

Dry Bulk / Quantity Measurements and other challenges

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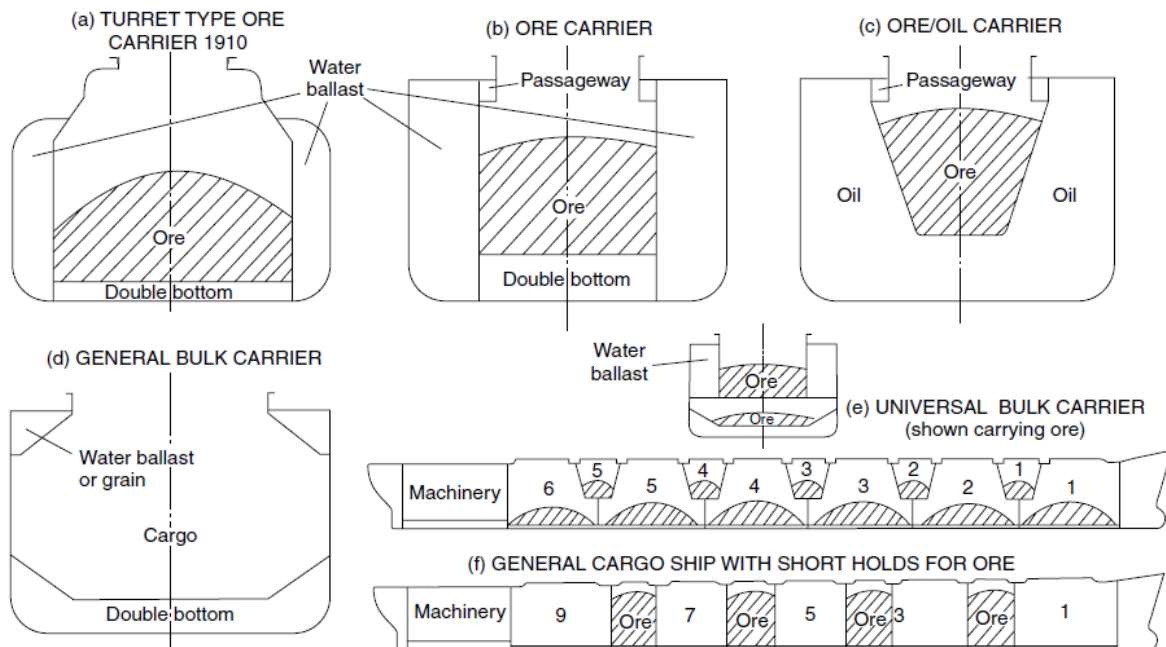
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Dry Bulk Operations and different measurement types

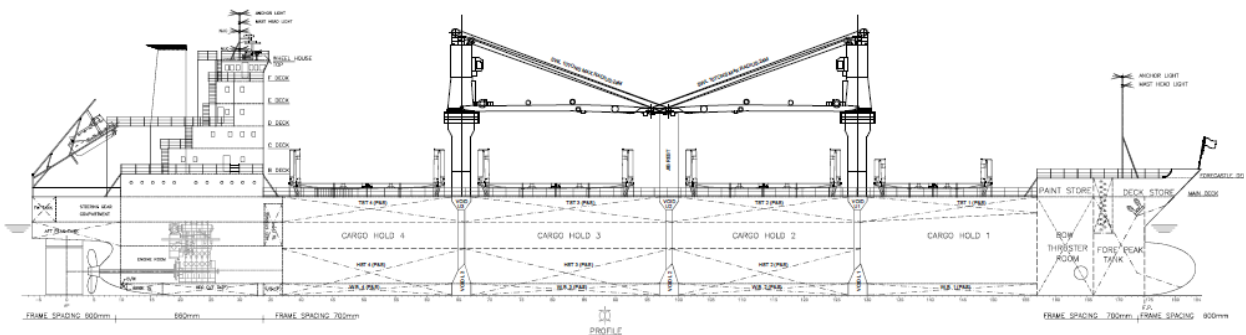
Over 15-17% of our merchant vessels are comprised of these amazing bulk carriers.

As of 1999, the International Convention for the Safety of Life at Sea defines a bulk carrier as a ship constructed with a single deck, top side tanks and hopper side tanks in cargo spaces and intended to primarily carry dry cargo in bulk; an ore carrier; or a combination carrier. But, let us not get into the technical lingo first, a bulk carrier as a general purpose cargo-carrying ship which is employed to carry enormous amounts of bulk unpackaged cargo in its single-deck structure. Broadly there may be 2 types of bulk cargoes:

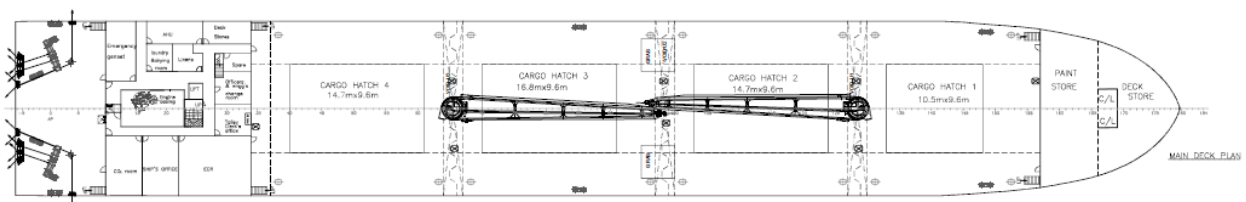
- Liquid bulk cargo transported by chemical tankers, crude oil carriers, product tankers, petroleum tankers.
- Dry bulk carriers carrying ore, grains, raw materials, coal, steel etc.
- Another special type of carrier called OBO carriers are found which carry all the three in combinations (Ore-Bulk-Oil) and that too in a single voyage.



Different types of bulk carrier based on cargo arrangement.
(Copyright: Ship Construction, D.J. Eyres)



Profile view of a bulk carrier.



Plan view of a bulk carrier (Main Deck Plan)

Now, let me come to the point. A simple bulk carrier is a single deck, high capacity cargo ship mainly intended for carrying unpackaged bulk cargo. It normally has a complex internal hull structure designed to meet its efficiency, capacity and storage, strength as well as safety.

Types of Bulk Carriers Depending on Size and Capacity

There are various types of bulk carriers based on their containment capacity or deadweight, sizes and dimensions and sometimes business and corporate standards. Some of the common types of bulk carriers are:

- **MINI BULKERS:** Deadweight (dwt) capacity < 10000 tons.
- **SMALL HANDYSIZE CARRIERS:** 20000-28000 tons DWT.
- **HANDYSIZE CARRIERS:** 28000-40000 tons DWT.
- **HANDYMAX:** 40000-50000 tons DWT.
- **SEAWAYMAX:** It is a design-specified type made to cross the St. Lawrence Seaway and has the beam restricted to within 23.16 m.
- **AFRAMAX:** 75000-115000 tons DWT.
- **SUEZMAX:** Specially designed to pass the Suez Canal and has the load capacity up to 150000 tons DWT.
- **PANAMAX:** Designed specifically to traverse the Panama Canal with breadth/beam within 32.2m and a capacity of 65000-80000 tons
- **CAPESIZE:** It is designed specifically to move through the Cape of Good Hope and Cape Horn.
- **VLBC or Very Large Bulk Carriers:** These are huge sized, with tonnage capacity of 80000-120000 tons DWT.

Hull form

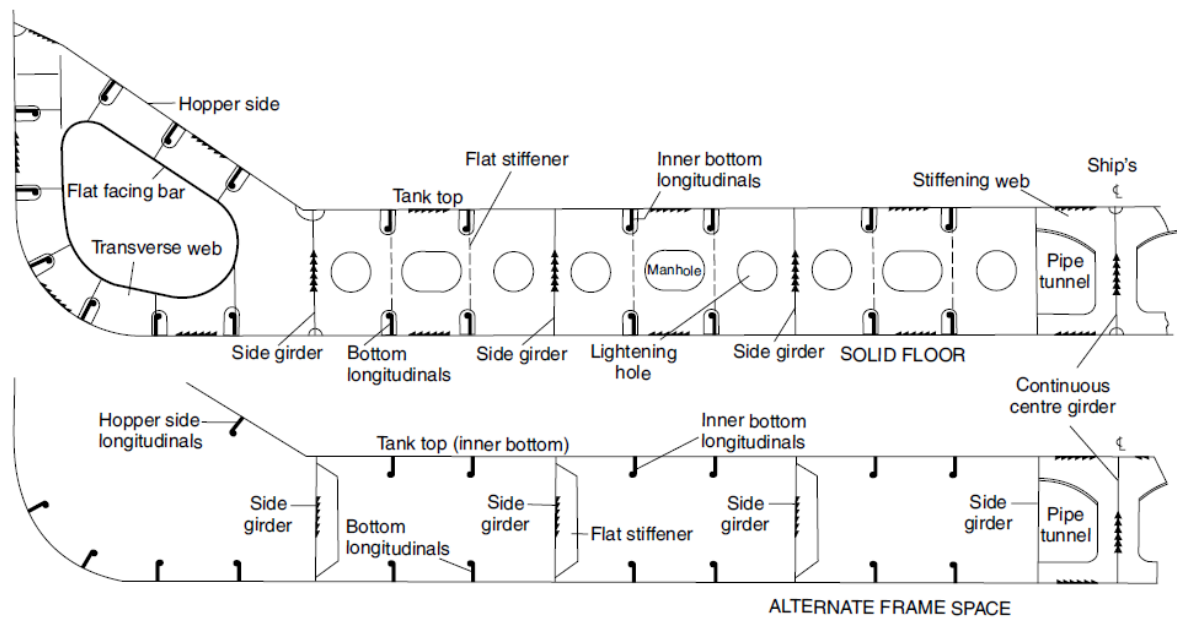
Now a bulk carrier has the main concern of carrying large amounts of loaded bulk cargo “economically and safely” from one place to another in stipulated time over varying distances. So, think about it, the prime concern driving all the vessels should be capacity and cargo-friendliness and not speed or luxury. So, in all the ships which are essentially of displacement-type (slow speed), it has a broader and fuller hull form.

A broader beam has a fuller bow as well as a stern to accommodate large amounts of cargo, reducing its concerns on speed. In terms of the body plan or the lines plan, the buttock lines or the curvature lines of the hull both fore and aft are far spaced accounting for its fullness.

Now the hull form of a bulker is generally cell-guided to account for its longitudinal strength (for larger ships) and is web framed (in shorter ships) to account for its transverse strength. The basic design of the hull form of bulk carriers is mainly comprised of a thick double shell plating and girded by tanks in the sideways, bottom, and top zones.

Strength of the Hull Girder

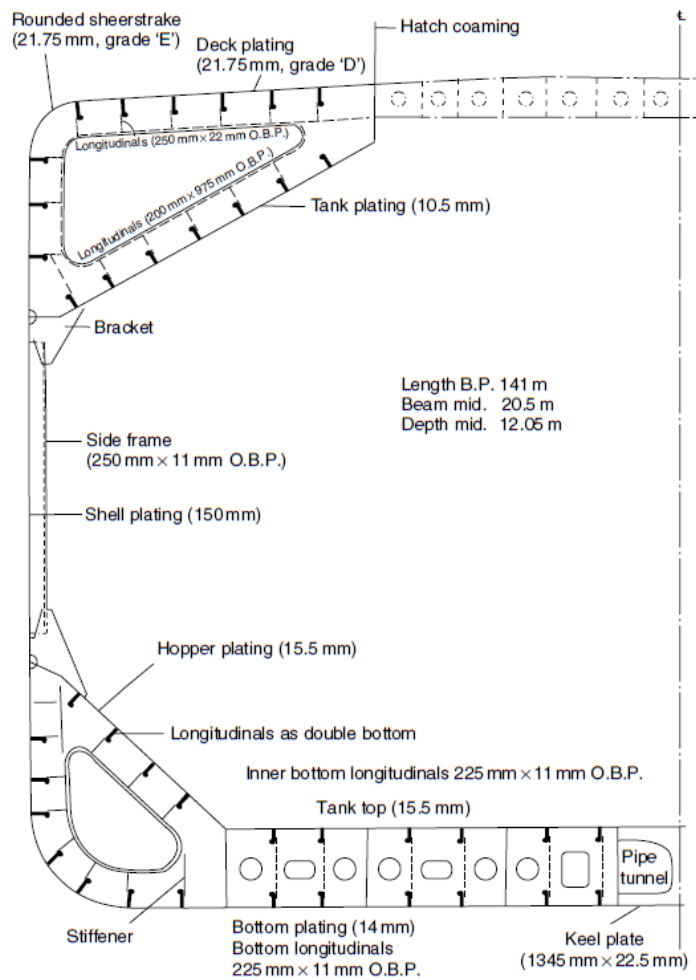
The double bottom structure not only adds to strength of the hull girder and protect the bulk cargo inside from any kind of oceanic disturbance. It also provides a protective layer against accidental flooding, breakage, leakage or grounding of a ship.



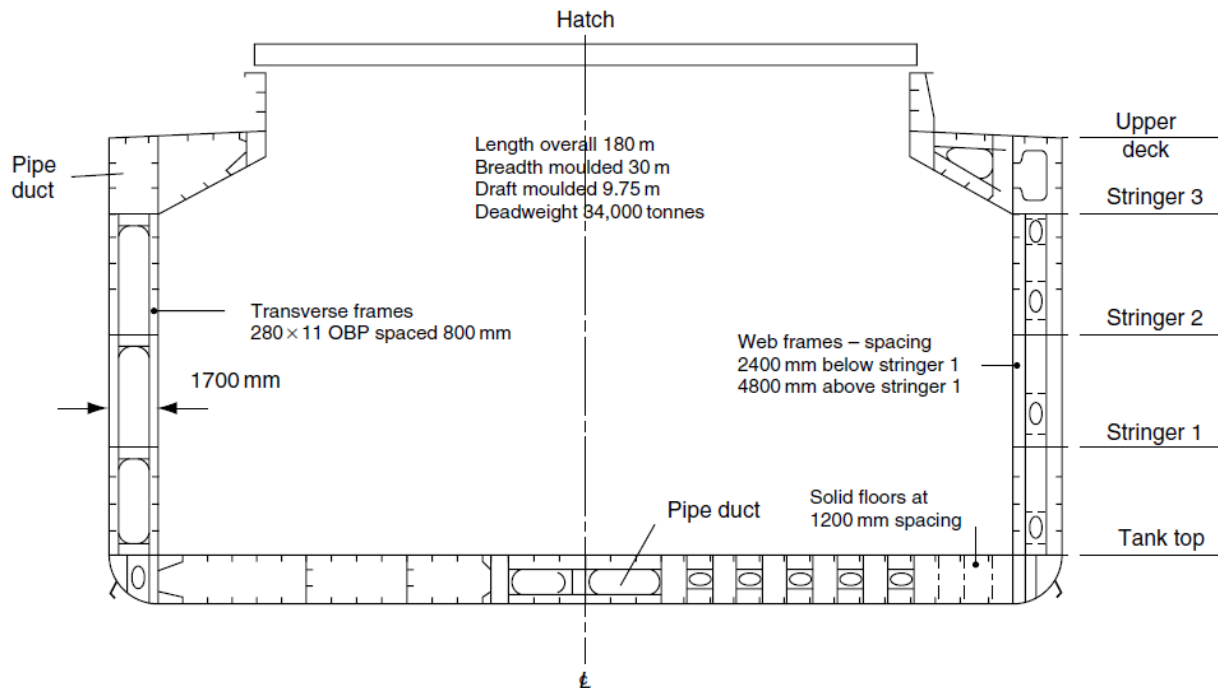
Double bottom structure (Solid floor and Bracket floor arrangement)
(Copyright: Ship Construction, D.J. Eyres)

The elaborate arrangement of tanks with the double bottom tank below, lower hopper side tank or bilge tank at the bilge or the upper hopper side tank underneath the corners of the upper weather deck mainly account for the ballasting systems in ships. Ballasting is an operation done by the intake of some amount of freshwater or seawater in the tanks for the purpose of maintaining the stability and buoyancy of the ship (hence maintaining its center of gravity in diverse sea conditions). The tanks also have manholes for the purpose of surveying, discharging, repairing and maintenance.

The deck and hull elements have an elaborate arrangement of girders and stiffeners for providing longitudinal strength. These may be welded or riveted depending on their location both in transverse and longitudinal direction.



Midship Section of a single skin bulk carrier. (Copyright: Ship Construction, D.J. Eyres)



Midship Section of double skinned bulk carrier.
(Copyright: D.J. Eyres)

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.

There are 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 complex and time-consuming way of attempting to determine the weight of cargo loaded onboard a ship. Many factors are involved, practically none of which can be established with 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.
- 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.



Bulk Carrier GT:63,153 tons Summer DWT:138,808 tons LOA:266m Beam:40m Draught: 15m

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, lowcost 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.



Ore Carrier GT:107,512 tons Summer DWT:218,283 tons Length:305m Beam: 54m Draught:11 m

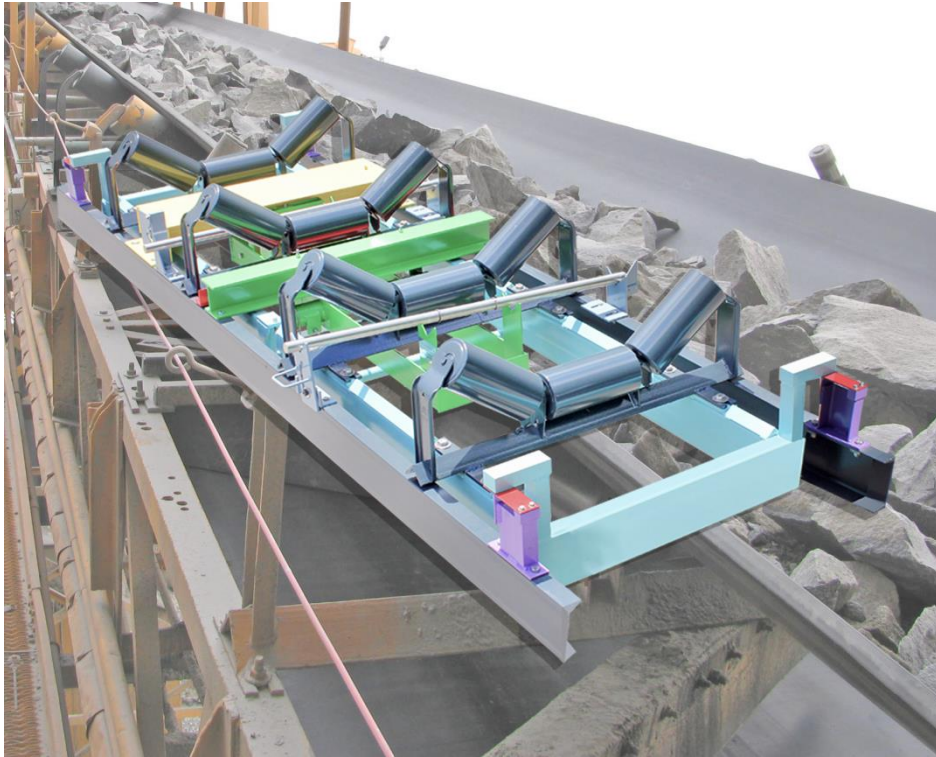
Automatic load cell gross weighers:

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 neither to verify the weight of a cargo as stated by shippers nor to determine any loss of cargo in transit.

Draft Surveys are generally accepted as being accurate to + or – of 0.5%

- Hayler, William B.; Keever, John M. (2003). *American Merchant Seaman's Manual*. Centerville, MD: Cornell Maritime Press. ISBN 0-87033-549-9.
- Morrell, Robert W. (1931). *Oil Tankers* (Second ed.). New York: Simmons-Boardman Publishing Company.
- Turpin, Edward A.; McEwen, William A. (1980). *Merchant Marine Officers' Handbook* (Fourth ed.). Centerville, MD: Cornell Maritime Press. ISBN 0870333798
- Autoridad del Canal de Panamá (2005). MR Notice to Shipping Number N-1-2005. (PDF). *Notices to Shipping*. Balboa-Ancon: Autoridad del Canal de Panamá. pp. 11–12. Retrieved 2008-04-01.
- Bliault, Charles; Jonas, Martin; The North of England P&I Association (2016). *Bulk Cargoes: A Guide to Good Practice* (First ed.). UK: The North of England P&I Association. p. 280. ISBN 978-0-9574936-3-6.
- Frankel, Ernst G. (1985). *Bulk Shipping and Terminal Logistics*. Washington, D.C., U.S.A.: World Bank. ISBN 0-8213-0531-X.
- George, William (2005). *Stability and Trim for the Ship's Officer*. Centerville, MD: Cornell Maritime Press. ISBN 978-0-87033-564-8.
- Hayler, William B. (2003). *American Merchant Seaman's Manual*. Cornell Maritime Pr. ISBN 0-87033-549-9.
- International Maritime Organization (September 1999). "IMO and the safety of bulk carriers" (PDF). *Focus on IMO*. Retrieved 2007-04-09.
- Isbester, Jack (1993). *Bulk Carrier Practice*. London: The Nautical Institute. ISBN 1-870077-16-4.
- Lamb, Thomas (2003). *Ship Design and Construction Vol. I*. Jersey City: Society of Naval Architects and Marine Engineers. ISBN 0-939773-40-6.
- MAN Diesel Group (2005). "Propulsion Trends in Bulk Carriers" (PDF). MAN Diesel Group. p. 4. Retrieved 2007-04-12.
- International Association of Classification Societies (2007). "21: Evaluation of Scantlings of Hatch Covers and Hatch Coamings of Cargo Holds of Bulk Carriers, Ore Carriers and Combination Carriers (Rev. 4)". *Requirements Concerning Strength of Ships* (PDF). *Unified Requirements*. International Association of Classification Societies. pp. 21–1.
- Office of Data and Economic Analysis (July 2006). "World Merchant Fleet 2001–2005" (PDF). *United States Maritime Administration*. Retrieved 13 March 2007.
- Thompson, Mark L. (1994). *Queen of the Lakes*. Detroit: Wayne State Univ. Press. ISBN 0-8143-2393-6.
- United Nations Council on Trade and Development (UNCTAD) (2005). *Review of Maritime Transport, 2005*. New York and Geneva: United Nations.
- United Nations Council on Trade and Development (UNCTAD) (2006). *Review of Maritime Transport, 2006* (PDF). New York and Geneva: United Nations.
- Zera, Thomas F. (1996). *Ore-Oil Bulk: Pictorial History of Bulk Shipping Losses of the 1980s*. Bethel, CT: Rutledge Books. ISBN 0-9643937-7-8.
 - Law and Sea http://www.lawandsea.net/COG/COG_Bill_of_Lading2.html
 - <http://cargocal.com/openmeasurement.html>