TECHNICAL MEMORANDUM
DATE: May 2012
SUBJECT: ACCURACY CONSIDERATIONS IN TANK SOUNDINGS AND ORB VOLUME RECORDING

MARPOL regulations require that tank volumes are recorded in cubic meters to a reasonable degree of accuracy in Oil Record Books (ORB). However, what constitutes a reasonable degree of accuracy is not firmly established. This document discusses accuracy considerations and sets a reasonable standard for ORB volume recording as based on engineering considerations.

Based on the below discussion, it is concluded that, from an ORB recording point of view, the operator should only record tank levels to a tenth of a cubic meter in the ORB. This means the operator measures tanks to the accuracy available, makes the needed conversions and rounds the result to the nearest tenth of a cubic meter. This document notes that tank volumes can vary reasonably outside that accuracy range, and therefore may reflect such variations in the ORB. However, such variations do not need to be considered unless the operator notes volume anomalies that fall outside normal accuracy considerations for a particular tank.

BACKGROUND

Ships use a variety of tanks to process bilge water and engine room waste liquids (sludge). Traditionally these tanks are not sounded and monitored in a consistent fashion. However MARPOL requires that a ship maintains an oil record book (ORB). The ORB records volumes of waste and bilge liquid transfers aboard the vessel, and periodically (generally weekly) records the volumes in tanks aboard the vessel.

This process can be confusing since a volume transfer measurement in a certain tank may not show up consistently when the tank is measured at a later instant. It is possible that during the transfer, the transfer volumes are recorded at 5.1 cubic meters, while a later measurement of the source tank indicates that the tank has lost 6.0 cubic meters. This can lead one to conclude that 0.9 cubic meters have been lost.

This inconsistency can be a pure error, but can also be related to inherent limitations in measurement accuracies.

There might be a tendency by ship's crews to consolidate such inconsistencies. The officer in charge (OIC) may choose to split the difference or decide to use one measurement rather than another, but inevitably this will become a very time consuming, ultimately inaccurate and, from an engineering point of view, senseless exercise.

Instead, it is necessary to deal with this problem on an engineering measurement level. Engineers never record exact numbers, knowing that ultimately a measurement will always have inherent inaccuracies. Engineers avoid this by measuring to reasonable accuracy. Indeed, very few engineering measurements have accuracies above 99%.

Since there is an, often misconstrued, assumption that ORB measurements are bookkeeping records (as in the dollars have to add up), rather than engineering measurements, very significant disputes can arise when the numbers do not appear to "add up".

As such, a methodology needs to be established with regard to shipboard tank measurement and recording that passes appropriate and reasonable engineering standards, which then can be applied to ORB volumes. This document establishes such a standard.

SHIPBOARD TANK MEASUREMENT ACCURACIES:

Shipboard volume measurements are particularly difficult to achieve to accuracies of 99% or more for the following reasons:

1. Measurements are taking by measurement of the tank liquid level. Tank level measurements may be by sounding tape or by electronic or pneumatic reading device. Inherently these measurements have limited accuracy. A sounding tape cannot be measured to much better than one centimeter, which on a tank that may have only 30 centimeters of liquid in it, already represents a 3% error. Pneumercators use head pressure to determine tank levels. LevelCom gauges, a typical brand, are electronic/pneumatic gauges. Inherently these systems are accurate +/- 2 cm, which, again, on a low tank level may result in spectacular inaccuracies. Furthermore, with these gauges the user needs to know the density of the tank's liquid since these gauges can only be accurate to one specific liquid density, which on high tank levels can result in significant errors.
2. Tank level measurements are sensitive to ship's list and trim. Most longitudinally oriented tanks are measured at the tank's aft end. This means that the measurer needs to know the vessel trim to be able to correct his tank measurement.

3. Tank shape can have a very significant effect on the ability to take accurate measurements. A double bottom tank can contain a significant amount of liquid even though it may sound as empty.
4. Ship motions will affect tank measurement due to liquid movement. Sounding tapes will wet to the highest tank level during movement of liquid in the tank. As such, sounding tape measurements in a seaway will be inherently higher than during calm weather. At some stage ship motions can make tank measurements with sounding tapes meaningless. Electronic and pneumercator systems can also have difficulties establishing reasonable tank levels during heavy weather.
5. Tank levels are converted to volume measurements using sounding tables. Sounding tables list tank levels and read across to tank volumes. Sounding tables are developed by shipyards, but may not be completely accurate, and inaccuracies may not be discovered while the ship is in operation due to the above measurement restrictions.
6. The sounding tables may or may not include appropriate trim and heel corrections.
7. It may not be reasonable to require ship's crews to provide trim conversions on engine room tank volume measurements, either from a work load point of view or due to a simple lack of accurate vessel trim measurement while the ship is underway.
8. The sounding tables may or may not be provided in appropriate volume units which may introduce conversion errors.
9. Some tanks may not have detailed sounding tables and may only have been provided with sounding graphs which inherently do not provide reasonable accuracy.
10. Unpumpable tank residue will affect the accuracy of tank volume estimates based on soundings.

The above shows that on occasion errors may be as high as 10% (low tank volumes, ship motions and long shallow tanks) or more.

However, for purposes of ORB recording there are various measures that can be implemented that will allow recording to higher levels of accuracy.

MEASUREMENT SYSTEM CONSIDERATIONS

Noting that very often the measurements that are most relevant are transfer measurements, it becomes important that repeatability accuracy is high. There are some positive considerations in this regard. For example, while LevelCom gauges have tank level measurement accuracies of +/- 2cm, at the same time they have high repeatability. Therefore a transfer from such a tank will show to a higher degree of accuracy as long as the tank level is not very low in the tank.

Typically a high volume/low depth tank aboard a commercial ocean going vessel may have a sounding rate of 0.2 cubic meters per centimeter.

Therefore when transferring tank liquids, assuming that the vessel's trim is known and the sea is reasonably smooth, liquids from these tanks can be measured to an accuracy of 0.2 cubic meters, if there is accurate liquid level to volume conversion.

This is the highest possible accuracy from the largest tanks aboard ocean going vessels. Smaller tanks may provide higher reading accuracies on the ability to measure volume transfers as long as the tanks are reasonably full.

This, however, is still related to liquid measurement levels, and conversion to volumes may introduce further errors.
Worst case volume transfer accuracies are expected to be in the range of +/-0.4 cubic meters (+/- 0.2 cubic meters level measurement plus +/-0.2 cubic meter conversion accuracy) in optimal conditions (no seaway, etc.). At the same time it is known that measurement accuracies of 0.01 cubic meters are not achievable even on the smallest tanks.

The above indicates that measurement recording to 0.1 cubic meters accuracy is barely achievable, and that on tank volume records, depending on the tank and conditions, the last digit (representing a tenth of a cubic meter, 100 liters) is inherently questionable.

ORB RECORDING STRATEGY

The above indicates that recording volumes on large tanks to accuracies higher than whole cubic meters is barely relevant from an accuracy point of view. However, from a recording efficiency point of view, it appears that for ORB recording purposes it would be reasonable to record tank levels to a tenth of a cubic meter. This means the operator measures tanks to the accuracy available, makes the needed conversions and rounds the result to the nearest tenth of a cubic meter.

It is understood that invariably there will be variations and inconsistencies in the last tenth of levels and volumes.

These inconsistencies do not need to be specifically analyzed by shipboard crews, but inconsistencies that arise in larger quantities (more than a cubic meter in large shallow tanks, or more than 0.3 cubic meters in small tanks) need to be investigated and, if they cannot be resolved aboard the vessel, or reasonable ascribed to tank measurement problems (heavy weather, changed trim, etc.) need to be reported, recorded, and processed through management systems.

There will also potentially be issues with measurement consistencies related to the presence of solid sludge in tanks, tank evaporation and inherent measurement inaccuracies in tanks that are nearly empty. Such issues should be reasonably recorded in the ORB once an operator becomes aware of them.

Recording conditions truthfully in the ORB can never get anybody in trouble therefore do not interpret and adjust records to make the ORB look “nice”.

If there is a switch from a remote to a manual tank measurement (or vice versa) this should be recorded in the sounding log. If this appears to result in confusion in the ORB a category “I” note should be provided in the ORB.

Since this document is the only known document that provides any type of guidance with regard to ORB recording accuracies, it is considered to be applicable as of this date until further notice and is considered to be a state of the art document.