



# Carefully to Carry

## Measurement of bulk cargoes

It is widely accepted that during the transportation of bulk cargo, some loss will unavoidably occur but when the shortage exceeds a percentage regarded as customary in that trade the carrier is often held responsible. One of the causes of shortage claims is that it is virtually impossible to precisely determine the weight of large quantities of dry bulk cargoes either afloat or ashore.

### Determination of weight onboard ship

Two methods of determining the weight of a dry bulk cargo loaded onboard a ship have in the past been used:

- On the basis of the 'free space' in a compartment (measurement and stowage factor).
- On the basis of draught surveys.

### Measurement and stowage factor

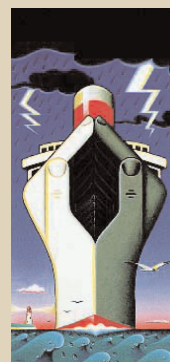
On completion of loading, the free space in each cargo hold is measured and from this the volume occupied by the cargo is calculated. This volume when divided by an assumed stowage factor, gives the approximate weight of the cargo. This method gives no more than an estimation. Furthermore, the exact stowage factor is seldom known and the assumed figure may be quite inaccurate. The stowage factor can be ascertained correctly only by a laboratory analysis of samples from the cargo. Proper sampling is essential since the analysis must take into account the nature of the cargo, the moisture content, the percentage of foreign matter present and the age of the commodity. The figure may also vary considerably for other reasons. For example, in grain cargoes, so called 'spout lines' may develop since grain in a cargo hold tends to separate into heavier and lighter components. Also almost all bulk grain cargoes settle during transport as the kernels and shells collapse. The result is an increase in weight per unit volume and a lower stowage factor. It follows in such cases that the weight of cargo calculated on the basis of free space measurement after loading will indicate a greater quantity of cargo than that calculated before discharge, if the same assumed stowage factor is used.

### Draught surveys

Although a draught survey is simple in principle, in practice it is frequently a complicated and timeconsuming way of attempting to ascertain the weight of cargo loaded onboard a ship. Many factors are involved, practically none of which can be established with a complete degree of accuracy.

A draught survey starts with a reading of the ship's draught, on both sides; forward, amidships and aft. There are a number of limiting factors:

- Often it is difficult to accurately read the draught because of the prevailing weather conditions and the presence of waves on the water surface.
- The draught should be read from a position as close to the waterline as possible in order to avoid parallax but this may not always be practicable.



"The carrier shall properly and carefully load, handle, stow, carry, keep, care for and discharge the goods carried."

Hague Rules,  
Articles iii, Rule 2

### Carefully to Carry Advisory Committee

This report was produced by the Carefully to Carry Committee – the UK P&I Club's advisory committee on cargo matters. The aim of the Carefully to Carry Committee is to reduce claims through contemporaneous advice to the Club's Members through the most efficient means available.

The committee was established in 1961 and has produced many articles on cargoes that cause claims and other cargo related issues such as hold washing, cargo securing, and ventilation.

The quality of advice given has established Carefully to Carry as a key source of guidance for shipowners and ships' officers. In addition, the articles have frequently been the source of expertise in negotiations over the settlement of claims and have also been relied on in court hearings.

In 2002 all articles were revised and published in book form as well as on disk. All articles are also available to Members on the Club website. Visit the Carefully to Carry section in the Loss Prevention area of the Club website [www.ukpandi.com](http://www.ukpandi.com) for more information, or contact the Loss Prevention Department.

- A ship moored in a tidal stream or current will be affected by squat, especially in shallow water and this will have a further effect.
- A draught can be affected when there is a large difference between the temperature of the air and of the water. This will cause a difference in the expansion of the submerged and the emerged sections of the ship. There is no currently acceptable method of correcting for this.
- When a ship is not on an even keel (as is always the case before loading and after discharge) the draught readings must be corrected for trim. It should be borne in mind that at such times, the draught marks are not in line with the forward and after perpendiculars.
- The draught must be corrected for the density of the water in which the vessel is floating. The determination of the density of dock water is not easy. It is difficult to obtain a reliable average density because this will vary at different levels and locations around the ship.
- Finally, the draught has to be corrected for hog and sag. This correction is generally calculated on the basis that a ship will bend parabolically, which is not in fact the case.

Eventually a mean draught figure is obtained (a double mean of means) which by comparison with the ship's displacement scale, gives the corresponding displacement. The ship's displacement table may not however always be completely accurate. This is usually supplied by the shipbuilder and the methods used to make up the tables may not always be totally reliable. Similarly the trim correction may be derived by the use of various formulae not all of which are entirely accurate.

## A draught or displacement survey

This method entails reading the draught before and after loading and thereafter comparing the two displacement figures. The difference between the two is the weight of the cargo loaded. Whilst this method eliminates the need to allow for the 'variables' and the 'constant', there are still certain disadvantages.

If, during loading and discharging, no shifting of weights were to take place other than the movement of cargo, then the calculation could be considered to be reasonably accurate. In practice, this seldom occurs. Frequently ballast is loaded or discharged during cargo work and it is unlikely that the exact amounts of ballast involved can be accurately calculated.

When sounding ballast tanks, especially with a large stern trim, it is difficult to ascertain whether a tank is completely dry. When a ballast tank is pressed up to overflowing it does not necessarily follow that the tank is 100% full. When tanks are filled quickly in the trimmed condition, up to as much as 10% of the tank capacity may be taken up by air pockets.

Moreover, the densities of the water in the ballast tanks may not be known to the necessary accuracy. This may affect the figures considerably, especially where large

quantities of ballast are involved. Other 'variables' may also change during cargo operations as fuel stores and water are consumed or replenished. These amounts also can rarely be calculated with any degree of accuracy.

## Determination of weight ashore

When dealing with claims for short delivery, which are commonly based on the accuracy of shore weights, the following points should be considered:

### Mechanical weighing

Mechanical weighing ashore may be effected by any one of the following methods:

- Weighing individual bags.
- Taking lorry loads of bagged cargo over a weighbridge.
- Taking lorry loads of bulk cargo over a weighbridge.
- Conveyor belt feed/automatic weighing direct into ship.
- Automatic weighing at ship through silo weigh-bins and chute systems.

### Fixed and mobile bag weighers

These are manufactured to various specifications and include:

- Semi-automatic machines suitable for low output, low-cost bagging requirements.
- Portable automatic bag weighers which can deal with both sacks and bulk.
- Fully-automatic bag weighers which will record both gross and/or net weights and which are suitable for flow materials such as grain, granular fertilizer, seeds, pulses, pellets, plastic granules, rice, refined sugar and other similar products.

Mechanically these machines may be accurate to within  $\pm 1\%$  for bags weighing between 20 and 50kg.

When weights increase to 100 and 250kg accuracy will improve to between 0.5% and 0.2%.

The degree of accuracy depends upon:

- The index allowances set by the operator for the weight of an empty bag.
- The degree of care exercised by the operator in maintaining the mechanical system.

### Automatic bulk grain weighers

These machines are suitable for weighing grain and free-flowing materials fed from elevators, conveyor belts, storage hoppers or silos. They are produced in various sizes and can record weight cycles from 30kg up to 5 tonnes. They can deliver at rates of up to 1,000 tonnes per hour. When this machinery is correctly installed and maintained by the manufacturers, and regularly inspected by a reliable local regulatory authority, an accuracy of  $\pm 0.1\%$  is to be anticipated. Such degree of accuracy is a general requirement within the grain trade. It should however be stressed that the degree of accuracy attained depends upon regular inspection, servicing and maintenance.

### Automatic load cell gross weighers

These machines are designed to handle dry materials and powders with grain sizes not greater than 25mm. They are used in continuous weighing cycles of 10-50kg and the accuracy of these machines is better than 0.2% in most cases.

### Vibratory feed high speed net weighers

This type of machine is normally utilized for such commodities as coal, coke, processed fuel and similar commodities; five weighings of 25kg/minute or four weighings of 50kg/minute. Accuracies of better than 1.0% can be expected.

### Conveyor belt weigh systems

There are a number of conveyor weigh systems. At best, the error is likely to be within 0.5% of true weight for capacities of up to 6,000 tonnes/hour, increasing to 1% to 2% of true weight for flow capacities of 2,000 tonnes/hour (i.e. these systems may be less efficient when the maximum flow capacity is not utilized).

Where an unexplained short-landing occurs at a discharge port this may prove to be a worthwhile field of investigation. If the cargo has been loaded and weighed on a conveyor system, then both the load-port terminal and the discharge port terminal should be asked to produce the manufacturers' full specification and brochures for the equipment utilized. If the guaranteed accuracy is not better than between 1% and 2% of true weight, considerable errors may arise. For a shipment of 100,000 tonnes, for example, an indicated 'loss' of 2,000 tonnes might be possible, where accurate weighing would have probably indicated a discrepancy of no more than 500 tonnes (based on a 'transport' difference of 0.5%).

## Weighbridges

These heavy-duty machines for the weighing of empty and fully-loaded road vehicles are produced in a range of types and sizes depending upon the environment and the local requirements. In most instances, they are intended to operate in a wide range of temperature conditions from -10°C to +50°C, dependent upon local regulations. In extreme conditions where temperatures may be regularly outside these parameters the manufacturers should be consulted. Weighbridges can be supplied to weigh from 20 tonnes in 5kg divisions up to 60 and 80 tonnes in 20kg divisions. In the United Kingdom, the Weights and Measures Authority certifies weighbridges for 10kg divisions up to 50 tonnes and for 20kg divisions upward to 80 tonnes. Because of the manner in which weighbridge scales are graduated and operate, manufacturers can do no more than guarantee an accuracy of half of one scale division or less. Thus, on a 20 tonne weighbridge, with 10kg divisions, the error could be  $\pm 5\text{kg}$  ( $\pm 0.025\%$ ). An 80 tonne weighbridge will have an accuracy of  $\pm 10\text{kg}$

( $\pm 0.0125\%$ ). Most weighbridge systems can be indexed in the control house for any debris, water, ice, snow, which may have accumulated between one lorry being weighed and the next but, if the correct indexing is not applied (or is deliberately ignored or wrongly set) the weights recorded will be in error to a greater degree than would be expected by the manufacturers or the licensing authority.

## Conclusion

It is probably reasonable to say that the accuracy of shore weighing of bagged and bulk commodities is unlikely to be better than within 0.2% and, in conveyor/weigh-belt systems, may be no better than  $\pm 2\%$ . There are no technical means by which the exact weight of a dry bulk cargo on a ship can be accurately determined. The weights may be approximately determined by free space measurement or by draught survey but neither of these methods is sufficiently accurate to verify the weight of a cargo as stated by shippers nor to determine any loss of cargo in transit.