RELIABLE BUNKERING PRACTICES ENHANCED BY NEW TECHNOLOGIES

WHITE PAPER

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INTRODUCTION

Fuel costs make up to 30% - 70% of the overall ship operating costs depending on the ship type. Hence, it is important to accurately quantify the amount of bunker fuel on the vessel. The fuel bunkering process is essential to all ships that rely on fuel oil for operation. Marine fuel bunkering comes in different forms and this white paper focuses on the reliable monitoring of Marine Fuel Oil (MFO) using Mass Flow Meters (MFM). New bunkering standards using mass flow metering, specifically TR48 [1] published by Enterprise Singapore (national standards organisation) have been introduced in Singapore by the Maritime and Port Authority (MPA) of Singapore. The use of MPA-approved Mass Flow Meters (MFM) for all Marine Fuel Oil (MFO) bunker delivery in the Port of Singapore was made mandatory in January 2017. This white paper demonstrates recent technological developments and highlights the importance of systems developed for accurate monitoring of fuel bunkering in the shipping industry. The certification of the MFM, the approval process and acceptance tests used are also discussed in this paper to inform the users on the steps needed to secure bunkering certifications. Best practice used for MFM installations will contribute to the development of ISO 22192 for bunkering of marine fuel using the Coriolis mass flow meter (MFM) system installed on bunker tankers and the committee draft for ISO 21562 Bunker fuel mass flow meters on receiving vessels is also under development.

> *"As the first port in the world to mandate the use of mass flow meters for bunkering, we will set a new benchmark for bunkering practices worldwide"*
>
> *Transport Minister, Singapore, Lui Tuck Yew*

A good understanding of the fuel bunkering measurement process and how it is quantified is important to prevent industry malpractice. Singapore, as the first port in the world to make mandatory the use of mass flow metering (MFM) systems for bunkering, aims to raise efficiency and productivity in the industry. The technological developments which led to the implementation process of the MFM are discussed to encourage industry best practice. Shipulse BunkerXchange, developed by Ascenz allows crew and surveyors to monitor ongoing bunkering activities. This system provides real-time visualization of bunker profiles for improved productivity and procurement assessment. Bunker reports and data can be exported or transmitted securely back to shore. The importance of such systems in underpinning efficient bunkering procedures is highlighted.

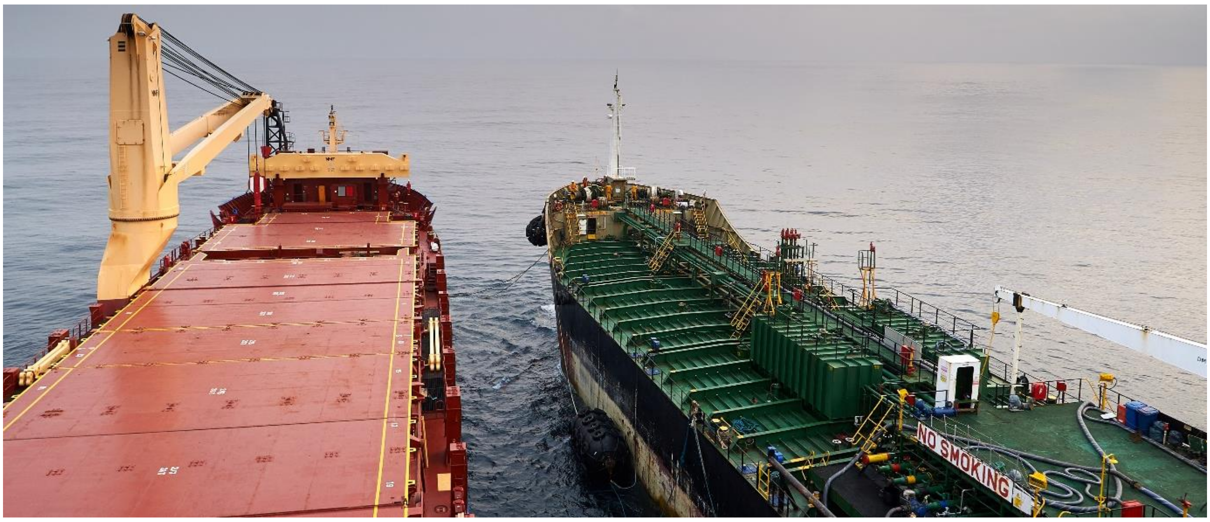

Figure 1: Bunker tanker

Key aspects of accurate bunkering

The bunkering process involves transferring bunker fuel (HFO, MGO, etc) to a ship. A bunker tanker is typically used to supply fuel to ships whilst a receiving ship receives cargo from a bunker tanker at either port or at designated anchorage area. Strict bunkering procedures and practices are required to ensure safety, to prevent fires, to prevent overflow of oil or oil spillages and monitor that the ship receives the bunkers in the quantity and quality specified in the bunker purchase contract. In addition, accurate bunkering measurements are required to prevent industry malpractice, such as cappuccino bunkers, fuel with high water content and questionable flow meters that are not certified. There is also a need to check if the ship receiving bunkers is actually getting the fuel quantity shown on the measurement device, i.e. the MFM. Several key aspects to ensure accurate bunkering will be discussed. The common phenomena that influence accurate bunkering measurements are explained and used to help understand the possible causes that affect the bunkering measurement process. These include, but not limited to managing dead volume, partially filled pipe conditions and excessive aeration during bunkering. Solutions and procedures developed to ensure accurate bunker measurements will also be discussed. These include careful selection of the correct meters, the introduction of plate fixtures in pipes to increase accuracy, the packing of meters and smart bunkering processes.

The main causes of inaccurate bunkering

In order for flow meters to be able to accurately measure mass flows, pipelines need to be fully filled with single phase liquid. In reality, this might not always be the case and this can cause inaccurate bunkering due to partially filled pipes and excessive aeration. The presence of dead volume, the amount of fluid trapped between bunker tanker and receiving vessel which cannot be removed from within the pipelines is also discussed as this circumstance often leads to bunkering disputes caused by lack of understanding of the process.

1. Partially filled pipes

During the bunkering process, when a bunker tanker transfers cargo to a receiving vessel, there may be a significant height difference between the bunker tanker and the receiving vessel throughout the bunkering process as shown in Figure 2, leading to one of the main causes of partially filled pipes.

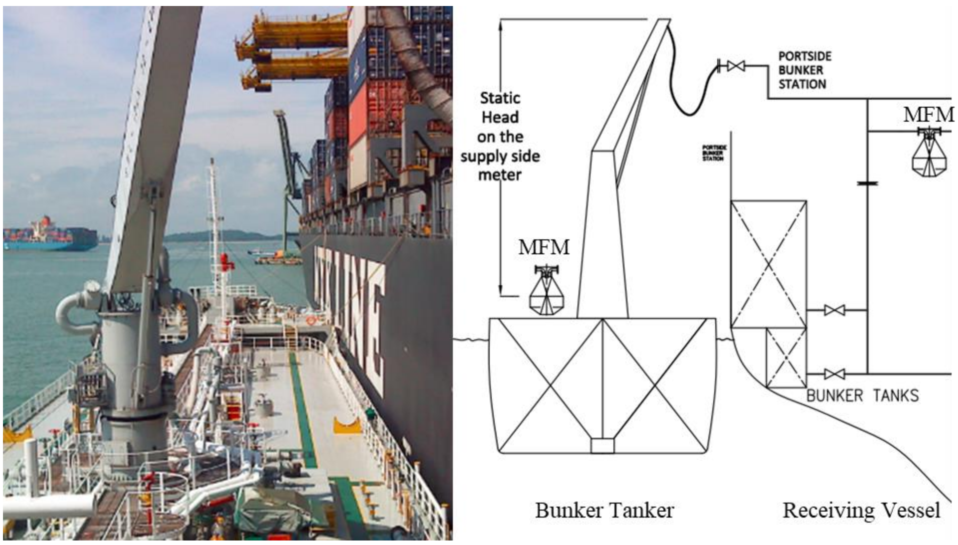

Figure 2 Height differences which often occur between a bunker tanker and the receiving vessel (left); Schematic diagram showing elevation difference between supply and receiving ends of flow measurements (right)

Figure 2 also shows the schematic diagram of an example of static head that must be overcome between bunker tanker and receiving vessel and that often leads to the partially filled pipes scenario. The fuel is transferred from a lower point to a higher point at the beginning of the bunkering operation. When the fuel reaches the highest point of the bunker hose, unavoidable sudden draining down of fuel into the receiving tanks is expected and this often leads to negative pressure and partially filled pipe conditions. Figure 3 shows an example of a partially filled pipe and a mass flow meter.

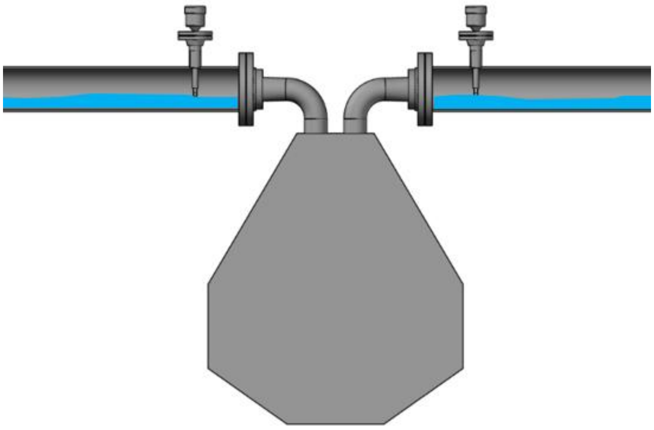

Figure 3 Partially filled pipe with mass flow meter

Complications arise when similar measurement systems are installed both on the supply side and receiving side, where significant variation in measurements exist when comparing the bunkering fuel data from both ends. During the bunkering process, the flow and process conditions encountered within each meter is different. The position of the meters on the supply side experiences higher back pressure with their low elevation, ensuring a fully filled pipe and sensor. However, on the receiving vessel, there are often gaps and the fluid does not necessary fully fill up the meters and pipes due to the filling up of void pipes during the start of the bunkering process. The partially filled pipe leads to inaccuracy when measuring fuel flow through pipe, as the sensors are not able to properly quantify the flow within the pipelines, such as the difficulty to maintain coil oscillation. Hence, the fuel meters on the bunker tanker may not be able to detect the presence of partially filled pipe conditions at the receiving end of the pipe unless the crew are informed otherwise. In addition to carefully selecting and installing flow meters, effective communication and observations throughout the transferring process need to be taken to ensure that pipes are fully filled. This is also known as line packing, a phenomenon where the liquid is flowing in the full body of the pipe.

2. EXCESSIVE AERATION IN PIPES

Prior to commencing the bunkering process, the bunker hose and most of the bunker pipelines will be filled with air and vapor. The existence of air and gas within the same pipeline results in a multiphase

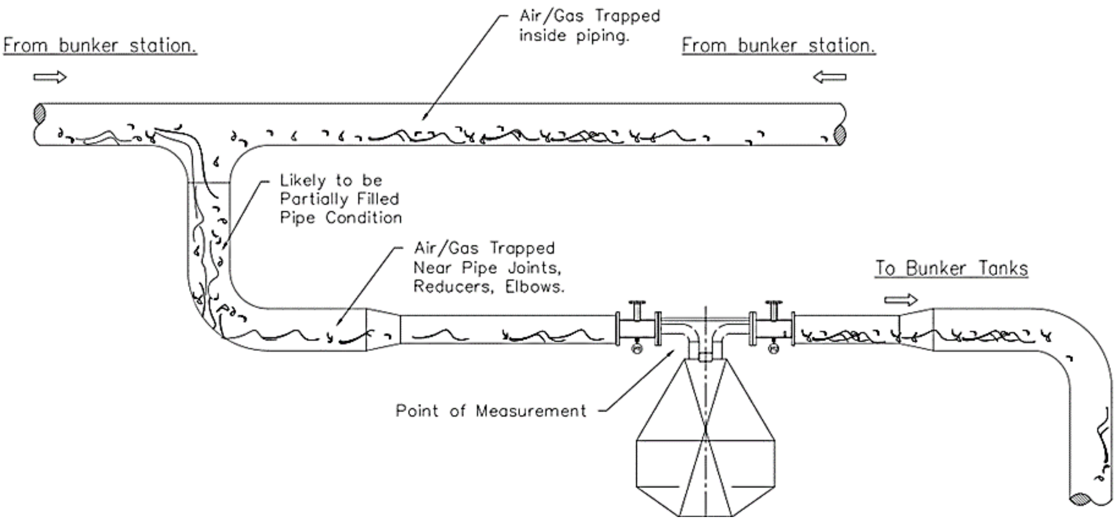

Figure4 Excessive aeration under low flow conditions

flow that will negatively affect flow meter measurement accuracy. The trapped air in the pipelines is usually flushed out by high pressure caused by high liquid flow volume. However, due to the corners and bends of the pipelines, it is difficult to fully flush out the trapped air which can lead to excessive aeration in pipes. This is more obvious under low flow conditions during bunkering, where the vapor trapped in the pipes remains and is pushed through out of the piping system into the receiving tanks. Figure 4 shows an example of an excessive aeration under low flow conditions. Changes in pressure and temperature, flow profile and sloshing inside the pipes will lead to the introduction of trapped vapor into the flow stream, further reducing the accuracy of fluid measurement.

3. Existence of Dead Volume

Another common cause of differences between bunker measurements which is often perceived as an inaccuracy in measurement is the presence of dead volume. Dead volume is the amount of fluid which cannot be removed from within the pipelines. This happens during the end of the bunkering process, where the residual fluid remains within the pipelines between the two measurement points of the supply bunker tanker and the receiving vessel. The fuel would have left the supply bunker tanker and measured but will not have entered the receiving vessel, which causes a significant difference between fuel transferred accounted from the supply side and the receiving side. The existence of dead volume is caused by the long pipeline that the fluid needs to travel from the supply side on the bunker tanker to the receiving ship. This difference in fuel measured as a result of dead volume should be corrected when bunker notes are compared to avoid misconceptions of inaccurate measurements between two flow meters. Figure 5 shows the portion of pipes where dead volumes can occur during bunkering.

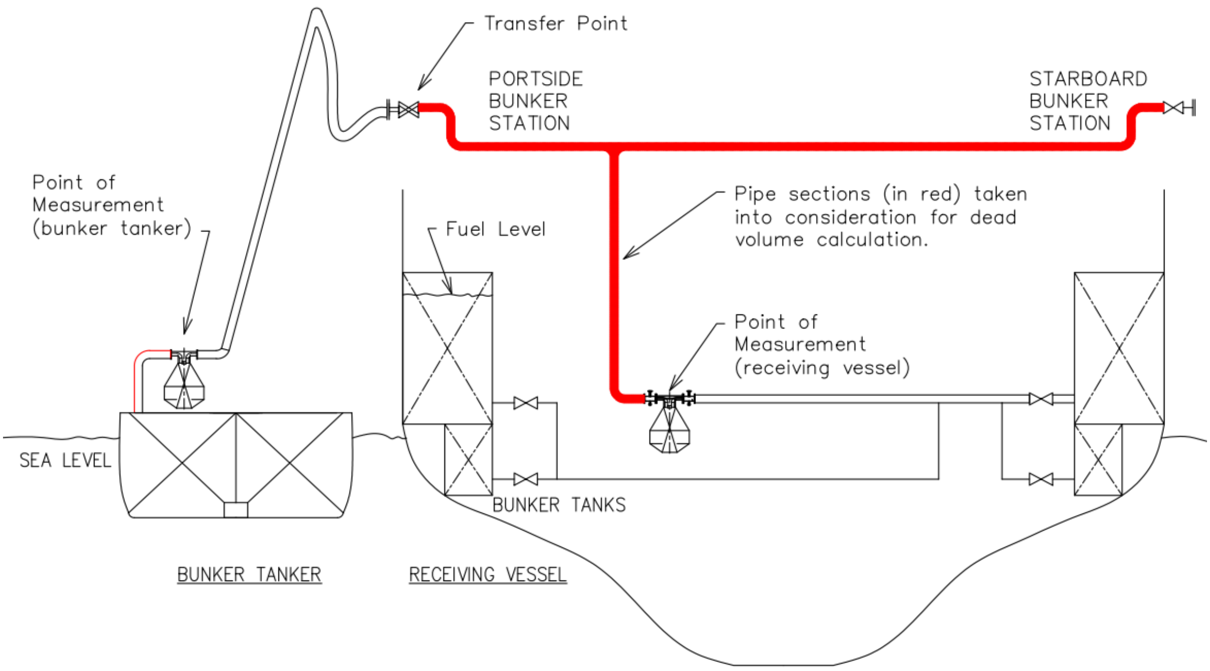

Figure 5 Schematic view of potential areas of dead volume during bunkering

The dead volume is calculated to estimate the quantity of fluid which may potentially be trapped between the transfer point and the point of measurement. The calculated dead volume is used to determine the *minimum measurable quantity* (MMQ) for each bunkering operation. Each bunker stem size must exceed the MMQ value to ensure accurate measurement. For example, some approved MMQ calculation documents assume 25% of full volume as dead volume for horizontal pipes and 10% for vertical pipes which are drainable by gravity. For the pipe sections which have tendency to be full before or after bunkering, 100% of the pipe volume is assumed to be dead volume. The total dead volume for the system is the sum of the dead volumes for each respective pipe sections. The MMQ is calculated to meet the overall system accuracy which is certified as 0.5%. For example, if the dead volume is calculated as 2 tonnes, the minimum bunker quantity must be equal or more than 400 tonnes to ensure the system accuracy of 0.5%.

BEST PRACTICES TO ENHANCE ACCURATE BUNKERING

Accurate bunkering is important as it directly affects safety, identifies the actual amount of available fuel and also the cost of fuel transferred. In order to increase the credibility of bunkering measurements, flow meter selection, and best practices to ensure fully packed meters, the use of technology to improve flow measurements and smart analysis of data is discussed.

1. METER INSTALLATION AND SELECTION

Proper meter selection and installation procedures are critically important to ensure correct measurements. The whole process from meter selection includes choosing the right type of meters with marine approval standards, explosion proof certificates, and marine class approval certificates. Meter sizing is also important and is dependent on the operating flow rates and volumes required. For instance, a Coriolis mass flow meter (MFM) is certified by the Maritime Port Authority (MPA) of Singapore for bunkering processes. MFM is defined in ISO 10790 as a device consisting of a flow sensor (primary device) and a transmitter (secondary device). This type of meter measures the mass flow rate which is obtained through deflection of the oscillating measuring tubes, whereas a change of the base oscillation frequency accounts for the density of the fluid. The MFM also provide measurements of the process temperature of the fluid. The tubes are usually concealed in a container which protects the unit in case of leakage. The Coriolis MFM does not contain moving parts such as gears, which results in easier maintenance and reduces the risk of wear and tear. The meter also provides output of process data such as mass flow, density, temperature and volumetric flow. For diagnostic purposes, the drive gain can be used which indicates the power output of the drive-in percentage. Under simple conditions the drive gain value is approximately 20%, depending on the sensor size. In case of two-phase flow, the value of drive gain may increase up to 100%. The density of fluid passed through the meters is measured and this does not require calibration when measuring fluids of different densities. Figure 6 shows an example of the internal section of a Coriolis mass flow meter.

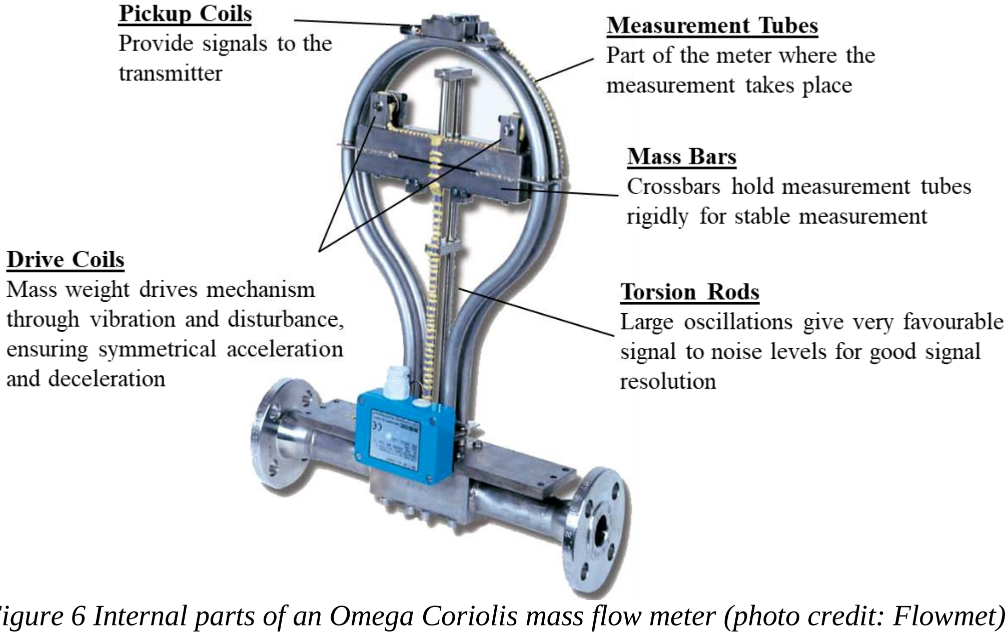

Figure 6 Internal parts of an Omega Coriolis mass flow meter (photo credit: Flowmet)

Further emphasis is given to the MFM system where proper installation plays a big role in obtaining reliable mass flow rate. The MFM system comprises the mass flow meter, its ancillary devices, pipelines and sealing points. The installation procedure includes careful pre-selection screening and site surveys, due to the different configurations of pipelines in each vessel. Besides understanding the system drawings of the pipelines, the layout of pipes must be carefully considered as corners, bends and heads will influence the readings of the flow meters if the installation location is not optimal. The location of the manifolds, loading lines, cargo pumps, flow booms, piping arrangement of the entire system, location of spectacle blanks, valves, location of installation of meter and other components need to be taken into consideration. The flow meter system installation on vessels often requires retrofitting of pipe. Added complexity is present when identifying the best physical location of the installation due to space constraints. Figure 7 shows an example of a carefully selected installation location of the MFM to minimize the partially filled pipe condition and also to maintain higher back pressure on the sensor. A careful survey should be carried out prior to any fuel meter installations. The pipe line inspection for possible bypass line, bunker stations, safety valve setting, and location should be determined. Additional information including process parameters such as minimum and maximum flowrates, operating temperatures and pressures should be confirmed. These parameters are then used for meter selection using sizing software tools in which the pressure drop across the meter at different flowrates is evaluated.

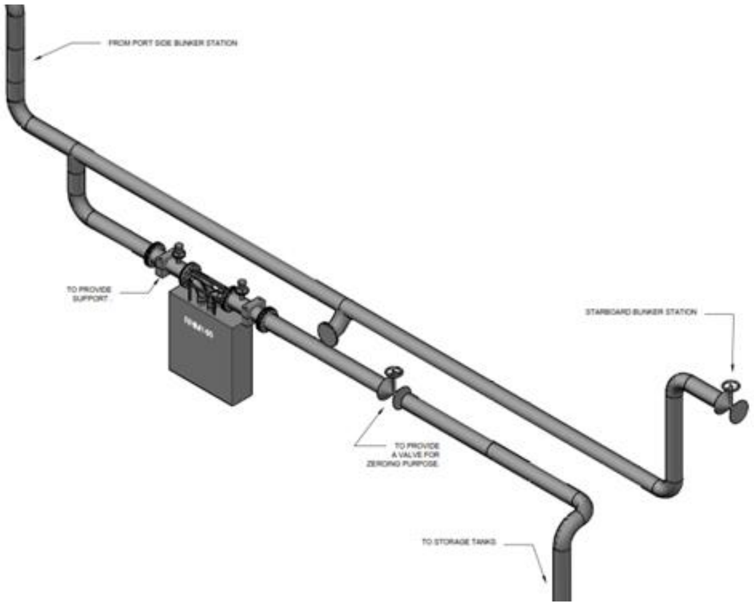

Figure 7 Recommended MFM installation location to prevent partially filled pipe

2. Packing of meters

The process of filling up of pipelines with fluid is also commonly known as line packing. The entire process of bunkering is an 'Empty-Full-Empty' application, where at the beginning, most of the pipes are empty. During the actual bunkering, full and partially full conditions are observed. At the end of the bunkering, the pipes need to be cleared to prevent possible spillage when disconnecting the bunker hose. In order to avoid a partially filled pipe that contributes to inaccurate measurements of fuel flow during bunkering, it is important to ensure the bunker piping system is filled up as soon as the delivery process starts. At the beginning of the delivery process, the bunker pipelines, which are above the liquid level in the storage tank, are almost always empty due to gravity flow, resulting in the bunker line that is usually empty unless in conditions where the pipe sections are at lower elevations compared to the fuel levels in the storage tank. The fully filled pipe condition is maintained throughout the delivery process. During bunkering, partially filled pipe portions may happen unless a reasonably high flow rate is maintained, and strict operating procedures are to be followed to keep the bunker pipe lines full as quick as possible. Packing the meters must be conducted in a fast and practical manner at the and throughout the delivery process.

In order to achieve this condition, communication between the bunker tanker and the vessel is required to establish the maximum possible flow rate as quickly as possible without compromising safety regulations. The receiving vessel shall communicate with the bunker tanker if air is detected in the system. The root cause of excessive aeration should be identified, which could be caused by either deliberate action or unavoidable operation requirements. The ability to demonstrate the presence of excessive aeration can increase awareness of this technical issue with the crew and discourages malpractice, such as the deliberate introduction of air into the system. Line packing needs to be conducted carefully to achieve the best measurements. Aeration within the pipelines needs to be minimized. The proportion of the total measured quantity under aerated flow conditions must be minimised.

3. USING PLATE FIXTURES

In cases where there are partially filled pipes, a plate fixture can be added to increase the accuracy of measurement of fluid flow. Careful selection of a suitable location for installation of the sensor and an investigation into the need of a device such as a plate fixture to manipulate the back pressure should be considered during installation of the flow meter system. A plate fixture is introduced to improve accuracy of bunkering measurement by elevating fuel flow. To optimise measurement accuracy, a marine bunker measurement system may incorporate two level switches at both downstream and upstream sides of the sensor tubes of a mass flow meter. The level switches will send a signal to activate the totalizers when fuel oil is present, and a signal is sent to deactivate totalizers when the flow stops. The addition of a plate fixture reduces false registering of fuel flow due to unbalanced partially filled sensor tubes. Figure 8 shows an example of a plate fixture to elevated flow of a partially filled pipe and also the installation location of two-level switches before and after the mass flow meter. These additional fixtures promote more accurate and reliable measurements of fluid flow.

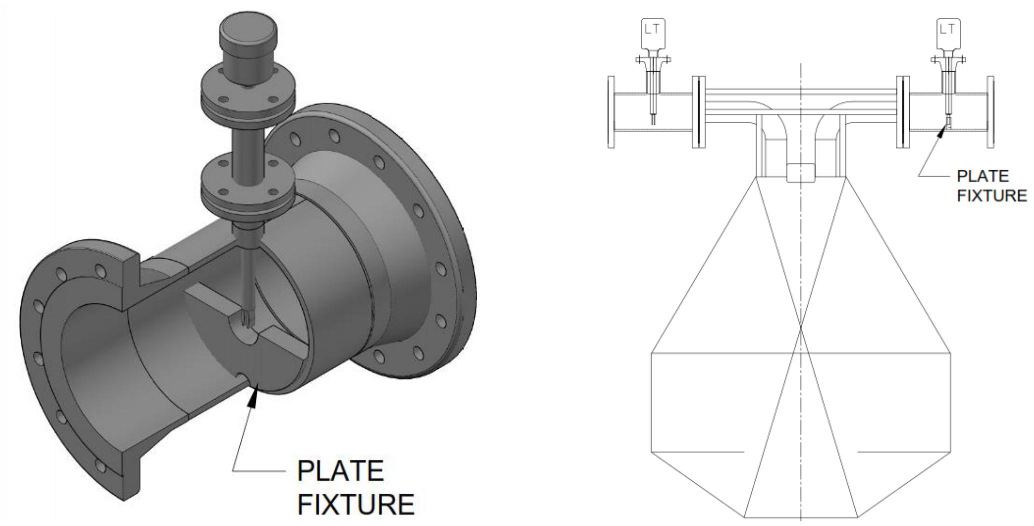

Figure 8 Plate fixtures can be used to prevent partially filled pipes (left) and installation location of the plate fixture with a mass flow meter (right)

4. SYSTEM INTEGRITY

System integrity ensures that the MFM system is set up and approved for bunkering operations and is secured against any interference before, during or after bunkering operations. The entire system integrity includes the meter selection and installation, the acceptance test and the system monitoring during operations.

Each MFM system must be accompanied by approved documentation, equipment checks for mechanical, software, electrical and operational security. Where in doubt, authorities can be consulted, such as the National Weights and Measures Authorities or National Maritime Agencies. Upon completion of installation, the MFM system is checked to ensure system security, where:

- **Equipment** shall be sealed against unauthorised adjustment, tampering or dismantling.
- **Software** shall be protected to guard against any unauthorised changes. Any changes made to the software must be otherwise authorised and documented.
- **Data** collected during the bunkering process such as the history of operations, batches and critical alarms are stored for a minimum of three months for references.
- **Critical alarms** shall be activated if there is power failure, equipment communication failure or meter and bunkering computer failure. The bunkering shall not proceed if any such critical alarm is found to be activated, and the implementing authority is notified immediately.

System integrity of the entire installation and commissioning of the MFM system is scrutinised carefully. The MFM system pipelines are designed or modified to ensure that all bunkering operations go through an approved MFM. At the planning stage of MFM system installation, the bunker tanker owner or operator identifies the ancillary devices, together with any blanks and flanges that needs to be sealed. The sealing plan and Class-approved piping diagram must be permitted by authorised bodies before the work is carried out. Once the system is sealed to ensure system integrity, the seal verification report shall be submitted to the implementing authority.

Should the MFM need to be removed for software and hardware updates or re-calibrated, the existing configuration of the meter has to be downloaded and recorded before any seal is broken. This is to ensure authorisation of the meter configuration, otherwise any other changes must be approved by the implementing authority. Only authorised parties are allowed to break the seals and re-seal. Prior to re-sealing, zero verifications on the MFM must be conducted and the meter calibration frequency requirements should be met. Proper maintenance of the MFM system is carried out and the system must be readily available for inspection and verification by the implementing authority.

As part of overall good practice, prior to the bunkering operation, the metering system, bypasses, blanks and all sealing points should be checked and confirmed against the approved piping modification and meter installation drawings. The piping integrity and seal checks can be carried out jointly by the cargo officer, chief engineer and bunker surveyor (if engaged). The seal numbers observed should match the seal numbers recorded in the latest seal verification report onboard the bunker tanker.

Any possible flow diversion before and after the meter which is not indicated in the approved piping modification drawing is strictly prohibited. Figure 9 shows an example of a possible illegal flow diversion line on the bunker tanker and the receiving vessel which would result in incorrect records of fuel transferred.

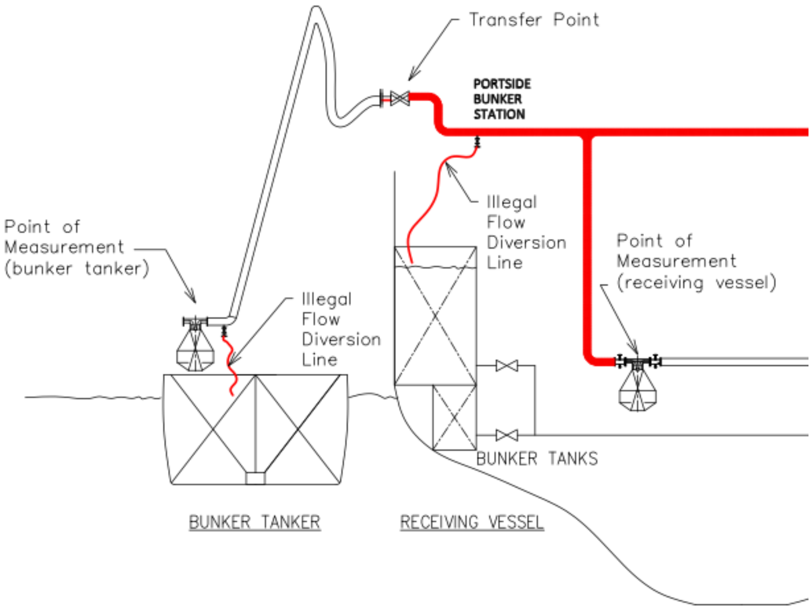

Figure 9 Example of potentially illegal flow diversion lines on a bunker tanker and a receiving vessel

From a bunker tanker's perspective, during the process of receiving cargo (loading at terminal or performing barge to barge transfer operations), flow diversion at the upstream of the flow sensor (before meter inlet) into the receiving tanker's tank(s) will result in meter readings being lower than the actual received quantity. Likewise, during the delivery operation, the use of a flow diversion outlet will result in a higher meter reading compared to the actual supplied quantity.

On the other hand, from a receiving vessel's perspective, during the process of receiving cargo (bunkering operation), a flow diversion at the upstream of the flow sensor (before the meter inlet) into the receiving vessel's tank(s) will result in meter readings that are lower than the actual received quantity.

5. SMART BUNKERING DATA MONITORING

Data collected from the mass flow meters are gathered on a platform to be displayed allowing observation of mass flow during bunkering in real time. Typical data that are displayed are the bunker mass flow rate (*t/h*), density (kg/m^3), the temperature (*°C*), drive gain (*%*), and totalising of the bunker fuel. These data can be used to detect abnormalities that may occur during the bunkering process. For example, the presence of aeration can be detected when the drive gain shows a sudden spike. An example of bunker data demonstrating abnormalities is shown in Figure 10.

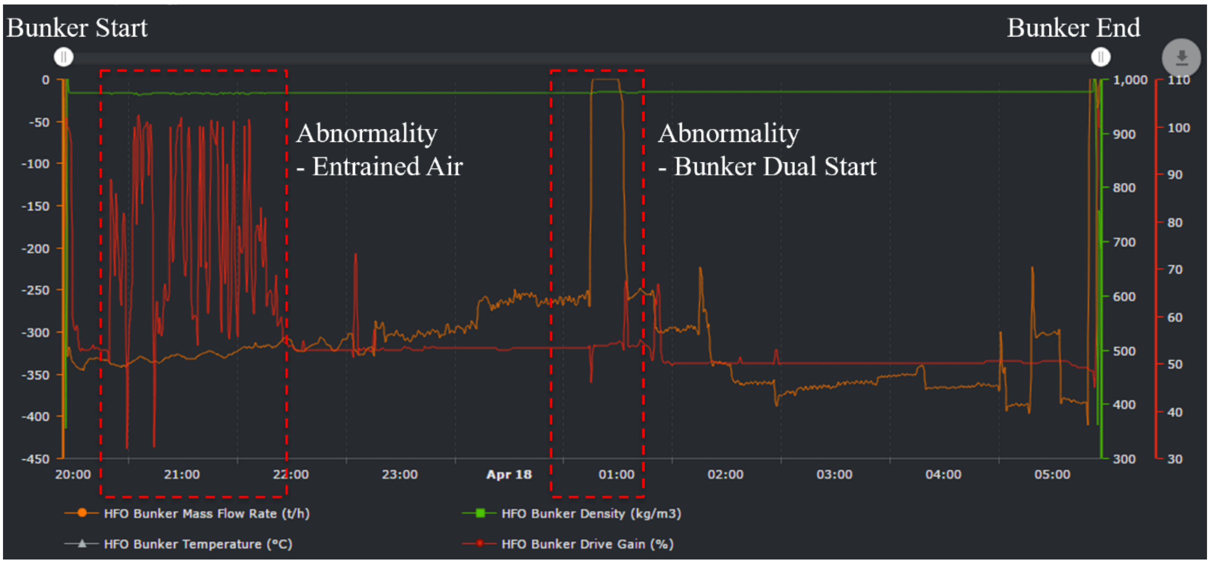

Figure 10 Examples of abnormalities detected using bunkering data

Live display of bunkering data allows careful monitoring to ensure good bunkering practices are carried out. From the data, aeration can be detected, and bunker tanker crews can be alerted to examine the root cause of the issue, such as the piping, valves, circulation lines and pump suction lines. Data collected can be used to create reports on the overall bunkering process to provide a record for comparison between different bunkering processes (Figure 11). A typical bunkering process consists of an initial part indicating the start of bunkering, followed by normal bunkering, change of tanks, and end of bunkering. A high percentage of unknown indicates that the bunkering process was not reliable, and that accuracy cannot be guaranteed. The proportion in red indicates excessive aeration, labelled as entrained air. The systematic documentation of each bunkering operation will allow the receiving vessel with data logger to compare bunkering patterns when receiving bunker from different ports and different suppliers. For example, a trend can be plotted to determine whether any bunker tanker supplies higher than usual aerated fuel. The carefully documented bunkering process will also ship operators and bunker suppliers to increase accountability and promote good practice during bunkering.

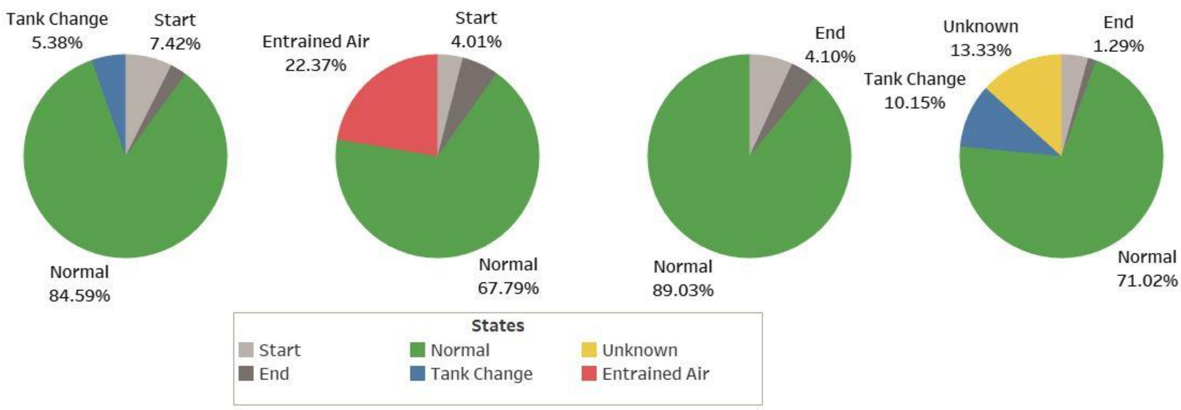

Figure 11 Examples of reporting of bunkering operations showing proportion of specific bunkering activity

CERTIFICATIONS

To ensure accountability in the measurements of fuel, mass flow meter selection and installation procedures abide in a series of standards. Mass flow measurement is based on the Coriolis principle which accounts for the rate of mass flow. Certification of the MFMs is important to provide accountability and integrity of the installed system. There are two main certification procedures that provides the certification of the MFM for the bunkering process, namely the European Union's Measuring Instruments Directive (EU's MID) and Singapore's Technical Reference (TR) 48.

TR48 is a provisional standard which has been put in place for two years since early 2017. The experience gained during this period will eventually be used to further develop the Singapore Standard. MPA implement TR48 for all Marine Fuel Oil (MFO) bunker delivery in the Port of Singapore. This became mandatory with effect from 1 January 2017. The TR 48 has an accuracy class of 0.5% for the bunker tanker. MID type examination certificates are typically required for non-interruptible measuring systems intended for delivery and reception of marine fuel to and from ships, barges and sea-going vessels. An accuracy class of 0.5% is required for both installation on bunker tankers and receiving vessels.

Feedback on the use of Technical Reference TR 48:2015 (Bunker mass flow metering) will be used for development of the ISO 22192 (Bunkering of marine fuel using the Coriolis mass flow meter (MFM) system) for installation on bunker tankers, and for the development of ISO 21562 (Bunker fuel mass flow meters on receiving vessel - Requirements).

Feedback and trial from the TR48 will be used to further develop the ISO 22192 (Bunkering of marine fuel using the Coriolis mass flow meter (MFM) system) and the development of ISO 21562 (Bunker fuel mass flow meters on receiving vessel - Requirements). TR48 requires additional steps in the approval process as compared to the MID certification procedure. The meter calibration in TR48 requires calibration to be carried out using bunker fuel and must be traceable to Singapore national metrology institute's bunker fuel Primary Liquid Flow Standard. The accuracy of a MFM for bunker fuel is divided into three levels, where level 1 discuss about the water calibration against a traceable reference, level 2 highlights the transferability from water to bunker fuel and level 3 discuss the uncertainty due to two phase liquid measurement in empty tanks. During level 3 testing TR48 will carry out verification for two phase quantification, including stripping and complete discharge of fuel oil at least three times during barge in / barge out process. This is to ensure that the bunkering measurement system installed is reliable.

Careful installation procedures are carried out during each installation and these should follow the 8-step approval process to ensure that the MFM system passes the official acceptance test to ensure acceptable set-up onboard. These certification stages include

1. Procurement of MFM system (sizing of MFM).
2. Arrival of MFM system (Complete water calibration and submission of all required documents to national weights and measures authority).
3. National weights and measures authority's approval.
4. Installation of MFM system (Installation and development of sealing plan).
5. MFM system commissioning (Submission of lass endorsed revised piping diagram and proposed seals location, submission of MFM vendor and bunker craft operator's attestation on system and crew readiness for acceptance test, and completion of sealing).

6. Acceptance test of MFM system (Three runs of tests of loadings and deliveries with national maritime agency chartered bunker tanker).
7. Verification of MFM system (Submission of test data and test documents to Singapore national metrology institute).
8. Submission of documents to national maritime agency for approval of all relevant documents.

Among the other standards that need to be complied with are the Singapore Standard Code of Practice for Bunkering (SS 600) and the Singapore Standard Specification for Quality Management for Bunker Supply Chain (QMBS) (SS 524).

SMART BUNKERING

The ability to visualise live data of the entire bunkering process enable crew to be more aware of the bunkering activity. The continuous data captured during the delivery process and the feature to allow data to be viewed in the form of a delivery profile at any instance in time promotes transparency where the mass of fuel transferred at any point of time can be determined. A smart bunkering system is also able to detect changes in operating conditions such as change in supply tank and clearing of lines at the end of the delivery. The delivery profile data can be extracted from the system, if required. Smart bunkering is not mere visualisation of the situation but offers valuable analysis throughout the bunkering process as shown in Figure 11.

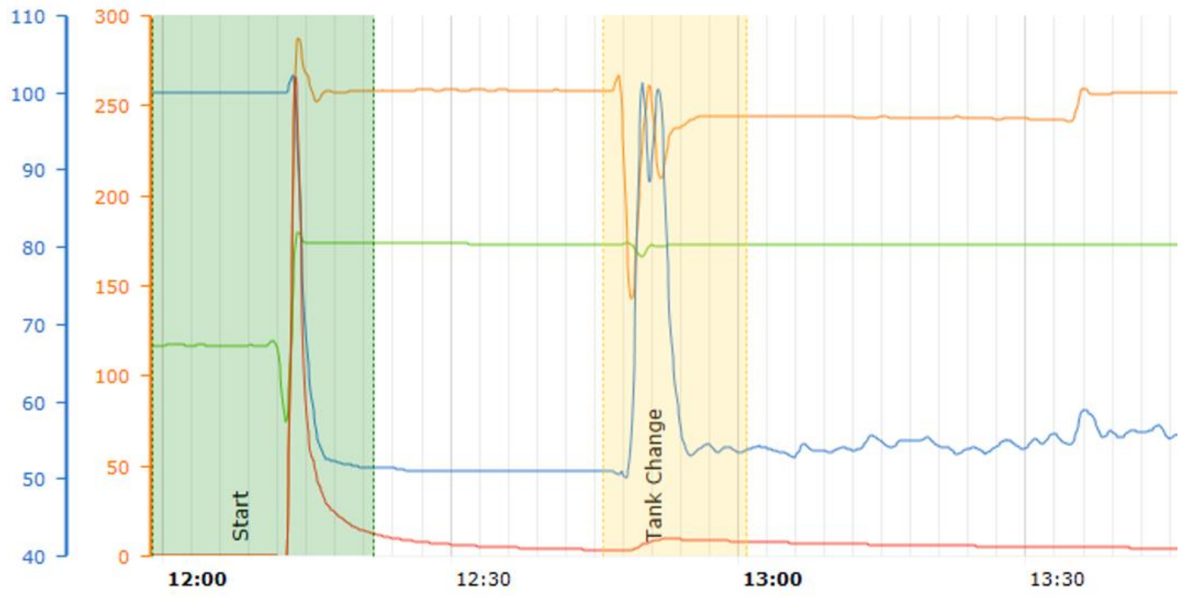

Figure 11 Examples of live visualisation and analysis of bunkering process

Ascenz offers a smart bunkering analysis module, where the bunkering activities are monitored under **BunkerXchange HMI** (BXHMI), which is a data logger and visualisation tool. Integrated within the **Shipulse Platform**. This will allow operations and procurement staff to have automated analysis on each bunkering operation and on the overall performance and activity trends. Instant analysis of data will allow abnormalities to be detected and resolved quickly.

Since 2008, Ascenz has installed over 1400 MFM and manages bunkering data for about 450 vessels around the world. The experiences and lessons learned from the mass fuel meter installation and meter selection is highlighted to pioneer and lead encourage and to pioneer the best practices of fuel meter installation in the industry.

With the advancement of technologies and software, machine learning can be used to promote smart bunkering, where the first product of its kind was launched by Ascenz in September 2018. Different machine learning techniques are used for descriptive and predictive analytics for automated bunker analysis. With the different combinations of data, automatic identification and classification of operations can be recognized throughout the entire bunkering process. The bunkering data are also used for predictive bunkering, where the flow rate, density and frequency can be modelled and is compared to the actual data set of the bunkering process. Deviations between the predicted data set and the actual data set will be used for alerting any possible safety breaches or malpractices.

CONCLUSIONS

A clear understanding of the possible contributions of inaccurate bunkering measurements were discussed. Solutions are provided in terms of best practices during operations and also additional procedures which are being used to increase the accuracy of measurements. Advanced analysis supported by machine learning techniques are being brought to bear on the bunkering process to encourage smart and reliable bunkering. The use of data and precise and reliable documentation will increase positive competitiveness of bunker tankers to provide the best possible bunkering services the industry can offer.

Ascenz has installed over 1400 MFM and manages about 450 vessels around the world including container vessels, workboats, bunker barges and tankers. The experiences and lessons learned from the mass fuel meter installation and meter selection is highlighted, to encourage and to pioneer the best practices of fuel meter installation in the industry. With the data logging and smart data platform of Shipulse, continuous research is being carried out to encourage continuous improvements and encourage innovations in the industry.