

Fuel flow meters

Introduction

Fuel flow meters are used to give a real-time indication of engine fuel economy on a commercial fishing vessel during operations, but are also an effective means to monitor engine and vessel performance. Fitting fuel flow meters can have a positive impact on fuel consumption, particularly with respect to savings made whilst steaming. Even small adjustments to revs settings can result in significant fuel savings of around 10 - 20%.

A Seafish study investigated the accuracy and precision of fuel flow meters looking at the most accurate way to meter fuel consumption, the cost to fishermen, how to fit the device and whether the sensors were suited to the environmental conditions onboard fishing vessels. This fact sheet reports on the results of the study which covered:

- **Phase I:** desk study investigation;
- **Phase II:** testing the accuracy and repeatability of selected fuel meters under laboratory conditions;
- **Phase III:** testing the accuracy and repeatability of six selected individual fuel meters on a marine diesel engine;

- **Phase IV:** testing the accuracy of four complete fuel monitoring solutions on a marine diesel engine.

Testing was carried out at the Camborne School of Mines (University of Exeter) test cell facility.

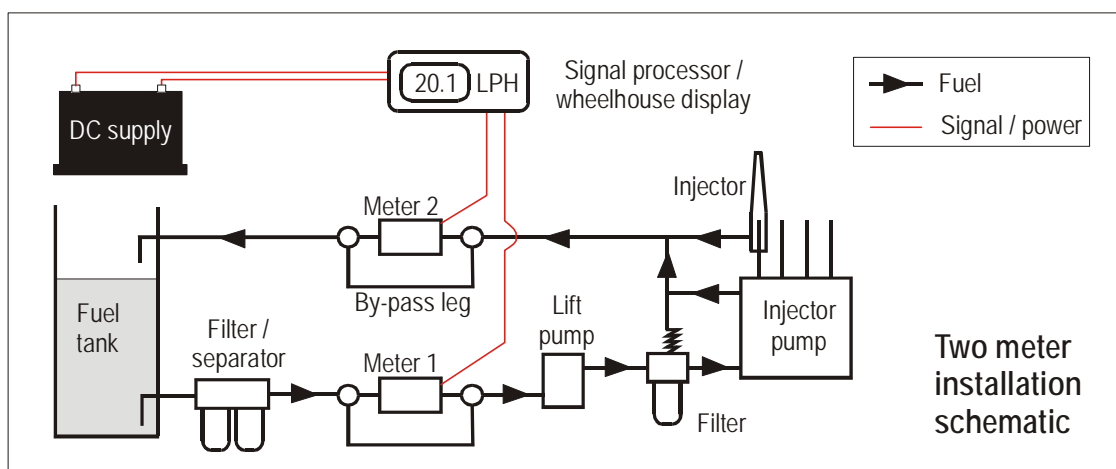
Choosing a meter

Rated Flow Rates

For accuracy the most important factor in selecting a suitable fuel meter is determining the diesel feed and return rates at full power for the engine. Using this information it is possible to select fuel meters with the correct range for the flows to be measured.

One or two meters

Some diesel engines have negligible return flow rates and will only require installation of a single meter on the feed line. Diesel engines with significant return fuel flows may require fitting a second meter. The full scale range of the second meter should match the maximum return flow expected. Fuel consumption is found by taking the difference between the two meter readings.



Wheelhouse display

As well as considering the type and range of flow rate sensor to use, the means of displaying the fuel consumption sensed must be considered too.

Some manufacturer's devices are supplied with bespoke display units. Others are not, and the display unit will need to be matched to the sensors and procured. A crucial point in this respect is ensuring that the display unit can accommodate the type of signal provided by the fuel meter namely a voltage, a current, a pulse count or a frequency, and has enough channels for two-meter installations.

Temperature corrections

'Smarter' metering systems will make corrections for the temperatures of the fuels. This is especially important for two meter systems because the return fuel can be much warmer than fuel fed to the engine, and thus will have expanded. One significant advantage of mass flow rate meters (such as Coriolis meters) is that they do not require temperature correction.

Power

Some fuel meter sensors or their displays need power. The work found that most manufacturers of meters provided the same meter with a range of power options, including 12 and 24V systems.



Meter by-pass legs

Some meters use moving parts that work by opposing the flow of fuel. If such parts jammed, then this could be a significant issue during operations. For this reason it is recommended that inline fuel meters are installed with a by-pass leg.

Pressure across the meter

When selecting a meter, also consider the pressure drop across the meter; the lower this is the better.

Size, bulk and materials

Some of the meters identified in the work were quite bulky and their adoption would mean that greater planning for the installation will be required. However, most devices were quite compact and should pose few problems in installation. Look for devices that are specifically designed for fuel use.

Accuracy and repeatability of fuel flow meters

Individual flow meters

In the experimental work six different individual meters were selected that spanned three classes:

- Turbine flow meters
- Positive displacement meters
- Ultrasonic, pressure differential and true mass flow meters.

Macnaught M1: A positive displacement meter of oval gear type (~£260/unit ex VAT).
<http://www.macnaughteurope.com/>

Flowtech Oval MIII: A positive displacement meter of oval gear type (~£190/unit ex VAT).
<http://www.oval.co.kr/>

Kobold DRZ: A positive displacement meter of oscillating piston type. (~£258/unit ex VAT).
<http://www.kobold.com/>

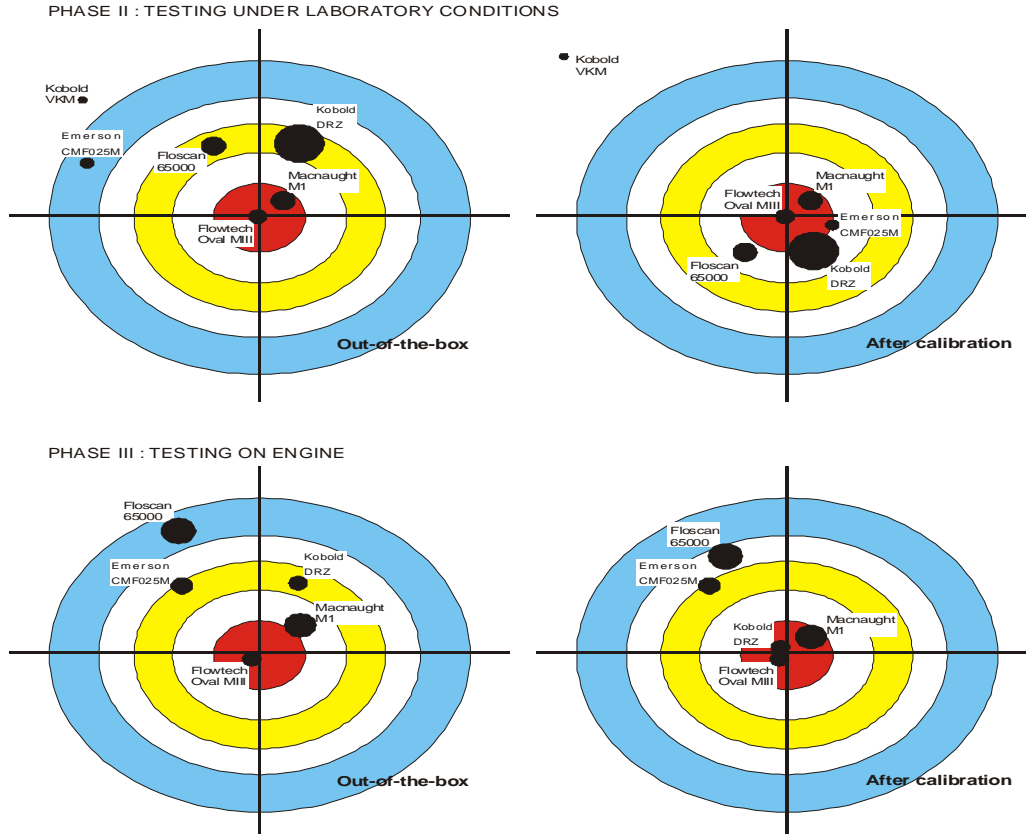
Kobold VKM: A pressure differential meter of variable aperture type (~£190/unit ex VAT). <http://www.kobold.com/>

Floscan 65000 Cruisemaster: A turbine meter (£583 for 2 meters and wheelhouse display unit.) <http://www.floscan.com/>

Emerson CMF025M: A true mass flow meter, of Coriolis type. (~£3500). <http://www.emersonprocess.com/>

Only the Floscan 65000 provided a complete package of meters. The others all required a wheelhouse display unit. A DataTrack 285 unit capable of handling 2 input signals (voltage, current, pulse count or frequency) was used (~cost: £330 ex VAT). <http://www.bomara.com/>

The investigation results are summarised below. On the targets, the greater the distance of the centre of the circle from the centre of the target, the more inaccurate the device. Devices with smaller circles on the target have better repeatability. The targets on the left show the relative performance of the meters before calibration (out-of-the-box), and the targets on the right show the accuracy and repeatability after calibration. The upper targets reflect laboratory experimental conditions, the lower targets reflect testing on a marine diesel engine, equipped with an accurate fuel delivery system.



Individual flow meters - Conclusions

- The targets show that one of the best all round performers was the Flowtech Oval MIII. After calibration and testing the Kobold DRZ performs well too.
- Skippers with engines rated in excess of 650kW (800 hp) are advised to look at the Coriolis meter option. The potential savings associated with accurate and precise indication of fuel consumption may justify the greater expense of this type of meter.
- There was a notable lack of turnkey solutions available to fishermen. Further research was needed to offer better information and choice to fishermen.

Turnkey solutions

The same tests were also carried out on four complete fuel monitoring systems:

Floscan C/M 6500



Oval Mill Flowmate



AIC 4008



P. H. Fuel Consumption meter



The P.H. Flowmeter was developed in Denmark and is a bespoke fully fitted system, designed specifically to fit a vessels specific engine and engine room requirements. Although this system has not undergone testing at the test cell, it has been included in this fact sheet as it is currently being used by a large number of Scandinavian and UK flag fishing vessels. The sensor can cope with changes in fuel oil temperature (up to a temperature of 150°C) as fuel is measured from the supply from the day tank to the engine.

For the P.H. Flowmeter the price quoted on page 6 of this fact sheet includes design, construction and fitting, and also includes an eight week payment/removal guarantee. If the system once fitted is not working accurately and reliably after an eight week period the system will be removed free of charge with no payment required.

Wheelhouse display

All of the systems come with a wheelhouse display unit as part of the package. The units can all display and record the fuel flow rate and display a totalised fuel flow. By monitoring the flow rates on the displays, skippers can adjust the revolutions of the engine and the pitch of the propeller optimally to produce lower fuel consumption, or the most economic speed.

Temperature Compensation

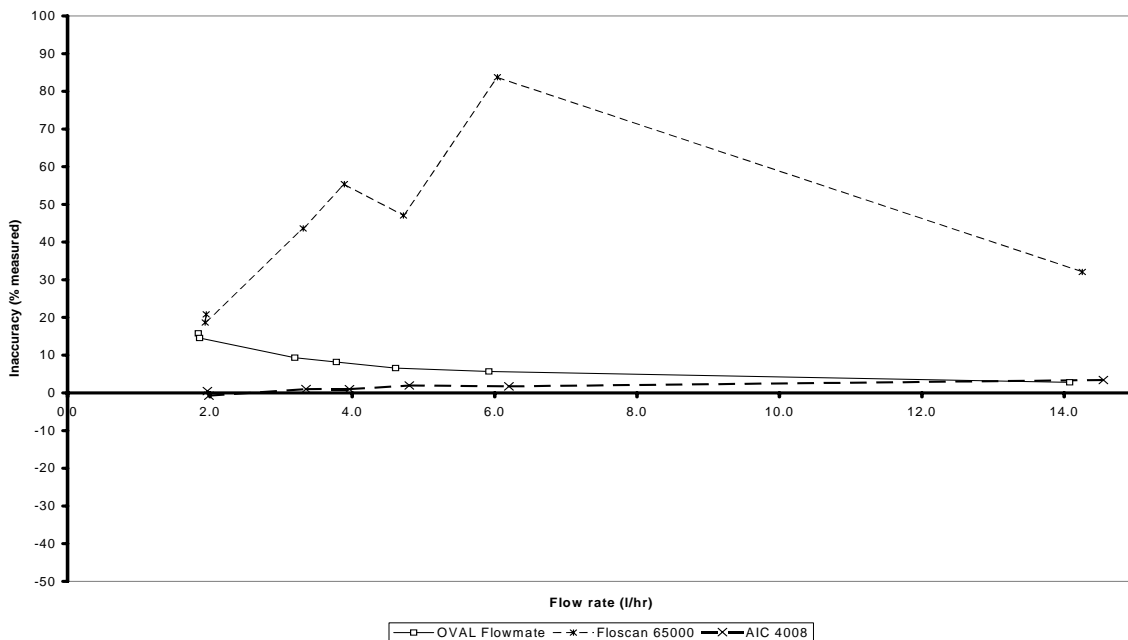
On some larger engines the return fuel can be much warmer than the fuel fed to the engine and will have expanded. Fuel meters that use volume as a means of measurements need to account for this expansion in order to provide accurate measurements. The AIC and P.H flow meters overcome this issue by only measuring the fuel supplied to the engine from the fuel tank.

The Oval Flow pet meter uses a flow computer to compensate for the fuel expansion due to temperature change. The Oval MIII and Floscan 65000 do not account for expansion and are thus therefore not recommended on engines where this may be an issue.

Meter Accuracy

The accuracies of the units vary. In previous trials carried out on board fishing vessels skipper's found it very difficult to calibrate the fuel meters once installed on their engines. This led to large variations in the fuel consumption indicated compared to the actual amounts of fuel consumed by the vessel. In order to take account of this, testing of the fuel meters at the test cell has been done 'out of the box' that is, as delivered by the manufacturers. The test cell results for the 3 units tested are shown in the chart below:

Accuracy of flow meters tested on the CSM Dynamometer Test Cell Engine versus fuel consumption



Units used a Datatract 284 signal processor and display unit, except the AIC 4008 which used a bespoke processor and display.

Comparison of complete fuel monitoring systems

Device	Oval Mill	Oval Flowpet	Flowsan C/M 65000	AIC 4008	P.H. Flowmeter
Meter type	Oval Gear	Oval Gear	Turbine meter	Oscillation pattern	System A–AB-B-D and E type
Quoted Accuracy	0.50%		Not reported	Acc +/- 1% Rep +/- 0.2%	N/a
Flowrate (l/h)	100	10-1600 l/hr	Not reported	200 l/hr	250-5500 l/hr
Cost (£) per meter	£225	Full installation	£583	Full installation	Full installation incl fitting
Est cost of full installation (not fitted)	£755	£2,640	£1,500	£1,500	€5,000 - €8,000 in the range 500 – 1200 Hp.
Inaccuracy of indicated flow rate 'out of the box' (% FS)	6.81%	Not tested	39.47%	1.83%	Tested by manufacturer
Flowrate 'out of the box' (% FS)	0.33%	Not tested	6.78%	0.05%	Tested by manufacturer
Temperature compensated	No	Yes	No	Yes	Yes
Fitting included	No	No	No	No	Yes
Fuel range	1.5 – 500 l/h	10-1600 l/hr	1-180 l/hr	4-200 l/hr	Range up to 5,500 l/hr
HP	Up to 750 Hp	750 Hp	Up to 270 Hp		Up to 25,000 Hp
Display system	Tracker 283 Digital indicator	Flow computer with temperature compensation	Floscan analogue and digital fuel display units	BC 3033 Display	Standard P.H. Flowmeter version 1.0 & optimiser system 2.0 for total fuel management

Contact details:

Device	Company website	UK/Ireland Distributor	Contact
Oval Mill	www.oval.co.jp	www.icenta.co.uk	T: 0845 895 1020
Oval Flowpet	www.oval.co.jp	www.icenta.co.uk	T: 0845 895 1020
Flowsan C/M 65000	www.flowsan.com	www.merlinequipment.com	T: 01202 697979
AIC 4008	www.flowmeter-aic.com/	www.btrack.co.uk	T: 01373 466500
P. H. Flowmeter	www.ph-maskinfabrik.dk	www.marfrie.nl	T: ++31 (0) 6 17476583

Complete fuel monitoring systems - Conclusions

- For the smaller to medium class of engines (up to 750 Hp), with no requirement for temperature compensation, the Oval Mill system supplied by Incenta Controls looks to provide the most cost effective solution. The fitting of this system proved to be straight forward with fitting instructions supplied by the manufacturer.
- Skippers with vessels with larger engines (>750 Hp) or a requirement for temperature compensation are advised to investigate temperature compensated units in order to achieve a good level of accuracy. The AIC 4008 combined with the B3033 signal processor provided an accurate indication of engine fuel consumption in our tests and would suit vessels with a fuel usage of up to 200 l/hr.
- From our tests larger vessels with engine demands above this 200 l/hr level should consider the Flowpet supplied by Incenta or the bespoke P.H. Flowmeter system. The P.H Flowmeter although the most expensive system on test is the only one that is built specifically for each vessel and supplied fully fitted. Both these meters account for changes in fuel temperature.

Recommendations

- It will be difficult for skippers to improve on sensor calibration procedures conducted in a laboratory, or in a manufacturer's quality assurance department, if trying to calibrate a meter on board. Fuel meters should thus be calibrated before they are installed and it is recommended that meters requiring calibration on-board are avoided, if possible. If this issue is taken into account, the oval gear meters have proved the most accurate and repeatable devices tested 'out-of-the-box'.
- By following the guidelines set down in this fact sheet, interested skippers will be able to ensure they purchase the right flow meter to meet their needs
- Whilst great effort and care was taken to source meters suitable for the fishing industry, other suitable units are available on the market and this fact sheet is not an endorsement of those devices tested.

For further information contact:

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This fact sheet updates FS18-12.08
 December 2008 which covered six individual
 fuel flow meters.