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A STUDY OF VARIOUS PROPOSALS FOR A UNIVERSAL SYSTEM OF TONNAGE MEASUREMENT OF SHIPS

Submitted by the United States

The attached paper is submitted by the United States delegation for the information of the Technical Committee.

A Study of Various Proposals For A Universal System of Tonnage Measurement of Ships

Submitted as Information For
The Conference by the United States of America

1. During 1965 the member-governments of the Working Group of the IMCO Subcommittee on Tonnage Measurement gathered data on more than 500 ships which the Delegation from Denmark analyzed with a view to evaluating certain proposals and developing other formulas for consideration of the Subcommittee.

2. The Subcommittee was unable to agree on any one proposal so it recommended that three basic proposals (A, B and C) be transmitted by the IMCO Secretariat to governments for consideration by the Conference on Tonnage Measurement scheduled to convene in London 27 May 1969.

3. When it became apparent that a number of the parameters which would be generated by one of the basic proposals and by certain other proposals that were being made would give results differing greatly from present gross and net tonnages, the United States decided that it would be useful to carry out a further study using the IMCO data to compare those proposals which could be analyzed by electronic computer. Some of the results of that study are shown in the Appendices to this paper.

4. As a preliminary step in the procedure, an evaluation of the data was devised which resulted in the elimination of approximately thirty

ships from the sample because of anomalies such as ships having volumes measured for tonnage exceeding the molded volumes of the spaces or because important parameters were omitted. The sample retained for use included 471 ships.

5. The data for each ship were examined to ascertain whether or not the ship should be treated as a ship whose register tonnages indicated a shelter 'tween deck exemption so that the computer could be instructed to call upon the appropriate parameters for the various proposals.

6. Further, the water-ballast deduction figures were examined to ensure that the water-ballast space had been included in the under deck tonnage and the gross tonnage once but not twice. Examples were found where the space had been included twice and examples were found where it had been omitted.

7. The formulas in the various proposals and suggested amendments were used to compute the tonnages of the ships in the sample. Techniques previously employed by the Danish delegation as well as certain other techniques shown in the Appendices to this paper were used to develop formulas giving optimum results and to evaluate those results.

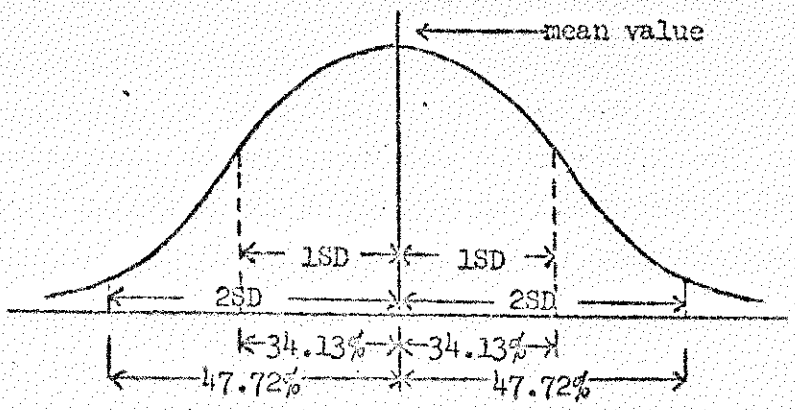
8. The United States Delegation may cite from its study when such questions as the need to provide parameters with values reasonably

close to present tonnages are considered. The Delegation requests that its paper and additional information it has developed be examined in connection with consideration of the individual proposals.

9. The United States has the capability to continue the computer study during the Conference and insofar as parameters and time are available will undertake to supply such service as the Conference may find appropriate.

10. In way of explaining the enclosed charts it is first necessary to review some of the fundamentals of statistical analysis. One of the most often referred to parameters in statistics is a very elusive term called standard deviation. Statistical texts define the standard deviation as the nonnegative square root of the variance. The standard deviation is usually in reference to the normal (Gaussian or Laplace) or bell-shaped distribution about the mean value. Statisticians tell us that a large enough sample of anything can always be represented by the normal distribution. When reference is made to one standard deviation it means that under a normal distribution, if we move one standard deviation from the point or line about which we have taken our variance we cover 34.13 percent of our sample. As there is no sign connected to standard deviation and we can go in both a plus or minus direction, one standard deviation covers a total of 68.26 percent of our sample. Likewise when reference is made to two standard deviations we cover 47.72 percent of our sample on either

side of the variance point for a total coverage of 95.44 percent. The below illustration is offered in way of explanation.



11. In this particular study standard deviation has been measured with respect to two quantities, about the mean and about the origin. The origin is taken as the line which would give zero deviation for each vessel.

12. This study mainly deals with 471 vessels for which members of the Subcommittee on Tonnage Measurement of IMCO supplied data and is conducted in two cycles. The first cycle deals with all vessels while the second cycle eliminates those vessels which have deviations greater than twice the standard deviation about the mean in the first cycle. In this way it was felt that vessels which possibly still have erroneous data or do not lend themselves to a proposal would be eliminated. In general five percent of the vessels in the first cycle will be eliminated from the second cycle. For several of the basic proposals the IMCO fleet was actually considered to be three

fleets: the entire fleet of 471 vessels, a small ships fleet containing only those vessels with a register gross tonnage less than 2000, and a large ships fleet containing vessels of 2000 gross register tons and over.

13. As we are only approaching the normal distribution (a plot of one of the proposals showed this to be the case) in this study, one should keep in mind that the standard deviation for any one proposal has little meaning in itself. Its value is realized when it is used to compare proposals. The proposal which gives the smallest standard deviation will be the one which has the overall least deviations for the individual vessels.

14. Appendix I gives the formulas used in arriving at the various quantities appearing on the charts.

Proposal A

According to Proposal A, gross tonnage is the summation of the tonnages of the spaces below the second deck, the space in the 'tween decks and the space above the upper deck less certain exemptibles. The available data presented in IMCO TM/WG VII did not include the necessary parameters to permit analysis of gross tonnage according to Proposal A. As the net tonnage by Proposal A is derived from the gross tonnage, the net tonnage could not be analyzed either.

Proposal B

Like proposal A, proposal B calls for two parameters, a gross tonnage and a net tonnage.

a) The gross tonnage is arrived at by extrapolating from a displacement quantity to a volume concept in the following manner:

$$GT = 1.185\ (.35 * \Delta * D/H) - .115\ (.35 * \Delta\ ) + .95 * S4$$

where Δ is displacement in long tons to the summer load line.

D is the depth to the upper deck or, in the case of a shelter deck vessel, to the second deck.

H is the draft corresponding to the summer load line.

S4 is the molded volume of the passenger spaces above the tonnage deck in register tons (units of 100 cubic feet or 2.83 cubic meters).

GT is the gross tonnage by the formula.

The first term on the right hand side converts from displacement to an extrapolated hull volume under the tonnage deck. The second term on the right hand side allows for a reduction for double bottoms and frames. The third term provides, of course, for inclusion of the passenger spaces above the tonnage deck.

The results of the measurement of gross tonnage by this proposal on the IMCO fleet are contained on pages 1 thru 3 of Appendix II.

b) Net tonnage by proposal B is completely independent of gross tonnage and is determined in the following manner:

$$NT = 0.8 * VG + 0.6 * VGR + .95 * S4 + .95 * PB$$

where NT = net tonnage by the formula

VG = cargo grain cubic below the tonnage deck. in register tons (units of 100 cubic feet or 2.83 cubic meters).

VGR = refrigerated cargo grain cubic below the tonnage deck in register tons (units of 100 cubic feet or 2.83 cubic meters).

S4 = molded volume of passenger spaces above the tonnage deck in register tons.

PB = molded volume of passenger spaces below the tonnage deck in register tons (units of 100 cubic feet or 2.83 cubic meters).

For the IMCO fleet contained in IMCO TM/WG VII the parameters VGR and PB were not given so the formula for Net Tonnage by Proposal B reduced to:

$$NT = 0.8 * VG + .95 * S4$$

The results of the measurement of net tonnage by this proposal on the IMCO fleet are contained in Appendix III.

Proposal C

This proposal calls for the determination of two parameters, gross tonnage incorporating the entire volume of the closed spaces, and displacement.

(a) The formula used in the computer analysis for the determination of gross tonnage by this proposal is as follows:

$$GT = (V2 + S5) / 1.2$$

where GT is the gross tonnage by the formula.

V2 is the molded hull volume under the upper deck given in register tons (units of 100 cubic feet or 2.83 cubic meters).

S5 is the molded volume of the entire enclosed superstructure given in register tons (units of 100 cubic feet or 2.83 cubic meters).

The results of the measurement of gross tonnage by this proposal on the IMCO fleet are contained on pages 1 thru 3 of Appendix II.

(b) As it was not specifically stated in proposal C as to what the displacement term was to be a measurement of, i.e. gross or net tonnage, it was compared with both. The formula used in the computer analysis for the determination of tonnage by this proposal is as follows:

FT = displacement in metric tons

The results of the measurement of gross tonnage by this proposal on the IMCO fleet are contained on page 1 of Appendix II.

The results of the measurement of net tonnage by this proposal on the IMCO fleet are contained in Appendix III.

Proposal C (Danish Amendment)

The Danish Amendment to proposal C calls for one parameter for tonnage measurement namely displacement expressed in register tons. Here again as only one parameter is called for, the computer compared this proposal with both register gross and net tons. The formula used in the computer analysis for the determination of tonnage by this proposal is as follows:

$$FT = .35 * \Delta$$

where FT is formula tonnage and may be either net or gross tons.

Δ is displacement in long tons at the summer load line.

The results of the measurement of gross tonnage by this proposal on the IMCO fleet are contained in pages 1 thru 3 of Appendix II.

The results of the measurement of net tonnage by this proposal on the IMCO fleet are contained in Appendix III.

Proposal by the Netherlands

In IMCO TM/CONF/3 the Netherlands suggested a proposal for gross tonnage by modifying the coefficient of the Proposal C volume concept. The expression for gross tonnage is as follows:

$$GT = V\,(.135 + .035\ LOG_{10}\ (V))$$

where GT is the formula gross tons.

V is the total enclosed molded volume in cubic meters and is equal to (V2 + S5) where V2 is the molded volume under the upper deck and S5 is the molded volume of superstructures.

The results of the measurement of gross tonnage by this proposal on the IMCO fleet are contained on pages 1 thru 3 of Appendix II.

Proposal by Norway

Norway submitted a compromise proposal in TM/CONF/9/Add.1 which called for two parameters, gross tonnage and net tonnage. Since the net tonnage is in all practicality the same as net tonnage by Proposal B the results are identical to those contained in Appendix III.

The formula used in the computer analysis for the determination of gross tonnage is

$$GT = 0.9943 * V + .95 * S4$$

where GT is the gross tonnage by formula.

V is in register tons and for closed vessels is taken as V2, the molded volume under the upper deck, and for shelter deck vessels taken as V4, the molded volume under the second deck.

S4 is the molded volume of passenger spaces above the tonnage deck in register tons.

The results of the measurement of gross tonnage by this proposal on the IMCO fleet are contained on pages 1 thru 3 of Appendix II.

The remaining two proposals were not analyzed by using the IMCO fleet. They were analyzed by using data provided for ships of several nationalities by the Panama Canal Company. The IMCO fleet was not used because at the time of compilation of the data for computer analysis neither of the proposals had been received nor was it anticipated that the parameters used in the proposals would be needed. However, the Panama Canal Company Fleet was available and as it contained these parameters it was used.

Proposal by Finland

Finland in IMCO TM/CONF/8 suggests the measurement of gross tonnage as follows:

$$GT = 0.7 * DWT$$

where GT is the formula gross tons.
DWT is the deadweight in metric tons

The results of the measurement of gross tonnage by this proposal in the Panama Canal Fleet are contained in Appendix IV.

Proposal by Spain

Spain in IMCO TM/CONF/3/Add.1 suggests the measurement of gross tonnage as follows:

a) for vessels with a length between perpendiculars less than 100 meters

$$GT = 0.03\ L^{2.5}$$

b) for vessels with a length between perpendiculars greater than or equal to 100 meters

$GT = 0.003\ L^3$

where GT is the gross tonnage by the formula.
L is the length between perpendiculars in meters.

The results of the measurement of gross tonnage by this proposal on the Panama Canal Fleet are contained in Appendix IV.

Appendices 5 and 6 show a scatter diagram on the total fleet for the various proposals mentioned in this paper.

Appendix 5 is on gross tonnage and Appendix 6 is on net tonnage.

APPENDIX ONE

DEFINITIONS

RG = Register tonnage

FG = Formula tonnage

DEV = Percent deviation

SD_o = Standard Deviation about the origin

SD_m = Standard Deviation about the mean

DMEAN = Mean Percent Deviation

N = Number of vessels

$$DEV = \left(\frac{RG - FG}{RG} \right) \times 100$$

$$DMEAN = \frac{\varepsilon DEV}{N}$$

$$SD_o = \sqrt{\frac{\varepsilon (DEV)^2}{N-1}}$$

$$SD_m = \sqrt{(SD_o)^2 - \frac{(\varepsilon DEV)^2}{N(N-1)}}$$

$$\text{Fleet Percent tonnage change} = \left(\frac{\varepsilon RG - \varepsilon FG}{\varepsilon RG} \right) 100$$