	-0.479	0.483	0.481
Stage Start TP09	20 min haul in of nets			0.00	0.00	0.00	-0.16	0.10	0.00	-0.16	0.10	0.00	0.00	-0.39	-0.3668	-0.37	-0.37	-0.488	-0.469	-0.469	-0.469	0.489	0.471
Stage Start TP10	20 min tickover: net handling & unload																						
Stage Start TP11	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.26	0.02	0.00	-0.26	0.02	0.00	0.00	0.00	0.0000	0.00	0.00	-0.020	-0.020	-0.020	-0.020	0.020	0.020
Stage Start TP12	4 hour trawl			0.00	0.00	0.00	-0.10	0.17	0.00	-0.10	0.17	-0.30	-0.30	-0.25	-0.2504	-0.25	-0.25	-0.423	-0.423	-0.423	-0.423	0.425	0.425
Stage Start TP13	20 min haul in of nets			0.00	0.00	0.00	-0.16	0.07	0.00	-0.16	0.07	-0.93	0.00	-0.15	-0.1843	-0.18	-0.18	-0.217	-0.256	-0.256	-0.256	0.222	0.257
Stage Start TP14	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.23	0.01	0.00	-0.23	0.01	0.00	-0.73	-0.42	-0.4150	-0.42	-0.42	-0.429	-0.426	-0.426	-0.426	0.429	0.428
Stage Start TP15	15 minute gentle cruise to port			0.00	0.00	0.00	-0.27	-0.01	0.00	-0.27	-0.02	0.00	0.00	-0.10	-0.0909	-0.09	-0.09	-0.082	-0.076	-0.076	-0.076	0.082	0.076
Stage Start TP16	Tick over for 1 hour																						
End Test	End of test																						

Fuel	M&W Batch 4 BS590 diesel
Specific gravity	0.855 kg/litre
Calorific value	45.12 MJ/kg
	12.534 kWh/kg
	10.716 kWh/litre

	Work Obs. Sum	Work Comp. Sum	Work Red. Sum	Fuel Mass	Fuel Volume	Fuel Energy	SFC Mass	SFC Volume	SFC Energy	Eff. Agg.
Total over whole test	0.00	-0.11	0.11	-0.26	-0.26	-0.26	-0.369	-0.369	-0.369	0.370
Total over whole test (check)	0.00	-0.11	0.11	-0.26	-0.26	-0.26	-0.369	-0.369	-0.369	0.370
Total over census stages	0.00	-0.11	0.12	-0.25	-0.25	-0.25	-0.363	-0.363	-0.363	0.365
Total over census stage 1	0.00	-0.11	0.05	-0.15	-0.15	-0.15	-0.204	-0.204	-0.204	0.205
Total over census stage 2	0.00	-0.10	0.15	-0.33	-0.33	-0.33	-0.476	-0.476	-0.476	0.478
Total over census stage 3	0.00	-0.11	0.15	-0.28	-0.28	-0.28	-0.431	-0.431	-0.431	0.433

Narrative / Comment:

This table compares the performance of the test engine at the benchmark condition (when the engine had its first oil change without the oil dosed with Belesta LC2) with the performance when the engine had its second oil change with the oil being conditioned with LC2 (after). As the stages progress, the general trend is that the SFC improves with the "2nd rinse" of LC2, but the lubricant additive consistently outperforms the straight oil (0.426%, 0.479% and 0.423%) during the 4 hour long trawl stages of the cycle. Over all census stages the SFC improvement is 0.363%.

Further comparison of DayTrawl tests between Phase A and Phase D

Percentage difference between 2 DayTrawl tests (Positive values mean the benchmark was lower, negative values mean the technology tested was lower)

Benchmark: DayTrawl benchmark with new oil & filter
Technology tested: DayTrawl with new oil & filter

Stage	Description	Start time	End time	Duration	Engine Speed Ave.	Torque Obs. Ave.	Torque Comp. Ave.	Torque Red. Ave.	Total Work done in stage Obs. Sum	Total Work done in stage Comp. Sum	Total Work done in stage Red. Sum	Stage fuel consumption Initial	Stage fuel consumption Final	Stage fuel consumption Ave.	Total fuel consumed Mass	Total fuel consumed Volume	Total fuel consumed Energy	Specific fuel consumption in stage Instantan. Ave.	Specific fuel consumption Aggregate over stage Mass	Specific fuel consumption Aggregate over stage Volume	Specific fuel consumption Aggregate over stage Energy	Engine Efficiency Ave.	Engine Efficiency Agg.
		hh:mm:ss	hh:mm:ss	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	(%)	(%)
Stage Start TP00	15 minute tick over under zero load																						
Stage Start TP01	15 minute gentle cruise from port			0.00	-0.01	0.00	-0.40	-0.27	-0.01	-0.41	-0.28	-1.32	0.00	-0.66	-0.7086	-0.71	-0.71	-0.387	-0.432	-0.432	-0.432	0.390	0.434
Stage Start TP02	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.34	-0.18	0.00	-0.34	-0.18	-1.42	-0.72	-0.88	-0.8818	-0.88	-0.88	-0.696	-0.700	-0.700	-0.700	0.700	0.705
Stage Start TP03	5 min gentle cruise while shooting			0.00	0.02	0.00	-0.39	-0.19	0.01	-0.38	-0.18	0.00	-1.12	-0.56	-0.4525	-0.45	-0.45	-0.393	-0.276	-0.276	-0.276	0.391	0.277
Stage Start TP04	4 hour trawl			0.00	0.00	0.00	-0.14	0.13	0.00	-0.14	0.13	-0.90	-0.91	-1.18	-1.1811	-1.18	-1.18	-1.306	-1.305	-1.305	-1.305	1.324	1.322
Stage Start TP05	20 min haul in of nets			0.00	0.00	0.00	-0.24	0.10	0.00	-0.24	0.10	-0.93	-0.90	-0.77	-0.7791	-0.78	-0.78	-0.866	-0.875	-0.875	-0.875	0.871	0.883
Stage Start TP06	20 min tickover: net handling & unload																						
Stage Start TP07	5 min gentle cruise while shooting			0.00	0.02	0.00	-0.39	-0.03	0.01	-0.38	-0.01	-1.10	-1.11	-1.38	-1.3216	-1.32	-1.32	-1.369	-1.309	-1.309	-1.309	1.389	1.326
Stage Start TP08	4 hour trawl			0.00	0.00	0.00	-0.14	0.27	0.00	-0.14	0.27	-0.89	-0.91	-1.06	-1.0558	-1.06	-1.06	-1.321	-1.320	-1.320	-1.320	1.339	1.338
Stage Start TP09	20 min haul in of nets			0.00	0.00	0.00	-0.24	0.23	0.00	-0.24	0.23	-0.93	-0.91	-1.11	-1.1004	-1.10	-1.10	-1.336	-1.327	-1.327	-1.327	1.356	1.345
Stage Start TP10	20 min tickover: net handling & unload																						
Stage Start TP11	5 min gentle cruise while shooting			0.00	0.00	0.00	-0.39	0.09	0.00	-0.39	0.09	-1.11	-2.22	-1.67	-1.5556	-1.56	-1.56	-1.755	-1.644	-1.644	-1.644	1.790	1.672
Stage Start TP12	4 hour trawl			0.00	0.00	0.00	-0.14	0.29	0.00	-0.14	0.29	-0.90	-1.22	-0.97	-0.9699	-0.97	-0.97	-1.258	-1.258	-1.258	-1.258	1.276	1.274
Stage Start TP13	20 min haul in of nets			0.00	-0.01	0.00	-0.24	0.14	-0.01	-0.25	0.12	-0.93	-1.82	-1.16	-1.1521	-1.15	-1.15	-1.286	-1.275	-1.275	-1.275	1.301	1.291
Stage Start TP14	2.5 hr steaming to trawl site			0.00	0.00	0.00	-0.34	0.04	0.00	-0.34	0.04	-1.47	-1.46	-1.44	-1.4404	-1.44	-1.44	-1.477	-1.477	-1.477	-1.477	1.498	1.500
Stage Start TP15	15 minute gentle cruise to port			0.00	0.00	0.00	-0.40	-0.01	0.00	-0.40	-0.01	-1.39	-1.35	-1.26	-1.2727	-1.27	-1.27	-1.250	-1.258	-1.258	-1.258	1.266	1.274
Stage Start TP16	Tick over for 1 hour																						
End Test	End of test																						

Fuel	M&W Batch 4 BS590 diesel
Specific gravity	0.855 kg/litre
Calorific value	45.12 MJ/kg
	12.534 kWh/kg
	10.716 kWh/litre

	Work Obs. Sum	Work Comp. Sum	Work Red. Sum	Total fuel Mass	Total fuel Volume	Total fuel Energy	SFC Mass	SFC Volume	SFC Energy	Engine Efficiency Agg.
Total over whole test	0.00	-0.17	0.20	-1.11	-1.11	-1.11	-1.305	-1.305	-1.305	1.322
Total over whole test (check)	0.00	-0.17	0.20	-1.11	-1.11	-1.11	-1.305	-1.305	-1.305	1.322
Total over census stages	0.00	-0.16	0.20	-1.08	-1.08	-1.08	-1.280	-1.280	-1.280	1.297
Total over census stage 1	0.00	-0.17	0.09	-1.10	-1.10	-1.10	-1.192	-1.192	-1.192	1.207
Total over census stage 2	0.00	-0.14	0.27	-1.06	-1.06	-1.06	-1.321	-1.321	-1.321	1.339
Total over census stage 3	0.00	-0.17	0.26	-1.07	-1.07	-1.07	-1.328	-1.328	-1.328	1.346

Narrative / Comment:

This table compares the starting DayTrawl test in the Belesta sequence of tests, with the closing DayTrawl test in the Belesta sequence of tests. In each case, the engine has received an oil change and an oil filter change only, that is, the LC2 lubricant conditioner was not added in either case. The result is interesting as an improvement in SFC of 1.280% is obtained across all the census stages of the tests.

Summary of Results

Table 05: Summary of DayTrawl test data

Date Conducted	Date Added	Description	Torque Drift Correction			Fuel		Whole test - excluding tick over stages Consumption			Total work done			Specific fuel consumption			Efficiency	Change (Volume)	Change (Volume)
			Dyno days	Gain	Offset	Density	GCV	Mass	Volume	Energy	Obs. Work	Comp. Work	Reduced Work	Mass	Volume	Energy			
						(kg/m3)	(kJ/kg)	(kg)	(litres)	kWh, fuel	(kWh)	(kWh)	(kWh)	(kg/kWh)	(litres/kWh)	(kWh fuel / kWh	(%)	%	%
25/03/2008	16/05/2008 07:08	Fossil DayTrawl Test - without use of Vaughan EM	21.411	1.01222	-2.27558	0.855	45.288	180.07	210.61	2265.28	676.89	693.22	692.12	0.260	0.304	3.273	30.554	0.000	
26/03/2008	16/05/2008 07:10	Fossil DayTrawl Test - with use of Vaughan EM co	22.346	1.01269	-2.48298	0.855	45.288	178.76	209.07	2248.74	676.88	694.27	693.98	0.258	0.301	3.240	30.861	-0.996	
28/03/2008	16/05/2008 07:11	Fossil DayTrawl - after exhaust modification	23.359	1.01242	-2.46293	0.855	45.288	178.12	208.32	2240.70	676.88	694.02	692.44	0.257	0.301	3.236	30.903	-1.130	
31/03/2008	16/05/2008 07:13	Fossil DayTrawl - 2nd test after exhaust modificati	24.301	1.01210	-2.42565	0.855	45.288	177.05	207.08	2227.31	676.87	693.65	690.45	0.256	0.300	3.226	30.999	-1.438	
04/04/2008	05/04/2008 18:21	Short test with HTM silencer	24.594	1.01200	-2.41402	0.855	45.288	11.49	13.44	144.59	40.82	41.96	41.62	0.276	0.323	3.474	28.787	0.000	
08/04/2008	08/05/2008 07:23	Fossil DayTrawl - DayTrawl without perm. Magnets	25.547	1.01168	-2.37630	0.855	45.288	177.27	207.33	2230.00	676.87	693.19	691.58	0.256	0.300	3.225	31.012	0.000	
09/04/2008	08/05/2008 07:35	Fossil DayTrawl - DayTrawl with perm. Magnets	26.492	1.01136	-2.33891	0.855	45.288	176.64	206.59	2222.07	676.88	692.85	692.39	0.255	0.298	3.209	31.160	-0.472	
25/04/2008	15/05/2008 18:40	ShortDayTrawl with 2.5 inch CSM exhaust	26.693	1.01129	-2.33095	0.855	45.288	11.58	13.54	145.68	40.82	41.90	41.59	0.278	0.326	3.503	28.549		
01/05/2008	15/05/2008 19:34	Short DayTrawl 3 inch CSM exhaust	26.836	1.01124	-2.32527	0.855	45.288	11.45	13.40	144.09	40.82	41.90	41.83	0.274	0.320	3.444	29.032	0.443	
01/05/2008	15/05/2008 19:35	Short DayTrawl 3 inch CSM exhaust	26.912	1.01122	-2.32226	0.855	45.288	11.41	13.35	143.59	40.82	41.90	41.83	0.273	0.319	3.433	29.131	0.101	
01/05/2008	15/05/2008 19:36	Short DayTrawl 3 inch CSM exhaust	26.986	1.01119	-2.31937	0.855	45.288	11.40	13.33	143.42	40.82	41.90	41.82	0.273	0.319	3.429	29.160	0.000	
14/05/2008	29/06/2008 09:33	DayTrawl with large and small maxpower magnets	28.202	1.01078	-2.27123	0.855	45.288	175.01	204.69	2201.66	676.88	692.22	691.50	0.253	0.296	3.184	31.41	-0.431	
20/05/2008	29/06/2008 09:36	DayTrawl with maxpower magnets removed	29.136	1.01047	-2.23426	0.855	45.288	175.45	205.21	2207.22	676.88	691.87	690.26	0.254	0.297	3.198	31.27	0.000	
13/06/2008	29/06/2008 09:42	DayTrawl for Ffi additive testing - no tablets	30.074	1.01015	-2.19712	0.855	45.122	176.89	206.88	2217.07	676.88	691.52	689.05	0.257	0.300	3.218	31.08	0.000	0.000
14/06/2008	29/06/2008 09:44	DayTrawl with Ffi additive	30.992	1.00984	-2.16078	0.855	45.122	175.23	204.95	2196.34	676.88	691.18	690.02	0.254	0.297	3.183	31.42	-1.075	-1.075
16/06/2008	29/06/2008 09:47	DayTrawl benchmark with new oil & filter	31.989	1.00951	-2.12131	0.855	45.122	173.73	203.20	2177.54	676.88	690.82	690.05	0.252	0.294	3.156	31.69	0.000	-1.925
18/06/2008	29/06/2008 09:50	DayTrawl with new oil & filter, Belesta LC2 (5%)	32.995	1.00917	-2.08150	0.855	45.122	173.14	202.50	2170.11	676.89	690.44	691.60	0.250	0.293	3.138	31.87	-0.564	-2.479
01/07/2008	06/07/2008 07:30	DayTrawl with new oil & filter, Belesta LC2 (5%) (2	33.990	1.00883	-2.04211	0.855	45.122	173.30	202.69	2172.17	676.88	690.07	690.86	0.251	0.293	3.144	31.80	-0.363	-2.282
04/07/2008	06/07/2008 07:33	DayTrawl with new oil & filter	34.976	1.00850	-2.00307	0.855	45.122	171.86	201.00	2154.02	676.88	689.71	691.45	0.249	0.291	3.115	32.10	-1.280	-3.181

Discussion and Conclusions

Key Findings

Results from all DayTrawl tests relevant to the Fuel Systems Testing work reported herein are brought together in Table 05 above. The central findings of the test work are as follows:

- The FuelVantage Digital Fuel Treatment system, marketed by Vaughan Industries Ltd (http://www.magyk.com/) brought about a **1.00%** improvement in specific fuel consumption for the CSM Dynamometer Test Cell diesel engine.
- The Ethos Maxpower large permanent magnet fuel conditioner system, marketed by Ethosworld.com Ltd (http://www.max-power.org.uk/index.php) brought about a **0.47%** improvement in specific fuel consumption for the CSM Dynamometer Test Cell diesel engine.
- Belester LC2, a lubricating oil additive marketed by Belesta (http://www.belesta.com/), a subsidiary of Belzona Polymerics Limited (http://www.belzona.com/) brought about specific fuel consumption savings of between **0.36%** and **0.56%**.
- Further testing of both large and small Max-power permanent magnets, marketed by Ethosworld.com Ltd (http://www.max-power.org.uk/index.php), and the latter being applied with opposing poles on the fuel lines leading to individual injectors, brought about specific fuel consumption savings of **0.43%**.
- MPG-CAPS fuel combustion catalyst tablets, marketed by Fuel Freedom International, FFi Europe Ltd, (http://www.myffi.biz/t-MPG-CAPS.aspx) brought about specific fuel consumption savings of **1.08%**
- It is possible that combinations of technologies could produce further enhancements. For example, providing an engine treatment dose of MPG-CAPS and following this with a sequence of oil changes (with and without Belesta LC2) brought about a **3.18%** improvement in specific fuel consumption.
- The methodology for calculating these changes has been refined in comparison to results presented in the *Diesel Fuel Additives Testing; An abstracted report from the Biofuels for the Fishing Industry project"*, prepared for SeaFISH in February 2008. The revised methodology has been applied to the data with the result that Additive A produces a **0.44%** improvement, but the remaining additives B to G produce improvements no greater than **0.08%** improvement.
- Exhaust systems, marketed by Vortex Performance Exhausts Ltd (http://www.vortex-performance-exhausts.co.uk/index.php) ultimately did not feature in the comparative testing programme. Work for Vortex is ongoing but is still at the developmental testing stage at present.

- The Calorific Value Enhancer (CVE) system, marketed by Enersol Ltd (http://www.enersolcorp.com/motive/index.cfm) ultimately did not feature in the comparative testing programme as Enersol were undertaking developmental testing elsewhere.

Indicators for Further Work

A modified DayTrawl test schedule

Through interactions with suppliers and manufacturers during the progress of the work, accounts have been provided of in-service tests conducted elsewhere where the improvements offered by products have been greater in magnitude than have been determined here. While the evidence base for such tests remains uncertain, the possibility of fuel savings in service of greater magnitude than determined herein cannot be ruled out. This is in part due to the specific nature of the DayTrawl test itself.

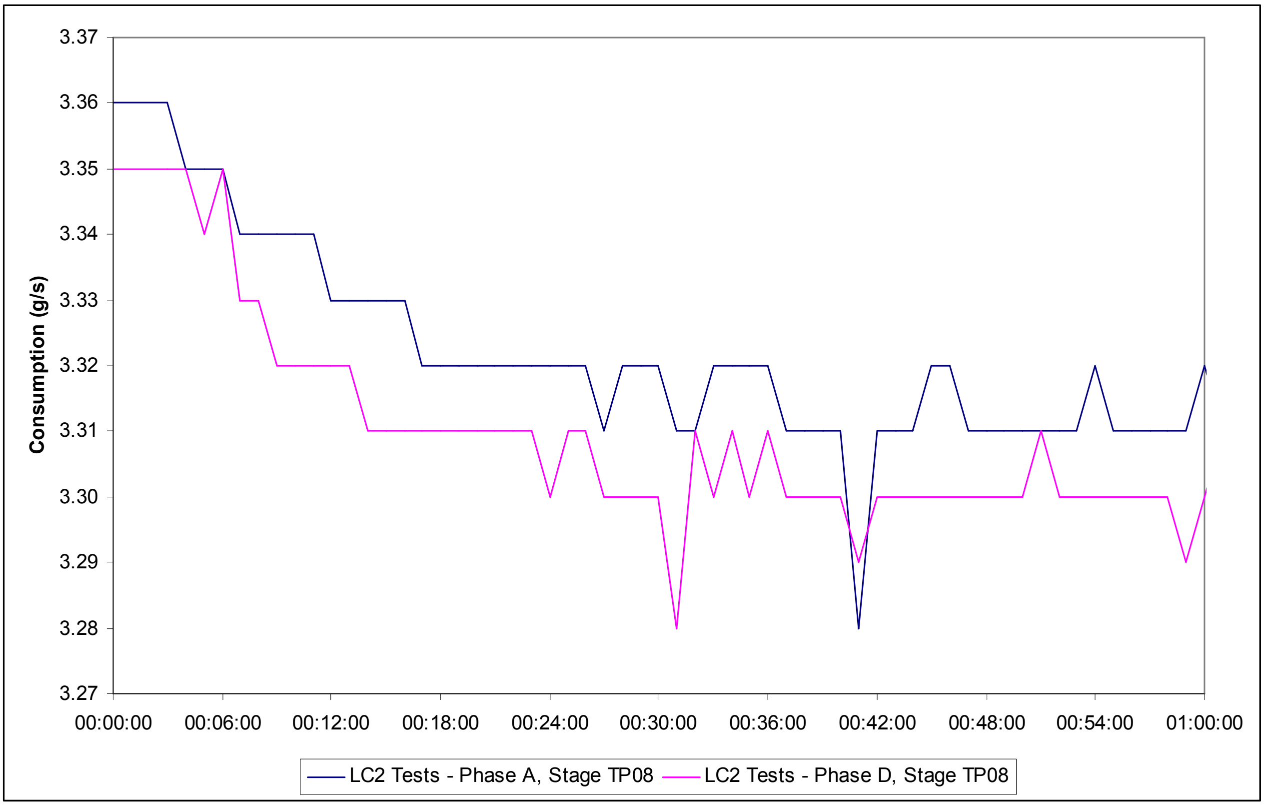


Figure 12: Fuel consumption transients after change from DayTrawl Stage TP07 to TP08 (4 hour trawl) at time 00:00:00.

For the DayTrawl tests reported in this work, the stage fuel consumption figures indicate that for the 4 hour trawl stages, fuel consumption at the beginning of the stage is greater than the fuel consumption at the end of the stage whereas the final and average stage fuel consumption values are invariably similar. This suggests that fuel consumption is higher during or immediately after transients in load on the engine; fuel consumption drops when the engine has settled to a new operating condition within the test schedule and is confirmed by the plot of minute average fuel consumption for the first hour of a 4 hour trawl stage presented in Figure 12. For both tests presented, the fuel consumption immediately after the stage change is approximately 1.5% higher than the ‘asymptotic’ value.

Practically, during in-service operation, the load on the engine is likely to be varying continuously, the degree of variation depending on, among other factors, the severity of the wave, wind and current conditions. As the load varies, the engine rotational speed will vary but will recover toward a value determined by the nominal rack position, effected by the engine speed control function of the governor. The governor function allows more or less fuel to be metered to the engine injectors if the engine speed is lower than or higher than, respectively, the value defined by the nominal rack position set by the skipper. If, during in-service operation, the load on the engine remains steady (as is specified during each stage of the DayTrawl test schedule), the governor will meter precisely the amount of fuel required to keep the engine speed constant, and at a speed corresponding to the nominal rack position set by the skipper.

Due to the constant loading conditions defined and maintained by the SCADA system, at present the various stages of the DayTrawl test cycle must be considered rather ideal in nature, because they effectively factor out the role of the governor in regulating the engine speed in the face of varying engine load. It is to be expected that a dynamic loading condition on the engine is closer to the norm rather than the exception in in-service operation and thus in consideration of comparative testing results herein, centred around the current DayTrawl test cycle, it should be noted that they are indicative of the fuel savings obtainable during the most ideal operating conditions of weather and tide.

Of course this raises the question of how fuel economy is affected under less than ideal conditions. After a large transient in loading, from 38Nm to 287Nm between stages 07 and 08, Figure 12 indicates that fuel consumption increases. These increases do not reflect the action of the governor, as explained above, rather they reflect the ultimate establishment of a new thermal equilibrium of the engine with its operating environment. If the regulating function of the governor was embodied in the DayTrawl test schedule by superimposing a low amplitude load variation over the steady loading values of each stage, then it is suspected that the aggregate engine efficiency would reduce further (fuel consumption would increase further for the same work delivered) in comparison to the results obtained currently. Such measures are presented in Figure 13 with the period of variation greatly exaggerated for illustrative purposes only. A key point to note is although the load variations (and the consequent engine speed variations) appear rather random, the SCADA system would ensure that this prescribed duty was followed exactly, DayTrawl test, after DayTrawl test.

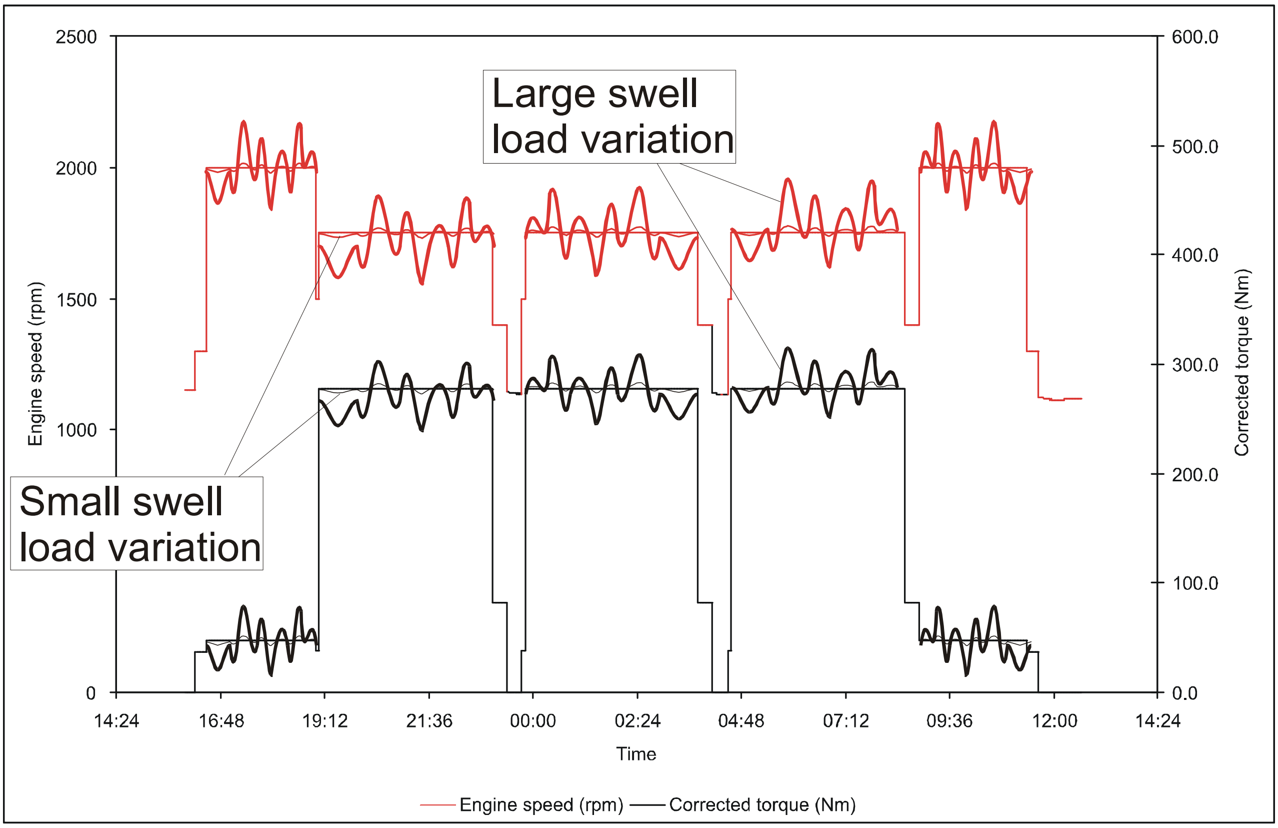


Figure 13: Illustration of proposed improvement of DayTrawl test schedule to reflect dynamic loading environment. Period of variations greatly exaggerated.

The schematic schedule illustrated in Figure 13 could be 'synthesized' or alternatively, and more appropriately, torque and engine speed instrumentation could be installed on an in-service vessel and record the actual duty cycle and the test cell could be programmed to repeat the observed cycle exactly - and repeatedly.

Whether or not the effect of any of the technologies tested herein would be enhanced under a revised 'dynamic loading' DayTrawl test schedule depends on whether or not they have been designed to suit such dynamic operating conditions.

Heat recovery options

The ~600ºC exhaust gas temperatures measured suggests a Carnot efficiency of 67% for the engine. Assuming that the test engine follows a practical ideal diesel cycle, with compression ratio of 16:1 and a cut-off ratio of between 3 and 4, suggests a practical ideal efficiency between 53% and 57%. Within the DayTrawl test cycle results presented herein, the highest observed thermal efficiency of the diesel engine in converting energy in the fuel into useful shaft work is around 35%. Undoubtedly some of the work developed by the engine will be used to power auxiliary engine components, such as the fuel pump, which has reduced the observed efficiency to this value. However, whichever measure of efficiency is adopted it is clear that a substantial amount of the energy contained within the fuel is ultimately delivered as heat; 65% of the energy in the fuel is dissipated as heat taking the observed efficiency as the 'safest' value. The results of the tests reported herein and in the earlier fuel additives report, suggest that the magnitudes of fuel economy improvements brought about by the various technologies are likely to be small. To have a beneficial effect on the economics of fishing comparable with the significance of the fluctuations in the price of fuel, reductions in fuel consumption may need to be more significant. Given the magnitude of the fuel energy dissipated as heat, utilisation of this heat could provide more substantial economic benefits in two ways suggested below:

- Utilisation of recovered heat to drive ammonia absorption refrigerators that displace auxiliary diesels driving vapour compression refrigerators. Cost savings are realised by no longer needing to fuel the auxiliary diesel engine. Coefficients of performance of certain absorption refrigeration cycles are in the range of 40%, meaning that around 40% of the high grade heating power of the exhaust gas steam could be used to provide cooling power to fish stores. A 100kW diesel engine with a thermal efficiency of 35% may be able to provide refrigeration power of the same order.
- Utilisation of recovered heat to produce steam to drive a generator to power auxiliary vessel systems, displacing diesel generating sets. Cost savings are realised by no longer needing to fuel the auxiliary diesel genset. Rankine cycle efficiency would be around 30% meaning that around 30% of the energy available in the high grade (600ºC) heat in the exhaust gas stream could be converted into electrical energy. A 100kW diesel engine with a thermal efficiency of 35% may be able to provide electrical power of the same order.

In the face of prolonged high prices for marine fuel, both of these options would be worth investigation with a desk based feasibility study in the first instance.

Further investigation of (electro-)magnetic fuel conditioning technologies

Undoubtedly the topic of (electro-)magnetic fuel conditioning technology ignites huge debate in those interested in the subject of improving fuel economy. One only has to peruse one of the many internet chat sites dealing with the subject (such as: http://boards.fool.co.uk/Message.asp?mid=10969874&sort=whole) to note that, those promoting the technology have genuine belief in and stand by their products, mainly on the basis of a body of empirical evidence built up through (satisfied!) client interactions. At the same time, there are other individuals who quickly become incensed with what they view as undoubtedly 'flaky', 'erroneous' or even 'disingenuous' attempts to provide scientific evidence that testifies to the efficacy or otherwise of (electro-)magnetic technologies in improving fuel economy.

The electrical conductivity of diesel hydrocarbons lies somewhere 2.5×10^{-10} S/m and 1×10^{-11} S/m, the former corresponding to high sulphur diesel fuel and the latter corresponding to ultra low sulphur diesel fuel. In comparison, water has an electrical conductivity around 5 orders of magnitude higher. With electrical conductivities as low as that for diesel, it is straightforward to understand why sceptics find it hard to conceive that a direct interaction exist between an (electro-)magnetic field and the fuel, let alone that it can lead to improvements in fuel economy reported anecdotally—and factually in our results.

The Ethos Max-power Ltd explanation for how their product works requires just such a direct interaction:

"As the fuel passes through the powerful magnetic field of the MAXPower's neodymium super magnets, its molecules gain a beneficial positive charge which helps them to combine more readily with the negatively charged oxygen in the air. Additionally, the clusters of molecules are split apart from one another and are aligned in a much more orderly fashion …"

The purpose of the work reported herein was to determine whether there was an effect, not to try to explain or interpret the results. Given the controversy surrounding the issue of (electro-)magnetic fuel conditioners, it is clear that the results for this technology obtained from the test rig should initiate further work. If it is accepted that the purely hydrocarbon species in diesel fuel do not undergo electromagnetic interactions, then suggestions for further work, specifically pertaining to (electro-)magnetic fuel conditioning units include:

1. Undertaking further test procedures to confirm, or otherwise, the findings of this round of testing. In the current round, three separate, independent test procedures with (electro-)magnetic technologies (each involving test durations over 42 hours) all showed improvements in fuel economy between 0.4% and 1.0%.
2. Investigation of whether the fuel economy improvements arising from (electro-)magnetic conditioners actually result from the devices acting upon non-hydrocarbon components of the fuel, for example: i) low concentrations of water, ii) additive compounds routinely added to diesel, iii) chemical species with sulphur which are known to have higher electrical conductivities. Sulphur compounds in diesel include thiols (R-SH), thiophenes (C_4H_4S – very crudely, ring compounds containing sulphur atoms), organic sulphides (R-S-R) and disulphides (R-S-S-R).
3. Comparison of the actual strength of (electro-)magnetic fields surrounding fuel lines with field strengths used in field ionization of hydrocarbons for analytical determinations. Field ionization mass spectrometry of cyclohexane was reported by Klespera and Röllgen in 1999. (*International Journal of Mass Spectrometry, Vol 185-187, pp 189-194*). Cyclohexane is a known chemical species of diesel fuel. Such studies show that it is in fact possible to ionise at least one component of diesel fuel, but field strengths have to be very high.
4. Investigation of whether there are any circumstances where diesel or its constituent species can be considered a weakly electro-rheological or magneto-rheological fluid, (a fluid with a

viscosity characteristic in shear that is dependent on the strength of (electro-)magnetic field applied). Experimental work with paraffin-water emulsions reported by C. Balan, C. Broboana D., Gheorghiu, E. and Vékás, 2008 (*J. Non-Newtonian Fluid Mech. Vol 154, pp 22–30*) suggest that this may not be the case, although this is being queried. However, the viscosity of electro- or magneto- rheological fluids can reduce in the presence of the respective fields. Reductions in viscosity may produce improvements in atomisation of fuel at the injectors.