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DATE: 21 JUNE 1995

Dear Member

re: DRAFT SURVEY

We attach herewith a copy of the report from Burness, Corlett and Partners, Naval Architects and Maritime Consultants on the levels of accuracy inherent in the measurement of large bulk carriers that precludes them being considered the finite weighing device the UNECE Draft Survey Code suggests.

Expressed as a percentage of dead weight (cargo), BCP considers modern bulk carriers built using computer assisted technology could have a mean error in measured accuracy of 0.21% with a range of 0.66% whilst older bulk carriers could have a mean error of 0.54% with a range of 0.83%.

The draft survey code conveniently overlooks the effects of these inherent errors which can be considerably larger than the minor corrections the Codes time consuming processes set out to resolve as its justification.

We recommend CETOA uses the report in a timely submission to the International Standards Organisation and when appropriate the IMO to illustrate there are greater factors effecting the accuracy of determining the weight of cargo by draft survey than the draft survey process itself and to avoid putting at risk the reputation of ISO standards the Code should be rejected.

We also recommend members consider using the report to enthuse their national representatives who attend the ISO and IMO working group meetings to reject the code on the grounds it will not improve accuracy due to the presence of much larger indeterminable factors and over time would substantially add to the cost of dry bulk materials.

We would appreciate your comments.

Yours faithfully
per pro THE SECRETARIAT

J D HOLDEN
Chairman

MEASUREMENT OF CARGO LOADED
BY DRAFT SURVEY

BCP/J/5616

May 1995

1. Introduction

1.1 Burness Corlett & Ptns. (IOM) Limited (BCP) have been requested by the Coal Exporting Terminal Operators Association (CETOA) to carry out an investigation into levels of accuracy achievable in practical circumstances in the determination of the amount of cargo loaded in bulk carriers by draft survey.

1.2 The draft survey process essentially involves measuring the drafts of the ship on arrival at the terminal in ballast, calculating the ballast removed and other alterations (such as stores or bunkers) during loading, and finally measuring the drafts on departure. Values of ship displacement are again determined from the ship's data at the drafts concerned and the cargo is established as the difference between arrival and departure displacements plus the ballast discharged and adjusted for stores, bunkers etc.

1.3 CETOA have asked BCP to consider the levels of inaccuracy inherent in this procedure for four generic ship types, namely:

    1) Handy size bulker of about 40.000tdwt
    2) Panamax bulker of about 70.000tdwt
    3) Small Capesize of about 110.000tdwt
    4) Large Capesize of about 150.000tdwt

1.4 There are certain values that are considered absolutely accurate for draft survey purposes. They are:

    i) The ship's hydrostatics
    ii) The ship's tank capacity tables

1.5 Other measures are considered sufficiently accurate for the purpose of cargo determination, namely:

    i) Trim correction for displacement
    ii) Trim correction for tank capacities
    iii) List correction for the above
    iv) Corrections for the hog or sag of the ship

1.6 There is of course a limit to the accuracy with which the drafts themselves can be read and this is largely dependant on circumstances. For the purposes of this investigation, a statistically defined level of error in reading the drafts has been assumed, as set out in Section 4 of this report.

2. Conclusions

2.1 This report investigates the likely accuracy with which cargo may be measured using draft surveys, taking account of the normal errors inherent in a ship's definition, and other sources of error including hog and sag correction, ballast capacities and the accuracy with which the drafts can be read. The conclusion of the report is that the total error may be up to about 0.5% of the total cargo loaded, or as high as 1% in the case of older tonnage in poor structural condition.

2.2 While the accuracy with which the actual drafts may be measured is significant, other factors such as the correction method for hog or sag, the determination of densities and the capacity of ballast tanks are also very important in determining the overall accuracy of the measurement. These latter values cannot reasonably be assessed any more accurately than is done at present, by using the ship's documentation and normal terminal facilities.

2.3 Further errors normally of lower magnitude, include thermal effects, errors in the ship's hydrostatics, the effects of density variations and errors in the positioning of draft marks and sounding pipes.

2.4 Our statistical review, detailed in Section Four below, shows that while the majority of draft surveys will result in an evaluation of cargo loaded accurate to within about 0.2%, it is not realistically possible to avoid errors of up to 0.5% from time to time.

3.   General Considerations of Error Sources

3.1   Basic Ship Data

3.1.1   The ship is presented at a terminal with hydrostatics and a loading manual containing data that is normally regarded as correct. In particular, it is assumed that the difference in displacement at two drafts (arrival and loaded) is correctly provided by the tables. In this report, four ship types are considered, as set out in Table 3.1.

3.1.2   Virtually all modern (i.e. post 1970) vessels will have had their hull forms defined on a computer for the calculation of hydrostatic, stability and longitudinal strength data. This is computed by numerical methods, such as Simpson's Rule, involving small approximations both in theory and in treatment of detail such as the thickness of shell plating and treatment of rapidly changing sections at each end.

3.1.3   We have seen vessels defined on the basis of about 40 sections along the length which is generally adequate for practical purposes. Error levels found were up to about 0.01% of displacement in the difference between the deep and light draft displacements.

3.1.4   Trim corrections also have to be made to find displacement, usually more significantly at the ballast draft. Our assessment of the usual corrections for LCF and MCT indicates very good accuracy, so that the difference between arrival and departure displacement assuming perfectly taken drafts and no ship distortion would be correct to within 0.015%, or about 30 tonnes for the large Capesize.

3.1.5   The other area of doubt, assuming perfect physical conditions, is in the capacities of the tanks. Here there are some further areas of approximation, namely permeability and sometimes failure to account explicitly for bulkhead plating thickness. Permeability may be calculated or it may be assumed on a custom and practice

basis, often 0.975 for double bottoms and peaks, and 0.98 or more elsewhere. Permeability should of course include allowance for piping etc. in the tank as well as the structure of the ship. Accuracy is important in absolute terms here because the tanks are normally operated full (pressed up) in ballast and empty when the ship is loaded. The whole capacity or more correctly weight of ballast removed will therefore be added into the calculation of the cargo loaded. Again given a rigid clean ship, perfect pumping, accurate definition and calculation by numerical means, a pretty accurate outturn could be expected, with the influence of approximately calculated permeability probably creating a potential·error of no more than 0.03% of the total capacity and about 0.01% of displacement.

3.1.6   Total expected error in these ship definition areas, where calculation of permeability is included. would therefore not exceed 0.025% which is about 50 tonnes in the case of our large Capesize. If, however. permeability is estimated by standard "rule of thumb", as with many ships. the error can be much larger .

3.1.7   If permeability is incorrectly assumed. errors of up to 10 times this level can arise. Calculations for a large Capesize bulker double bottom/side tank indicate a permeability of about 98.2%. If the assumed permeability was 98.0%. this would involve an error of 0.2% of the ballast capacity of about 60,000 tonnes, or about 0.07% of dead weight.. Clearly larger errors could arise; say with a double bottom assumed permeability of 97.5% and actual of 98.5%, producing an error of 600 tonnes. Indications from calculations show that permeability is normally underestimated by standard formulae. so this would usually result in an underestimate of ballast discharged and hence an overestimate of cargo loaded. with error potentially as high as 1.0% of ballast capacity, around 0.4% of dead weight in extreme cases.

3.2 Constant

3.2.1 Determination of the constant is part of the cargo measurement process. The constant is found as the difference between the displacement in the ballast arrival condition as measured from the drafts, and the displacement as determined by the summation of the known quantities on board plus the ship's lightweight. It therefore generally includes the ballast capacity errors mentioned above. The constant should always be positive and is recognised as representing lightship growth, accumulation of unaccounted stores, heavy deposits in ballast tanks, etc. The constant normally changes for each load and discharge, reflecting generally the inaccuracy of the calculation rather more than changes in lightship growth or accumulated stores etc.

3.2.2 The constant may introduce further errors in the draft survey where it includes a significant amount of mud, scale or other heavy deposits in the ballast tanks. These displace the ballast and so the calculation of the quantity of ballast discharged is incorrect. Although the final loaded draft survey accounts for the constant, it ignores the overestimate in ballast discharged, in general leading to an increase in the apparent cargo loaded.

3.2.3 The amount of this error is of course entirely dependant on the amounts of deposits in the tanks and this varies from ship to ship. In our experience it can account for over 1% of ballast tank capacity, as much as 5% in a double bottom. In the large Capesize, this represents a range of variability of the order of 1000tonnes, probably skewed towards zero error but in general all on the side that overestimates the cargo loaded. The error could thus be about 0 to 0.7%, probably peaking to 0.1 or 0.2%.

3.3 Hog and Sag Corrections

3.3.1 This is an area which is amenable to calculation, in that the computer can bend the ship according to its strength and the bending moments applied, then balance the buoyancy and LCB

with the weight and LCG. Many vessels in fact sag or hog by amounts that are not entirely consistent with the loading, due to permanent deformation or structural interactions. This can be allowed for to some extent by modifying the ship's strength is particular areas, but discontinuities of the hull girder are not so easily simulated if they exist, and errors in draft survey results may be rather large. This applies mostly to older vessels.

3.3.2 Section 4 of this report contains some statistical analysis of the effects of hog and sag when calculated by approximate methods and combined with an estimated, but realistic, random error level in reading drafts. One factor here is the increase in error that can occur when the peak or trough of the ship's deflected shape is not coincident with midships, where the drafts are read. In many vessels, particularly older vessels with large engine rooms and large deck houses, the cargo area is centred well forward of amidships so the sag or hog characteristics can be unsymetrical. This alone can produce errors of up to 0.5% of displacement.

3.3.3 As with the effects of ballast errors. the means of correction for hog and sag can produce large errors. potentially as high as 0.5% of displacement in extreme circumstances. In the majority of cases, however, the error will be limited to around 0.1% or 0.2% of displacement. The error is likely to be worse for older ships which are prone to permanent deformation. have corrosion which weakens parts of the hull girder and permits additional flexure and which may still be constructed from higher tensile steel and are subject to higher stresses and strains. resulting in more hogging and sagging distortions.

3.4 Other Distortion and Tolerance Problems

3.4.1 There are a variety of other means by which the ship presented for loading may not be identical to that described in the Trim and Stability booklet, apart from hog and sag. The vessel may be twisted, bent laterally, or even rippled between major bulkheads. It is possible that the vessel was built (and inclined) precisely to

the drawings in a cold climate, but expands when loading in warm water and under a hot sun.

3.4.2   Most of these factors are small and often more or less self cancelling when the ballast displacement is subtracted from the loaded displacement. Older vessels. however, do sometimes exhibit slightly set-in side shell panels between the upper and lower hopper/saddle tanks. This has less effect on the ballast displacement, as much of the panel is out of the water, but more in the loaded condition when the panels are immersed. A large Capesize with tanks set in by an average of around half the plate thickness would lose about 50 tonnes displacement, an error of 0.025%. Any more severe setting in of panels would of course have a more serious effect.

3.4.3   Tolerances at shipyards can result in divergence between the vessel as built and the design. These of course affect tank capacities as well as the hull form. We have not come across any examples of major divergences of this nature in bulk carriers.

3.4.4   When a vessel is exposed to solar heating, the vessel bends due to the greater thermal expansion at deck level. A detailed calculation has been performed to consider the large Capesize vessel with an air temperature of 30°C and a water temperature of 15°C. The deck was at 60°C due to direct solar heating. The thermal bending moment was found to be just over 100,000 tonne metres, which is about ¼ of the maximum Still Water Bending Moment for the vessel in the Load Condition. The vessel responds to the thermal bending moment by hogging and so this would reduce the still water sag in the Load Condition. In the ballast condition it would augment the existing hog by about $1/3$rd. However, this would of course be included within the measured draft and corrected for, as detailed in Section 4 of this report.

3.5 Density

3.5.1   There are two major areas of doubt with density measurements, namely the water is which the ship is floating and the ballast water.   Both are generally measured by hydrometer to 5 significant figures, e.g. 1.0243 tonnes/m^3 which is to 0.01%, but the true accuracy of most hydrometers is about 0.02%, taking the meniscus into account.

3.5.2   Normally one or two readings are taken of ballast water density and typically four from the water in which the ship is floating. This is normally adequate to obtain density within about 0.02% but occasionally there will be difficulties, particularly if the vessel is in a tidal area with a large freshwater input from a river.   This can affect density readings on a continuous basis throughout the day.

3.5.3   Density should have a random error although the tendency to take readings from near the surface may skew the error towards the light side.   A mean error of around 0.015% of displacement may arise taking both ballast and sea water density errors into account.

3.5.4   Some vessels are listed as well as trimmed at draft survey.   This slightly alters the TPC, the MCT and the tank calibrations. Correction factors can be applied by draft surveyors but further small errors, dependant on the magnitude of the list, will be present largely because the shape of the ship, as opposed to a wall sided box ,is not generally taken into account. For small angles of list, total error should not exceed 0.01%.

3.6 Operational Matters

3.6.1   Some operational practices can lead to small or moderate errors. If the final loaded trim is slightly bow down, possibly due to fuel carried forward, there may be some ballast left unpumpable in the double bottoms.   Quantities in engine room tanks can at times cause problems when transfers are made or if bunkering has

occurred. If holds were ballasted to levels below the hatch coaming, inaccuracy may well be quite large due to errors in the ullage measurement position. These errors are largely preventable but occur easily and can cause 0.1% or 0.2% error quite readily.

TABLE 3.1

SHIP CHARACTERISTICS

TYPE	MAX DWT TONNES	LOA M	LPP M	B M	D M	T M	LIGHTWEIGHT TONNES	DISPLACEMENT TONNES
Large Capesize	169080	294.16	281.94	44.25	25.05	18.44	30250	199330
Small Capesize	103328	256.5	243.8	38.9	20.6	15.1	19670	123000
Panamax	70600	233.6	223.6	32.2	18.7	13.67	13000	83600
Handy Size	37765	201.3	186.0	27.8	15.6	11.2	9955	47720

4. <u>Statistical Investigation into the Effects of Hog and Sag and Inaccuracy in Draft Readings.</u>

4.1 Amongst the largest errors to have been identified are those involving correction for hog and sag, and those associated with reading the draft marks. In order to assess the likely impact of these errors, a statistical study using our "Crystal Ball" statistical forecasting software suite has been carried out for the large Capesize vessel. Two conditions have been examined, with differing amounts of hog and sag. Condition 1 is a full load arrival or departure condition with sag and Condition 2 is a ballast arrival or departure condition with hog.

4.2 In order to treat the effects of draft error, hog and sag all together, use has been made of the Monte Carlo Simulation option. The start point for this method of analysis is the measured draft. The error in each individual measurement is assumed to lie between $\pm$ 3cm maximum. The distribution of error is assumed to have a Standard Deviation of 1.8cms, which means that 80% of measurements will have an accuracy better than $\pm$ 2cms. This distribution is based on a BCP staff mariner's experience. The distribution is shown in Fig. 4.1.

4.3 Six measurements are assumed, forward, midships and aft, taken both Port and Starboard. Each measurement is assumed to have the same distribution of measurement error as above. The simulation samples each draft measurement and applies a random error according to the assumed distribution, i.e. in 100 samples, 80 will lie within $\pm$ 2cms and 20 will be greater, but less than $\pm$ 3cms. The Port and Starboard samples are meaned and then used as the input to the various methods of hog/sag correction. Three methods were used:-

    i)   Hog x C_f with $C_f = {}^2/_3$

    ii)   Hog x C_f with $C_f = \frac{3}{4}$

    iii)   Mean of Means, Tm - (Ta + Tm x 6 + T_F)/8

4.4 Correction was made for trim to the LCF position. The second correction was not applied, as this would make the simulation inordinately complicated; however, in the ballast condition, which has less than 1 metre trim, this would only amount to a few tonnes. The displacement calculated using these three formulae was compared to the actual as

determined by BCP computer calculations on the precise hull definition with computed hog or sag.

4.5   The actual displacement for Condition 1 used in the simulation was 196,269 tonnes with a sag of 17.4cm. Condition 2 had a displacement of 98,206 tonnes with a hog of 16.1cm. The results for Condition 1 using the $C_f = \frac{3}{4}$ approximation are shown in Fig.4.2. In this figure, it can be seen that the mean error is 151 tonnes. The variability in the error has a range of over 1,000 tonnes at worst. In statistical terms, 80% of the simulations had an error which varied between $\pm$ 175 tonnes about the base error of 151 tonnes. 20% of the simulations exceeded this, but fell between $\pm$ 512 tonnes about the base error of 151 tonnes.

4.6   The results of the 10,000 simulations for Conditions 1 and 2 are shown in Table 4. The row entitled "Mean Draft (ignoring hog)" yields the actual displacement gained or lost by hog or sag. At nearly 1,400 tonnes its effect cannot of course be neglected. The $C_f = \frac{2}{3}$ method produces consistently small mean errors, but the variability is greater than the mean of means method.

4.7   Comparing the "$C_f = \frac{2}{3}$" method (i) with the "mean of means" (iii) method shown in Table 4, the inherent errors in the approximate methods can be seen. The $C_f = \frac{2}{3}$ yields a mean error of -17 tonnes with a maximum variability of $\pm$ 455 tonnes. i.e. all values will lie between -472 tonnes and +438 tonnes, as shown on the right of Table 4. The "mean of means" method yields a greater mean error of +150 tonnes, but the range of all values lies within $\pm$ 279 tonnes. i.e. between -129 tonnes and +429 tonnes. The best 80% of the simulations gave errors of $\pm$ 165 tonnes for method (i) and $\pm$ 150 tonnes for method (iii), i.e. 80% of values lay between -182 and +148 tonnes for method (i) and between 0 and +300 tonnes for method (iii).

4.8   Overall, there is no best method. The "mean of means" reduces the variability caused by measurement error. but it gives the greatest mean error.

4.9   In the ballast condition, the errors are of the same order of magnitude, but represent a greater % error on displacement. For example, method (i) gives a mean error of +0.05% and method (iii) gives -0.10%. However,

the maximum errors using method (i) are -0.41% and +0.51%, whereas method (iii) gives -0.36% to +0.15%.

4.10 The net errors result from the difference between the load displacement and the ballast displacement. It can be seen in Table 4 that the mean errors are compounded, i.e. if the ballast error is light, then the load error is heavy when using the same method. Hence the net error is the absolute sum of the two mean errors. Again, for this vessel, method (i) produces the least mean error at 0.04% of deadweight, but has the greatest variability at -0.45% and +0.37%. Method (iii) gives a mean error of +0.16%, but reduced variability from -0.12% to +0.34%.

4.11 Calculations were also performed to investigate the effect of maximum sag occurring other than at midships. For the large Capesize it was found that moving the maximum sag 8% forward of midships caused an additional error of 80 tonnes, or 0.04% of deadweight. The additional error is due to two factors:-

   i)   The sag determined at midships is less than the maximum sag.

   ii)   The approximate methods assume a symmetrical deflection.

In the case of a homogeneously loaded large vessel, the maximum sag is likely to occur near midships. However, smaller vessels have a proportionally larger engine room which is likely to push the maximum deflection forward of midships. The effect is also likely to occur in some ballast conditions and particularly in part or jump loaded conditions.

4.12 It should be noted that the above calculations have compared the calculated displacement (using approximate formulae for hog and sag) with the precise displacement in the hogged or sagged condition. A major part of this calculation is the displacement at the mean draft taken from the hydrostatics. Here it has been assumed that the hydrostatics are 100% accurate. However, as shown in Section 3.1 this is not always the case and so any error in the hydrostatics is additional to the figures shown in Table 4.

Summary of Hog and Sag Corrections
## (including measurement error, port & stbd.)

Method of calculation	Mean Error	Variability Maximum "+/-"	Variability 80% "+/-"	Error on Actual Displacement (in Tonnes) Least	Lowest 40%	Highest 40%	Greatest
Load Condition 1							
Mean draft (ignoring sag)	-1366						
Sag Correction (Cf=2/3)	-17	455	165	-472	-182	148	438
Sag Correction (Cf=0.75)	151	512	175	-361	-24	326	663
Mean of Means	150	279	150	-129	0	300	429
Actual Sag:-			0.1739 metres				
Actual Displacement:- 196269 tonnes							
Ballast condition 2							
Mean draft (ignoring hog)	1209						
Hog Correction (Cf=2/3)	46	450	154	-404	-108	200	496
Hog Correction (Cf=0.75)	-98	521	163	-619	-261	65	423
Mean of Means	-100	251	110	-351	-210	10	151
Actual Hog:-			0.1610 metres				
Actual Displacement:- 98206 tonnes							
Net Error in Displacement							
Load - Ballast condition							
Mean draft (ignoring hog/sag)	-2575						
Hog/sag Correction (Cf=2/3)	-63	657	224	-720	-287	161	594
Hog/sag Correction (Cf=0.75)	249	735	238	-486	11	487	984
Mean of Means	249	446	162	-197	87	411	695

Assumptions:-

Measurement has Standard Deviation
of 1.8cms with maximum error
of +/- 3cms

Table 4

Forecast: MEASURED DRAFT

Frequency Chart 10,000 Trials Shown

Frequency

Cell F6

Probability

METRES

Fig.4.1

Fig.4.2

Sheet1
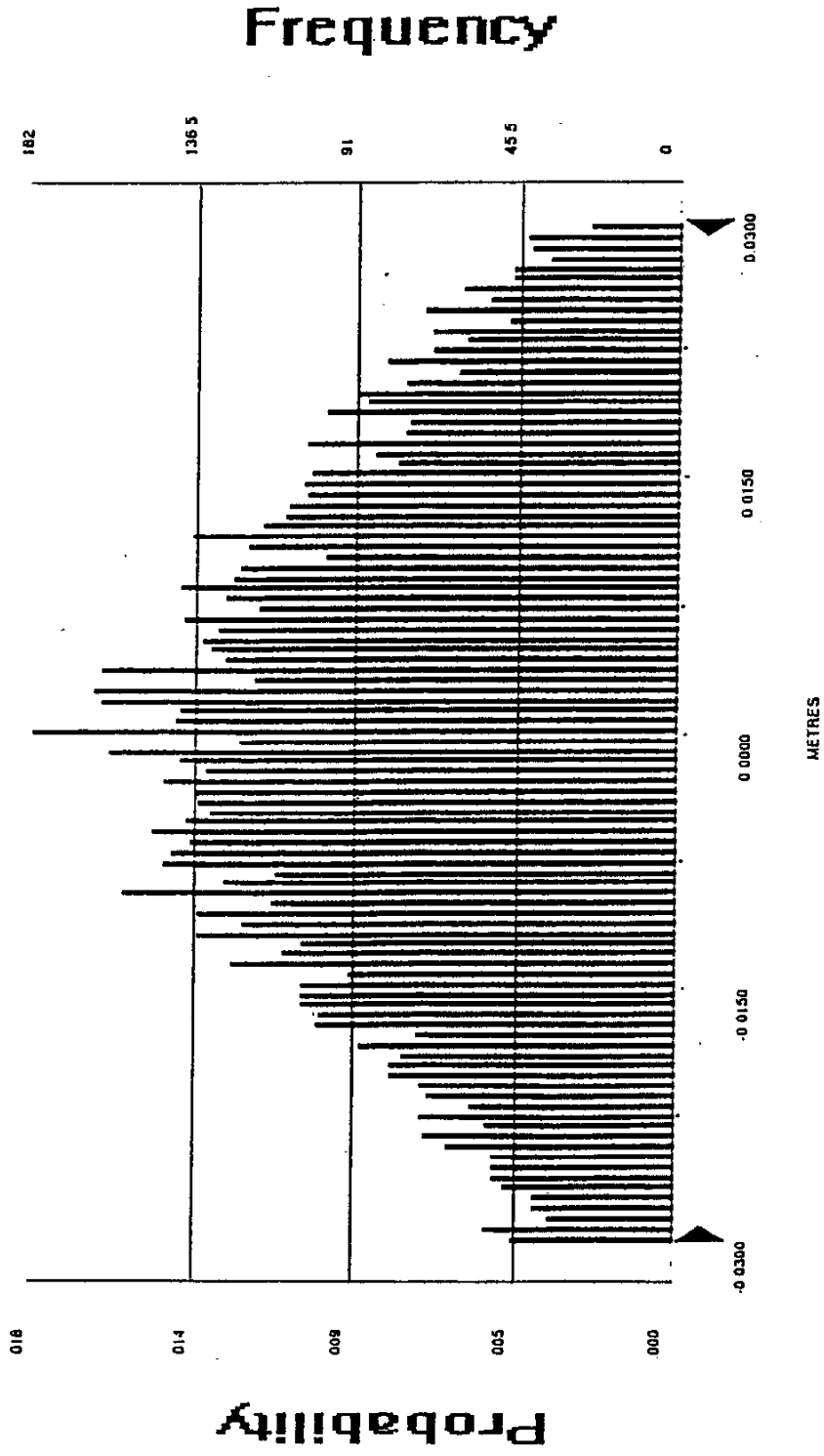
Forecast: DIFFERENCE (Cf=0.75)

Frequency Chart 9,996 Trials Shown

Cell P14

Page 4

5. <u>Assessments for the Four Ship Types</u>

5.1   Most elements contributing to the errors in measurement of cargo deadweight can be scaled using the appropriate scaling relationship, thus linear relationships exist between the amount of sag and the ship's length, and errors in tank capacity due to permeability, mud, deformation etc. will be at similar percentages to the large Capesize.

5.2   Actual relationships between ballast capacity, deadweights and displacement are similar for the ship types. so again percentages are not changed noticeably.

5.3   An investigation into the effect of the changes in ship size on the accuracy of the hog or sag corrections showed little effect on the percentage deadweight error.   The small Capesize and the handy size had slightly lower errors than the large Capesize. and the Panamax a slightly larger error.   It can be seen in Table 5 that for the smallest vessel, the error in method (i) has increased and that in methods (ii) and (iii) has reduced. This suggests that the choice of method is affected by the fullness of the waterplane or waterplane coefficient C_W.

5.4   There is again an effect due to the draft error being absolute rather than proportional to ship size, but this is minimised because the draft does not change by large percentages between the four vessels and because a difference is taken between two sets of averaged drafts.   This relegates the scale effect into a second order problem.

5.5   Given the general level of uncertainty associated with the assessment of accuracy, we are of the opinion that the size of vessel involved, within the parameters set out at Table 3.1. has no major significance on the percentage error of the cargo calculation.

Sheet1

Table 5

Effect of Vessel Size on error in Hog / sag correction

LBP (metres)	Max Displacement (tonnes)	Deadweight (tonnes)	Sag (metres)	Actual Sag Volume (tonnes)	Error due to use of approximate methods					
					Method 1		Method 2		Method 3	
					(tonnes)	% Dwt.	(tonnes)	% Dwt.	(tonnes)	% Dwt.
281.94	196269	169080	0.1740	1363	-14.9	-0.0088	153.6	0.0908	153.6	0.0908
243.84	123000	103328	0.1506	893	-19.3	-0.0187	89.9	0.0870	89.9	0.0870
223.60	83200	70610	0.1381	623	-9.6	-0.0136	67.1	0.0950	67.1	0.0950
186.00	47720	37765	0.1149	365	-15.7	-0.0416	27.9	0.0739	27.9	0.0739

Method 1 = Cf = 2/3
Method 2 = Cf = 3/4
Method 3 = Mean of means

6. <u>SUMMARY OF ERRORS</u>

6.1 Table 6.1 below sets out errors for the vessels as approximate percentages of deadweight. A number of errors relating to permanent deformation and capacities of tanks are particularly applicable to older ships, so this category of error has been added at the end.

6.2 The table provides an estimate of the mean error considered likely with the range of error within which the majority of the results will lie. The errors and their ranges are summed, giving an indication of the maximum likely error, but the mean square of all the errors produces a more realistic estimate of the likely overall error.

6.3 It can be seen that for newer ships. accuracy should be about 0.2% but may be as bad as about 0.87% from time to time.

6.4 For older vessels, where some permanent deformation of the hull has occurred, or where distortions to side shell panels are particularly sever or where structural interactions causing hull girder discontinuities are present, larger errors of around 0.5% mean and over 1% from time to time may be anticipated. Most of this error arises due to departure from the designed or predictable response of the vessel and is very difficult to correct.

TABLE 6.1

APPARENT ERRORS IDENTIFIED

ITEM	MEAN ERROR % DEADWEIGHT	RANGE OF ERROR % DEADWEIGHT
Hog/Sag & Drafts	0.1%	0.15%
Ballast Cap	0.1%	0.4%
Density	0.02%	0.03%
Hydrostatics	0.01%	0.01%
Distortion	0.01%	0.01%
Constant	0.15%	0.5%
Trim Correction	0.015%	0.015%
SUM	0.405%	1.015%
RMS	0.21%	0.66%

Old Vessel	0.5%	0.5%
RMS	0.54%	0.83%

- POSITION PAPER -

UN-ECE CODE OF UNIFORM STANDARDS AND PROCEDURES
FOR THE PERFORMANCE OF DRAFT SURVEYS OF COAL CARGOES

1) As the UN-ECE Draft Survey Code is used in the draft survey of a relatively small percentage of Australia's coal exports (less than 1.5%), there is little evidence at this point in time to suggest the code has had any appreciable affect on the loading and despatch of coal shipments. To date it has been used almost exclusively in response to a single ECE interest.

2) On the shipments that have called for its use, there is no evidence to suggest the UN-ECE Draft Survey Code procedures have produced more accurate results than the normal procedures followed by the independent superintendency companies at Australian ports.

3) The following situations would however cause serious concern if the code were to become more widely adopted :

-   Utilising existing survey resources the time required to perform the initial draft survey would increase substantially, delaying the commencement of loading and often the despatch of a ship by as much as five hours.

-   Alternatively, the time may be reduced by the employment of additional surveyors if they are available, the cost of which is estimated to at least double and possibly treble the cost of draft surveys; and

. These delays may be incurred on a large number of ships currently serving in the world's sea-borne coal trades unable to supply the surveyor with the detailed information the UN-ECE draft survey code procedures require. This would have a serious effect on the capacity of coal exporting terminals and increase the cost of surveys.

These matters are explainable.

The intention of the code as argued by the team of draft survey experts at their meeting in Rome in March 1990 was to provide a worldwide standard format for the conduct of draft surveys that would serve as a guide to unqualified personnel.

The independent superintendency companies in Australia engaged by mutual agreement between the buyer and seller of coal to determine the weight of coal cargoes by draft survey employ professional surveyors, a prerequisite for which is the internationally recognised qualification of a foreign-going Master Mariner's Certificate of Competency (Class One Master). This ensures the practitioners have a sound knowledge of naval architecture, ship construction, operational practices and professional ethics. Australian draft surveyors are therefore more than adequately qualified for the task.

Whilst the code states that unqualified surveyors may be educated from suitable text books augmentated by on the job training, such a practice fails to meet the standards of superintendency companies in Australia and any reduction in existing standards is unlikely to meet the quality assurance standards the sellers of Australian coal expect.

As a result of already having in place these high standards, the UN-ECE draft survey code introduced no new qualities that were considered to contribute to or improve upon the accuracy of draft surveys performed at Australian coal terminals.

The UN-ECE draft survey code and its exaggerated procedures documented as forms A, B, C, D1, D2, D3 and E are considered a time consuming exercise that contributes little towards accuracy or the reliability of draft surveys but would have a significant impact on their cost.

The basis of the code is a mistaken assumption that a ship is an accurate weighing instrument that justifies the finite measurement of contained weights to the nearest kilogram.

Naval architects, ship builders and classification societies recognise the impracticality of providing the type of ship to transport bulk cargoes they could guarantee would have an accuracy of less than 0.5%. To achieve a greater degree of accuracy would involve adopting aeronautical standards involving the certified weighing of every component that goes into the building and maintenance of the ship and achieving similar standards of accuracy in the volumetric measurement and calibration of a ship's tank capacities. It would also require resolving the effects of solarbending the code acknowledges.

Australian coal exporting terminals have for a number of years been conscious of these problems and recognised that as ship sizes increase, so too would the effect of these inherent inaccuracies.

With the financial support of their Users, coal terminals have progressively turned to modern technology for a solution. This has resulted in major terminals installing modern weightometers that achieve consistent levels of accuracy better than 0.25%.

This has allowed coal terminals to monitor the results of draft surveys and to confirm the views Surveyors have held that certain ships have inbuilt errors that affect the accuracy of draught surveys and these errors occur irrespective of the loading or discharging port.

A delay of the magnitude surveyors are suggesting would be experienced and its effect on the turnround of ships to satisfy an unnecessary step by step clerical documentation for the benefit of unqualified surveyors, fails in its entirety to recognise the tremendous cost of idle capital investment that would occur in both coal terminals and ships.

A five hour delay on each ship berthed at a coal loader would reduce Australia's coal exporting terminal capacity from its current 165 million tonnes to less than 145 million tonnes per annum, estimated to cost in the order of $US325 million to replace. On a global basis including the cost of replacement tonnage to offset the delays to ships, the impact on the World's seaborne coal trade would conservatively exceed $US1 billion.

The solution to improving weight determination lies not with the introduction of onerous procedures themselves reliant on the imperfections of using a ship as a weighing instrument, but in the recognition and acceptance of available technology that has allowed the reliability and accuracy of weightometers to exceed that achievable by draft survey. The attached paper refers to such an example.

This would cause the role of the draft surveyor to change from being a measurer and surveyor of ships to becoming a monitor and surveyor of weightometers.

A UN code for the weight determination of coal cargoes that addresses this criteria would be considered more appropriate to the future needs of the industry.

J D Holden

10 August 1993

Encl.

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PROCEDURES AND COMPUTATIONS

FORMULA FOR WEIGHT DETERMINATION

INCLUDING A CASE OF COMBINATION SHIP LOADING

INITIAL SURVEY

1. **Drafts:**

    Forward, aft and midship drafts to be read on both port and starboard sides of the vessel. Utilizong the vessel's "Draft Correction Tables", the foward and aft drafts are corrected. This correction reduces the actual draft read to their respective perpendiculars, upon which the "Displacement Tables" are calculated. The correction varies according to the "trim" of the vessel, and is usually "negative" for the forward draft and "positive" for the aft draft, if the vessel is trimmed by the stern. All signs are reversed if the vessel is trimmed by the head. Final draft calculated using the double mean of means principle.

2. **Dock Water Density:**

    Water density to be checked at forward and aft ends of the main deck at 15% depth, 50% depth and 85% depth. Water samples to be taken with a "Tumble-fill" salinometer pot. Temperatures of the water also to be noted and necessary corrections made to the density read on the hydrometer. (North-west uses a "glass type" hydrometer made in Japan).

3. **Fresh Water Tanks:**

    All fresh water tanks to be sounded and the quantity of water, in them, to be ascertained using the vessel's sounding tables which should include "trim/heel" corrections.

4. **Ballast Water Tanks:**

    All ballast tanks to be checked and ballast water calculated using the vessel's tables. This should also include "corrections for trim and heel. Samples of ballast water to be obtained and density established.

Where ballast tanks are pumped out fully with vessel trimmed heavily to the stern, (where construction would allow tanks to be "dry"), and where a zero sounding is found, then ballast quantity is recorded as "nil".

5. **Oil Tanks:**

(a)   All fuel oil, diesel oil and lubrication oil figures to be obtained from the Chief Engineer.

(b)   All slop tanks, if any, to be sounded.

(c)   Quantity of fuel and lubrication oils (if any) consumed during period of vessel's loading to be resonably agreed with the Chief Engineer.

(d)   Bunker certificates to be sighted and quantities recorded, together with specific gravity, where known, so that change in quantity of fuel on-board at arrival and depature can be calculated.

6. **Cargo Residue:**

Quantity of cargo remains on the deck and in the hold spaces to be noted.

7. **Displacement Calculation:**

(a)   Using the double mean of means draft figure obtained, as described in Item No. 1, and utilizing the vessel's hydrostatic tables, the displacement tonnage for the above draft is obtained.

(b)   This displacement is then corrected for trim, using either the "displacement correction for trim" in the hydrostatic tables, or the following two formulas:

1st Correction:
$$\frac{\text{Trim X C.F. X TPC}}{\text{LBP}}$$

Where: Trim = trim of vessel is cms.

C.F. = center of flotation in metres.

TPC = tons per cm.

LBP = length between perpendiculars in metres

This correction is -ve if C.F. is forward of midship.

This correction is +ve if D.F. is aft of midship.

(The above signs hold true if vessel is trimmed by the stern. Reverse signs, if trimmed by the head).

2nd Correction: Trim X MCT 50 cms. X 50
                                                   ─────────────────────────
                                                             LBP

Where: Trim = trim in metres.

        MCT = moment of change trim difference 1 50 cms.

        LBP = length between perpendiculars in metres.

This correction is always +ve.

(c)   The resulting displacement is then corrected for density, using this formula.

DISPLACEMENT X DIFFERENCE BETWEEN SALT & DOCK WATERS
───
            SALT WATER DENSITY (1025)

Since the dock water is usually always lower than 1.025 (salt water), this correction is always -ve.

The tonnage obtained is herein called "A".

(d)   The known quantity of liquids, (fresh water, ballast water and oil), as calculated in Items 3, 4 and 5, are herein called "a", are then subtracted from "A".

The resulting displacement ("A-a") is a combination of the vessel's light ship plus the "constant".
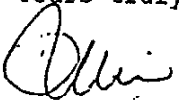

FINAL SURVEY

After the vessel has completed loading, a similar procedure to the above (Items 1 - 7) is followed and a displacement, herein called "B-b" is obtained. This figure is the loaded displacement of the vessel. The difference, ("B-b") minus ("A-a"), gives the cargo loaded to the said vessel.

If further information is required please do not hesitate to contact the undersigned. Thanking you.

Yours truly,

Capt. D. Quinn,
President,
Northwest Marine Surveyors Ltd.

DQ/lc

CODE OF PRACTICE FOR DRAFT SURVEYS

A. **MEASUREMENTS TO BE RECORDED**

1. **DRAFTS**: Forward, aft and midship drafts to be recorded on both port and starboard sides of the Vessel.

2. **DOCK WATER DENSITY**: Water density to be checked at forward and aft ends of main deck at 15% depth, 50% depth and 85% depth. Water samples to be taken with a "tumble-fill" Saliometer pot and measurements to be made using the hydrometer on both surveys.

3. **FRESH WATER TANKS**: All fresh water tanks to be sounded and the quantity of water in them to be ascertained.

4. **OIL TANKS**:
   a) All quantities of fuel, diesel oil and lubrication oil to be noted using Vessel's arrival and departure figures.

   b) Bunker certificates to be sighted and quantities recorded, together with specific gravity where known so that change in the quantity of fuel onboard at arrival and departure can be calculated.

B. **CALCULATIONS**

Corrected drafts to be calculated on the double mean of means principle. Dock water densities on arrival and departure to be calculated as on average of all the six (6) readings taken. Displacements to be calculated from hydrostatic tables wherever possible (not deadweight scales).

1. **TRIM CORRECTION**: No. 1 correction to be used at all times. No. 2 correction to be used where trim exceeds 1.0 metres.

2. **CALIBRATION OF TANK SOUNDINGS**: All soundings of ballast and fresh water to be corrected for trim/heel at time of sounding. If trim correction tables are not available OR if Vessel is at excessive trim, loading is to be stopped until Vessel is in suitable condition. The Vessel would then assume all responsibility for delays incurred.

C. **STORES/SPACES**

Taken onboard or put ashore to be taken into account by surveyor.

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Telex: 04-51499

Date _____

S.S./M.V. _____

Port _____

MATE'S RECEIPT
(NON NEGOTIABLE)

THE FOLLOWING AMOUNT OF _____

_____

HAS BEEN RECEIVED ONBOARD IN GOOD ORDER AND CONDITION

_____

_____

_____
CHIEF OFFICER