Measure for measure

Claus Møller Petersen explains why A.P. Moller - Maersk, the world's highest volume bunker buyer, is installing mass flow meters in an effort to stamp out the practice of short deliveries of bunker fuel and make the industry more transparent

Claus Møller Petersen is Business Development Manager for the A.P. Moller - Maersk Group, a worldwide organisation with about 117,000 employees and offices in around 130 countries. Its global headquarters are in Copenhagen, Denmark. In addition to owning one of the world's largest shipping companies, the group is also involved in a wide range of activities within the energy, shipbuilding, retail and manufacturing industries.

Contact:
Claus Møller Petersen
Maersk Oil Trading
Tel: +45 3363 4187
Fax: +45 3312 4431
Email: MOTBD@maersk.com
Web: www.maersk.com

Disputes over the quantity of fuel delivered by a bunker barge to a receiving vessel remain a daily issue in the shipping world. As a result of the problems this can cause, A. P. Moller - Maersk has embarked on a project to install mass flow meters onboard its vessels. This is a deliberate move designed to improve transparency in the bunker industry. At the same time, it will assist in making bunkering operations much smoother and easier because the constant fight over quantity discrepancies will simply disappear.

Although highly affected by the volatile ups and downs of crude oil prices, the cost of bunker fuel remains one of the major factors in the daily costs of running a vessel. Therefore, it is obviously of paramount importance for shipowners to have access to an accurate method of measuring the quantity of delivered bunker fuel.

However, as a shipowner, A.P. Moller - Maersk probably is the first to recognise that when big container vessels are designed and built – now and in the past – the main focus inevitably is on optimising the number of containers that the vessel is able to carry. Less attention is paid to the bunker tanks which are typically placed wherever they might fit, invariably in odd sizes and dimensions which might often be difficult to measure with an absolute and definite accuracy.

In addition, and to be frank, on today's worldwide bunker barge fleet, a lot of equipment in use dates from as far back as the 1980s. Old does not necessarily mean bad, but we should not ignore progress, if and when improvements are possible. And this goes for measuring systems as well as for other aspects of bunkering. We all have an obligation to optimise and improve procedures and operations whenever possible, and whenever it makes sense from a business point of view. Basically, we just want accuracy.

For participants in the bunker market, it might be assumed that an open and transparent bunker market would be in everybody's interest. From a supplier's point of view, detailed and transparent knowledge of a specific market and port will support the optimisation of sales, marketing and pricing.

Maersk Oil Trading, being the in-house bunker broker for the Maersk fleet, procures and trades around 13 million metric tonnes (mt) annually, in more than 200 different ports. The company obviously has a clear desire and obligation to make the right bunker decisions. This includes determination of the best bunker ports to visit and the precise volumes to be purchased, but it also means that the company can focus on which ports deserve most attention when we are planning future developments and projects.

From a pure and simple human point of view, we consider it generally understood and accepted that you get what you pay for. We believe this applies for most aspects of life – including the bunker industry. Furthermore, putting the crews of our vessels into situations where they have to discuss bunker quantity measurements and argue over any discrepancies with delivery barge crews in heated disputes, is not fair. Nor is it conducive to creating the kind of respectful work environment that we want for our employees.

All of the above factors contribute to our clear wish to have an accurate and

This document, and more, is available for download from Martin's Marine Engineering Page - www.dieselduck.net

Emerson Coriolis flow meter installed on the *Dirch Maersk*.

trustworthy measuring device for our bunker intake. We strongly believe that the development within flow meter technology has now reached a stage where the level of accuracy is satisfactory. We first discussed the installation of bunker flow meters back in 1999, but at that time, the technology was simply not available. Today, we have gained confidence in this specialist measuring equipment through our own tests and through those of third parties and are now putting a lot of effort into more testing and development of this equipment. The clear purpose of this is obviously to further improve the measuring accuracy of the flow meter as it relates to bunker fuels, but it is also to work towards setting certification and calibration procedures recognised by world-ranking institutions and respected by the industry.

The type of Coriolis mass flow meters that we are installing on A.P.Moller - Maersk ships are already used extensively within other oil and gas industries, petrochemicals, food and beverage industries, and are widely-recognised as being custody transfer-approved equipment. We are confident that a modern state-of-the-art mass flow meter fitted onboard one our ships will provide a more accurate measuring mechanism than the type of measuring systems used on many bunker barges around the world today.

'We would expect our suppliers, barge operators and other shipowners to take an active role in this process and we strongly encourage an open and constructive dialogue in order to reach a common understanding of the issue'

On an annual basis, Maersk buys 13 million mt of marine fuel and undertakes 12,000 bunkering operations, but we have discovered that there is an average discrepancy of 1.5% between the readings taken by Maersk vessels and those provided by suppliers or barge operators – a considerable and unwarranted extra cost for a player of Maersk's weight in the shipping industry.

Following the successful trials of an Emerson mass flow meter onboard the *Dirch Maersk* container vessel, a second is currently being installed on a second ship, and over 50 meters are scheduled to be fitted across the fleet during the first half of 2009. In due course, we expect to fit flow meters on all Maersk ships.

By taking this initiative to install flow meters onboard our vessels, we fully accept our leadership role in this process. That includes the responsibility to ensure that our measurements are accurate, transparent and trustworthy to all participants in the bunker process. This will include, but is not limited to, sufficient and officially approved certification and calibration procedures, standard operation procedures for maintenance, and other parameters.

We would expect our suppliers, barge operators and other shipowners to take an active role in this process and we strongly encourage an open and constructive dialogue in order to reach a common understanding of the issue. At the same time, we wish to highlight that we very much look at this as a deeply-needed opportunity to improve the image and reputation of the bunker industry. And we expect our flow meter readings to be considered the final and binding figures for quantity settlement for future bunker deliveries.

This document, and more, is available for download from Martin's Marine Engineering Page - www.dieselduck.net

The air apparent

Dr Manus Henry explains what Coriolis mass flow meters are and their advantages over conventional bunker quantity measurement techniques

Contact:
Dr Manus Henry
Director
Invensys University Technology Centre for Advanced Instrumentation
Department of Engineering Science
University of Oxford
Tel: +44 1865 273913
Email: manus.henry@eng.ox.ac.uk

At The *Bunkering Symposium* in Antwerp, on 11 December 2008, Claus Møller Petersen of A.P. Moller-Maersk, the world's largest container vessel line, announced a major new initiative. Frustrated by what Maersk estimates to be an average of 1.5% shortfall in bunker deliveries, the company is installing fifty Coriolis mass flow meters across its fleet over the next six months, and will be looking for agreement from its suppliers that they will accept these meter readings as the basis for payment, rather than the conventional, barge-based dip readings (see page 37).

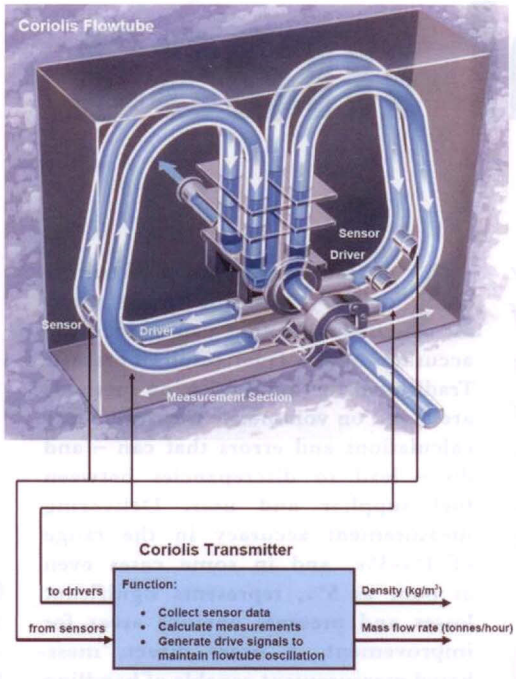
'Honestly speaking, we definitely have more confidence in these devices than we have in some barges' old-fashioned measuring equipment around the world,' stated Petersen. This challenge to a central basis of the bunker supply industry – that payment is based on the measurements of the seller, not the buyer – has significant repercussions, which will unfold over the coming months and years. But what are Coriolis mass flow meters, and what advantages can be claimed for them over conventional bunker quantity measurement techniques?

A Coriolis meter consists of an (essentially mechanical) vibrating flowtube through which the fuel passes, and an (essentially electronic) transmitter. Manufacturers offer a range of flowtube geometries, usually classified as either 'straight' and 'curved' designs. Flowtube diameters range from less than one millimetre (mm) up to 30 centimetres (cm) or 12 inches, although only a few suppliers offer the larger sizes (above 15 cm or six inches) suitable for bunkering applications. Whatever their size and shape, all Coriolis flowtubes operate on the same principle. Along the measurement section of the flowtube, two parallel pipes are forced to vibrate back and forth by one or two electromagnetic drivers. The level of vibration is very small, typically no more than a millimetre, even on the largest flowtubes. The frequency of the vibration varies with the design of the flowtube – for example, a curved flowtube might vibrate eighty times a second (80Hz), while a straight tube might vibrate at 600Hz – but the exact frequency of vibration depends upon the density of the fuel in the flowtube. This means that if the frequency of vibration is measured precisely via the two vibration sensors on the flowtube, then the density of the fuel can be calculated. The signals from the two sensors are also used for the calculation of the mass flow rate. In outline, the flow of fuel through the vibrating tubes causes a slight twisting of the pipework, which can be detected as a slight phase or time shift between the two sensor signals.

The other part of the meter, the electronic transmitter, collects the sensor signals, carries out the mass flow and density calculations, and maintains flowtube vibration by generating a suitable drive signal. The flowtube temperature is also monitored to provide temperature-based corrections to the mass flow and density measurements. Early Coriolis meter transmitters were built using relatively complicated analogue circuitry. However, the development of digital electronics for consumer goods has led to all-digital designs. With two channels of input (the sensors) and two outputs (the drivers), the Coriolis meter is not unlike a stereo music system – in fact, at least one modern transmitter design incorporates an audio codec chip developed for mixing desks. Using the audio analogy, the transmitter processes the high-fidelity but low-level sensor signals, generating the density measurement by very accurate determination of the signal pitch (to a few parts per million), while the mass flow is derived from the delay or echo between the two sensor signals (determined to within a few nanoseconds). The final task of the transmitter is to process the sensor signals to generate appropriate high level output signals sent to the flowtube drive coils (comparable to driving the speakers coils of

'Coriolis meters are commonly regarded as the most accurate flow meters in widespread industrial use, with both density and mass flow readings typically accurate to 0.1%'

This document, and more, is available for download from Martin's Marine Engineering Page - www.dieselduck.net



a sound system). For a Coriolis meter the level of the output signal is adjusted on a continuous basis to keep the flowtube vibrating at constant amplitude.

Coriolis meters are commonly regarded as the most accurate flow meters in widespread industrial use, with both density and mass flow readings typically accurate to 0.1%. As discussed in a recent article (see *Bunkerspot* October/November 2008, page 42), a major weakness of Coriolis meters used to be that aerated flow (i.e. gas entrained in the fuel) could stop the meter vibrating. Other metering technologies also have difficulties in dealing with 'cappuccino fuels', and hence the limited use of metering in the bunkering industry, until recently. However, pioneering work by the **University of Oxford** and **Invensys Process Systems** has led to a new generation of meters that can maintain good performance even with aerated liquid, and as a further benefit can detect and report the level of air in the fuel, even below 1% of air by volume. It is this latest generation of Coriolis meter that has inspired the confidence expressed by Maersk.

The traditional measurement procedure of the bunkering industry consists of the following steps. For each tank on the barge a dip reading is obtained, usually by hand, to gauge the height of the fuel. Look-up tables are used to convert the liquid level into liquid volume, which include corrections for the list of the barge. However, bunker fuel is sold by the tonne, and so a further stage of calculation is necessary to convert the liquid volume into mass, using the density of the fuel, as certified by the supplier, and corrected for temperature. This procedure, applied to all relevant tanks on the barge before and after the bunker transfer, gives the change in mass of fuel in the tanks, and hence the quantity of fuel that has been transferred to the receiving ship.

The Coriolis meter offers a much more detailed scrutiny of the bunker transfer process, by providing continuous monitoring of mass flow rate, density and temperature of the fuel throughout the entire bunkering. The totalised mass, along with other useful parameters such as the mass-weighted average temperature and density, is indicated at the end of the transfer. One key advantage over tank dipping, which simply cannot be over-emphasised to those used to volume-based measurements, is that the Coriolis meter measures the mass flow rate directly and independently of the density of the fuel oil. It has no need of corrections for density, and any temperature compensation is dealt with internally. Thus it does not need to rely on any external information (such as the certified density of the fuel from the supplier, spot readings of temperature, or indeed the barge look-up tables) in order to accurately determine the transferred quantity.

'Compared with the price volatility of bunker fuels over the past twelve months, the incremental costs associated with metering are unlikely to be significant'

The second key advantage of a Coriolis meter over the tank dipping procedure is that the Coriolis meter provides a continuous reading, while tank dips only provide snap shots of the liquid levels in the tank at the beginning and end of bunkering. A metering skid can generate time profiles of flow rate, temperature and density, air content, as well as potentially other parameters such as supply pressure and sulphur content where additional instrumentation is fitted. Such time profiles can offer quality assurance to both the receiving vessel (consistency of delivered product) and to the supplier (validation of operating procedures), and be of great value in quickly resolving quantity or quality disputes, as discussed in the previous *Bunkerspot* article.

A third key advantage of Coriolis metering is the ability to routinely check and where necessary recalibrate the meter, either *in situ* or at a test laboratory. In other oil and gas custody transfer applications, regular meter proving is a standard requirement, and its introduction into the bunkering industry could bring an additional level of quality assurance simply unavailable with tank dipping procedures.

So, if some of the major shipping lines are introducing metering onto their ships, does it follow that bunker suppliers need to consider fitting them on their barges too? Some points to consider: Quality and quantity monitoring can greatly assist suppliers, by metering barge loading as well as bunker deliveries, and ensuring optimal use of the barge (for example, optimising throughput of the barge by maximising flowrate and avoiding unnecessary tank stripping). Do you want your customers to know more about your bunker delivery quality than you do?

In addition to the metering skid itself, there is the cost of modifying the barge, and regular maintenance and calibration expenses. These costs will inevitably be passed on from bunker suppliers to their customers. However, compared with the price volatility of bunker fuels over the past 12 months, the incremental costs associated with metering are unlikely to be significant, and it is clear from Maersk's announcement that at least some large customers consider quality of supply to be more important than lowest cost.

Perhaps some suppliers will hope that the issues of quantity assurance will simply fade away. However, given the unprecedented challenges facing the industry (the sulphur directives, volatile prices and now the economic downturn) it may be that the fog of uncertainty surrounding quantity and quality of supply is an indulgence that the industry, and certainly the major shipping companies, can no longer afford.

This document, and more, is available for download from Martin's Marine Engineering Page - www.dieselduck.net

Critical mass

Steve Jones explains why accurate measurement of delivered volumes is so important to the bunker industry and describes the testing and development of mass flow meters currently underway

Steve Jones is the Business Development Director of Emerson Process Management, which helps businesses automate their production, processing and distribution in the chemical, oil and gas, refining, pulp and paper, power, water and wastewater treatment, metals and mining, food and beverage, pharmaceutical and other industries. A division of Emerson, Micro Motion, invented the first practical Coriolis flow meter in 1977, and is consistently rated as the world's leading Coriolis flow meter supplier. Emerson is based in St Louis, Missouri and listed on the New York Stock Exchange.

Contact:
Steve Jones
Emerson Process Management
Micro Motion Division
Tel: +1 303 530 8166
Fax: +1 303 530 8462
Email: Bunkering@Emerson.com
Web: www.emerson.com

Accurate measurement of bunker delivery quantities poses many challenges that can reduce the accuracy of the final results obtained. Traditional fuel oil bunkering methods are based on volumetric measurements, calculations and errors that can – and do – lead to discrepancies between fuel supplier and user. Delivering measurement accuracy in the range of 1%-3%, and in some cases even as poor as 5%, represents significant losses and presents obvious areas for improvement. A more direct, mass-based measurement capable of handling the challenging application area of fuel oil bunkering would provide significant advantages to the industry as a whole.

Other benefits provided by accurate fuel oil measurement are tighter control and visibility to the amount of fuel consumed to assist with initiatives directed at improving fuel efficiency, and for these reasons Coriolis mass flow measurement poses an attractive solution to bunker measurement within the marine industry.

The application

Metering heavy fuel oil (HFO) is not an easy application for flow measurement technologies. Flow meters must be able to handle the different bunker grades used, along with any impurities that have not been filtered out and varying degrees of entrained gas in the oil. This makes for a very challenging application, not to mention other environmental influences such as vibration, product solidifying and the need for low pressure drop.

For traditional bunkering measurement, look-up tables and a density measurement are used in conjunction with the 'dip' to calculate the total 'mass' of the bunker fuel delivered. Needless to say, there are many factors that contribute to errors in this calculation, such as the strike plate location, the dip tape, accuracy of tables, tank straps, and human error.

Coriolis flow measurement technology accurately measures the mass flow directly and eliminates the need for any mathematical conversions. Coriolis flow technology is clearly suited to HFO applications, particularly bunkering, where customer billing is based on mass.

'Coriolis flow measurement technology accurately measures the mass flow directly and eliminates the need for any mathematical conversions'

Coriolis technology

The first practical Coriolis flow meter was introduced over 30 years ago by **Micro Motion**, now part of **Emerson Process Management**. Today, Micro Motion technology is used in various industries around the world with over 600,000 Coriolis meters installed.

The adoption of Coriolis flow meters is rapidly increasing as it offers solutions to many of the challenges faced in metering applications. Coriolis meters are non-intrusive, meaning that there are no moving parts or obstructions in contact with the fluid being measured. In addition to mass measurement, a single device provides an independent and very accurate density measurement of the fluid and a temperature measurement – three measurements from one device.

A known challenge to Coriolis meters is to accurately measure fluid with entrained gas or in two-phase flow conditions. Because entrained gas generates significant noise on the measurement signal, technical innovation has been required to overcome this common barrier. Based on years of experience and technical expertise, Emerson's Micro Motion technology has solved this dilemma through state-of-the-art digital signal processing algorithms to handle additional noise created by the entrained gas, and improved meter structure for stability and robustness in two-phase flow environments.

Micro Motion Coriolis measurement technology has been proven to tolerate portions of air in liquid and still deliver acceptable performance. This is critical for bunker delivery operations where tank stripping means that air will be entrained at certain times during the delivery.

A unique feature of Micro Motion Coriolis flow meters that is valued in

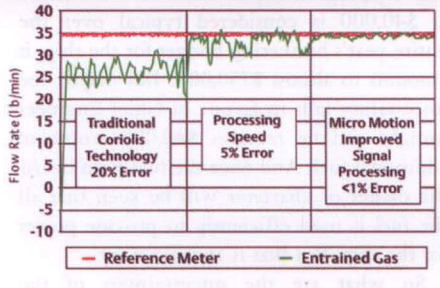
This document, and more, is available for download from Martin's Marine Engineering Page - www.dieselduck.net

Emerson Coriolis flow meter onboard Vitrol's barge, the *Antwerp*.

bunker applications is *in-situ* meter verification. Meter verification technology on Micro Motion meters measures the actual mechanical characteristics to a very high accuracy – in line and without removing the meter. When a change in the meter's tube performance is detected, the results determine whether measurement performance remains within the original factory specifications. This technique enables a quick and easy means to verify performance in-line, thereby negating the need to remove the meter for calibration unless otherwise demanded by local regulatory bodies.

Experience

To address the growing demand to improve the accuracy of bunkering measurement, Emerson has been conducting bunker measurement mass flow meter trials. These trials have been conducted in association with **A.P.Moller-Maersk** (as the end-user of the fuel) as well as **ExxonMobil Marine Fuels** (as the seller of the fuel), and **Victrol N.V.** (as the transportation link of the fuel). Phase I of the ExxonMobil / Victrol trial has seen a Micro Motion ELITE CMFHC3 Coriolis meter installed



and operating on the Victrol barge in the Port of Antwerp, Belgium for six months during 2008.

The trial has shown favourable results and is now entering Phase II where Emerson and ExxonMobil will complete further testing of Coriolis meter performance and refine the actual operating procedures with a view to gaining custody transfer certification.

Weights and measures

Custody transfer certification requirements lay out the accuracy requirements of any measurement system used in the billing of customers. The accuracy of the equipment and the measurement system design must be such that weights and measures can approve the performance of the system and validate it for legal metrology.

Maersk initiative

In addition to the project testing taking place with ExxonMobil, A.P.Moller-Maersk has undertaken its own, independent programme to validate Coriolis measurement technology in bunkering applications by installing the same Micro Motion Coriolis flow measurement solution on its own vessels (see page 37).

These projects reflect operators who have the same goal: to charge or be charged for the fuel oil they supply and to pay only for the fuel oil received. This goal can only be realised through superior accuracy of measurement, no matter the port of call, from an internationally recognised and certified metering solution.

Conclusion

While Emerson continues to work with A.P.Moller-Maersk, ExxonMobil and others to provide international metrology certification of Coriolis measurement in fuel oil bunkering applications, initial test results illustrate the great potential this technology offers to the advantage of the marine industry as a whole.

This document, and more, is available for download from Martin's Marine Engineering Page - www.dieselduck.net