Science, opinion and art

Part I: Draught surveying and ocean-going vessels — a practical example

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Dynamic weighing systems, such as belt scales, weigh-bridges or balances, have removed a lot of uncertainty from the quantity of cargo loaded or discharged by vessels. Nevertheless, these measurements may have the appearance of being weighted in favour of the vendor or the purchaser through inaccuracy or doubt, requiring the determination of the weight of a ship and its cargo by draft surveying for the purposes of releasing bills of lading, fulfilling contracts and paying invoices by calculating the cargo quantity aboard. This applies mainly to bulk cargoes, as container vessels and specialist carriers have developed other methodologies to better fit their needs. There may also be issues relevant to the stability and capacity of a vessel; which are addressed by a draught survey.

It would be nice to be able to state categorically that all draught surveys are easily proven according to scientific means, but this is too glib as it implies a state of perfection that simply does not exist in the marine environment. The easiest way to illustrate the subtleties and complexities of draught surveying is to follow a surveyor on board a vessel about to discharge a cargo of dry bulk...

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The ship is all fast and the pilot has left the bridge. The agent huddles with the master and the immigration officer in murmured conversation. The officer nods, the agent heaves a sigh of relief as he calls the draft surveyor to say that he can have the chief mate and read the drafts. Alas, many encounters with immigration or customs officers do not end with a sigh of relief.

The longshoremen are surly with impatience, fully mobilized, pent-up energy barely controlled, waiting for immigration procedures to complete and the signal for them to board the vessel, take over the deck, and commence the discharge in their inimitably efficient ways. Any delay costs time, and time costs money and the person costing them time and money is the draught surveyor whose measuring and calculating rarely needs less than 90 minutes and sometimes longer.

The draught surveyor's first obligation is to identify himself to the vessel's mate, usually in the ship's deck office. There, one may find the surveyor festooned with gear; which must be portable: hard

Photos courtesy Tim Ellis

The MV Federal Sumida, *fully laden, just prior to the commencement of discharge. Note the welling-up around the hull: the difference between the true water line and the observed waterline is about five centimetres.*

The MV Glory Moon *— note that the forward draught marks are affected by the current and extra care will be required to obtain good readings*

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hat, steel-toed boots, waterproofs topped with hi-viz vest, gloves, a certified flashlight, hydrometer, water sampling bucket with a long line attached, sounding tape in metres and feet, sounding pipe extension, water paste, Manometer, water finding paste, notebook and pencil, calculator or laptop, a device to sample ballast water, binoculars, camera, telephone (to call the agent with the results) and lifejacket. Every draft survey requires the rules be restated: "ballast tanks full or empty, vessel upright and trimmed within one per cent of vessels length overall, ballast not to be moved, cranes immobilized, hatches open or closed, no taking on fuel or fresh water, tugs not pushing, mooring lines fixed".

The draft surveyor's race against time is on: read drafts from fixed and floating platforms; measure specific gravity and temperature at 50 per cent of the depth of the immersed draft (although temperature corrections are almost never made); take the chief engineer's totals for fuel oils, diesel and lubes unless reading them oneself; sound all ballast and fresh water tanks; receive the ship's constant from the mate; and then, taking these into account and using the ship's data manuals, calculate the displacement and confirm a cargo figure — made a bit easier with a laptop and dedicated software...until a deficiency emerges. Double check figures, maybe draft a dubious ballast tank a second time, or reconfirm the constant, check the math and finally deliver a figure, usually one that agrees with the mate's own calculation, but not always. Wise surveyors always double-check the first draft they have taken before returning to the ship's office — if it has changed then one may assume that the vessel is ballasting or engaging in some other business incompatible with the draft survey. Then, and only then, can the discharge begin. Now sometimes, and more often in today's world of real- time management, the draft surveyor will get the drafts but the rest of the measurements must be taken whilst the vessel is preparing for discharge: discharging sequence discussed, hatches opened, equipment and personnel mobilized, all making room for errors that cannot be easily discerned or corrected.

"Math" you say! Sounds like easy work in Excel but it is not, and for a variety of reasons. Surveyors in general, and draft surveyors in particular, bring peculiar gifts to their profession: acute vision, the ability to climb a Jacob's Ladder and function for long periods without sleep to name but three. Others are a good facility with figures and clear understanding of the forces brought to bear on the vessel viz-a-viz the viability of the survey figure. This knowledge can be gained from study, but in the reality of the marine environment, study is not a substitute for experience. Accuracy is key.

Archimede's Principal is that a floating object displaces its own weight of the liquid in which it floats. The essence of a survey comprises two sets of measurements: 1) those prepared by the builder and annotated by the ship's officers which allow one to calculate exactly what the vessel displaces at any given ballast or cargo condition, no matter what trim or list from the perpendicular in any plane, hog or sag, salt or fresh water; and 2) the measurements taken at the time of the survey by the surveyor and sometimes by the mate. Mates always used to accompany the surveyor, not for companionship but to compile their own survey measurements for the vessel's record and as a yardstick for errors. These days are behind us as modern vessels rely more and more on measuring apparatus for calculation by onboard computing systems, and with manning pared to the bone, the mate may not be available or, worse yet, he or she may lack the necessary skills and experience.

The survey itself begins in the ship's office with the ship's particulars followed by a reading of the drafts by boat and from fixed structures, often using both methods: two forward, two mid-ship and two aft. These measurements must take into account variations due to wind,

current and tidal flow and waves. Wind can cause water to pile up against one side of a vessel, leaving a low-pressure zone on the other; current and tidal flows cause wakes and bow waves further confusing drafts; and wave action requires intense scrutiny of draught marks to divine averages suitable for use in calculations. From outside the vessel, the surveyor then returns aboard and, utilizing his hydrometer and thermometer (often contained in custom built equipment), measures the water temperature and specific gravity, sometimes at several depths and locations, but usually at 50 per cent of the mean draft. Equipment such as the thermometer and hydrometer are certified accurate but the draft readings rely on experience. When extremes prevent draft measurements, long reels of tubing may be employed to provide a Manometer or a wave damping tube may be employed to resolve the draft measurements.

With the measurements in hand, the surveyor then moves to the bow and, starting at the fore peak, measures the level of salt and fresh water in each ballast or storage tank. Modern vessels tend to be economical with tanks and require less soundings, perhaps 15 on a handy-max of 50,000MT, but older vessels may have more tanks — and more tankage means more complexity as the shape of tanks could be anything from tall and square-sectioned tubes to complex rhomboids. The vessel's builder is responsible for producing tables to calculate the ullage of any given tank, but these are only as reliable as the builder's attention to detail and can be tenuous at extremes of trim and list. The vessel itself provides a figure for stores, called the "constant", and this figure will often include the weight of repairs and additions, equipment on board that is not part of the light-ship calculation, for example barrels of cleaning fluids carried on deck and whether or not the ship's plunge pool is full or empty.

At last, the surveyor can sit down and begin his calculations. Around him are the ship's stability book with displacement, TPc, Lcf, Mctc, Light Ship, Deadweight, LBP, Fd, Ad (see notes) and the hydrostatic pages. The surveyor corrects the draughts, adjusts for hull deformation caused by hog or sag using the maths of the parabola or by a deflection calculation, corrects for trim and density and applies the list correction, takes the constant into account and adds the figures provided by the Chief Engineer (if these were not taken by the surveyor during drafting, for ballast, fresh water, fuel and others). Presto! The cargo figure emerges — smiles all around if it fits and curses and more work if it does not.

Keep in mind that all this is done whilst frozen stiff or bathed in sweat, constantly interrupted, and battling language, competing measuring systems, brilliant sunshine, rain, nighttime and wind, the receiver and his impatient stevedore, and a client who will argue about every dollar charged even if the survey takes five hours instead of 90 minutes through no fault of the surveyor. The surveyor will do this again when the vessel is completely discharged. This to double check the first calculation; which is itself a double-check of the survey performed at the loading port.