GENERAL INFORMATION FOR GRAIN LOADING

Contains information and comments on:

U.S. Coast Guard Regulations for Carriage of Grain in Bulk

I.M.O. Regulations (International Code for the Safe Carriage of Grain in Bulk)

Recommendations of National Cargo Bureau, Inc.

NATIONAL CARGO BUREAU INC.

30 Vesey Street
New York, N.Y. 10007

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1994 Edition

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U.S. Department of Transportation
United States Coast Guard

Commandant
U.S. Coast Guard

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The 1994 Edition of the "General Information for Grain Loading," prepared and distributed by National Cargo Bureau, Inc., provides guidance for shipowners, operators, agents, ship masters, and other seagoing personnel for compliance with the national and international regulations relative to the stowage and carriage of bulk grain.

The 1994 Edition is totally revised and supersedes all previous editions. It includes information on the International Code for the Safe Carriage of Grain in Bulk which was implemented by the International Maritime Organization (IMO) on January 1, 1994. These regulations are the culmination of 24 years of research, experimentation, and development by members of the IMO Sub-Committee on Containers and Cargoes.

This booklet is intended to facilitate the loading of bulk grain at U.S. ports by providing information on the pertinent regulations as well as general information on grain data, stability calculations, and stowage arrangements.

Subject to the conditions set forth in the Navigation and Vessel Inspection Circular, "Requirements for Vessels Carrying Bulk Grain Cargo," which is included herewith, the U.S. Coast Guard endorses this publication.

J. W. Kime

J. W. KIME
Admiral, U.S. Coast Guard
Commandant

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PREFACE

This booklet contains a compilation of information about the International Grain Rules, the regulations of the U. S. Coast Guard which apply to the carriage of bulk grain, recommendations, suggestions, and other information relating to loading bulk grain aboard vessels and is intended as a handy reference for ship masters, deck officers, surveyors and other members of the maritime industry.

This booklet has been prepared from information obtained from sources believed to be reliable and accurate. National Cargo Bureau does not guarantee its accuracy and completeness and does not assume any responsibility or liability for damage which may arise from the use of this booklet or its contents.

NATIONAL CARGO BUREAU, INC.

National Cargo Bureau was incorporated as a non-profit organization in May 1952 and began its actual operation on November 19, 1952. The Bureau was created to render assistance to the United States Coast Guard in discharging its responsibilities under the 1948 International Convention for Safety of Life at Sea* and for other purposes closely related thereto.

By assignment and under the authority of the United States Coast Guard, the certificates issued by National Cargo Bureau, Inc. may be accepted as prima facie evidence of compliance with the provisions of the Dangerous Cargo Act and the Rules and Regulations for Bulk Grain Cargo.

National Cargo Bureau, Inc. is a continuation and amplification on a broader base of the inspection services formerly performed by The Board of Underwriters of New York and The Board of Marine Underwriters of San Francisco and now operates on a nation-wide basis.

* *Subsequently superseded, successively, by the 1960 and 1974 Safety of Life at Sea Conventions*

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National Cargo Bureau, Inc. is authorized to conduct any type of inspection or survey that is incidental to the loading or discharging of a ship and issues appropriate certificates and/or survey reports for services such as described below:

1. The loading, stowage and securing of general cargo on and under deck, including special surveys of heavy or large items;
2. The approval on behalf of governmental administrations of vessel plans for the stowage of bulk grain cargoes under the existing international regulations;
3. The stowage of bulk grain cargoes, including vessel suitability and arrangements;
4. The stowage of explosives and packaged and bulk hazardous materials in accordance with the requirements of the Code of Federal Regulations, including preloading and shipboard temperatures and the loading and stowage of metal borings, shavings, turnings and cuttings;
5. The stowage of ore concentrates and/or dry bulk cargoes in accordance with the IMO Code of Safe Practice for Bulk Cargoes;
6. The loading of bulk tallow, grease and similar commodities in cargo tanks;
7. Inspection of cargo compartments for cleanliness and condition prior to loading or when a ship is to load at another port or for charter purposes;
8. Inspection of refrigerated cargo prior to loading, including taking and recording temperatures at the time of loading; and inspection of refrigerated spaces for cleanliness and temperatures;
9. Discharging of various bulk cargoes, including cleanliness of receiving railroad cars, barges, handling equipment, etc.;
10. Vessel readiness to discharge jute and jute products;
11. Cargo and space measurement surveys;
12. Hatch surveys, including condition of cargo prior to, during, and after discharge;
13. Surveys of import and export unboxed automobiles;
14. Determination of tonnage of cargo loaded on or discharged from ships or barges by immersion computation;
15. On-hire, off-hire and condition surveys of cargo compartments and handling gear;
16. Condition of cargo and packaging at point of origin and/or prior to being loaded, including stowage;
17. Witness tank soundings of ships and barges including the computation of the quantity of liquids in tanks;
18. Cargo container inspections:
    (a) Inspection and certification of containers and road vehicles for transportation under Customs seal
    (b) Condition of the container for suitability to receive any particular cargo

(c) Stowage of the cargo in the container

(d) Inspection of containers for handling damages

(e) Inspection of containers for leasing purposes

(f) Inspection of the securing of containers on deck

(g) Inspection of containers loaded with hazardous cargo for compliance with U. S. Coast Guard regulations and/or International Maritime Dangerous Goods Code;

19. Consultation service to ensure proper completion of the Dangerous Cargo Manifest;

20. Stowage of cargo in barges including LASH and SEABEE;

21. Witnessing of tests and certification of shipboard cargo gear (accredited by U. S. Cost Guard and U. S. Department of Labor);

22. General planning and consultation services concerning any of the above or other cargo-related problems;

23. Special cargo and/or safety inspection of specific requirements of governments, ship operators, insurance companies or shippers;

24. Providing training and conducting seminars on cargo stowage and safety-related matters.

The issuance of an NCB Loading Certificate indicates that the cargo observed has been stowed in compliance with the applicable U. S. Coast Guard regulations or recommendations or in the absence thereof, in accordance with recommendations of National Cargo Bureau, Inc.

NAVIGATION AND VESSEL INSPECTION CIRCULAR NO. 5 - 94

Subject: REQUIREMENTS FOR VESSELS CARRYING BULK GRAIN CARGO

1. **PURPOSE.** This circular calls the attention of Coast Guard field units, shippers and carriers of bulk grain cargo to the International Maritime Organization's (IMO) Code for the Safe Carriage of Grain in Bulk, referred to as the Grain Code, which entered into force on January 1, 1994. The Grain Code specifies stability, loading requirements, and Documents of Authorization for each vessel that loads grain in bulk.

2. **DIRECTIVES AFFECTED.** This circular cancels and supersedes NVIC 2-78.

3. **BACKGROUND.** In response to the growing need for broader regulation of the carriage of all cargoes which may pose a hazard to ships or personnel, the Maritime Safety Committee (MSC) decided to replace the original Chapter VI of the Safety of Life at Sea Convention, 1974 as amended, (SOLAS), which contained detailed regulations on the carriage of grain in bulk, with requirements of a more general nature and to place the detailed provisions on grain in a mandatory code. SOLAS Chapter VI previously titled "Carriage of Grain" is now titled "Carriage of Cargoes". At the 59th session in May 1991, MSC adopted amendments to SOLAS Chapter VI Part C Regulation 9 (resoiution MSC.23[59]) to make the International Code for the Safe Carriage of Grain in Bulk mandatory. The Grain Code became effective January 1, 1994. The Grain Code is available to the public from the IMO as publication 240-E. Information on obtaining this publication can be found in enclosure (1).

4. **DISCUSSION.**

   a. The Grain Code applies to all vessels that load grain in bulk in U.S. waters, except those engaged solely on voyages on rivers, lakes, bays, and sounds, or on voyages between Great Lakes ports and specific St. Lawrence River ports as referred to in the Load Line Convention. The St. Lawrence River ports exempted include those ports as far east as a straight line drawn from Cap de Rosiers to West Point, Anticosti Island, and as far east as a line drawn along the 63rd meridian from Anticosti Island to the north shore of the St. Lawrence River.

   b. A Document of Authorization is required for each vessel to which the Grain Code applies except vessels on certain intracoastal voyages, provided they comply with the alternative conditions found in enclosure (2). The U.S. Coast Guard has delegated the authority to issue Documents of Authorization to the National Cargo Bureau, Incorporated (NCB). Information on contacting NCB can be found in enclosure (1). Requirements for obtaining a Document of Authorization are summarized in enclosure (3). The Document of Authorization format is shown in enclosure (4).

   c. Vessels to which the Grain Code applies are required by the Code of Federal Regulations to obtain a Certificate of Loading before each sailing. A Certificate of Loading, issued by the NCB, attests that the stability of the vessel complies with the information approved by its Document of Authorization, or otherwise is in compliance with enclosure (2) before each voyage from a U.S. port. The Certificate of

Loading is recognized by the Coast Guard as evidence of compliance with regulation 7.2 of the Grain Code.

d. A vessel which carries a cargo of grain in bulk should not, at the same time, carry any solid bulk cargo which may liquefy unless such cargo is tested and the moisture content is equal to or less than the transportable moisture limit. Testing should be conducted in accordance with the procedures set forth in the Code of Safe Practice for Solid Bulk Cargoes, International Maritime Organization publication No. 260-E.

5. **IMPLEMENTATION.** Officers in Charge, Marine Inspection, are encouraged to bring this NVIC to the attention of appropriate individuals in the marine industry within their zone.

(Signed) J.C. CARD
Rear Admiral, U.S. Coast Guard
Chief, Office of Marine Safety, Security and Environmental

Encl.: (1) Sources for Obtaining Additional Information

(2) Voyages and Conditions for those Vessels Exempted from the Requirements of Obtaining a Document of Authorization

(3) Requirements for U.S. Vessels Obtaining Documents of Authorization

(4) Document of Authorization Format

SOURCES FOR OBTAINING ADDITIONAL INFORMATION

The International Code for the Safe Carriage of Grain in Bulk (IMO Resolution MSC.23(59)), publication No. 240-E can be obtained from:

Publication Section
International Maritime Organization
4 Albert Embankment
London SE1 7SR
United Kingdom
Telephone: 44(0)71-735 7611
Fax: 44(0)71-587 3210 or

New York Nautical Instrument and Service
140 West Broadway
New York, NY 10013
Telephone: (212) 962-4522
Fax: (212) 406-8420

2. Documents of Authorization and additional Grain Code compliance guidance can be obtained from:

National Cargo Bureau, Incorporated
30 Vesey Street
New York, NY 10007-2914
Telephone: (212) 571-5000
Fax: (212) 571-5005

VOYAGES AND CONDITIONS FOR THOSE VESSELS EXEMPTED FROM THE REQUIREMENTS OF OBTAINING A DOCUMENT OF AUTHORIZATION

1. Vessels without a Document of Authorization may carry grain in bulk subject to the limitations imposed by Sections 8.3 or 9 provided their stability complies with the requirements regarding subdivision of cargo compartments, securing of hatches, trimming of cargo and metacentric height as detailed in Section 9 of the Grain Code.

2. Vessels on the following voyages:
   a. United States ports along the Northeast Coast from as far south as Cape Henry;

   b. Wilmington, NC and Miami, FL;

   c. United States ports in the Gulf of Mexico;

   d. Puget Sound ports and Canadian West Coast ports or Columbia River ports, or both; or

   e. San Francisco, Los Angeles, and San Diego, CA

   f. Great Lakes ports to United States ports along the Northeast coast as far south as Cape Henry do not need a Document of Authorization if they comply with the following conditions:

   a. The master or person in charge is satisfied that the longitudinal strength of his vessel is not impaired.

   b. The master or person in charge ascertains the weather to be encountered on the voyage and determines it does not pose a risk.

   c. Potential heeling moments are reduced to a minimum by carrying as few slack holds as possible.

   d. Each slack surface has been leveled.

   e. The transverse metacentric height (GM), in meters, of the vessel throughout the voyage, after correction for liquid free surface, has been shown by stability calculations to be in excess of the required GM (GM_R), in meters.

      (1) The GM_R is the sum of the increments of GM (GM_I) multiplied by the correction factor, f.

      where: $f = 1$ if r is ≥ 0.268 or
      $f = (0.268 \div r)$ if r is < 0.268.
      $r =$ (available freeboard) $\div$ (beam of the vessel) and

      (2) The GM_I for each compartment which has a slack surface of grain, i.e., is not trimmed full, is calculated by the formula given below:

      $$GM_I = (B^3 \times L \times 0.0661) \div (Disp. \times SF)$$

      where: B = breadth of slack grain surface (m)
      L = Length of compartment (m)
      Disp.= Displacement of vessel (tonnes)
      SF = Stowage factor of grain in compartment (cubic metres/tonne)

REQUIREMENTS FOR U.S. VESSELS OBTAINING DOCUMENTS OF AUTHORIZATION

1. General Requirements. The grain stability information required by the Grain Code that must be included in the Document of Authorization is in addition to that provided to the master in accordance with 46 CFR 170.110 and 42.15-1.

2. Stability Information. Stability information in the format of a grain loading booklet or a grain loading appendix to a Trim and Stability booklet shall be submitted to the NCB for approval.

   a. The submittal should contain:

      (1) 5 copies of the grain loading stability information which is to be approved by the Document of Authorization.

      (2) 1 copy of the calculations supporting the above mentioned grain loading stability information.

      The data above must be in complete agreement with that found in the Trim and Stability booklet.

   b. The NCB is authorized to perform any additional stability review prerequisite to approval if, in addition to the grain loading stability information, the documentation contains stability data pertinent to other bulk cargoes or to cargoes which will be carried simultaneously with bulk grain such as deck cargo or containers on deck.

   c. After review, NCB will forward one copy of the approved grain loading information to Commanding Officer, U.S. Coast Guard, Marine Safety Center, 400 Seventh Street S.W., Washington D.C. 20590-0001. NCB will inform the Marine Safety Center of any additional stability related review conducted and recommend an appropriate statement which may be included in the U.S. Coast Guard stability letter.

   d. NCB will issue the Document of Authorization to the submitter. The Document of Authorization will have the format shown in enclosure (4).

3. Coast Guard Marine Safety Center Oversight. Upon receipt of the approved grain loading conditions, the Coast Guard Marine Safety Center will perform oversight to the degree necessary and forward the new stability letter to the submitter with copies to the cognizant Officer in Charge, Marine Inspection and to the NCB. A stability letter is not required if the information can be placed on the Certificate of Inspection or the Load Line Certificate.

4. Tank Vessels. Under the authority of Section 5 of the Code, a tank vessel designed solely for the carriage of liquids and which is issued a Document of Authorization, may be exempted from trimming when the vessel:

   a. has two or more longitudinal, oil-tight bulkheads arranged so as to substantially reduce the horizontal volumetric heeling moment, and

   b. has an adequate number of expansion trunks and access (butterworth) openings to meet the intent of Regulation 10.3.1 of the Code.

   Whenever bulk grain is carried, the vessel shall not carry any liquid cargo.

5. Unmanned Barges. Unmanned barges, except for deck cargo barges, may be issued a Document of Authorization without obtaining an approved grain loading stability booklet, when calculations and supporting plans demonstrate that the barge, when

loaded to its maximum load line assignment with all compartments in which it is anticipated to carry bulk grain trimmed full, meets the requirements of section 7 of the Grain Code.

If for any reason upon completion of loading a compartment is partially filled with bulk grain, the grain must be secured as described in Sections 16, 17, or 18 of the Code or else discharged from the vessel.

6. Single Voyage Document of Authorization. A vessel without a Document of Authorization and not exempted by enclosure (4), may engage in a single voyage carrying grain in bulk by:

   a. Submitting stability calculations together with supporting plans to the NCB, for the proposed, specific loading condition. If the calculations indicate compliance with the provisions of Section 7 of the Code, a single voyage approval will be issued by the NCB prior to loading.

   b. Upon satisfactory completion of the loading in accordance with the approved plan, a certificate of loading will be issued.

DOCUMENT OF AUTHORIZATION FORMAT

Date of issue

DOCUMENT OF AUTHORIZATION TO LOAD BULK GRAIN

Based upon a review of pertinent plans and calculations, it has been determined that the SS (or MV) ______________________ meets the requirements of the International Code for the Safe Carriage of Grain in Bulk. Accordingly, under the authority granted by the U.S. Coast Guard, the SS (or MV) __________________ may load grain provided the ship complies with the stability information contained in the following booklet:

Identification of booklet containing the grain loading stability information bearing an approval stamp by the National Cargo Bureau, Inc. dated ________________.

GENERAL INFORMATION ON THE INTERNATIONAL GRAIN RULES

The information in this booklet is intended for use by ship masters and ship operators when engaged in the ocean transport of grain in bulk. It is their responsibility to comply with the mandatory regulations for such carriage as set forth in the International Code for the Safe Carriage of Grain in Bulk (hereinafter referred to as "the Code"), if these regulations are applied by either the home Administration, i.e., their national flag, and/or by the Administration at the port of loading. It is not intended for use by naval architects or ship designers.

The descriptive material and the amplifying information on the regulations, as contained in this booklet, are not intended as official interpretations but rather as explanations as to how these regulations are understood by the surveyors of the National Cargo Bureau, Inc., which is the agency, designated by the U. S. Coast Guard, to enforce the provisions of the Code on ships loading bulk grain at United States ports. In all cases where the intent or meaning of any I M O Grain Rule discussed in this booklet is subject to question, resolution must depend solely on the content of I M O publication No. 240E. This publication can be purchased at most nautical bookstores or, directly, from:

International Maritime Organization
Publications Section
4 Albert Embankment
London SE1 7SR
United Kingdom
Telephone: +44(0)71-735-7611
Fax: +44(0)71-587-3210
Telex: 23588

FOREWORD

International Maritime Organization

The International Maritime Origination (I M O) is a specialized agency of the United Nations which deals with maritime affairs, principally, those involved with the improvement of safety at sea and protection of the environment. It was established in 1948, and is supported by 133 member nations. Acting in concert, these member Administrations develop recommendations and regulations. In the case of regulations, they mutually agree to incorporate them into their national laws and thereby give effect to such regulations on a worldwide basis. The organization is headquartered in London, England.

Principle of the I M O Grain Rules

The I M O Grain Rules are based on the recognition that in a compartment nominally filled with grain there exists a void space between the surface of the grain and the overhead of the loaded compartment and that, due to the motions of the ship in a seaway, there is a possibility that grain will shift, unsymmetrically, into this void and thereby cause a possibly dangerous loss of stability. The Rules minimize this possibility by requiring that the grain be trimmed to a level surface so that a large angle of motion is needed before the grain will move or, alternatively, by physically restraining the surface of the grain against movement. Additionally, the Rules require demonstration by calculation that at all times during a voyage the ship will have sufficient intact stability to provide adequate residual dynamic stability after taking into account the adverse effect of a grain shift if one should occur. Since the magnitude of a grain shift depends upon various dynamic factors, it cannot be precisely anticipated. Therefore, the I M O Grain Rules "assume" an angle of grain shift and then specify a minimum level of acceptable stability for the carriage of grain in terms of the resultant angle of heel due to the assumed grain shift, required residual righting energy after such shift, and initial metacentric height. It should be noted that the pattern of grain movement prescribed in the I M O Grain Rules is not intended to portray the actual movement of the grain surfaces as the ship moves in a seaway. Nevertheless, it is considered that the calculated heeling moment based on this prescribed pattern of grain movement adequately represents the actual effects which may be encountered.

Limitations of the I M O Grain Rules

The scope of the Code is limited to matters which relate to the intact stability of the ship. It does not relate to the following matters: damage stability, hull strength, fire safety, pollution prevention, fumigation, matters pertaining to the individual safety of persons on board the ship, or matters pertaining to the satisfactory out-turn of the cargo.

These concerns are not unique to the carriage of grain and must be considered by the owners and the master in the context of the regulations, instructions, or responsibilities which are otherwise applicable.

HISTORY

Grain has been carried aboard ships for thousands of years. As one of the major items in the maritime market, it attracted attention because of its importance and the special problems it presented. The tendency of grain, when carried in its bulk natural state, to shift within the cargo space of a ship moving in a seaway represents a potential hazard to vessel and crew. Consequently, the problems raised by such carriage are often the subject of national requirements and international agreements.

At the international Conference on Safety of Life at Sea, 1948, international regulations applicable to the carriage of grain in bulk were developed and incorporated in Chapter VI, entitled "Carriage of Grain and Dangerous Goods", of the International Convention for the Safety of Life at Sea, 1948. These regulations proved effective as far as safety was concerned.

However, in the light of this safety record, and in view of the increasingly high costs of the required temporary fittings and/or bagged grain, a review of the regulations adopted in 1948 was undertaken. Revisions to the regulations were made at the International Conference on Safety of Life at Sea, 1960, and incorporated in the International Convention for the Safety of Life at Sea, 1960. Under these provisions, ships which met specified stability requirements were allowed to substitute large feeders for shifting boards formerly required in and beneath the feeders and the limitation on the carriage of heavy grain in upper tween-decks was eliminated. A new concept called "common loading" was introduced which allowed two or more compartments separated by decks to be treated as a single compartment

The 1960 Conference also recognized the need for international agreement on all aspects of the safe carriage by sea of bulk grain and recommended that Governments submit to the International Maritime Organization details of their practices with a view to reaching an international agreement on requirements for the strength of grain fittings.

Although the 1960 Convention did not enter into force until 1965, most of the Contracting Governments to the 1948 Convention, wishing to take advantage of the economic aid to shipping, in 1961 put the revised chapter VI into effect as an equivalent. In a period of about 4 years following the introduction of the new rules, six ships loaded with grain were lost and there were several cases where a severe list from shifting grain had caused a ship to return to port for correction of its list.

Early in 1963, the work of a technical body within IMO studying intact stability of ships, re examined the data on which the grain rules of Chapter VI were based, particularly those relating to grain settlement from feeders into the holds and the ability to fill all the spaces between the beams and the wings and ends in the hold by trimming. IMO, recognizing the need to obtain empirical data, initiated a survey to which masters of ships of many nationalities loading bulk grain in all parts of the world contributed. Further studies and tests were carried out by the Sub-Committee on Subdivision and Stability and the Sub-Committee on Bulk Cargoes which confirmed that certain principles on which the regulations were based were invalid and as such rendered the basic requirements unattainable.

Thus, after review of all the regulations of chapter VI, in the light of the aforementioned studies, new grain regulations were prepared. These regulations adopted by the Assembly of IMO in October 1969 (resolution A.184(VI) and commonly known as the "1969 Equivalent Grain Regulations" have been widely accepted and used, in particular by Administrations of countries involved in the international carriage of grain. As a companion measure, the Assembly adopted resolution A.184(VI) which recommends that Governments similarly apply the 1969 Equivalent Grain Regulations to ships of less that 500 gross tonnage.

When adopting the Equivalent Grain Regulations, the Assembly requested the Maritime Safety Committee to study data compiled as a result of their application and determine their suitability as an amendment to chapter VI of the 1960 Convention.

Accordingly, this evaluation and review was carried out by the Sub Committee on Containers and Cargoes (formerly the Sub Committee on Bulk Cargoes) over a period of 3 years. It was found that the use of the 1969 Equivalent Grain Regulations resulted in enhanced safety in the transport of grain in bulk and proved to be more practical, and in most cases, less expensive than the application of the requirements of chapter VI of the 1960 Convention.

The 1969 Equivalent Grain Regulations were only slightly amended in the light of operational experience, and the amended text was initially adopted by the IMO Assembly in November 1973 (resolution A.264(VIII) as an amendment to the 1960 Convention. When adopting the IMO Grain Rule, the IMO Assembly revoked resolution A.184(VI) which included the 1969 Equivalent Grain Regulations provisions of the new IMO Grain Rules annexed to resolution A.264(VIII) as a total replacement for chapter VI of the 1960 Convention. It was recognized that approvals issued under the provisions of the old 1969 Equivalent Grain Regulations (A.184(VI)) would be considered as generally complying with the new IMO Grain Rules.

The Sub-Committee on Containers and Cargoes recommended in 1980 that valid approvals under resolutions A.184(VI) and A.264(VIII) be deemed to be in compliance with, or equivalent to, the requirements of chapter VI of the 1974 Convention, provided that no alteration affecting the approval of grain loading information had taken place after such approval was given. The Sub-Committee further agreed to this end that the approval of ships under the requirements of regulation 12 of chapter VI of the 1960 Convention should remain valid, provided that all the requirements of that regulation were met and further that no alteration affecting the approval of the grain loading information had subsequently been made. Finally, it was also agreed to recommend that no further documents would be required where valid approvals existed for the ships described above.

These recommendations were approved by the Maritime Safety Committee at its forty-second session in May 1980. The amended text was to form the basis of new international requirements for the carriage of grain in bulk and to be known as the "IMO Grain Rules". Apart from a few minor editorial changes, the text of these Rules and the text of chapter VI of the International Convention for the Safety of Life at Sea, 1974, which entered into force on 25 May 1980, are identical.

Also, during this interim period, certain Administrations made some changes in the grain rules as applied to their own ships. One of these was to give a dispensation from trimming the ends of filled holds on specially suitable ships. Another was the experimental use of wire reinforcing mesh as a means for securing a slack grain surface.

In November 1981 the Maritime Safety Committee, at its forty-fifth session, adopted a number of amendments to the 1974 Convention, including some related to chapter VI.

In 1992, at its fifty-ninth session, the Maritime Safety Committee decided to restructure chapter VI of the International Convention for the Safety of Life at Sea, 1974 (SOLAS 1974), to apply to a broader spectrum of cargo-related matters and to transfer the mandatory regulations pertaining to the carriage of grain in bulk to a new document entitled "The International Code for the Safe Carriage of Grain in Bulk. These changes went into effect on January 1, 1994.

INFORMATION ON REQUIREMENTS

Application

In accordance with requirement 1, regulation 9, Part C, chapter VI of SOLAS 1974, as amended, and regulation A 1.1 of the Code, the Code applies to, and is mandatory for all ships regardless of size, including those of less than 500 gross tons, which carry bulk grain on an international voyage. However, it should be noted that two of the requirements in the Code apply only to ships built after January 1, 1994. One is a requirement pertaining to the provision of a table of permissible heeling moments. This is discussed in a paragraph marked with an asterisk, on page 27. The other requirement pertains to the immersion of the deck edge and is stated in the second paragraph on page 26.

As provided for in regulation A 8 of the Code, Documents of Authorization which were previously approved under Regulation 12, chapter VI of SOLAS 1960, or I M O Resolutions A.184(VI) or A.264(VIII), will continue to be recognized. Existing ships holding such Documents are not required to obtain new Documents of Authorization indicating compliance with the Code. More information on Documents of Authorization is given on page 28.

In the case of vessels registered in the United States, the Code applies to all ships and barges carrying grain in bulk, whether or not engaged on an international voyage except that voyages on inland waters, the Great Lakes, and specified coastal waters are exempted.

Definition of Grain

> 2.1 The term *grain* covers wheat, maize (corn), oats rye, barley, rice, pulses, seeds and processed forms thereof, whose behavior is similar to that of grain in its natural state.

The term "pulses" includes edible seeds for such leguminous crops as peas, beans or lentils. Maize includes varieties such as sorghum (milo). Nuts such as peanuts in the decorticated form are included. However, undecorticated (unshelled) forms are not. These requirements apply to saw-delinted cottonseed and acid-delinted cottonseed but not to linted cottonseed. The requirements do not apply to processed grains such as flour or soybean meal, but processing is not the determining criteria. For example the requirements do apply to rapeseed pellets. In general, when there is a question as to whether or not the requirements apply to an agricultural commodity, the angle of repose, (i.e., the natural angle with horizontal which a freely poured pile will attain) should be carefully measured. If it is 30 degrees or less, the requirements of the Code should be deemed to apply.

Trimming

When grain is free poured into a compartment it arranges itself into a pile of conical shape. The angle of the surface of the grain with horizontal varies with the specific variety of the grain but may be as much as 30 degrees. This is termed the angle of repose. If the pile is static, the surface would remain undisturbed. However, if the grain is in a ship and is subjected to the motions of a ship at sea, the grain surface could move in response to this motion moving the center of gravity of the grain mass. This is a grain shift. This off-center weight condition is a GRAIN HEELING MOMENT which causes the ship to heel.

But if the surface of the grain is levelled to a zero degree angle with horizontal, then the ship would have to roll in excess of the angle of repose, for example 30 degrees, before the grain would shift. Consequently, to minimize the possibility that bulk grain will shift at sea, the I M O Grain Rules require that the grain be trimmed, i.e., levelled after it has been loaded.

The magnitude of a grain shift depends upon the amount of open space above the grain into which it can move. Thus when a compartment is filled to the maximum extent possible, the adverse effect of the grain shift, i.e., the grain heeling moment, will be less than if the compartment is partly filled. The Grain Rules recognize this by assuming a 15 degree shift of grain when the compartment is filled as opposed to a 25 degree shift when a compartment is partly filled. In both cases the grain is trimmed, but there is a much greater volume of open space above the grain surface when the compartment is partly filled.

> 2.2 The term *filled compartment, trimmed,* refers to any cargo space in which, after loading and trimming as required under A 10.2, the bulk grain is at its highest possible level.

This is understood to mean that, in the hatchway, the grain is filled to the level within the coaming which will be at the underside of the hatchcovers or the underside of the hatch beams which either frame or support the hatchcovers. The grain must be trimmed level at this height.

Beneath the deck, outboard and fore and aft of the hatch opening, the grain must be trimmed level to the maximum extent possible. Because of the capability of the machines used for trimming this is generally to a level slightly above the bottom of the hatch side girders and hatch end beams.

Figure 1 illustrates a transverse section through a filled compartment, trimmed. Figure 2 shows a compartment which appears to be trimmed, filled but which is not because the spaces outside the periphery of the hatchway were merely free-poured.

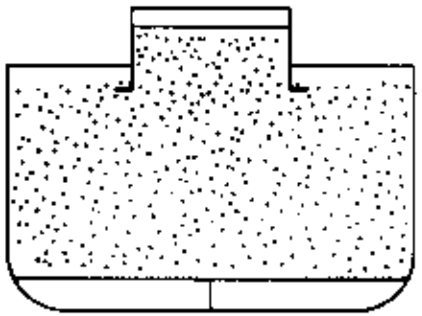


Figure 1
ACCEPTABLE

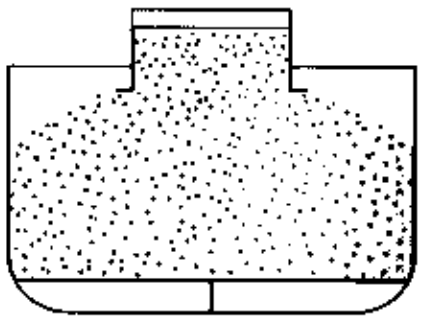


Figure 2
UNACCEPTABLE

> 2.3 The term *filled compartment, untrimmed,* refers to a cargo space which is filled to the maximum extent possible in way of the hatch opening but which has not been trimmed outside the periphery of the hatch opening either by the provisions of A 10.3.1 for all ships or A 10.3.2 for specially suitable compartments.

As illustrated in Figure 3, below, grain does not have to be trimmed if its surface is permanently restrained by graintight structure which slopes at an angle of 30 degrees or more. On most bulk carriers this is achieved by having the structural design include upper wing tanks extending the length of the holds, port and starboard. In accordance with regulation A 2.7 compartments so fitted are termed *specially suitable*. And, while in a filled compartment, the grain is restrained against shift in the areas to the port and starboard of the hatch opening, it is not similarly restrained by the horizontal surface on the underside of the deck forward and aft of the hatch opening. By regulation A 10 3.2, trimming is not required in these areas but only in specially suitable compartments and only when the compartment is otherwise filled, i.e., the bulk grain is filled to the maximum extent possible in way of the hatch opening.

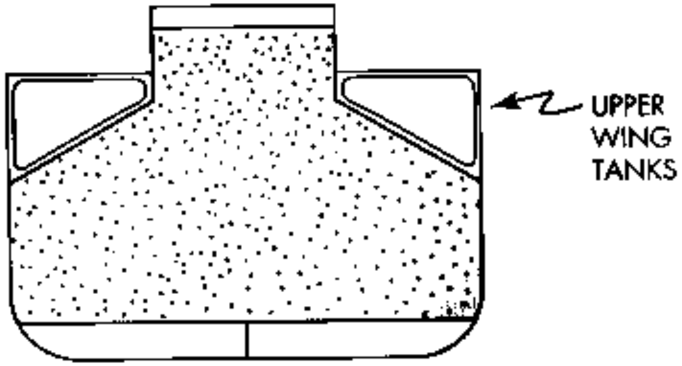


Figure 3
ACCEPTABLE

Figure 4 shows a longitudinal section, on the centerline, through a filled compartment with untrimmed ends.

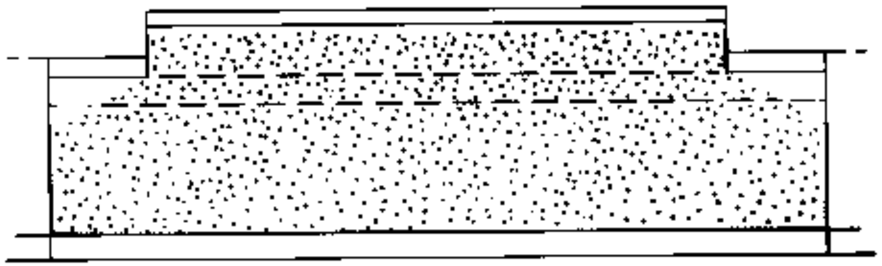


Figure 4

Additionally, the Grain Rules provide that the filled compartment, untrimmed status can be applied to compartments which are not specially suitable but, instead, are provided with *feeder ducts, perforated decks or other similar means* which reduce the open volume of space above the free-flowed grain surface so that it is equivalent to that which would obtain if there were no feeding arrangements and the space was trimmed in the normal manner. Acceptance of this alternative must be included in the approved grain loading information referenced in the ship's Document of Authorization. Figure 5 illustrates a transverse section through a ship with a filled lower hold which does not have to be trimmed because of the use of deck perforations in the tween deck.

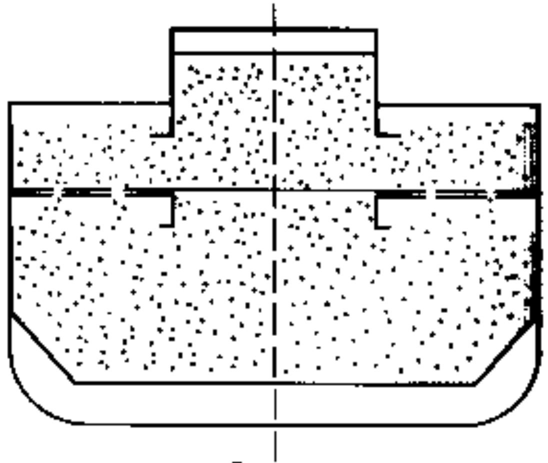


Figure 5

With this type of arrangement, the surveyor will always want to ascertain, before loading commences, that covers, if any, have been removed from all deck openings or that all feeding ducts are fully open to pass grain.

> 2.4 The term *partly filled compartment* refers to any cargo space where in the bulk grain is not loaded in the manner prescribed in A 2.2 or A 2.3.

Whenever a compartment is not filled then, as required by A 10.6, the entire grain surface must be trimmed level to minimize the possibility of a grain shift. It is to be especially noted that there is no such status as *almost filled*. Either a compartment is filled in accordance with the prescription in requirements A 2.2 or A 2.3, or it must be regarded as partly filled. In the former case, the Grain Rules assume a potential grain shift of 15 degrees. In the latter case, the rules assume the more severe effect of a 25 degree shift. Figures 6 and 7 show examples of partly filled compartments.

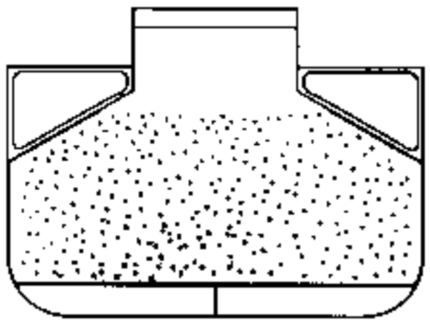


Figure 6

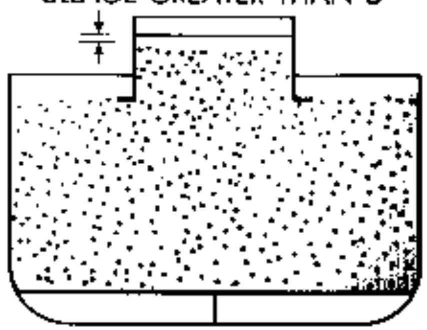


Figure 7

In addition to filled and partly filled, there is another stowage arrangement which should be mentioned. On multi-deck ships, such as break bulk or general cargo ships, regulation A 10.6 permits LOADING IN COMBINATION, (also known as common loading). In this type of loading the hatch covers in the intermediate decks, i.e., the tween decks, are left in the fully open position. Thus the grain in way of the vertically aligned hatch openings is a homogeneous column and void spaces exist only beneath the peripheral decks at each level and, of course, beneath the uppermost, closed hatch cover. The grain in the peripheral areas must be filled and trimmed level. This procedure completely eliminates the void space beneath the hatch covers at every level except the uppermost and, therefore, results in a smaller grain heeling moment than would apply if the filled grain heeling moments at each level were summed.

There are a few caveats concerning the use of this option. The data to calculate the grain heeling moments which apply for this condition must be included in the approved grain loading booklet. The hatch covers in the tween decks must be in the fully open position. And, if they are the retractable type they must not, when in the open position, prevent the grain in the peripheral areas from attaining the filled, trimmed condition. Figure 8 shows a transverse section through a cargo hold which is loaded in combination.

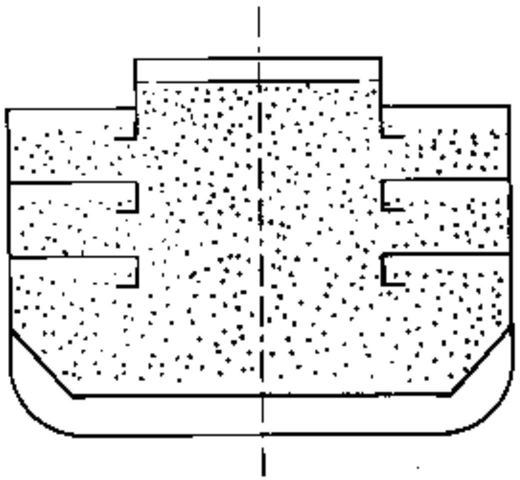


Figure 8

Volumetric Heeling Moments

Before departure from port, the grain in a ship has been loaded symmetrically and trimmed level. So the center of gravity of the grain mass is on the centerline and the ship is upright. This UPRIGHT CONDITION is specifically required by regulation A.7.3. Since the weather, sea, and even operating condition of the ship cannot be anticipated for the duration of a voyage, it is possible that, in spite of the precautions which have been taken, the grain will shift. If this occurs the center of gravity of the grain mass will move off the centerline of the ship and the distance it moves multiplied by the weight of the grain constitutes a force, known as the GRAIN HEELING MOMENT, which will list the ship. The magnitude of this moment depends upon three factors: the angle of shift (15 or 25 degrees as assumed by the regulations), the internal geometry of the ship (i.e., the shape of the space into which the grain shifts), and the weight of the grain.

Because of the tedious and lengthy arithmetic involved, it is not practical for the ship's officers to calculate the grain heeling moments for a specific loading condition. However, since the angle of grain shift and the internal geometry of the ship always remains the same, the naval architect, in accordance with directions set forth in Part B of the Code, can pre-calculate the volumetric heeling moments for the various cargo compartments and the different ullages of grain in the compartments. Of course, a volume times a distance cannot exert a force. But a volume of space divided by the stowage factor of the commodity which fills the volume, equals a weight. So the regulations utilize the mathematical stratagem of tabulating volumetric heeling moments which, when divided by the stowage factor (as defined in rule A 2.6) of whatever variety of grain is loaded, gives the grain heeling moment. Thus,

$$\text{Grain Heeling Moment} = \frac{\text{Volumetric Heeling Moment}}{\text{Stowage Factor (per A 2.6)}}$$

A Volumetric Heeling Moment, since it represents an unreal concept of a volume times a distance, has an unusual dimensional unit, namely m^4, as derived below:

Volume	x Distance	= Moment
m^3	m	m^4

It becomes a physical moment when divided by the A 2.6 stowage factor:

$$\frac{\text{Volumetric Heeling Moment } m^4}{\text{Stowage Factor } m^3/\text{tonne}} = \text{Heeling Moment Tonne metres}$$

Stowage Factor

Because of the way stowage factor is utilized in grain stability calculations, it has a different definition than is usually applied in commercial, maritime practice. In accordance with regulation A 2.6, stowage factor means the volume per unit weight (ft^3/long ton or m^3/tonne) as attested by the loading facility. While this value allows for the interstices between the grain particles, it does not include "broken stowage", i.e., the space left vacant when the compartment is nominally filled. This approach is necessary because the weight of the mass of grain which moves transversely in a grain shift, is the actual weight and not a weight reduced by the void spaces which constitute the broken stowage in the compartment as a whole. Since loading facilities in the United States usually furnish test weights per bushel, see page 96 in this booklet as to how this data can be translated into the stow factors specified by the Code.

It is to be noted that when calculating the weight of grain which can be stowed in a compartment (i.e., for use in calculating the displacement of the ship), the conventional stowage factor, which allows for broken stowage, should be used. Generally, this is based on knowledge of previous loadings and/or on the experience in the port.

In the case of ***filled, untrimmed compartments*** the data in the Grain Loading manual, listing the reduced volume for this condition, generally understates the volume. This is because Part B of the Code directs the naval architect to base his calculation on an angle of repose for the grain of 30 degrees whereas it may actually be as low as 23 degrees. Thus, if these values are used more grain may be loaded in the "filled, untrimmed" compartment than the calculations anticipated. This can result in a deeper draft and/or a greater ullage in another compartment which was planned to be partly filled. Unless there is prior experience to rely on, it is wise to use the full capacities for *filled, untrimmed compartments* in initial calculations so any differences will be on the safe side and remediable.

Stability Requirements

Once the grain heeling moment has been determined, the response of the ship to this moment, i.e., the permanent angle of heel and, also, the amount of reserve stability which remains, depends upon the hydrostatic properties of the ship at the actual displacement and vertical center of gravity. The Code prescribes the following requirements in these regards:

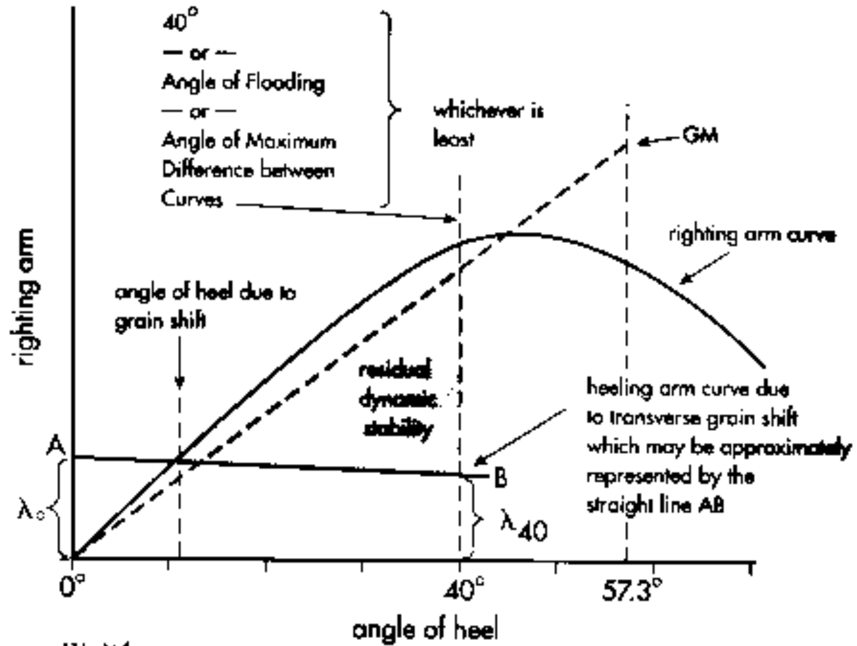
7.1 The intact stability characteristics of any ship carrying bulk grain shall be shown to meet, throughout the voyage, at least the following criteria after taking into account in the manner described in Part B of this Code and, in figure A7, the heeling moments due to grain shift:

.1 the angle of heel due to the shift of grain shall not be greater than 12° or in the case of ships constructed on or after 1 January 1994 the angle at which the deck edge is immersed, whichever is the lesser;

.2 in the statical stability diagram, the net or residual area between the heeling arm curve and the righting arm curve up to the angle of heel of maximum difference between the ordinates of the two curves, or 40° or the angle of flooding (θ_f), whichever is the least, shall in all conditions of loading be not less than 0.075 metre-radians; and

.3 the initial metacentric height, after correction for the free surface effects of liquids in tanks, shall be not less than 0.30 m.

See diagram next page ▶



(1) Where:

$$\lambda_o = \frac{\text{assumed vol. heeling moment due to transv. shift}}{\text{stowage factor x displacement}}$$

$$\lambda_{40} = 0.8 \times \lambda_o$$

Displacement = weight of ship, fuel, fresh water, stores etc. and cargo.

(2) The righting arm curve shall be derived from cross-curves which are sufficient in number to accurately define the curve for the purpose of these requirements and shall include cross-curves at 12° and 40°.

Figure A7

7.2 Before loading bulk grain the master shall, if so required by the Contracting Government of the country of the port of loading, demonstrate the ability of the ship at all stages of any voyage to comply with the stability criteria required by this section.

7.3 After loading, the master shall ensure that the ship is upright before proceeding to sea.

The first step in determining compliance with these requirements is to calculate the final displacement and vertical center of gravity corrected for the free surface of the liquids on board (KGv). This is the same calculation which is made for any cargo ship. From the KGv, the metacentric height (GM) can be calculated and, as required by A 7.1.3, it must be not less than 0.3 metres.

The volumetric heeling moment data, provided in the approved, grain loading information, is used to calculate the grain heeling moment for each compartment wherein grain is stowed. The sum of these moments is the total grain heeling moment which the Code assumes the ship may be subjected to if the grain shifts. This moment will cause the ship to heel and A 7.1.1 requires that this heel should not be greater than 12 degrees. On some ships with low freeboards, a 12 degree heel could immerse the deck edge which is a very undesirable condition. Therefore, the older version of the Grain Rules recommended that an angle of heel which immersed the deck edge should not be exceeded even if it was less than 12 degrees. One of the few changes which were instituted with the inception of the Code, namely, regulation A 6.3.2, was to make this a requirement for ships built after January 1, 1994.

The basic means for calculating the angle of heel which will result from an applied heeling moment is to construct a stability curve for the actual displacement and KGv from the information furnished in the ship's approved Cross Curves of Stability and to superimpose on it a second curve derived from the grain heeling moment as shown on Figure A7. A method for doing this is explained on page 54 in this booklet.

Regardless of initial GM, a ship which is heeled to an angle of 12 degrees could be in a very perilous condition. To guard against this, regulation A 7.1.2 requires that a ship heeled to an angle of 12 degrees, have a reserve of stability. This is a dynamic rather than a static amount and it is indicated in the Code as a minimum of 0.075 metre radians of residual area within specified boundaries on the aforementioned stability curve as shown on figure A7. A method for measuring this area is given on pages 56 and 57 in this booklet.

In some cases, but not all, one of the boundaries of the residual area may be the *Angle of Flooding* (θ_f), which is defined in regulation A 2.5, as the angle of heel at which openings in the hull, superstructures or deckhouses, which cannot be closed weathertight, immerse. Small openings, through which progressive flooding cannot take place need not be considered as open. Progressive flooding means that adjoining watertight compartments fill consecutively as the trim of the ship changes due to the gradually increasing weight of the flood water. Gooseneck vents or tank overflow pipes are examples of small openings which are exempted in this definition. Figure 9 illustrates the location of an air intake for the main engines, which would establish the angle of flooding. Note that the gooseneck vents at the deck edge do not establish the angle. Also, it is important to note that the angle changes as the draft of the ship changes. As the draft increases, the angle of flooding (θ_f) decreases.

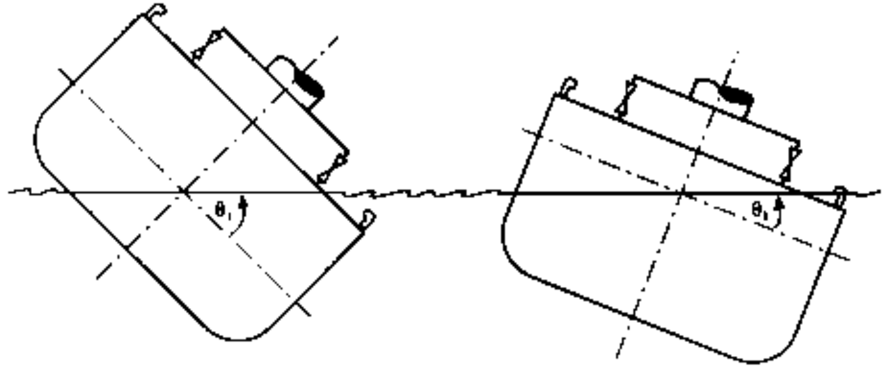


Figure 9

The construction of a stability curve from the Cross Curves of Stability and the measurements taken therefrom have been eliminated and the calculations necessary to determine compliance with regulation A 7.1 of the Code have been greatly simplified by the use of Tables or Curves of Maximum Permissible Heeling Moments. See regulation A 6.3.2 in the Code. In lieu of calculating the actual GM, angle of heel, and residual area which will obtain for a given displacement, KGv, and total grain heeling moment and then testing these values against the requirements of the Code, the naval architect pre-calculates the maximum heeling moment which will meet all three of these conditions for every combination of displacement and KGv within the range of the ship's operating conditions and lists them in curves or a table which is part of the data in the ship's approved Grain Loading Information. Thus all the ship's master has to do is calculate the displacement, KGv, and total grain heeling moment and check in the Permissible Heeling Moment Table (or curves) to determine if his calculated grain heeling moment is equal to or less than the permissible heeling moment listed in the table. Page 53 in this booklet gives an example of how this table is used and a method for interpolating as is usually necessary when using the table.

* Tables or curves of maximum permissible heeling moments are not required for ships built before January 1, 1994. However, most ships have them because of the time and errors saved by their use. They are required on ships built after that date. This is another one of the few changes in the Grain Rules which were instituted with the inception of the Code.

Notice that the Code requires, in regulation A 7.1, that these stability regulations must be met <u>throughout the voyage</u>. Thus it is not sufficient to check for compliance at the point where the ship completes loading, including bunkering, and departs upon its voyage. A check must be made for the departure condition and for the arrival condition, i.e., after the change in displacement and KGv due to voyage consumption of fuel and consumables. If the voyage is interrupted by calls at intermediate ports to load or discharge cargo (whether it is grain or not) or to bunker, the departure and arrival conditions must be calculated for each leg of the voyage. Additionally, if the condition upon arrival at the grain discharge port includes ballast which was not on board at the time of departure, then compliance with regulation A 7.1 must be confirmed at the point at which the ballast was taken. Although adequate stability, during ballasting, can be assured by judicious procedures it is wise to investigate the most unfavorable condition which can exist at this time, i.e., calculate the KGv without the reduction in KGv due to the ballasting but include the free surface effect of the ballast while the tank is being filled. Thus if ballast is required, it should be taken at a point in the voyage when the aforementioned condition meets the stability requirements of regulation A 7.1

Grain Loading Manual

Regulation A 3 requires that the information which the master needs to perform the stability calculations necessary to confirm compliance with the Code, be furnished in a GRAIN LOADING MANUAL. It may be drawn up in the language of the issuing country but if that language is neither English or French, the text shall include a translation into one of those languages. Thus the manual will be suitable for use by the ship's personnel and by the authorities at any port where the ship might load bulk grain. A copy of the Grain Loading Manual and any associated plans shall be maintained on board the ship in order that the master, if so required, can produce them for inspection and use by appropriate authorities at the ports of loading.

Regulation A 6 lists the specific data and information which is to be included in the Grain Loading Manual. However, these details are not the responsibility of the master. If the Grain Loading Manual is approved by the Administration or an agency authorized to act on behalf of the Administration, then the content of the Grain Loading Manual shall be deemed to be in compliance with regulation A 6.

Document of Authorization

One of the basic principles of the International Convention for the Safety of Life at Sea, is that member nations will be responsible for the details of compliance with the requirements of the Convention and that other nations will accept, on good faith, that these details have been properly observed. But each nation retains the right to ascertain that any ship which conducts commerce from its ports has, in fact, been subjected to the promised oversight by its home Administration. In the case of ships carrying grain in bulk, the mechanism for accomplishing this is the Document of Authorization, described in regulation A 3.

The Document of Authorization is a certification made by an Administration which is signatory to the Convention or by an agency authorized to act on behalf of that Administration, that a specific ship under its registry is capable of carrying grain in bulk and that the information in the Grain Loading Manual, defining such capability, has been reviewed and is approved as being in compliance with the requirements of the Code. Thus when a ship of a nation which is signatory to the International Convention, presents itself to load grain at any port of a nation which is also signatory, the information in the approved Grain Loading Manual will be accepted as being correct and will be utilized to determine that the specific stowage arrangements and loading condition for the forthcoming voyage complies with all the requirements of the Code. Since over 130 nations are signatory to the Convention, this means that the Document of Authorization will be accepted at almost every port in the world.

Of course, if a nation is not signatory to the Convention, then member nations would not extend to its ships the benefits of being signatory, i.e., Grain Loading Manuals or Documents of Authorization would not be recognized.

Ships Without a Document of Authorization

Unlike a Trim and Stability booklet or a Cargo Ship Safety Construction Certificate, the International Convention does not require that every cargo ship have a Document of Authorization. Instead this Document is optional for ships, usually bulk carriers, for which it greatly facilitates their operations. The Code provides two options under which, subject to certain limitations, a ship without a Document of Authorization may load grain in bulk.

a) Under regulation A 3.5

The master must provide to its home Administration, plans and calculations which demonstrate that the proposed stowage arrangements and loading condition complies with the requirements of the Code. The calculations must include derivation of the volumetric heeling moments which are used as well as the calculations demonstrating compliance with regulation A 7.1. When the home Administration approves the calculations, the master must present the approval at the port of loading. Alternatively, and only if the home Administration so authorizes, the authorities at the port of loading may review and approve the calculations prior to permitting loading.

b) Under regulation 9

A ship without a Document of Authorization may carry a partial cargo of bulk grain without performing all the detailed calculations required under the option previously described, by utilizing the provisions of regulation 9, quoted below. Note that authority to use this option must be obtained from the home Administration

> 9.1 A ship not having on board a document of authorization issued in accordance with A 3 of this Code may be permitted to load bulk grain provided that:
>
> .1 the total weight of the bulk grain shall not exceed one third of the deadweight of the ship;
>
> .2 all filled compartments, trimmed, shall be fitted with centerline divisions extending, for the full length of such compartments, downwards from the underside of the deck or hatch covers to a distance below the deck line of at least one eighth of the maximum breadth of the compartment or 2.4 m, whichever is the greater, except that saucers constructed in accordance with A 14 may be accepted in lieu of a centerline division in and beneath a hatchway except in the case of linseed and other seeds having similar properties;
>
> .3 all hatches to filled compartments, trimmed, shall be closed and covers secured in place;
>
> .4 all free grain surfaces in partly filled cargo space shall be trimmed level and secured in accordance with A 16, A 17 or A 18;
>
> .5 throughout the voyage the metacentric height after correction for the free surface effects of liquids in tanks shall be 0.3 m or that given by the following formula, whichever is the greater;

$$GM_R = \frac{L\,B\,V_d\,(0.25\,B - 0.645\sqrt{V_d\,B})}{SF \times \Delta \times 0.0875}$$

Where:

L	=	total combined length of all full compartments (metres)
B	=	moulded breadth of the vessel (metres)
SF	=	stowage factor (cubic metres per tonne)
V_d	=	calculated average void depth calculated in accordance with B 1 (metres - Note: not millimetres)
Δ	=	displacement (tonnes); and

.6 the master demonstrates to the satisfaction of the Administration or the Contracting Government of the port of loading on behalf of the Administration that the ship in its proposed loaded condition will comply with the requirements of this section.

The factor V_d, average void depth, needed for the calculation required by this option necessitates reference to Part B of the Code, which contains the details needed by naval architects to prepare Grain Loading Manuals. However, tables to calculate V_d are provided on pages 62 and 63 of this booklet together with a rearrangement of the formula in regulation A 9.1.5, intended to make it easier to perform on a calculator.

Implicit in the option under regulation A 9, is the loading condition whereby no grain stability calculations are required. If, in accordance with regulation A 9.1.4, all the bulk grain cargo is carried in partly filled holds and secured, and the total weight of grain is limited as per A 9.1.1, then there is no grain stability requirement. However, if the Administration imposes a cargo ship stability requirement, then this would still apply.

Additional Grain Stowage Requirements

In addition to trimming to minimize the possibility that bulk grain may shift, regulation A 10 makes other requirements which are necessary to achieve this purpose.

Regulation A 10.4, requires that if there is no bulk cargo or other cargo above a lower cargo compartment containing bulk grain, the hatch covers shall be held in place either by having a sufficient mass of cargo above to hold the tween deck hatch covers in place or having permanent securing devices on the covers. The need for this is evident when considering that if the covers are not secured, a shift in the grain below could cause the covers to lift spilling the grain into the upper compartment and thereby generating a grain heeling moment as shown in Figure 10, below:

See diagram next page ▶

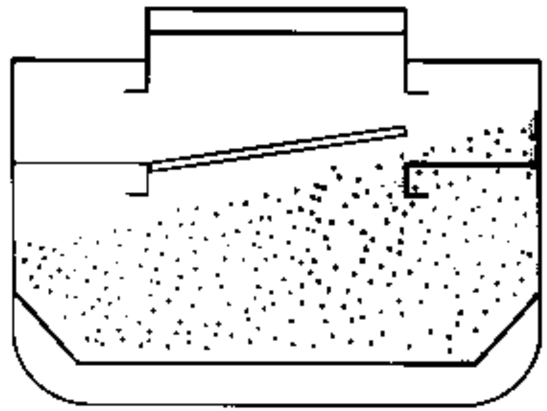


Figure 10

Similarly, regulation A 10.5 requires that when bulk grain is stowed on top of closed tween deck hatch covers which are not grain-tight, such covers shall be made grain-tight by taping the joints, covering the entire hatchway with tarpaulins or separation clothes, or other suitable means. It is obvious that if some of the bulk grain in an upper compartment, in the course of the voyage, shifts down to a lower compartment through the joints in the hatch covers, then the void space above the grain in the upper compartment will increase. This will increase the potential grain heeling moment to a greater value so that the stability calculations, made at the start of the voyage, will not indicate the actual status of compliance.

In the case of specially suitable compartments which are *filled, untrimmed* in accordance with regulation A 10.3.2, the grain in the spaces forward and aft of the hatchway is disposed at its angle of repose flowing outward from the lower edges of the hatch end beams. However, if there are feeding holes in the hatch end beams, as shown in Figure 11, the grain flows from the holes thereby reducing the void space which would obtain if the grain flowed from the lower boundary. Where such holes are provided the tabulated volumetric heeling moment takes credit for the smaller void space. Thus, when the hatchway is filled, time must be allowed for the feeding through the feeding holes to be completed. When feeding ceases and the hatchway is filled, then the hatch can be closed.

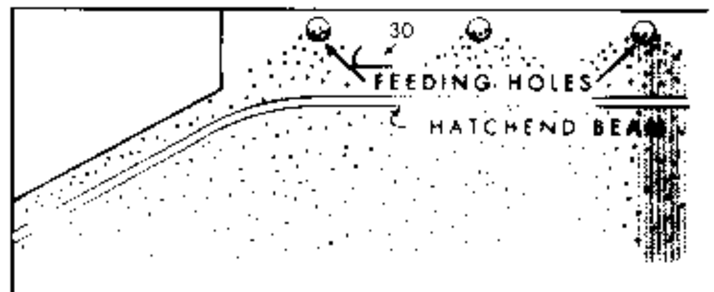


Figure 11

Other Methods of Achieving Compliance

In the event that the stability calculations for a proposed stowage arrangement do not meet the stability requirements of regulation A 7.1, alternate stowage arrangements should be investigated. If this is not successful, other, usually more costly, alternatives are available as follows:

A. Ballasting

If there is reserve deadweight, i.e., if the proposed loading condition does not bring the ship to its permitted Load Line draft, then taking ballast may be helpful. The ballast should be in the double bottom tanks and the tanks should be filled to eliminate free surface effect. Thus low weight will increase the displacement and lower the KG_V. Generally, this will increase the permissible grain heeling moment and this may be sufficient to make the proposed stowage arrangement acceptable.

If this alternative is to be used, the ballast must be on board at the time of departure. Sometimes, because of dirty harbor water or similar considerations, it is not advisable for the ship to ballast while at the loading berth. In such cases, the stability calculation should show the ballast on board and the master must certify that the ballasting will be completed enroute to sea and before the vessel departs sheltered waters. This certification may be in the form of a letter, on ship's stationery, signed by the master.

This option does not require any special information or endorsement in the Grain Loading Manual.

B. Overstowing

If one or more of the grain compartments is partly filled, the grain heeling moments for such compartments is much greater than it is for the filled compartments. The grain heeling moment for a partly filled compartment can be eliminated, i.e., reduced to zero, by securing the slack surface against shifting by overstowing it with bagged grain or with other cargo which will have the similar effect of restraining the grain surface against any movement. A reduction in the total grain heeling moment, achieved by this means, may be sufficient to bring the proposed stowage arrangement within the limit specified in the Permissible Heeling Moment Table.

This option does not require any special information or endorsement in the Grain Loading Manual.

The specific requirements for overstowing are given in regulation A 16, as follows:

16.1 Where bagged grain or other suitable cargo is utilized for the purpose of securing partly filled compartments, the free grain surface shall be level and shall be covered with a separation cloth or equivalent or by a suitable platform. Such platform shall consist of bearers spaced not more than 1.2 m apart and 25 mm boards laid thereon spaced not more than 100 mm apart. Platforms may be constructed of other materials provided they are deemed by the Administration to be equivalent.

16.2 The platform or separation cloth shall be topped off with bagged grain tightly stowed and extending to a height of not less than one-sixteenth of the maximum breadth of the free grain surface or 1.2 m, whichever is the greater.

16.3 The bagged grain shall be carried in sound bags which shall be well filled and securely closed.

16.4 Instead of bagged grain, other suitable cargo tightly stowed and exerting at least the same pressure as bagged grain stowed in accordance with A 16.2 may be used.

C. Saucers

The grain heeling moment may be significantly reduced in a filled compartment by constructing a saucer, as described in regulation A 14, below, in the square of the hatchway. This device has the same effect as a centerline, grain-tight bulkhead in that it prevents the grain from shifting across the entire breadth of the compartment, as illustrated in Figure 12.

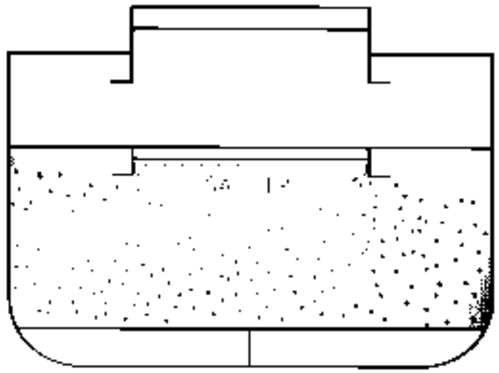


Figure 12

Unless there are grain-tight division forward and aft of the hatchway, the effect is limited to the longitudinal length of the saucer. The volumetric heeling moment which applies in a specific compartment when a saucer is fitted must be included in the approved Grain Loading Manual if this option is to be available for use by the ship.

The specific requirements pertaining to the use and construction of saucers are given in regulation A 14 as follows:

14.1 For the purpose of reducing the heeling moment a saucer may be used in place of a longitudinal division in way of a hatch opening only in a filled, trimmed, compartment as defined in A 2.2, except in the case of linseed and other seeds having similar properties, where a saucer may not be substituted for a longitudinal division. If a longitudinal division is provided, it shall meet the requirements of A 10.9.

14.2 The depth of the saucer, measured from the bottom of the saucer to the deck line, shall be as follows:

.1 For ships with a moulded breadth of up to 9.1 m, not less than 1.2 m.

.2 For ships with a moulded breadth of 18.3 m or more, not less than 1.8 m.

.3 For ships with a moulded breadth between 9.1 m and 18.3 m, the minimum depth of the saucer shall be calculated by interpolation.

14.3 The top (mouth) of the saucer shall be formed by the underdeck structure in way of the hatchway, i.e., hatch side girders or coamings and hatch end beams. The saucer and hatchway above shall be completely filled with bagged grain or other suitable cargo laid down on a separation cloth or its equivalent and stowed tightly against adjacent structure so as to have a bearing contact with such structure to a depth equal to or greater than one-half of the depth specified in A 14.2. If hull structure to provide such bearing surface is not available, the saucer shall be fixed in position by steel wire rope, chain, or double steel strapping as specified in A 17.1.4 and spaced not more than 2.4 m apart.

D. Bundling of Bulk Grain

Whereas a saucer is formed by a volume of bagged grain or similarly restrained cargo, the same result of preventing a transverse shift of grain across the entire breadth of the compartment, as illustrated in Figure 12, may be achieved by constructing a single, large bag of bulk grain which fills the hatchway and which is fixed in position by the structural boundaries of the hatchway. This is termed "bundling of bulk grain" and is an acceptable alternative to a saucer.

The volumetric heeling moment which applies when bundling of bulk grain is used in a specific compartment is the same as that which applies for a saucer used in the same location, and it must be listed in the Grain Loading manual if this option is to be available for use by the vessel.

The specific requirements pertaining to the method of "bundling of bulk grain" are given in regulation A 15, as listed below. It is to be noted that the limitations on its use are the same as those which apply to a saucer and are specified in regulation A 14.1.

As an alternative to filling the saucer in a filled, trimmed, compartment with bagged grain or other suitable cargo a bundle of bulk grain may be used provided that:

15.1 The dimensions and means for securing the bundle in place are the same as specified for a saucer in A 14.2 and A 14.3.

15.2 The saucer is lined with a material acceptable to the Administration having a tensile strength of not less than 2,687 N per 5 cm strip and which is provided with suitable means for securing at the top.

15.3 As an alternative to A 15.2, a material acceptable to the Administration having a tensile strength of not less than 1,344 N per 5 cm strip may be used if the saucer is constructed as follows:

.3.1 Athwartship lashings acceptable to the Administration shall be placed inside the saucer formed in the bulk grain at intervals of not more than 2.4 m. These lashings shall be of sufficient length to permit being drawn up tight and secured at the top of the saucer.

.3.2 Dunnage not less than 25 mm in thickness or other suitable material of equal strength and between 150 mm and 300 mm in width shall be placed fore and aft over these lashings to prevent the cutting or chafing of the material which shall be placed thereon to line the saucer.

15.4 The saucer shall be filled with bulk grain and secured at the top except that when using material approved under A 15.3 further dunnage shall be laid on top after lapping the material before the saucer is secured by setting up the lashings.

15.5 If more than one sheet of material is used to line the saucer they shall be joined at the bottom either by sewing or by a double lap.

15.6 The top of the saucer shall be coincidental with the bottom of the beams when these are in place and suitable general cargo or bulk grain may be placed between the beams on top of the saucer.

E. Strapping or Lashing

Partly filled compartments have the greatest volumetric heeling moments because they have a large volume of open space above the grain surface into which the grain can shift and, also, because the regulations assume a 25 degree shift instead of the 15 degree shift which applies when the compartment is filled. Consequently, a significant reduction in grain heeling moment can be achieved by totally preventing a grain shift in a partly filled compartment and thus reducing the grain heeling moment attributable to that compartment to zero. This may be accomplished by fabricating a somewhat costly construction which completely covers the slack grain surface and physically restrains it against any movement which may be generated by the motions of the ship at sea.

The use of this option does not require any special information or endorsement in the Grain Loading manual. The specific requirements pertaining to the details of construction are given in regulation A 17, as given below:

When, in order to eliminate heeling moments in partly filled compartments, strapping or lashing is utilized, the securing shall be accomplished as follows:

17.1 The grain shall be trimmed and levelled to the extent that it is very slightly crowned and covered with burlap separation cloths, tarpaulins or the equivalent.

17.2 The separation cloths and/or tarpaulins shall overlap by at least 1.8 m.

17.3 Two solid floors of rough 25 mm x 150 mm to 300 mm lumber shall be laid with the top floor running longitudinally and nailed to an athwartships bottom floor. Alternatively, one solid floor of 50 mm lumber, running longitudinally and nailed over the top of a 50 mm bottom bearer not less than 150 mm wide, may be used. The bottom bearers shall extend the full breadth of the compartment and shall be spaced not more than 2.4 m apart. Arrangements utilizing other materials and deemed by the Administration to be equivalent to the foregoing may be accepted.

17.4 Steel wire rope (19 mm diameter or equivalent), double steel strapping (50 mm x 1.3 mm and having a breaking load of at least 49kN), or chain of equivalent strength, each of which shall be set tightly by means of a 32 mm turnbuckle, may be used for lashings. A winch tightener, used in conjunction with a locking arm, may be substituted for the 32 mm turnbuckle when steel strapping is used, provided suitable wrenches are available for setting up as necessary. When steel strapping is used, not less than three crimp seals shall be used for securing the ends. When wire is used, not less than four clips shall be used for forming eyes in the lashings.

17.5 Prior to the completion of loading the lashing shall be positively attached to the framing at a point approximately 450 mm below the anticipated final grain surface by means of either a 25 mm shackle or beam clamp of equivalent strength.

17.6 The lashings shall be spaced not more than 2.4 m apart and each shall be supported by a bearer nailed over the top of the fore and aft floor. This bearer shall consist of lumber of not less than 25 mm x 150 mm or its equivalent and shall extend the full breadth of the compartment.

17.7 During the voyage the strapping shall be regularly inspected and set up where necessary.

F. Securing with Wire Mesh

This method of preventing a slack grain surface from shifting and thereby reducing the grain heeling moment to zero, is essentially the same as "Strapping or Lashing" except that the principal restraining force of the transverse cables spaced every 2.4 meters for the length of the hold, is transmitted to the overall, fabric-covered surface of the grain by means of a stiff, wire mesh of the type used to reinforce concrete instead of through a deck constructed of dunnage.

The use of this option does not require any special information or endorsement in the Grain Loading manual. The specific requirements pertaining to the details of construction are given in regulation A 18, as given below:

When, in order to eliminate grain heeling moments in partly filled compartments, strapping or lashing is utilized, the securing may, as an alternative to the method described in A 17, be accomplished as follows:

18.1 The grain shall be trimmed and levelled to the extent that it is very slightly crowned along the fore and aft centreline of the compartment.

18.2 The entire surface of the grain shall be covered with burlap separation cloths, tarpaulins, or the equivalent. The covering material shall have a tensile strength of not less than 1,344 N per 5 cm strip.

18.3 Two layers of wire reinforcement mesh shall be laid on top of the burlap or other covering. The bottom layer is to be laid athwartships and the top layer is to be laid longitudinally. The lengths of wire mesh are to be overlapped at least 75 mm. The top layer of mesh is to be positioned over the bottom layer in such a manner that the squares formed by the alternate layers measure approximately 75 mm x 75 mm. The wire reinforcement mesh is the type used in reinforced concrete construction. It is fabricated of 3 mm diameter steel wire having a breaking strength of not less than 52 kN/cm^2 welded in 150 mm x 150 mm squares. Wire mesh having mill scale may be used but mesh having loose, flaking rust may not be used.

18.4 The boundaries of the wire mesh, at the port and starboard side of the compartment, shall be retained by wood planks 150 mm x 50 mm.

18.5 Hold-down lashings, running from side to side across the compartment, shall be spaced not more than 2.4 m apart except that the first and the last lashing shall not be more than 300 mm from the forward or after bulkhead, respectively. Prior to the completion of the loading, each lashing shall be positively attached to the framing at a point approximately 450 mm below the anticipated final grain surface by means of either a 25 mm shackle or beam clamp of equivalent strength. The lashing shall be led from this point over the top of the boundary plank described in A 18.1.4, which has the function of distributing the downward pressure exerted by the lashing. Two layers of 150 mm x 25 mm planks shall be laid athwartships centered beneath each lashing and extending the full breadth of the compartment.

18.6 The hold-down lashings shall consist of steel wire rope (19 mm diameter or equivalent), double steel strapping (50 mm x 1.3 mm and having a breaking load of at least 49kN), or chain of equivalent strength, each of which shall be set tight by means of a 32 mm turnbuckle. A winch tightener, used in conjunction with a locking arm, may be substituted for the 32 mm turnbuckle when steel strapping is used, provided suitable wrenches are available for setting up as necessary. When steel strapping is used, not less than three crimp seals shall be used for securing the ends. When wire rope is used, not less than four clips shall be used for forming eyes in the lashings.

18.7 During the voyage the hold-down lashings shall be regularly inspected and set up where necessary.

G. Temporary Longitudinal Division

The grain heeling moment in a compartment, in either the filled or partly filled condition, can be significantly reduced by installing, usually on the fore and aft centerline, a longitudinal bulkhead which prevents the grain from shifting across the entire breadth of the compartment. This is an expensive alternative but it is available for use in a ship if the applicable volumetric heeling moment is listed in the ship's Grain Loading manual. If the grain is to be loaded on both sides of a longitudinal bulkhead, the stress on the bulkhead will be somewhat relieved. The Code contains regulations governing the design of divisions loaded on both sides and divisions loaded on one side only. The former is simpler and is covered by regulation A 11 and A 12, as given below:

11.1 *Timber*

All timber used for grain fittings shall be of good sound quality and of a type and grade which has been proved to be satisfactory for this purpose. The actual finished dimensions of the timber shall be in accordance with the dimensions specified below. Plywood of an exterior type bonded with waterproof glue and fitted so that the direction of the grain in the face plies is perpendicular to the supporting uprights or binder may be used provided that its strength is equivalent to that of solid timber of the appropriate scantlings.

11.2 *Working Stresses*

(This regulation pertains divisions loaded on one side.)

11.3 *Other materials*

Materials other than wood or steel may be approved for such divisions provided that proper regard has been paid to their mechanical properties.

11.4 *Uprights*

.1 Unless means are provided to prevent the ends of uprights being dislodged from their sockets, the depth of housing at each end of each upright shall be not less than 75 mm. If an upright is not secured at the top, the uppermost shore or stay shall be fitted as near thereto as is practicable.

.2 The arrangements provided for inserting shifting boards by removing a part of the cross-section of an upright shall be such that the local level of stresses is not unduly high.

.3 (This regulation pertains divisions loaded on one side.)

11.5 *Composite section*

Where uprights, binders or any other strength members are formed by two separate sections, one fitted on each side of a division and interconnected by through bolts at adequate spacing, the effective section modulus shall be taken as the sum of the two moduli of the separate sections.

11.6 *Partial division*

Where divisions do not extend to the full depth of the cargo space such divisions and their uprights shall be supported or stayed so as to be as efficient as those which do extend to the full depth of the cargo space.

Applicable to Divisions Loaded on Both Sides:

12.1 *Shifting boards*

.1 Shifting boards shall have a thickness of not less than 50 mm and shall be fitted grain-tight and where necessary supported by uprights.

.2 The maximum unsupported span for shifting boards of various thicknesses shall be as follows:

Thickness	Maximum unsupported span
50 mm	2.5 m
60 mm	3.0 m
70 mm	3.5 m
80 mm	4.0 m

If thicknesses greater than these are provided, the maximum unsupported span will vary directly with the increase in thickness.

.3 The ends of all shifting boards shall be securely housed with 75 mm minimum bearing length.

12.2 *Other materials*

Divisions formed by using materials other than wood shall have a strength equivalent to the shifting boards required in A 12.1.

12.3 *Uprights*

.1 Steel uprights used to support divisions loaded on both sides shall have a section modulus given by

$$W = a \times W_1$$

Where:

W = section modulus in cubic centimetres

a = horizontal span between uprights in metres.

The section modulus per metre span W1 shall be not less than that given by the formula:

$$W_1 = 14.8\,(h_1 - 1.2)\ \text{cm}^3/\text{m}$$

Where:

h_1 is the vertical unsupported span in metres and shall be taken as the maximum value of the distance between any two adjacent stays or between a stay and either end of the upright. Where this distance is less than 2.4 m the respective modulus shall be calculated as if the actual value were 2.4 m.

.2 The moduli of wood uprights shall be determined by multiplying by 12.5 the corresponding moduli for steel uprights. If other materials are used their moduli shall be at least that required for steel increased in proportion to the ratio of the permissible stresses for steel to that of the material used. In such cases attention shall be paid also to the relative rigidity of each upright to ensure that the deflection is not excessive.

.3 The horizontal distance between uprights shall be such that the unsupported spans of the shifting boards do not exceed the maximum span specified in A 12.1.2.

12.4 *Shores*

.1 Wood shores, when used, shall be in a single piece and shall be securely fixed at each end and heeled against the permanent structure of the ship except that they shall not bear directly against the side plating of the ship.

.2 Subject to the provisions of A 12.4.3 and A 12.4.4, the minimum size of wood shores shall be as follows:

Length of shore (m)	Rectangular Section (mm)	Diameter of circular section (mm)
Not exceeding 3 m	150 x 100	140
Over 3 m but not exceeding 5 m	150 x 150	165
Over 5 m but not exceeding 6 m	150x150	180
Over 6 m but not exceeding 7 m	200 x 150	190
Over 7 m but not exceeding 8 m	200 x 150	200
Exceeding 8 m	200 x 150	215

Shores of 7 m or more in length shall be securely bridged at approximately mid-length.

.3 When the horizontal distance between the uprights differs significantly from 4 m, the moments of inertia of the shores may be changed in direct proportion.

.4 Where the angle of the shore to the horizontal exceeds 10°, the next larger shore to that required by A 12.4.2 shall be fitted provided that in no case shall the angle between any shore and the horizontal exceed 45°.

12.5 *Stays*

Where stays are used to support divisions loaded on both sides, they shall be fitted horizontally or as near thereto as practicable, well secured at each end and formed of steel wire rope. The sizes of the wire rope shall be determined assuming that the divisions and upright which the stay supports are uniformly loaded at 4.9 kN/m^2. The working load so assumed in the stay shall not exceed one third of its breaking load.

If the bulkhead is going to be loaded with bulk grain on one side only (this is usually the case when a temporary, transverse bulkhead is installed to reduce the length of a compartment), the further details of construction are given in regulation A 13. Since the application of this regulation requires a knowledge of structural engineering, if it is to be used on a ship, the plans and specifications for the bulkhead must be included in, or be a supplement to the ship's approved Grain Loading manual.

GENERAL INFORMATION ON GRAIN LOADING

ACCEPTANCE OF VESSELS TO LOAD BULK GRAIN AT UNITED STATES PORTS

CERTIFICATE OF READINESS

A Certificate of Readiness is a document which must be issued by the National Cargo Bureau surveyor before a ship can load grain at a United States port. The information presented in the following pages is intended to clarify the requirements for the issuance of the Certificate and thereby help prevent costly delays which might result from failure to meet them.

DOCUMENT OF AUTHORIZATION

The vessel should have on board a Document of Authorization (described on page 28 in this booklet), issued by the Administration of the country of registry or by an agency authorized to issue such documents on behalf of the Administration. The document shall accompany and refer to approved Grain Loading booklet which is provided to enable the Master to meet the requirements of the grain regulations.

CHANGE OF REGISTRY

When a vessel changes registry, the Grain Loading booklet must be approved or accepted by the new Administration or an agency authorized to act on behalf of that Administration and a new Document of Authorization issued. Owners and operators are cautioned that such approval is not automatic and may in some cases require preparation of a new booklet to conform with the requirements of the new Administration. Therefore, it is strongly recommended that timely action be taken to obtain such approval or acceptance by the new Administration to avoid possible delay when the vessel is presented to load grain.

SEAWORTHINESS

The vessel should have on board a valid Cargo Ship Safety Construction Certificate.

VESSELS WITHOUT DOCUMENTS OF AUTHORIZATION

A vessel which does not have on board a valid Document of Authorization may load grain under the requirements and limitations set forth in regulation A 3.5 or regulation A 9 of the Code. Information on these alternatives is given on pages 29, 30, and 65 in this booklet.

STABILITY CALCULATION

A stability calculation, signed by the Master, which demonstrates that the vessel will comply with the stability requirements of the Grain Loading booklet and the appropriate regulations at every stage of the voyage must be presented to the attending Surveyor before a Certificate of Readiness will be issued. Information on the correct preparation of the stability calculation is shown on page 67.

FITTINGS

All grain divisions which are to be utilized for the particular stowage arrangement shall be grain tight, in sound condition, and constructed in accordance with the requirements in regulations A 11 and A 12 of the Code, or the design and specifications as included in the approved Grain Loading manual, whichever is applicable.

Particular care must be taken to clean overhead beams, ledges, and the underside structure of steel hatch covers.

STRUCTURAL DEFECTS

The boundaries of cargo compartments in which grain is to be loaded shall be structurally intact and free of leaks. Deficiencies which may affect seaworthiness or the satisfactory carriage of the grain may have occurred after issuance of the Cargo Ship Safety Construction certificate. If such deficiencies are found, they shall be brought to the attention of the Master and evaluation or repair to the satisfaction of the Classification Society shall be required before a Certificate of Readiness to load grain can be issued.

PREPARING A SHIP FOR LOADING GRAIN

The following suggestions are offered for officers of ships carrying grain cargoes:

CLEANLINESS. It is essential that all spaces intended for grain be thoroughly clean, free of odor, free of loose rust and paint scale, and in every respect fit to receive grain. This means that the holds must be swept, washed (if necessary), and dried. Particular care must be taken to clean the overhead beams, ledges and the underside structure of steel hatch covers.

BILGES. Bilges and/or drain wells must be cleaned and then sealed with burlap or other suitable material which is graintight but not watertight. Bilge suctions and sounding pipes must be clear. Tween deck scuppers must be made graintight. That compartments be completely dry cannot be overstressed. This is especially applicable to wooden structures such as ceiling landing pads, bilge limber boards and grain fittings. Green lumber may cause dampness in grain fittings and should be avoided.

INFESTATION. A thorough inspection of the grain compartments should be made for any signs of insect or rodent infestation. This applies particularly to vessels which have previously carried grain cargoes. Any indication of infestation will be cause for rejection by government inspectors or their representatives who will then require fumigation or extermination prior to acceptance.

STRUCTURAL INTEGRITY. Cargo compartments shall be structurally sound. Cement boxes over holes or cracks affecting the watertight integrity are not permitted. Bulkheads below the main deck shall be watertight. Manholes on double bottom tanks under grain holds should be inspected for tightness, and, if necessary, the tanks should be tested by pressing up. Weather deck hatch covers should be inspected for water tightness and, if necessary, hose tested.

SHEATHING OF HOT BULKHEADS. Fireroom and engine room bulkheads which are subject to temperatures of 110 F. (43.3 C.) or above and are adjacent to holds in which bulk corn, soybeans, milo, sorghum, maize or rice are stowed, shall be sheathed. Sheathing shall also be required whenever bulk grain of any type is stowed adjacent to the bulkhead of a tank in which a heated liquid is carried.

DEEP TANKS. When grain is to be loaded in deep tanks, the ballast filling lines and heating coil lines shall be blanked in the tanks or in the engine room. Where deep tanks are not fitted with drain wells or covered bilges, the bilge suctions shall be adequately boxed.

WING TANKS. When grain is to be loaded into wing tanks, precautions should be taken against the entry of water through ballast filling lines, overboard discharge valves, deck vents, deck manholes and any other openings. Ballasting of wing tanks is to be avoided when grain is carried in the center holds.

ELECTRICAL WIRING. Wiring and electrical equipment which may be buried in bulk grain constitutes a significant hazard for fire. Unless essential to the underway operation of the ship, all electrical circuits in grain compartments shall be disconnected or defused.

PRECAUTIONS WHILE LOADING A GRAIN CARGO

The grain regulations are predicated on cargo spaces being as full as possible and well trimmed. Constant supervision and inspection by ship's officers is required to insure that this is done. Proper trimming can be ascertained by frequent sighting through trimming hatches and access manholes. When loading dusty cargoes, it may be necessary to interrupt loading periodically to allow the dust to settle sufficiently to inspect the trimming. When trimming machines are used, the throwing distance should be kept to a minimum. Poor trimming is difficult and expensive to correct.

TRIMMING HATCHES. When tween decks and lower holds are loaded in combination, trimming hatches and access manholes shall be left open. When the tween decks and lower holds are loaded separately, these openings must be closed.

SECURING OF TWEEN DECKS. When tween decks are secured by means of bundles or strapping, the tween deck must be sealed to prevent the settling of grain into the compartment below.

SECURING HATCH COVERS OF FILLED COMPARTMENTS. If there is no bulk grain or other cargo above a filled compartment the hatch covers shall be secured in an approved manner having regard to the weight of the covers and permanent arrangements provided for securing such covers.

ELECTRICAL FIRES. During loading operations serious fires in grain compartments can be caused by faulty electrical circuits in cargo compartments and by leaving portable cargo lights unattended in grain compartments. All electrical circuits in grain compartments must be disconnected or defused, and portable lights must be removed when not in use.

LOAD LINES. A Certificate of Loading will not be issued if the vessel is loaded ove her seasonal marks, after correction for density. In all cases, the applicable freeboard, a shown on the Load Line Certificate, will govern. The Certificate of Loading becomes void if, at any stage of the voyage, the vessel is loaded over her seasonal marks.

If, in order to remain within a certain seasonal area, the vessel must follow an indirect route to her destination, the stability calculation should indicate this fact, and there should be sufficient fuel and water on hand for the intended voyage. No allowance will be permitted for pumping out residual ballast after departure.

GREAT LAKES LOAD LINE REGULATIONS. All ships loading at U.S. ports on the Great Lakes must comply with the U.S. Coast Guard Great Lakes Load Line Regulations. 46 CFR 45.9 states as follows:

(a) For the purposes of the law and regulations prohibiting submergence of loadlines (46 U.S.C. 88c; 46 CFR 42.07-10) the marks assigned to vessels holding international loadline certificates apply during the following seasons:

(1) Vessels assigned freeboards as new vessels under the International Load Line Convention, 1966—
- (i) Winter — November 1 through March 31;
- (ii) Summer — April 1 through April 30 and October 1 through October 31;
- (iii) Tropical — May 1 through September 30.

(2) Vessels assigned freeboards as existing vessels under the International Load Line Convention, 1966 —
- (i) Winter — November 1 through March 31;
- (ii) Summer — April 1 through April 30 and October 1 through October 31;
- (iii) Tropical — September 16 through September 30;
- (iv) Tropical Fresh — May 1 through September 15.

(b) **No allowances for lesser freeboards apply under any circumstances.**

LIST. A Certificate of Loading will be issued only if, after the completion of loading, and prior to departure, the vessel has no list or is listed less than one degree.

TRIM BY THE HEAD. If, at the completion of loading, the vessel is trimmed by more than one-half percent of the Length Between Perpendiculars (0.005 x LBP) by the head, a Certificate of Loading will be issued only if the Master furnishes a statement that he considers it safe to proceed in this condition.

LONGITUDINAL STRENGTH. Unless specifically permitted by the Grain Loading manual or the Trim and Stability booklet, the existence of empty or largely slack holds in a loaded ship causes concern about longitudinal strength. In such cases the Master shall satisfy the surveyor that the longitudinal strength of his vessel is not impaired.

WEATHERDECK HATCH COVERS. Precautions should be taken to prevent the leakage of water into grain cargoes through the joints of metal weatherdeck hatch covers which may be caused by the working of the vessel in heavy weather. Sealing of these joints by tape or other means is recommended.

OVERHEATING OF DOUBLE BOTTOM TANKS. Precautions should be taken to prevent damage to grain cargoes caused by overheating of double bottom or other fuel tanks. Engineer officers should be advised regarding this hazard.

CARRIAGE OF BULK GRAIN IN TANKERS

A tanker is defined as a vessel specially designed and constructed for the carriage of liquid cargoes in bulk, and in which the cargo spaces are subdivided into smaller compartments by longitudinal and transverse bulkheads.

There are certain requirements related to safety and good cargo outturn which must be met before a tanker can be considered ready to load bulk grain. These requirements include, but are not limited to, the following:

CLEANLINESS. Compartments are to be completely clean, dry, odor-free, and gas-free. All loose scale is to be removed. In case of doubt concerning odor, the compartment should be closed and reinspected twenty-four hours later.

PIPE LINES. All pipe lines to cargo compartments shall be thoroughly cleaned, drained, and blown dry. Heating coil lines and deck manifolds shall be blanked.

In tankers which have an independent stripping system, all pipe lines, except the stripping lines, are to be blanked off in the pump room.

In tankers which have the stripping lines attached to the main suction lines, all pipe lines, except those forming the stripping arrangement, are to be blanked off in the pump room or other locations as necessary.

In tankers where blanking is impossible due to the construction of the piping system, applicable valves shall be secured by means of chains, padlocks, and seals. The time and date of this operation, together with the seal numbers, shall be entered in the vessel's log book.

BOXING OF SUCTIONS. Tankers do not have bilge suction wells and therefore must be provided with boxes of 3" thick lumber or suitable perforated metal (minimum 16 gauge) which shall be constructed around the stripping line suctions. Such boxes shall be grain tight but not watertight, and have a capacity of not less than 22 cubic feet. Limbers or openings properly covered with burlap or mesh shall be provided to permit the entry of water. Where the inside diameter of the stripping line is 6 inches or less, the total area of such openings shall be determined by multiplying the inside cross sectional area of the stripping line pipe by six. Where the inside diameter of the stripping line exceeds 6 inches, the minimum total area of the openings shall be 180 square inches.

SOUNDING PIPES. Every compartment in which grain is carried shall be equipped with a sounding pipe having an inside diameter of not less than 1", the lower end of which is to be made grain tight but not watertight. Plastic pipes shall have a wall thickness of not less than .145 inches (Schedule 40 gauge). Such pipes are to be secured at sufficient intervals along their length to prevent bending, and shall be fitted with caps at the upper end and "T" fittings at the lower end.

STABILITY TERMS AND SYMBOLS

B – CENTER OF BUOYANCY - A single point within the portion of the ship's hull which is below the waterline and through which the force of buoyancy appears to operate.

KB – Height of Center of Buoyancy above the keel.

G – CENTER OF GRAVITY - A single point within the entire structure of the ship at which the total weight of the ship and all that is in her, appears to be concentrated.

VCG – VERTICAL CENTER OF GRAVITY - Height of the Center of Gravity of a cargo compartment or tank above the keel.

KG – Height of a vessel's Center of Gravity above the keel.

KGv – Virtual height of a vessel's Center of Gravity above the keel, obtained by adding the correction for liquid free surfaces, and, if applicable, the correction for vertical grain shifting moments to the KG.

M – METACENTER - The point of intersection of the verticals through the centers of buoyancy at two consecutive small angles of heel.

KM – Height of the Metacenter above the keel.

GM – METACENTRIC HEIGHT - The distance between the Metacenter and the virtual center of gravity. (KM-KGv)

MOMENT – The product of a weight multiplied by a distance.

HEEL – The transverse angle of inclination of a vessel.

HEELING (Upsetting MOMENT) –
The moment resulting from a transverse shift of weight through a given distance which tends to heel a vessel. Expressed as FOOT-LONG TONS or TON-METERS.

VOLUMETRIC HEELING MOMENT
The product of a volume multiplied by a transverse distance. Expressed as FT^4 (FT^3 x FT) or M^4 (M^3 x M). Converted to Heeling Moment by dividing by the stowage factor (or multiplying by the density) of a cargo.

GZ – RIGHTING ARM (Lever) - The horizontal distance between the force of buoyancy acting upwards through B and the force of gravity acting downwards through G.

RIGHTING MOMENT –
The product of the Righting Arm (GZ) multiplied by the displacement (weight) of the vessel.

TRIM TERMS AND SYMBOLS

TRIM – **The longitudinal inclination of the ship. It is measured as the difference between the forward and after drafts.**

LCB – **LONGITUDINAL CENTER OF BUOYANCY - Longitudinal distance of center of buoyancy from midships. (Sometimes measured from after perpendicular.**

LCG – **LONGITUDINAL CENTER OF GRAVITY - Longitudinal distance of center of gravity from midships. (Sometimes measured from after perpendicular.)**

MTI – **MOMENT TO TRIM ONE INCH**

TPI – **TONS PER INCH IMMERSION**

MTC – **MOMENT TO TRIM ONE CENTIMETER**

TPC – **TONS PER CENTIMETER IMMERSION**

FORMS FOR STABILITY CALCULATIONS

Every vessel, for which stability calculations are required by the Code, shall submit two copies of such calculations for the intended voyage to the attending National Cargo Bureau surveyor before a Certificate of Readiness can be issued. With the exception of ships which load under regulation A 9, the calculation shall be drafted on the National Cargo Bureau Grain Stability form. These forms with necessary insert sheets will be furnished on request by all local offices of the National Cargo Bureau.

In the case of the required GM calculation under regulation A 9, the calculation shall be fully documented although the format is not prescribed.

In both cases, the calculation shall be signed by the master and by the surveyor. One copy shall be retained on board the ship. The other copy shall be retained by the surveyor.

The information and examples shown in the following pages are intended to assist shipmasters and officers in the correct preparation of the stability calculation.

PREPARATION OF THE STABILITY CALCULATION

REQUISITE INFORMATION. The following information should be ascertained in order to prepare an accurate stability calculation:

1. The quantity and type of grain to be loaded.
2. An accurate estimate of the stowage factor.
3. The quantities of fuel and water on hand at departure, daily consumption, and the amounts to be taken at bunkering ports during the voyage.
4. The seasonal zones to be traversed during the voyage.
5. The quantities and stowage of other cargo to be carried in the ship at the same time as the grain cargo.
6. The distance and steaming time required to the port or ports of discharge.
7. Draft restrictions which may be encountered during the voyage.

With the above information on hand, the stability calculation should be prepared, using the typical conditions shown in the grain loading booklet as a guide.

UNITS. All tonnages used in the calculation should be shown in the same units as are used in the approved grain loading booklet. (A stowage factor conversion table is furnished on Page 98 for conversion from English to Metric units.) Tonnages and moments may be rounded off to the nearest unit.

CONDITIONS DURING THE VOYAGE

The stability calculation shall show:

1. The departure and arrival conditions.
2. The conditions on arrival and departure from bunkering ports. Additional insert sheets for Part II of the National Cargo Bureau Grain Stability Calculation form should be used for this purpose.
3. If any of the arrival conditions indicates the presence on board of ballast which was not shown in the departure condition, then an additional condition(s) shall be included which will demonstrate compliance with the intact stability requirement just prior to ballasting. This is referred to as an intermediate "worst" condition. The procedure for ballasting at sea is discussed in the last paragraph on page 27 in this booklet.

FREE SURFACE OF LIQUIDS. Part II of the Grain Stability Calculation form shall include a provision for the detrimental effect of the free surface of the liquids on board. Although this may be based on the actual condition of the tanks while the ship is at sea, it shall not be a lesser effect than is applied in the example conditions in the approved Grain Loading Manual. In the case of U. S. flag vessels, the calculation with respect to liquid free surface shall comply with U. S. Coast Guard regulation 170.285 as set forth in Title 46, Subchapter S of the Code of Federal Regulations. For all vessels while at sea, the free surface of liquids should be kept to a minimum by maintaining all tanks either full or empty with the exception of those in actual use.

PARTLY FILLED COMPARTMENTS. It is recommended that the maximum heeling moments and vertical centers of gravity of partly filled compartments be entered in the stability calculation, in which case, the grain may be loaded to any level in these compartments. If, in order to meet the intact stability requirements, it is necessary to use reduced heeling moments and centers of gravity based on estimated levels of grain in these compartments, it will be necessary to measure the ullages of the compartments at completion of loading to ascertain that actual levels agree with those shown in the calculation. If a discrepancy is found, it will be necessary to recalculate the stability and take corrective measures, if required, to meet the stability requirements.

WING TANKS. When wing tanks are loaded, the maximum heeling moments for these tanks should be used in the stability calculation, since it is impracticable, if not impossible, to trim these tanks full. The same stowage factor as that used in the center holds should be used for wing tanks, when converting volumetric moments to heeling moments.

PERMISSIBLE HEELING MOMENT TABLE. When using this table, if it is furnished in the Grain Loading manual, the entering arguments are the displacement and the virtual center of gravity (KGv). The latter is the center of gravity of the loaded ship (KG) increased by the liquid free surface correction. In some unusual cases, because of the manner in which the permissible heeling moments are presented, the Grain Loading manual requires an additional correction to the KGv to provide for the vertical shift of the grain. An entry for this correction is provided on Part II of the Grain Stability Calculation form. It is to be used only when so required by the instructions in the approved Grain Loading manual.

STATICAL STABILITY DIAGRAMS. In instances where the approved Grain Loading manual does not contain a Table of Permissible Heeling Moments, it is required to utilize the Cross Curves of Stability to prepare a stability diagram for each loading condition shown in the stability calculation and to derive therefrom the numerical values applied in the calculations necessary to prove compliance with the requirements of regulation A 7.1. A method of preparing such diagrams is shown on page 54.

BALLASTING. When, in order to meet stability requirements, ballast is required at time of departure, and ballasting is not possible at the loading berth due to draft restrictions, such ballasting must be completed while the vessel is in protected waters. The same condition would apply to deballasting at the port of destination.

SHIFTING BETWEEN PORTS. Vessels loading grain at two or more ports in the continental United States may, in some circumstances, be relieved from full compliance with the Code until the loading is completed at the last port before commencing the international voyage. The rules pertaining to this situation are given in Enclosure 2 to Navigation & Vessel Inspection Circular No. 5-94 (see page 10).

PART GRAIN CARGOES. Vessels which load part grain cargoes and subsequently load other cargo should indicate the proposed stowage on the initial stability calculation. If the final stowage arrangement varies from the original calculation, a revised stability calculation shall be prepared.

DISCHARGE AT MORE THAN ONE PORT. When the grain cargo is discharged at more than one port (or when other cargo used to secure the grain cargo is discharged prior to the grain cargo) it shall be the responsibility of the Master to fully comply with the requirements of the vessel's grain loading document and/or the requirements of local governing authorities, at every stage of the voyage.

PERMISSIBLE HEELING MOMENT TABLES *(Interpolation)*

When data on permissible heeling moments, hydrostatics, tank capacities, etc., are presented in tabular form, it is usually necessary to find values which fall between the values which are listed in the table. The arithmetic process for doing this is called interpolation. For example, consider a portion of a hydrostatic table:

DRAFT meters	DISPLACEMENT tons
3	12,570
3.50	13,035

What is the displacement for a draft of 3.17 meters?

The entering arguments are the drafts. The corresponding tabular values are the displacements. To define a formula these values can be represented as follows:

A_1	T_1
E	- - > R
A_2	T_2

where E is the entering argument and R is the interpolated result which is sought. Then the formula for interpolation is:

$$R = \left[\frac{(A_1 - E)(T1 - T_2)}{(A_2 - A_1)}\right] + T_1$$

substituting the numerical values

$$R = \left[\frac{(3 - 3.17)(12570 - 13035)}{(3.5 - 3)}\right] + 12570$$

This formula is amenable to solution on a calculator. All of the values in the table are positive and the result will be positive. If some of the intermediate values in the calculation are negative, the calculator automatically handles the algebra. Thus on a calculator with the algebraic operating system (AOS), enter:

(3 – 3.17) ÷ (3.5 – 3) x (12570 – 13035) + 12570 = 12728.1

Or on a calculator with the reverse polish notation (RPN) system

3 ENTER 3.17 – 3.5 ENTER 3 – ÷ 12570 ENTER 13035 – x 12570 +

The procedure is always exactly the same regardless of whether the arguments and/or the tabular values are ascending or descending.

A Permissible Heeling Moment table is usually arranged as shown below:

Displacement	Virtual Center of Gravity (KGv)				
	6.50	6.75	7.00	7.25	7.50
14000	3829	3351	2874	2396	1917
14200	3945	3461	2977	2493	2009
14400	4088	3596	3104	2613	2121
14600	4176	3677	3178	2679	2181
14600	4176	3677	3178	2679	2181

So if you require the permissible heeling moment when the displacement is 14287 tons and the KGv is 7.07 meters, it is necessary to perform three, separate interpolations as shown below:

	7.00	7.07	7.25	
14200	2977		2493	**3rd**
14287	---- R_1----	---- R_3----	---- R_2----	---- > R_3 = 2895.9
14400	3104		2613	
	1st		2nd	
	R_1 = 3032.3		R_2 = 2545.2	

CONSTRUCTING AND MEASURING A STATICAL STABILITY DIAGRAM

In the event that a ship's approved Grain Loading manual does not include a Permissible Heeling Moment Table (or Curves), it will be necessary to manually calculate the angle of heel and the residual area due to a grain shift in order to demonstrate compliance with the requirements pertaining to those criteria in regulation A 7 (see page 24).

To do this you must complete the calculations on Parts I, II, and the first half of Part III on the National Cargo Bureau Grain Stability Calculation form (hereinafter identified as the Form). This is the identical calculation which must be performed for any grain loading and furnishes the following information for the specific loading condition, i.e., departure, arrival, and if necessary, intermediate (see page 27).

Displacement
KGv
GM corrected for liquid free surface
Grain heeling moment

Next you must draw the stability diagram for the specific displacement and KGv. This requires recourse to the ship's approved Cross Curves of Stability. An example of the Cross Curves of Stability for a typical ship is shown on page 58.

To facilitate the process of drawing the stability diagram and to complete the remainder of the required calculation, you should use the Part VI insert to the Form. A copy of the insert showing a typical calculation is illustrated on pages 56 and 57. It uses data from the sample Cross Curves. The insert is intended to be self-explanatory but additional explanation is furnished in the paragraphs below which are keyed to the encircled numbers on the illustration.

① Normally the Cross Curves of Stability will be included in the approved Grain Loading manual or otherwise referenced in the manual and furnished separately.

② Discussion of the angle of flooding is given starting at the bottom of page 26. For ship which does not have a Permissible Heeling Moment table, the angle of flooding should be included in the information furnished in the approved Grain Loading manual.

③ The assumed KG of the Cross Curves will be stated on the Curves. In some cases it will be identified as the "pole height". In many cases the curves will be labelled as "KN Curves", then the pole height (assumed KG) is zero.

④ Since the assumed KG of the Cross Curves will probably not be identical to the actual KGv of the ship, the correction determined on line 4, will have to be used in the subsequent preparation of the stability diagram. As specially noted on the insert, it is important to retain the sign + or -.

⑤ The Angles of Inclination to be entered on line 5, depends upon which angles are presented on the Curves. The angles selected should cover the range from 5 to at least 45. If a curve for 12 is not presented, then use the closest one, usually 15. Generally, there is no curve for 5, but this is an important point which cannot be disregarded. Therefore, enter 5 as the first angle of inclination on line 5. How it will be utilized, if not provided on the Cross Curves, will be described in a subsequent paragraph.

⑥ Using the sample Cross curves on page 58, proceed as follows. For each angle of inclination find the point where a vertical line from the displacement scale intersects the curve labelled for that angle. Set a pair of dividers to that vertical dimension, transfer it to the righting arm scale at the left, and read off the value of the GZ.

⑦ The correction factor from line 4, multiplied by the sine of the angle of inclination, is the correction which must be added or subtracted from the GZ on line 6 to obtain the corrected GZ on line 8.

⑧ The corrected GZ's on line 8, are the righting arms at each angle of inclination for the displacement and KGv calculated on Part II of the form.

⑨ These points, righting arms versus angle of inclination, must be plotted on the graph on page 2 of the insert. Note that the left side of the graph does not have a calibrated scale. Therefore, the user must calibrate the scale to accommodate the range of righting arms he is working with. In the example, the largest righting arm is 2.888 feet. Since there are four major scale divisions, mark the scale for a range from 0 to 4 feet. (If you were working in meters, the equivalent maximum righting arm would be 0.82 meters. So it would be appropriate to mark the major divisions as 0, 0.25, 0.50, 0.75, and 1.0 meters.)

The corrected GZ at the 5° angle of inclination has not been defined. If a curve for 5° was included on the Cross Curves, then the procedure is the same as for the other angles. If it is not, and the calibrations on the left scale are of sufficient range, mark off the length of the GM on a vertical line at angle 57.3°. Draw a straight line from 0 to this point. Where a vertical line at 5° intersects this line, establishes the 5° GZ point.

Often, to provide a reasonable scale for the righting arm values, the range of calibrations entered on the graph does not permit a plot of the GM at 57.3°. In this case, the corrected GZ at 5° equals the GM times the sine of 5°. It is to be noted that the straight line plot or the alternative use of the formula provide the identical result.

Draw a smooth curve through the plotted points. This is the righting arm curve. It describes the inherent stability characteristics of the ship at the given displacement and KGv. Plot the grain heeling arms at angles 0° and 40°. These are values at (A) and (B) on page 1 of the insert. Draw a straight line through these two points. This line is a very close approximation of the curve of heeling moment arms generated by the assumed grain shift.

⑩ Inspection of the completed plot will indicate a point where the heeling moment curve intersects the righting arm curve. This is the angle of heel. If the assumed grain shift should occur with the ship loaded as described in Parts I and II on the Form, the ship would lay over and come to rest at this angle of inclination. To satisfy regulation A 7.1.1, this angle must not be greater than 12°.

⑪ When the ship is heeled to the angle determined on line 10 it must still have a reserve of stability to sustain it against possible weather and/or sea conditions. The amount of this reserve is indicated on the plot by the area between the righting arm curve and the heeling arm curve within the boundaries of the angle of heel and a limiting angle which is specified by the regulation. The limiting angle is defined on line 11. Note that it can never be greater than 40°. Note, also, that in selecting the angles of inclination on line 5, it is always necessary that the last angle investigated be 45° or greater. This will insure that a smooth curve drawn through the plotted points will detect a maximum righting arm if it should occur at an angle less that 40°.

⑫ The remainder of the calculation utilizes the data obtained from the graph to calculate, by Simpson's Rule, the residual area. This is the area described in 11, and to satisfy the requirements of regulation A 7.1.2, it must be not less than 0.075 meter radians.

PART VI

INSERT TO NATIONAL CARGO BUREAU GRAIN STABILITY CALCULATION FORM

To be completed when a Table of Permissible Heeling Moments is not provided in the approved Grain Loading manual. In such cases, compliance with regulation A7 of the International Code for the Safe Carriage of Grain in Bulk must be determined from a plot of the stability curve. Prepare one insert for each stage of the voyage. Use results from insert to complete Part III A.

SHIP: M/V ATLANTIC Check One: ☒ DEPARTURE From NEW ORLEANS

PORT: NEW ORLEANS DATE: 1-1-94 ☐ INTERMEDIATE

☐ ARRIVAL At ______

(1) IDENTIFICATION OF CROSS CURVES OF STABILITY: IN GRAIN LOADING MANUAL (See Note 1)

BASIC DATA: Displacement (From Part II) .... 14903 LT

KG, " " " .... 21.70 FT

GM " " " (must comply A7.1.3) .... 3.91 FT

Grain Heeling Moment (From Part III) .... 11,975 FT TON

(2) Angle of Flooding (See Note 2) .... 40°

(A) λ_0 Heeling Arm at Angle 0° (Gr. Heel. Mom. ÷ Disp.) 0.804

(B) λ_{40} Heeling Arm at Angle 40° (0.8 x Heel. Arm at 0°) 0.643

(3) Assumed KG of the Cross Curves 20

(4) GZ Correction Factor (Assumed KG - KG,) .... −1.70
(May be + or −, retain sign)

TABLE OF RIGHTING ARMS (GZ): Include data from 0° to 60° (minimum)

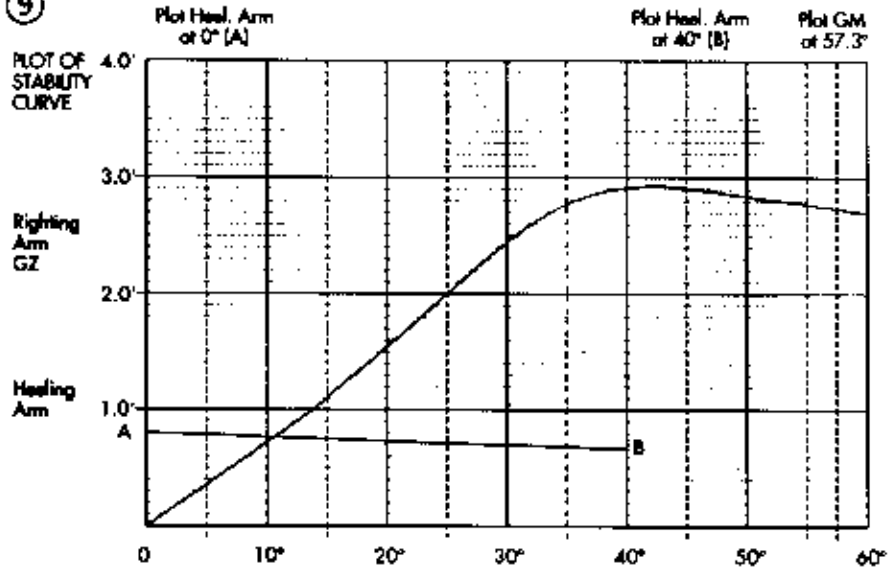
(5)	Angle of Inclination θ	5°	15°	30°	45°	60°	
(6)	GZ from Cross Curves	−	1.520	3.300	4.090	4.160	
	Sine θ	.087	.259	.500	.707	.866	
(7)	Corr. Factor x Sine θ (observe sign)	GM = 3.91	−.440	−.850	−1.202	−1.472	
(8)	Corrected GZ	.340	1.080	2.450	2.888	2.688	

NOTES: (1) Information required only if Cross Curves of Stability (or tabular data) is not furnished in the approved grain loading booklet.

(2) Angle of flooding means an angle of heel at which openings in the hull, superstructures or deckhouses, which cannot be closed weathertight, immerse. Small openings through which progressive flooding cannot take place need not be considered as open.

EXAMINED: ______ N.C.B. Surveyor ______ Master

(9)



(10) Determine from above plot: Angle of Heel ..... first intersection of righting arm curve with heeling arm curve

= 11° ..... must comply with A 7.1.1

Limiting Angle ... 40°, or Angle of flooding, or Angle at which there is maximum difference between righting arm curve and heeling arm curve } whichever is least

(11) = 40°

(12) RESIDUAL AREA CALCULATION Station Spacing (S) = (limiting angle − angle of heel) ÷ 2

S = (40 − 11) / 2 = 14.5° (See Note 3)

Angle of Inclination		Righting Arm	Heeling Arm	Differences		Product
Angle of Heel	11	−	−	0	1	0
Angle of Heel + S°	25.5	2.05	.71	1.34	4	5.36
Angle of Heel + 2S° i.e., limiting angle	40	2.89	.643	2.247	1	2.247

FOOT DEGREES ÷ 188 = METER RADIANS S = 14.5 x 7.607 (Sum) ÷ 3 = 36.767 Ft° (Residual Area)

METER DEGREES ÷ 57.3 = METER RADIANS

36.767 ÷ 188 = 0.194 METER RADIANS { must comply with A 7.1.2

NOTE: (3) This method applies in the usual case where 3 points describe the righting arm curve between the angle of heel and the limiting angle. If not, apply Simpson's Rule using 5 stations instead of 3 as shown.

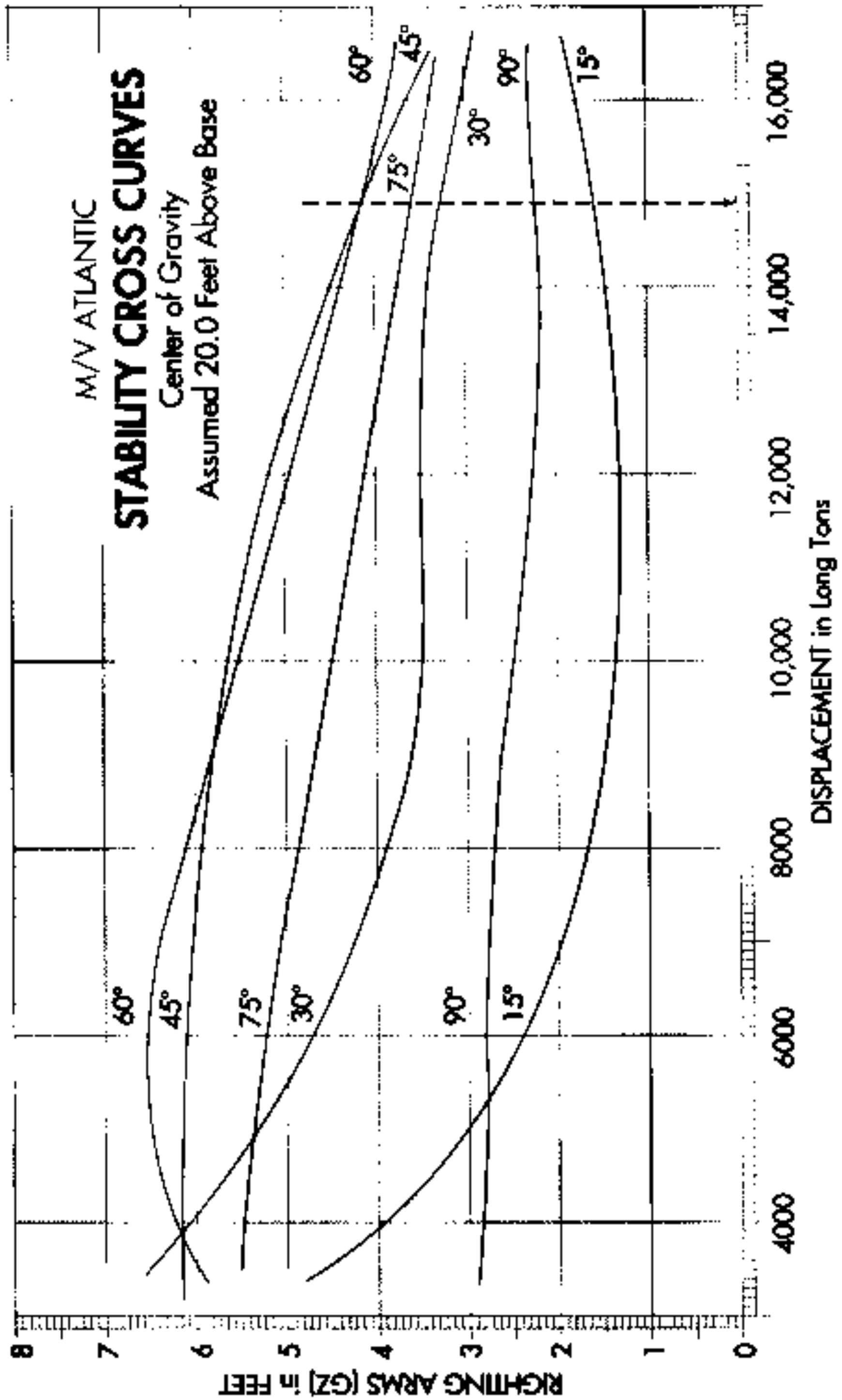
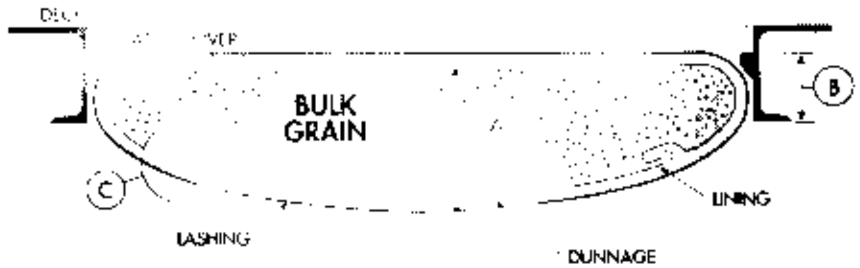


ILLUSTRATION OF

A SAUCER SECURED BY BUNDLING OF BULK GRAIN

(Specific requirements are detailed in regulation A 15)



(A)

MOULDED BREADTH OF SHIP	DEPTH OF SAUCER
Less than 9.1 m	[illegible]
Between 9.1 m and 18.3 m	Interpolate
18.3 m and over	1.8 m min.

(B) Bearing contact of saucer against ship's structure:

At least one half of dimension A - OR -

Secured in place by transverse lashings spaced not more than 2.4 m apart.

(C) To retain bulk grain within the saucer:

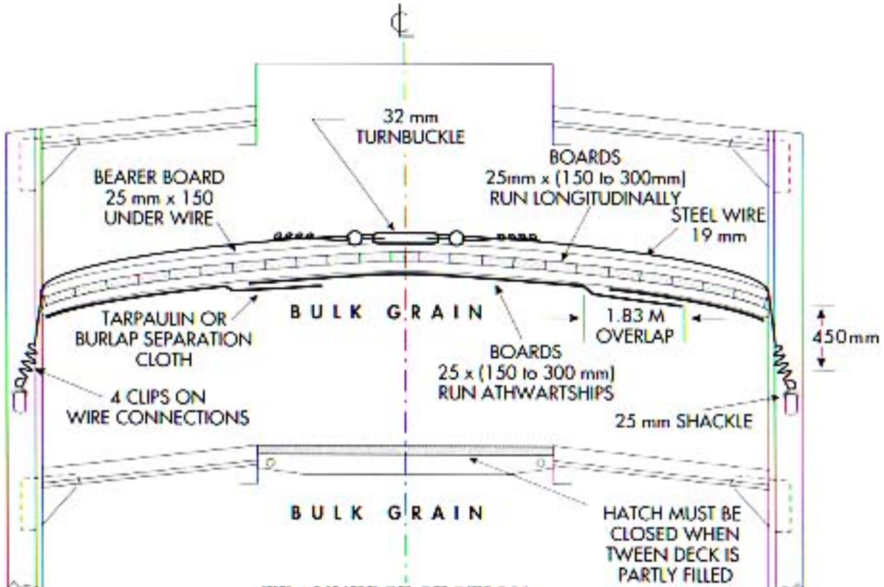
Lining material (strength 2687 N per 5 cm strip, i.e., 306.8 pounds per 1 inch strip) joined by sewing or double lap. - OR -

Lining material (strength 1344 N per 5 cm strip, i.e., 153.5 pounds per 1 inch strip) joined by sewing or double lap, restrained by transverse lashings spaced not more than 2.4 m apart and protected from chaffing by dunnage, 25mm thick min. and between 150 and 300 mm in width, placed longitudinally between the lashings and the lining material.

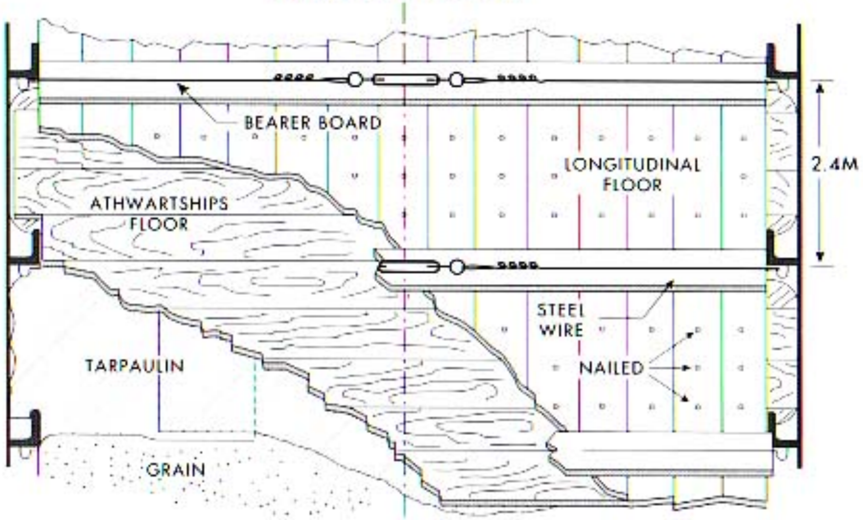
ILLUSTRATION OF

SECURING OF PARTLY FILLED COMPARTMENT BY STRAPPING OR LASHING

(Specific requirements are detailed in regulation A. 17)



TRANVERSE SECTION

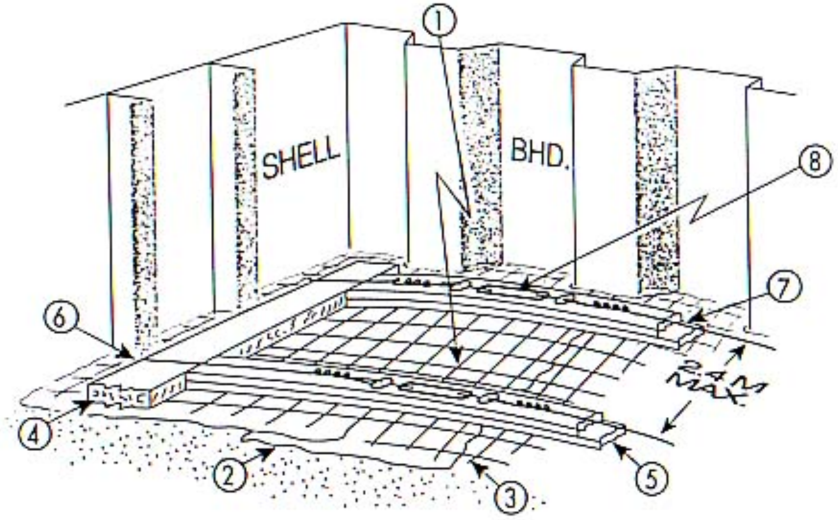


PLAN VIEW

ILLUSTRATION OF

SECURING OF PARTLY FILLED COMPARTMENT WITH WIRE MESH

(Specific requirements are detailed in regulation A. 18)



1. Grain slightly crowned along fore and aft centerline of cargo hold.
2. One layer of burlap or canvas tarpaulin (sections lapped 1.8 m minimum).
3. Two layers of wire reinforcement mesh (3 mm wire welded in 150 x 150 mm squares).
4. 50 mm lumber bearers against frames or shell to distribute the downward thrust of wire rope lashings at the sides.
5. Two layers of 25 mm lumber bearers directly beneath the wire rope lashings.
6. Steel wire rope lashings, 19 mm diameter, spaced 2.4 m maximum and attached to the framing about 450 mm below grain surface.
7. First and last transverse lashing to be close to forward and to after bulkheads.
8. 32 mm turnbuckle to tension lashing.

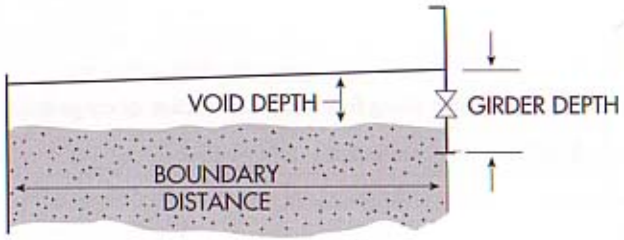
CALCULATION OF AVERAGE VOID DEPTH (Vd)

When bulk grain is stowed so as to satisfy the requirement of regulation A 2.2, i.e., "filled compartment, trimmed", it must be loaded and trimmed so that the bulk grain is at its highest possible level. Thus the regulations recognize that, due to the settling of the grain and restricted working space, it is not feasible to require that a filled compartment be one hundred percent filled. There will be a small void space between the trimmed surface of the grain and the overhead structure in the compartment. The regulations do not specify the depth of this void but, instead, "assume" a depth which varies depending upon the geometry of the overhead structure.

The numerical value assigned to the average void depth (Vd) is essential to the naval architect in the preparation of the data in the Grain Loading manual and the details for its determination are provided in regulation B 1. However, void depth (Vd) is not used by ship's personnel in any of the calculations required when the ship has a Document of Authorization and an approved Grain Loading manual.

In the case of a ship without a Document of Authorization which is permitted, by its Administration, to load a partial cargo of bulk grain in accordance with the provisions of regulation 9, the void depth in the compartment(s) wherein the grain is to be stowed, must be known because it is one of the factors to be applied in the formula for the required GM.

In lieu of reference to regulation BI, the following tables, in Metric and English units, furnish the average void depth (Vd):



(disregard feeding holes)

Transverse Section Through One Side of Ship

$$Vd = F_G + F_{BD}$$

where: Vd = Average void depth (metres for Metric, feet for English

F_G, F_{BD} = factors from Tables I and II

AVERAGE VOID DEPTH TABLE - METRIC

Table I

Girder Depth (metres)	F_G
0.1	- 0.375
0.2	- 0.300
0.3	- 0.225
0.4	- 0.150
0.5	- 0.075
0.6	+0.000
0.7	+0.075
0.8	+0.150
0.9	+0.225
1.0	+0.300
1.1	+0.375
1.2	+0.450
1.3	+0.525
1.4	+0.600
1.5	+0.675

IMPORTANT:

If Vd calculates less than 0.1 metres....THEN

Vd = 0.1 metre

Example:

Girder Depth = 0.5 meters
Boundary Distance = 4.2 meters

$Vd = F_G + F_{BD}$
= -0.075+ 0.430
= 0.355 metres

Table II

Boundary Distance (metres)	F_{BD}	Boundary Distance (metres)	F_{BD}
0.5	0.570	5.0	0.430
0.6	0.562	5.1	0.434
0.7	0.554	5.2	0.438
0.8	0.546	5.3	0.442
0.9	0.538	5.4	0.446
1.0	0.530	5.5	0.450
1.1	0.524	5.6	0.454
1.2	0.518	5.7	0.458
1.3	0.512	5.8	0.462
1.4	0.506	5.9	0.466
1.5	0.500	6.0	0.470
1.6	0.496	6.1	0.474
1.7	0.492	6.2	0.478
1.8	0.488	6.3	0.482
1.9	0.484	6.4	0.486
2.0	0.480	6.5	0.490
2.1	1.474	6.6	0.496
2.2	0.468	6.7	0.502
2.3	0.462	6.8	0.508
2.4	0.456	6.9	0.514
2.5	0.450	7.0	0.520
2.6	0.448	7.1	0.526
2.7	0.446	7.2	0.532
2.8	0.444	7.3	0.538
2.9	0.442	7.4	0.544
3.0	0.440	7.5	0.550
3.1	0.438	7.6	0.558
3.2	0.436	7.7	0.566
3.3	0.434	7.8	0.574
3.4	0.432	7.9	0.582
3.5 to 5.0	0.430	8.0	0.590

AVERAGE VOID DEPTH TABLE - ENGLISH

Table I

Girder Depth (inches)	F_G ft.
6	- 1.1014
9	- 0.9139
12	- 0.7264
15	- 0.5389
18	- 0.3514
21	- 0.1639
24	+0.0236
27	+0.2111
30	+0.3986
33	+0.5861
36	+0.7736
39	+0.9611
42	+1.1486
45	+1.3361
48	+1.5236
51	+1.7111
54	+1.8986
57	+2.0861
60	+2.2736

Table II

Boundary Distance (feet)	F_{BD} feet	Boundary Distance (feet)	F_{BD} feet
2.00	1.8413	16.50	1.4145
2.25	1.8213	16.75	[illegible]
2.50	1.8013	17.00	[illegible]
2.75	1.7813	17.25	[illegible]
3.00	1.7613	17.50	[illegible]
3.25	1.7413	17.75	[illegible]
3.50	1.7257	18.00	[illegible]
3.75	1.7107	18.25	[illegible]
4.00	1.6957	18.50	[illegible]
4.25	1.6807	18.75	[illegible]
4.50	1.6657	19.00	[illegible]
4.75	1.6507	19.25	[illegible]
5.00	1.6372	19.50	[illegible]
5.25	1.6273	19.75	[illegible]
5.50	1.6173	20.00	[illegible]
5.75	1.6073	20.25	[illegible]
6.00	1.5973	20.50	[illegible]
6.25	1.5873	20.75	[illegible]
6.5	1.5773	21.00	[illegible]
6.75	1.5635	21.25	[illegible]
7.00	1.5485	21.50	1.6181
7.25	1.5335	21.75	1.6331
7.50	1.5185	22.00	1.6481
7.75	1.5035	22.25	1.6631
8.00	1.4885	22.50	1.6781
8.25	1.4754	22.75	1.6931
8.50	1.4704	23.00	1.7080
8.75	1.4654	23.25	1.7225
9.00	1.4604	23.50	1.7370
9.25	1.4554	23.75	1.7516
9.50	1.4504	24.00	1.7661
9.75	1.4454	24.25	1.7806
10.00	1.4404	24.50	1.7951
10.25	1.4354	24.75	1.8159
10.50	1.4304	25.00	1.8359
10.75	1.4254	25.25	1.8559
11.00	1.4204	25.50	1.8760
11.25	1.4154	25.75	1.8960
11.50 to 16.40	1.4107	26.00	1.9160

IMPORTANT:

If Vd calculates less than 0.328 feet....THEN

Vd = 0.328 feet

Example:

Girder Depth = 36 inches
Boundary Distance = 19 feet 8 inches (19.67 feet)

$Vd = F_G + F_{BD}$
= + 0.07736 + 1.5414
= 2.315 feet.

CALCULATION FOR REGULATION A9

The formula for calculating the required GM in regulation 9 (See page 29), can be simplified for solution on an electronic calculator as follows:

Let

$$Q = \sqrt{Vd \times B}$$

Then

$$GMr = \frac{L \times Q^2 \times ((0.388 \times B) - Q)}{0.136 \times SF \times \Delta}$$

Where

Symbol	Meaning	Dimensions	
		Metric	**English**
GMr	Req'd Metacentric Ht.	meters	feet
L	Length of Compartment	meters	feet
B	Beam of Ship	meters	feet
Vd	Average Void Depth	meters	feet
SF	Stowage Factor	m^3/MT	ft^3/LT
Δ	Displacement	MT	LT

Example

Bulk grain stowing at 1.254 m³ /MT is stowed in Lower Holds Nos. 2 and 4. Length of No. 2 is 22 meters and length of No. 4 is 18.5 meters. In both holds the girder depth is 0.5 meters and the boundary distance is 4.2 meters. The beam of the ship is 34 meters and the displacement for the voyage is 23,807 metric tons,

Using Tables I and II, Vd = 0.355 m
Length of compartments = 22.0 + 18.5 = 40.5 m

$$Q = \sqrt{Vd \times B} = \sqrt{0.355} \times 34 = 3.47 \text{ m2}$$

$$GMr = \frac{L \times Q^2 \times ((0.388 \times B) - Q)}{0.136 \times SF \times \Delta}$$

$$= \frac{40.5 \times 3.47^2 \times ((0.388 \times 34) - 3.47)}{0.136 \times 1.254 \times 23807}$$

$$= \frac{40.5 \times 12.04 \times 9.72}{4060.14}$$

= 1.17 meters = Required metacentric height

EXAMPLES OF LOADING CONDITIONS

Examples of typical loading conditions, together with completed calculations on the National Cargo Bureau Grain Stability Calculation form, are shown on the following pages.

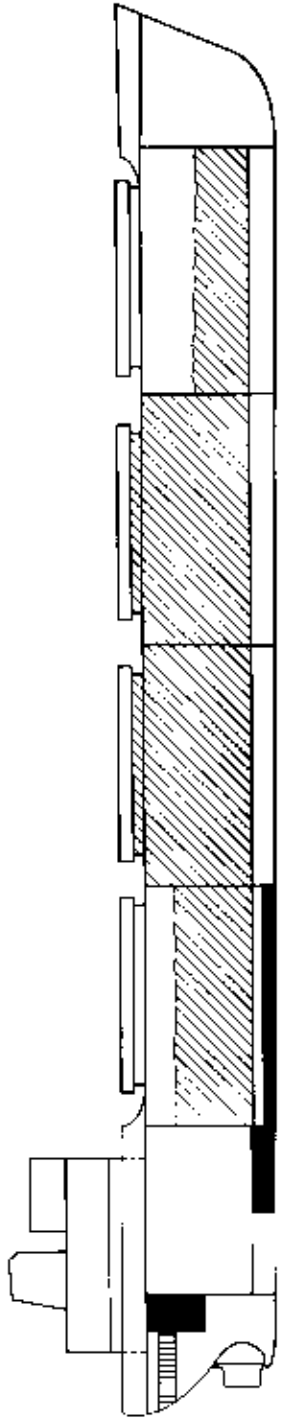
1. BULK CARRIER: A four hold log carrier, which has cargo holds which are not specially suitable, is loading a part cargo of grain at a Great Lakes port and then completing loading at Montreal before proceeding to sea. The loading at Duluth is to meet the requirements of the U. S. regulations for an exempted voyage (see page 10). The final loading is to meet the requirements of regulation A 7 of the International Grain Code. All holds must be trimmed.

2. BULK CARRIER: A seven hold bulk carrier, which is specially suitable in all holds, is loaded to meet the requirements of regulation A7 of the International Grain Code. The existing grain loading booklet was previously approved under I M O Resolution A.264(VIII). The full cargo of wheat has a stowage factor of 1.199 m³/tonne. Hold No. 1 is partly filled for trim purposes. Also, Hold No. 4 is partly filled. Both must be trimmed level. The other five holds are completely filled with the ends of the holds untrimmed.

3. GENERAL CARGO: A two deck general cargo ship is loaded to meet the requirements of regulation A 7 of the International Grain Code. Its grain loading booklet was previously approved under I M O Resolution A.264(VIII). The ship is designed with permanent, centerline bulkheads, forward and aft of the hatch openings in all cargo compartments. The grain loading booklet provides volumetric heeling moments for all compartments without centerline divisions and with centerline divisions. The instructions in the grain loading booklet state that the latter values may be used only when bundles, saucers, or temporary bulkheads are installed in way of the hatch openings. In this example, these arrangements are not used. The ship is loading a full cargo of wheat with a stowage factor of 45 ft³/LT. Loading in combination (see page 22), is used in No. 4 Tween Deck and No. 4 Lower Hold.

4. GENERAL CARGO: The same general cargo ship is loaded, with a full cargo of barley stowing at 55 ft³/LT, to meet the requirements of regulation A 7 of the International Grain Code. However, bundles (see page 33) are fitted in the hatchways so that the volumetric heeling moments with centerline divisions may be utilized. Also, ballast is necessary in order to meet the stability requirements upon arrival. Since the ballast was not on board at departure, an intermediate condition calculating the stability available at the time of ballasting, must be shown.

EXAMPLE 1: BULK CARRIER



Cargo

Fuel Oil

Fresh Water

See pages:

HOLD	CAPACITY Cu.Ft.	V.C.G. Ft.	HEELING MOMENT (FT.4) (Full Compartment)
1	138,741	24.9	38,500
2	200,875	21.7	52,300
3	201,878	21.4	52,300
4	193,873	22.1	55,700

PERMISSIBLE HEELING MOMENT TABLE

(Excerpt)

DISPLACEMENT (Long Tons)	VIRTUAL CENTER OF GRAVITY (KG_V) (Feet)			
	22.5	23.0	23.5	24.0
19,000	10,047	7,663	5,279	2,895
19,500	10,676	8,303	5,930	3,557
20,000	11,346	8,984	6,622	4,260
20,500	11,931	9,608	7,285	4,962

NATIONAL CARGO BUREAU, INC.

GRAIN STABILITY CALCULATION

S.S/M.V. SENECA		YEAR BUILT 1976 AT Ingalls
COUNTRY OF REGISTRY U.S.A.	NET TONNAGE 6385	OFFICIAL NO. 305 594
AGENT MINNESOTA SHIPPING CO.		

GRAIN LOADING BOOKLET APPROVED BY National Cargo Bureau

DRAWING NO. SRN-105799 DATE OF APPROVAL May 29, 1976

APPLICABLE REGULATIONS Int'l Grain Code

ADDENDUM FOR UNTRIMMED ENDS APPROVED BY National Cargo Bureau

DRAWING NO. No Dwg. # DATE OF APPROVAL October 15, 1979

LOADING PORT Duluth, MN and Montreal, Quebec

BUNKERING PORTS Montreal

DISCHARGE PORT Rotterdam

STEAMING DISTANCE 3500 MILES PER DAY 350 TIME 10 Days

DAILY CONSUMPTION: FUEL 25 LT DIESEL 3 LT WATER 10 LT

	DISPLACEMENT	DEADWEIGHT	DRAFT	FREEBOARD
*WINTER				
SUMMER	20,102 LT	15,891 LT	29' 10"	11' 8"
*TROPICAL				

FRESH WATER ALLOWANCE 7.63" TPI/TPC (AT SUMMER DRAFT) 64.2

* (If Applicable)

THIS IS TO CERTIFY THAT:

1. THIS CALCULATION IS PREPARED IN ACCORDANCE WITH THE REQUIREMENTS OF THE VESSEL'S GRAIN LOADING BOOKLET AND THE APPLICABLE GRAIN REGULATIONS;
2. THE STABILITY OF THE VESSEL WILL BE MAINTAINED THROUGHOUT THE VOYAGE IN ACCORDANCE WITH THIS CALCULATION.

CALCULATION PREPARED BY:
(TO BE COMPLETED IF FORM PREPARED BY OTHER THAN SHIP'S PERSONNEL)

NAME (PRINT) ______

COMPANY ______

SIGNATURE ______ DATE ______

C. Thompson
MASTER

EXAMINED: M. Burns
N.C.B. SURVEYOR

DATE: January 15, 1994

NOTE: ORIGINAL STABILITY CALCULATION AND GRAIN ARRANGEMENT PLAN TO BE SUMITTED TO THE N.C.B. SURVEYOR. ALL TONNAGES USED IN THESE CALCULATIONS SHALL BE SHOWN IN THE SAME UNITS AS USED IN THE GRAIN LOADING BOOKLET.

REV. 1/1/90

PART I

SHIP AND CARGO CALCULATION

TYPE OF GRAIN CORN STOWAGE FACTOR (S.F.) 50 CU.FT./L.T. – M³/M.T. ____

COMPT. NO.	CARGO (1)	S.F. (1)	GRAIN CUBICS 100%	GRAIN CUBICS ACTUAL (2)	WEIGHT (3)	V.C.G.	MOMENT (3)
DEPARTURE DULUTH							
1		50	138741	80,000	1600	17.6	28,160
2		↓	200875	–	4017	21.7	87,169
3			201878	–	4037	21.4	86,392
4			193873	126,200	2524	18.0	45,432
SHIP					4211	27.3	114,960
STORES					130	38.3	4,979
TOTALS					16519	22.22	367,092
DEPARTURE MONTREAL							
1		50	138,741	–	2775	24.9	69,098
2		↓	200,875		4017	21.7	87,169
3			201,878		4037	21.4	86,392
4			193,873		3878	22.1	85,704

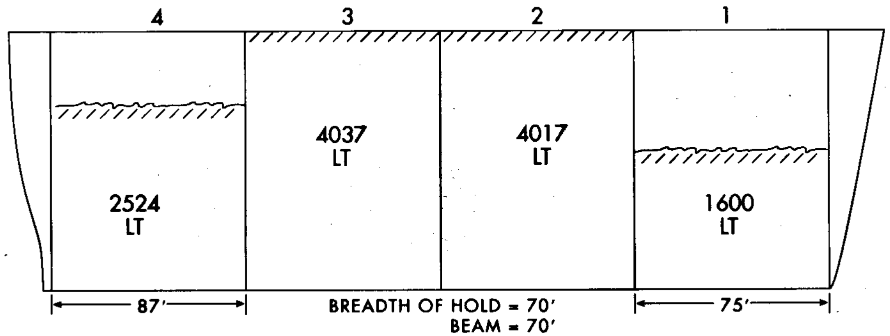
S.F. CuFt/LT	S.F. M³/MT	DEN. MT/M³
42	1.171	.854
42.5	1.184	.844
43	1.199	.834
43.5	1.212	.825
44	1.226	.815
44.5	1.240	.806
45	1.254	.797
45.5	1.268	.789
46	1.282	.780
46.5	1.296	.772
47	1.310	.763
47.5	1.324	.755
48	1.338	.748
48.5	1.352	.740
49	1.366	.732
49.5	1.380	.725
50	1.393	.718
50.5	1.407	.711
51	1.421	.704
51.5	1.435	.697
52	1.449	.690
53	1.477	.677
54	1.505	.664
55	1.533	.652
56	1.561	.641
57	1.589	.629
58	1.616	.619
59	1.644	.608
60	1.672	.598
61	1.700	.588
62	1.728	.579

THIS CALCULATION IS PREPARED IN:
☒ ENGLISH UNITS
☐ METRIC UNITS

	WEIGHT	V.C.G.	MOMENT
CARGO TOTALS	14,707		328,363
LIGHT SHIP	4211	27.3	114,960
STORES	130	38.3	4,979
SHIP AND CARGO TOTALS	19,048		448,302

(1) COMPLETE THESE COLUMNS IF MORE THAN ONE TYPE CARGO IS LOADED.
(2) FOR PARTLY FILLED COMPARTMENTS, SHOW ACTUAL CUBIC OCCUPIED IN ADDITION TO FULL CUBIC.
(3) WEIGHTS AND MOMENTS SHOULD BE SHOWN TO THE NEAREST WHOLE UNIT.

CARGO PLAN: INDICATE HOLDS, TWEEN DECKS, ENGINE SPACES, FITTINGS, STOWAGE, TONNAGES, ETC.



PART II

FUEL AND WATER CALCULATION

INTERMEDIATE SECTION IS REQUIRED TO BE COMPLETED IF **ARRIVAL** SECTION SHOWS BALLAST WHICH IS NOT LISTED IN **DEPARTURE** SECTION. **INTERMEDIATE** CONDITION IS BEFORE BALLASTING SO IT INCLUDES THE EFFECT OF FREE SURFACE BUT NOT EFFECT OF WEIGHT OF THE BALLAST WHICH IS TO BE TAKEN ABOARD.

		DEPARTURE: DULUTH				INTERMEDIATE: DEPART: MONTREAL				ARRIVAL: ROTTERDAM			
TANK	TYPE LIQUID	WEIGHT	V.C.G.	MOMENT	F.S. MOM.	WEIGHT	V.C.G.	MOMENT	F.S. MOM.	WEIGHT	V.C.G.	MOMENT	F.S. MOM.
SETT	F.O.	–				202	31.6	6383	136				
4 D.B.	F.O.	75	1.2	90	4350	281	1.2	337	4350	233	1.2	280	4350
5 D.B.	F.O.	125	3.5	438	460	125	3.5	438	460	125	3.5	438	460
D.O.	D.O.	36	28.0	1008	'176	116	28.0	3248	176	86	28.0	2408	176
F.W.T.	F.W.	–				200	35.8	7160	1918	100	35.8	3580	1918
A.P.	F.W.	64	28.0	1792	1918	130	28.0	3640	–	130	28.0	3640	
TOTALS LIQUIDS		300		3328	6904	1054		21,206	7040	674		10,346	6904
SHIP AND CARGO		16,519		367,092		19,048		448,302		19,048		448,302	
GRAND TOTALS DISPLACEMENT		16,819		370,420		20,102		469,508		19,722		458,648	

DEPARTURE	INTERMEDIATE	ARRIVAL
DEPARTURE KG 22.02	INTERMEDIATE KG 23.36	ARRIVAL KG 23.26
(1) FREE SURFACE CORR.(+) 0.41	(1) FREE SURFACE CORR.(+) 0.35	(1) FREE SURFACE CORR.(+) 0.35
(2) VERT. S.M. CORR. (+) ____	(2) VERT. S.M. CORR. (+) ____	(2) VERT. S.M. CORR. (+) ____
KG_V 22.43	KG_V 23.71	KG_V 23.61
DEPARTURE KM 28.84	INTERMEDIATE KM 29.15	ARRIVAL KM 29.06
DEPARTURE KG_V 22.43	INTERMEDIATE KG_V 23.71	ARRIVAL KG_V 23.61
DEPARTURE GM 6.41	INTERMEDIATE GM 5.44	ARRIVAL GM 5.45
REQUIRED MINIMUM GM ____	REQUIRED MINIMUM GM ____	REQUIRED MINIMUM GM ____

NOTES

(1) FREE SURFACE CORR. = $\frac{\text{SUM OF FREE SURFACE INERTIA MOMENTS}}{\text{DISPLACEMENT}}$ (THIS CORRECTION MUST BE APPLIED TO ALL SHIPS.)

(2) VERT. S.M. CORR. = $\frac{\text{SUM OF VERTICAL SHIFTING MOMENTS FOR CARGO}}{\text{DISPLACEMENT}}$ (THIS CORRECTION APPLIES ONLY WHEN VERTICAL SHIFTING MOMENTS ARE PROVIDED IN THE SHIP'S GRAIN LOADING MANUAL.)

PART III

STABILITY SUMMARY

COMPT. NO.	STOWAGE (1)	GRAIN DEPTH OR ULLAGE FT/~~M~~	VOLUMETRIC HEELING MOMENT FT^4/~~M^4~~	S.F. OR DENSITY (2)	GRAIN HEELING MOMENT L.T.-FT. M.T.-M.	VERTICAL SHIFTING MOMENT SEE NOTE 2 PART II FT^4/M^4	VERTICAL SHIFTING MOMENT L.T.-FT. M.T.-M.
1	F	0	38,500	50	770		
2	F	0	52,300	50	1046		
3	F	0	52,300	50	1046		
4	F	0	55,700	50	1114		
		TOTALS	198,000		3976		

(1) UNDER STOWAGE INDICATE "F" FOR FILLED COMPARTMENTS, "F-UT" FOR FILLED COMPARTMENTS UNTRIMMED, "PF" FOR PARTLY FILLED COMPARTMENTS, "SEC" FOR SECURED OR OVERSTOWED COMPARTMENTS.

(2) THE STOWAGE FACTOR USED IN PART III SHALL NOT EXCEED THE VOLUME PER UNIT WEIGHT (TEST WEIGHT) OF THE GRAIN. IF STOWAGE FACTOR IS SAME IN ALL COMPARTMENTS, DIVIDE TOTAL VOLUMETRIC HEELING MOMENT BY STOWAGE FACTOR OR MULTIPLY BY DENSITY TO OBTAIN GRAIN HEELING MOMENT. IF STOWAGE FACTOR VARIES, OBTAIN GRAIN HEELING MOMENT FOR EACH COMPARTMENT.

A. FOR VESSELS APPROVED UNDER REGULATION 4, CHAPTER VI, SOLAS 1974 or REGULATION 4, IMCO RESOLUTION A.264(VIII), SOLAS 1960 or REGULATION 4, IMCO RESOLUTION A.184(VI), SOLAS 1960

	DEPARTURE	INTERMEDIATE	ARRIVAL
DISPLACEMENT LT	16,819	20,102	19,722
KG_V FT	22.43	23.71	23.61
TOTAL GRAIN HEELING MOMENT	3976	3976	3976
MAXIMUM ALLOWABLE HEELING MOMENT		5768	5716
*ANGLE OF HEEL (12° MAX.)	See Part IV		
*RESIDUAL AREA .075 METER-RADIANS, 14.1 FT° OR 4.3M° MIN.			
*GM (0.3M OR 1 FT. MIN.)	6.4		

*TO BE COMPLETED IF VESSEL'S GRAIN LOADING BOOKLET DOES NOT INCLUDE A TABLE OF ALLOWABLE HEELING MOMENTS. IN SUCH CASE, STATICAL STABILITY DIAGRAMS DEMONSTRATING THIS INFORMATION SHALL BE ATTACHED HERETO.

B. FOR SPECIALLY SUITABLE SHIPS APPROVED UNDER SECTION V(B), PART B, CHAPTER VI, SOLAS 1974 or SECTION V(B), PART B, IMCO RESOLUTION A.264(VIII) REGULATION 12, CHAPTER VI, SOLAS 1960

$$\text{ANGLE OF HEEL} = \frac{\text{GRAIN HEELING MOMENT} \times 57.3}{\text{DISPLACEMENT} \times \text{GM}}$$

	DEPARTURE	INTERMEDIATE	ARRIVAL
TOTAL GRAIN HEELING MOMENT			
DISPLACEMENT			
GM (CORRECTED OF LIQUID FREE SURFACE)			
ANGLE OF HEEL (5° MAX.)			

PART IV
INSERT TO NATIONAL CARGO BUREAU GRAIN STABILITY CALCULATION FORM

To be completed when a vessel, carrying grain in bulk and engaged on a voyage on the inland or coastal waters of the United States, elects and is entitled to utilize the provisions of 46 CFR 172.030.

SS/MV SENECA **PORT** DULUTH

Col. No.	1	2	3	4	5	6	7	8	9	10
Slack Hold No.	L	L w/o C.L.	l w/ C.L.	Col. 3 div'd by 4	Col. 2 plus Col. 4	B	B^3	Col. 5 x Col. 7 x 0.0661	SF	Col. 8 div'd by Col. 9
1	75	75	0	0	75	70	343,000	1,700,423	50	34,008
4	87	87	0	0	87	70	343,000	1,972,440	50	39,450
									Sum col. 10	73,458

KEY
- L = Length of Hold
- B = Breadth of Grain Surface
- C.L. = Centerline Division
- SF = Stowage Factor

NOTES:
1. All dimensions must be in feet, long tons, and ft³/LT or, alternatively, in meters, tonnes, and m³/tonne.
2. Where a C.L. division halves the Breadth, Cols. 2 through 5 adjusts the calculation for this reduction.

DEPARTURE FROM:

Displ. = 16,819 GM (Corr) = 6.41 Mean Drf. = 26.10 F'board = 15.40 Beam = 70	r = Freeboard / Beam r = 15.40 / 70 = 0.220 If r < 0.268 then F = 0.268/r otherwise F = 1 F = 0.268/0.220 = 1.218	Req'd GM = Sum x F / Displ. = 73,458x1.218 / 16,819 Req'd GM = 5.32 Avail GM = 6.41

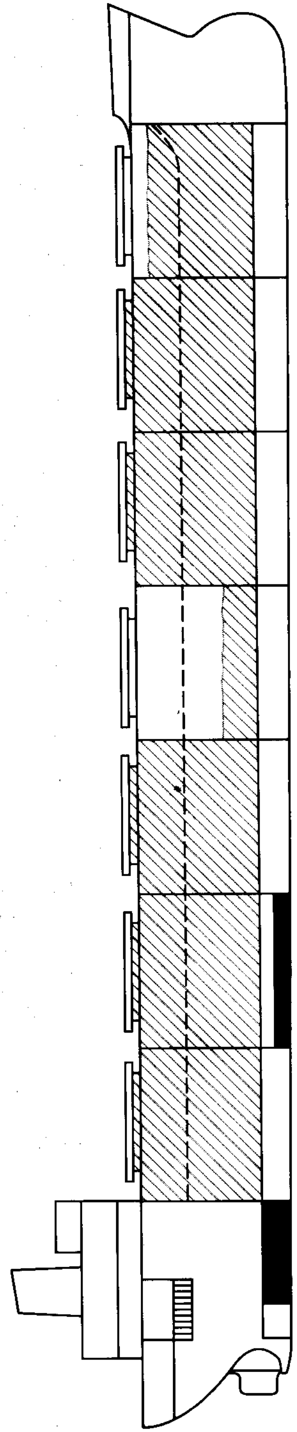
ARRIVAL AT:

Displ. = 16,694 GM (Corr) = 6.40 Mean Drf. = 25.93 F'board = 15.57 Beam = 70	r = Freeboard / Beam r = 15.57 / 70 = 0.222 If r < 0.268 then F = 0.268/r otherwise F = 1 F = 0.268/0.222 = 1.205	Req'd GM = Sum x F / Displ. = 73,458x1.205 / 16,694 Req'd GM = 5.30 Avail GM = 6.40

Examined M. Burns (N.C.B. Surveyor) C. Thompson (Master) Date 1-15-94

Rev. 5/94

EXAMPLE 2: BULK CARRIER



Cargo
Fuel Oil
Fresh Water

See pages:
66 Description of example
75 – 77 Excerpts from the Grain Loading Booklet
78 – 81 N.C.B. Grain Stability Calculation forms
82 Certificate of Readiness

CARGO HOLD GRAIN DATA

No. Hold No.	FILLED ENDS TRIMMED			FILLED ENDS UNTRIMMED		
	Volume m^3	V.C.G. m	Volumetric Heeling Mom m^4	Volume m^3	V.C.G. m	Volumetric Heeling Mom m^4
1	8,343	10.20	1,143	8,129	10.20	2,085
2	10,994	9.93	1,496	10,869	9.93	2,785
3	10,993	9.89	1,496	10,868	9.89	2,785
4	10,926	9.89	1,496	10,802	9.89	2,785
5	10,999	9.90	1,496	10,874	9.90	2,785
6	10,980	9.90	1,496	10,855	9.90	2,785
7	10,383	10.19	1,229	10,223	10.19	2,576

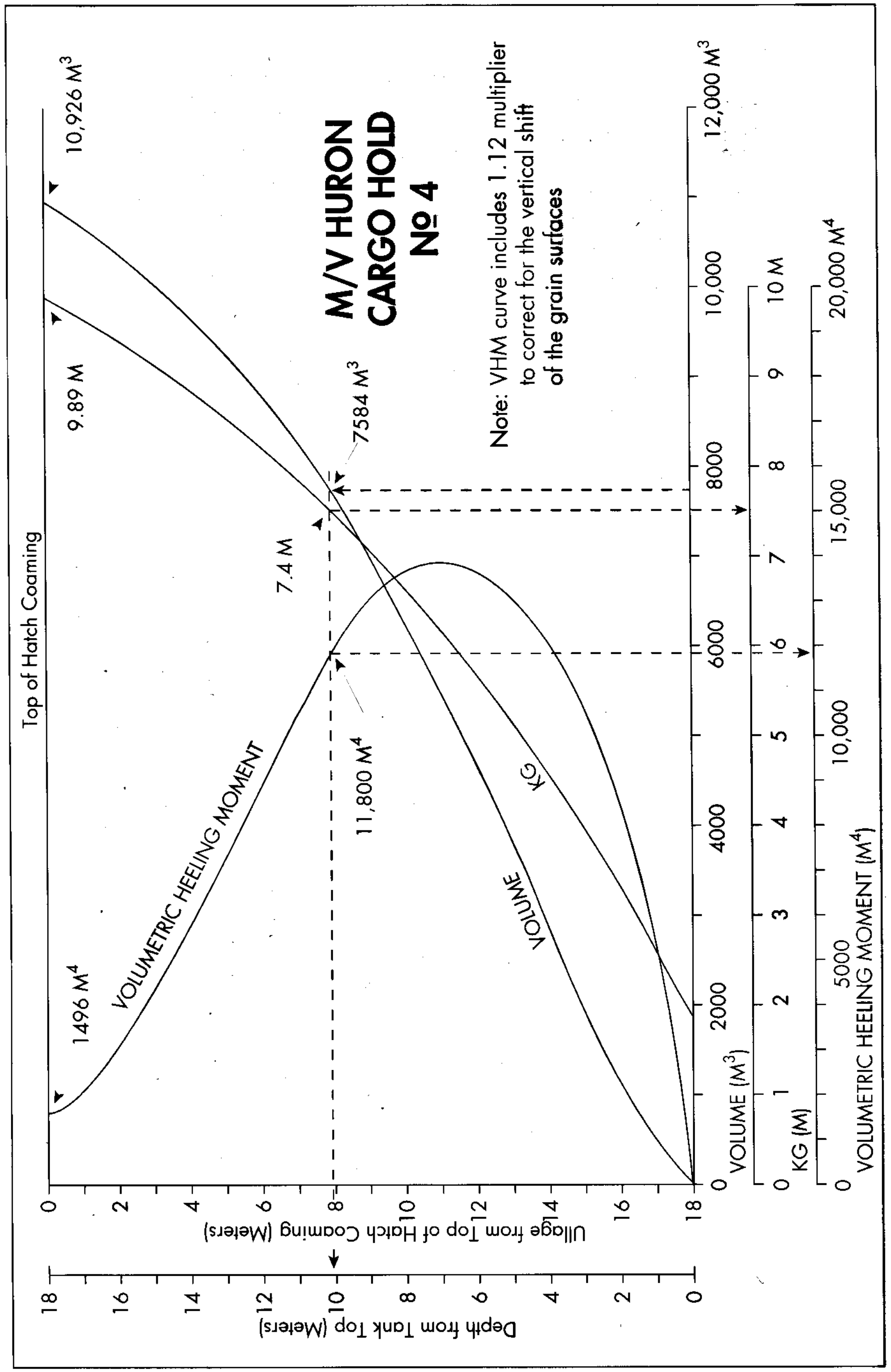
SUMMARY OF TANKS

TANK	CAPACITY M.T.	V.C.G. M	FREE SURFACE MOMENT (M.T.-M.) Slack	98% Full
S.W. BALLAST				
FOREPEAK	2,756	7.72	7,704	
1 DB P&S	2,812	1.57	24,624	
3 DB P&S	3,265	1.48	24,192	
5 DB p&S	1,327	1.98	6,048	
1 TS P&S	753	16.48	1,296	
2 TS P&S	2,648	16.11	5,328	
3 TS P&S	2,652	16.11	5,328	
4 TS P&S	2,624	16.14	5,328	
AFTERPEAK	519	12.39	4,320	
FUEL OIL				
2 DB P&S	1,484	1.48	11,420	144
4 DB P&S	1,457	1.48	11,420	144
DIESEL OIL				
6 DB P&S	200	1.18	430	43
FRESH WATER				
F.W.T.	262	16.36	520	
DISTILLED	94	16.39	140	
D.W.T.	168	16.34	330	

PERMISSIBLE HEELING MOMENT TABLE

(Excerpt)

DISPLACEMENT (Tonnes)	VIRTUAL CENTER OF GRAVITY (KG_V) (Meters)				
	8.5	9.0	9.5	10.0	10.5
69,500	45,535	37,715	29,895	22,075	14,255
71,000	46,041	38,260	30,479	22,698	14,917
71,500	46,570	38,829	31,088	23,347	15,606
72,000	47,120	39,419	31,718	24,017	16,316
72,500	47,688	40,027	32,366	24,705	17,044
73,000	48,267	40,647	33,027	25,407	17,787



NATIONAL CARGO BUREAU, INC.

GRAIN STABILITY CALCULATION

S.S/M.V. HURON		YEAR BUILT 1990 AT Beth. Steel
COUNTRY OF REGISTRY U.S.A.	NET TONNAGE 21,685	OFFICIAL NO. 306 594
AGENT PACIFIC STEAMSHIP AGENCIES		

GRAIN LOADING BOOKLET APPROVED BY National Cargo Bureau

DRAWING NO. 1035 Rev. 1 DATE OF APPROVAL July 1, 1985

APPLICABLE REGULATIONS Int'l. Grain Code

ADDENDUM FOR UNTRIMMED ENDS APPROVED BY Data in Grain Booklet

DRAWING NO. ______ DATE OF APPROVAL ______

LOADING PORT Seattle

BUNKERING PORTS -

DISCHARGE PORT Chittagong

STEAMING DISTANCE 8750 MILES PER DAY 350 TIME 25 Days

DAILY CONSUMPTION: FUEL 38 M.T. DIESEL 6 M.T. WATER 3 M.T.

	DISPLACEMENT	DEADWEIGHT	DRAFT	FREEBOARD
*WINTER				
SUMMER	72410 M.T.	60265 M.T.	12.44	2.27
*TROPICAL				

FRESH WATER ALLOWANCE 29 CM TPI/TPC (AT SUMMER DRAFT) 62.4 M.T.

* (If Applicable)

THIS IS TO CERTIFY THAT:

1. THIS CALCULATION IS PREPARED IN ACCORDANCE WITH THE REQUIREMENTS OF THE VESSEL'S GRAIN LOADING BOOKLET AND THE APPLICABLE GRAIN REGULATIONS;
2. THE STABILITY OF THE VESSEL WILL BE MAINTAINED THROUGHOUT THE VOYAGE IN ACCORDANCE WITH THIS CALCULATION.

CALCULATION PREPARED BY:
(TO BE COMPLETED IF FORM PREPARED BY OTHER THAN SHIP'S PERSONNEL)

NAME (PRINT) ______

COMPANY ______

SIGNATURE ______ DATE ______

R. Lane
MASTER

EXAMINED: T. Moore
N.C.B. SURVEYOR

DATE: Jan. 15, 1994

NOTE: ORIGINAL STABILITY CALCULATION AND GRAIN ARRANGEMENT PLAN TO BE SUMITTED TO THE N.C.B. SURVEYOR. ALL TONNAGES USED IN THESE CALCULATIONS SHALL BE SHOWN IN THE SAME UNITS AS USED IN THE GRAIN LOADING BOOKLET.

REV. 1/1/90

PART I

SHIP AND CARGO CALCULATION

TYPE OF GRAIN WHEAT STOWAGE FACTOR (S.F.) 43 CU.FT./L.T. 1.199 M³/M.T. ______

COMPT. NO.	CARGO (1)	S.F. (1)	GRAIN CUBICS M³ 100%	GRAIN CUBICS ACTUAL (2)	WEIGHT (3)	V.C.G.	MOMENT (3)
1			8343	8171	6815	10.1	68832
2			10994	-	9169	9.93	91048
3			10993	-	9168	9.89	90672
4			10926	7584	6325	7.4	46805
5			10999	-	9173	9.90	90813
6			10980	-	9158	9.90	90664
7			10383	-	8660	10.19	88245

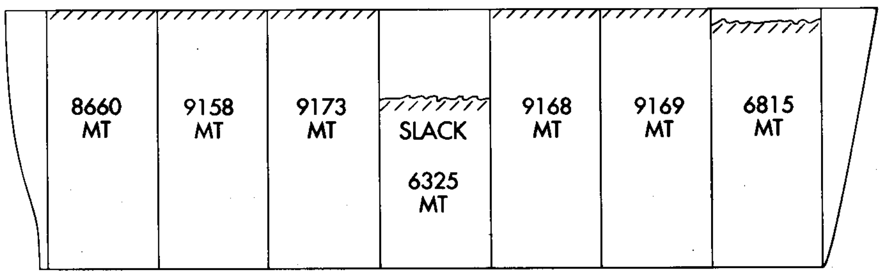
S.F. CuFt/LT	S.F. M³/MT	DEN. MT/M³
42	1.171	.854
42.5	1.184	.844
43	1.199	.834
43.5	1.212	.825
44	1.226	.815
44.5	1.240	.806
45	1.254	.797
45.5	1.268	.789
46	1.282	780
46.5	1.296	.772
47	1.310	.763
47.5	1.324	.755
48	1.338	.748
48.5	1.352	.740
49	1.366	.732
49.5	1.380	.725
50	1.393	.718
50.5	1.407	.711
51	1.421	.704
51.5	1.435	.697
52	1.449	.690
53	1.477	.677
54	1.505	.664
55	1.533	.652
56	1.561	.641
57	1.589	629
58	1.616	.619
59	1.644	.608
60	1.672	.598
61	1.700	.588
62	1.728	.579

THIS CALCULATION IS PREPARED IN:
☐ ENGLISH UNITS
☒ METRIC UNITS

	WEIGHT	V.C.G.	MOMENT
CARGO TOTALS	58468		567079
LIGHT SHIP	12095	10.54	127481
STORES	233	10.54	2456
SHIP AND CARGO TOTALS	70796		697016

(1) COMPLETE THESE COLUMNS IF MORE THAN ONE TYPE CARGO IS LOADED.
(2) FOR PARTLY FILLED COMPARTMENTS, SHOW ACTUAL CUBIC OCCUPIED IN ADDITION TO FULL CUBIC.
(3) WEIGHTS AND MOMENTS SHOULD BE SHOWN TO THE NEAREST WHOLE UNIT.

CARGO PLAN: INDICATE HOLDS, TWEEN DECKS, ENGINE SPACES, FITTINGS, STOWAGE, TONNAGES, ETC.



PART II

FUEL AND WATER CALCULATION

INTERMEDIATE SECTION IS REQUIRED TO BE COMPLETED IF ARRIVAL SECTION SHOWS BALLAST WHICH IS NOT LISTED IN DEPARTURE SECTION. INTERMEDIATE CONDITION IS BEFORE BALLASTING SO IT INCLUDES THE EFFECT OF FREE SURFACE BUT NOT EFFECT OF WEIGHT OF THE BALLAST WHICH IS TO BE TAKEN ABOARD.

		DEPARTURE: SEATTLE				INTERMEDIATE:				ARRIVAL: CHITTAGONG			
TANK	TYPE LIQUID	WEIGHT	V.C.G.	MOMENT	F.S. MOM.	WEIGHT	V.C.G.	MOMENT	F.S. MOM.	WEIGHT	V.C.G.	MOMENT	F.S. MOM.
4D.B.	F.O.	1200	1.5	1800	11420					250	1.5	375	11420
-	D.O.	200	1.2	240	430					50	1.2	60	430
FWT	F.W.	150	16.4	2460	520					100	16.4	1640	520
DIST.	F.W.	17	16.4	279	140					17	16.4	279	140
DWT	F.W.	50	16.3	815	330					25	16.3	408	330

	WEIGHT	MOMENT	F.S. MOM.	WEIGHT	MOMENT	F.S. MOM.	WEIGHT	MOMENT	F.S. MOM.
TOTALS LIQUIDS	1617	5594	12840				442	2762	12840
SHIP AND CARGO	70796	697016					70796	697016	
GRAND TOTALS DISPLACEMENT	72413	702610					71238	699778	

DEPARTURE	INTERMEDIATE	ARRIVAL
DEPARTURE KG 9.70	INTERMEDIATE KG ____	ARRIVAL KG 9.82
(1) FREE SURFACE CORR.(+) .18	(1) FREE SURFACE CORR.(+) ____	(1) FREE SURFACE CORR.(+) .18
(2) VERT. S.M. CORR. (+) ____	(2) VERT. S.M. CORR. (+) ____	(2) VERT. S.M. CORR. (+) –
KG_V 9.88	KG_V ____	KG_V 10.00
DEPARTURE KM 13.09	INTERMEDIATE KM ____	ARRIVAL KM 13.08
DEPARTURE KG_V 9.88	INTERMEDIATE KG_V ____	ARRIVAL KG_V 10.00
DEPARTURE GM 3.21	INTERMEDIATE GM ____	ARRIVAL GM 3.08
REQUIRED MINIMUM GM ____	REQUIRED MINIMUM GM ____	REQUIRED MINIMUM GM ____

NOTES

(1) FREE SURFACE CORR. = $\frac{\text{SUM OF FREE SURFACE INERTIA MOMENTS}}{\text{DISPLACEMENT}}$ (THIS CORRECTION MUST BE APPLIED TO ALL SHIPS.)

(2) VERT. S.M. CORR. = $\frac{\text{SUM OF VERTICAL SHIFTING MOMENTS FOR CARGO}}{\text{DISPLACEMENT}}$ (THIS CORRECTION APPLIES ONLY WHEN VERTICAL SHIFTING MOMENTS ARE PROVIDED IN THE SHIP'S GRAIN LOADING MANUAL.)

PART III

STABILITY SUMMARY

COMPT. NO.	STOW-AGE (1)	GRAIN DEPTH OR ULLAGE FT/M	VOLUMETRIC HEELING MOMENT FT⁴/M⁴	S.F. OR DENSITY (2)	GRAIN HEELING MOMENT L.T.-FT. M.T.-M.	VERTICAL SHIFTING MOMENT (SEE NOTE 2 PART II) FT⁴/M⁴	L.T.-FT. M.T.-M.
1	PF	1.7	2050	1.199	1710		
2	F-UT	0	2785	↓	2323		
3	F-UT	0	2785		2323		
4	PF	7.8	11800		9842		
5	F-UT	0	2785		2323		
6	F-UT	0	2785		2323		
7	F-UT	0	2576		2148		
		TOTALS	27566		22992		

(1) UNDER STOWAGE INDICATE "F" FOR FILLED COMPARTMENTS, "F-UT" FOR FILLED COMPARTMENTS UNTRIMMED, "PF" FOR PARTLY FILLED COMPARTMENTS, "SEC" FOR SECURED OR OVERSTOWED COMPARTMENTS.

(2) THE STOWAGE FACTOR USED IN PART III SHALL NOT EXCEED THE VOLUME PER UNIT WEIGHT (TEST WEIGHT) OF THE GRAIN. IF STOWAGE FACTOR IS SAME IN ALL COMPARTMENTS, DIVIDE TOTAL VOLUMETRIC HEELING MOMENT BY STOWAGE FACTOR OR MULTIPLY BY DENSITY TO OBTAIN GRAIN HEELING MOMENT. IF STOWAGE FACTOR VARIES, OBTAIN GRAIN HEELING MOMENT FOR EACH COMPARTMENT.

A. FOR VESSELS APPROVED UNDER REGULATION 4, CHAPTER VI, SOLAS 1974 or REGULATION 4, IMCO RESOLUTION A.264(VIII), SOLAS 1960 or REGULATION 4, IMCO RESOLUTION A.184(VI), SOLAS 1960

	DEPARTURE	INTERMEDIATE	ARRIVAL
DISPLACEMENT MT	72413		71238
KG_V M	9.88		10.0
TOTAL GRAIN HEELING MOMENT	22992		22992
MAXIMUM ALLOWABLE HEELING MOMENT	> 24017		23007
*ANGLE OF HEEL (12° MAX.)			
*RESIDUAL AREA .075 METER-RADIANS, 14.1 FT° OR 4.3M° MIN.			
*GM (0.3M OR 1 FT. MIN.)			

*TO BE COMPLETED IF VESSEL'S GRAIN LOADING BOOKLET DOES NOT INCLUDE A TABLE OF ALLOWABLE HEELING MOMENTS. IN SUCH CASE, STATICAL STABILITY DIAGRAMS DEMONSTRATING THIS INFORMATION SHALL BE ATTACHED HERETO.

B. FOR SPECIALLY SUITABLE SHIPS APPROVED UNDER SECTION V(B), PART B, CHAPTER VI, SOLAS 1974 or SECTION V(B), PART B, IMCO RESOLUTION A.264(VIII) REGULATION 12, CHAPTER VI, SOLAS 1960

ANGLE OF HEEL = $\frac{\text{GRAIN HEELING MOMENT} \times 57.3}{\text{DISPLACEMENT} \times \text{GM}}$

	DEPARTURE	INTERMEDIATE	ARRIVAL
TOTAL GRAIN HEELING MOMENT			
DISPLACEMENT			
GM (CORRECTED OF LIQUID FREE SURFACE)			
ANGLE OF HEEL (5° MAX.)			

Certificate of Readiness
— OF —
National Cargo Bureau, Inc.

No. ______________ *Port* Seattle, WA

This is to Certify, *that the* U.S. M/V HURON *(flag) (Name of Vessel) of* 21865 *tons register, built at* BALTIMORE

whereof B. LANE *is Master and now lying at* ANCHORAGE #6
is passed to load as follows:

GENERAL CARGO — Holds Nos. *******

BULK GRAIN — (Full Holds) Nos. 2, 3, 5, 6, and 7

(Part Holds) Nos. 1 and 4

Other BULK CARGOES (Identify Cargo) *******

HOLDS Nos. *******
said holds having been prepared in accordance with the regulations of the Commandant of the United States Coast Guard so far as applicable, and in accordance with the recommendations of National Cargo Bureau, Inc.

THIS CERTIFICATE VALID AT PORT OF ISSUANCE ONLY

THIS CERTIFICATE IS NOT A FORM OF INSURANCE, OR GUARANTEE, AND IS ISSUED ON THE FOLLOWING TERMS AND CONDITIONS: This Certificate and performance of services by National Cargo Bureau ("NCB") shall in no way be deemed to be a representation, statement, or warranty of seaworthiness, quality or fitness for a particular use or service, of any vessel, container, cargo, structure, item of material, or equipment. NCB shall not be liable for, and the party to whom this Certificate is issued agrees to indemnify and hold NCB harmless from and against any and all claims, demands, actions for damages, including legal fees, to persons and/or property which may be brought against NCB incidental to, arising out of, or in connection with the services to be performed hereunder, except for those claims caused solely by the negligence of NCB. NCB shall be discharged from all liability for negligent performance or non-performance of any services in connection with issuance of this Certificate, unless the same is discovered prior to and is claimed in writing made to NCB within 180 days and litigation is commenced within one year after performance of survey services. **THE COMBINED LIABILITY OF NCB, ITS OFFICERS, EMPLOYEES, AGENTS OR SUBCONTRACTORS FOR ANY LOSS, CLAIM, OR DAMAGE ARISING FROM NEGLIGENT PERFORMANCE OR NON-PERFORMANCE OF ANY SERVICES IN CONNECTION WITH THE ISSUANCE OF THIS CERTIFICATE, OR FROM BREACH OF ANY IMPLIED OR EXPRESS WARRANTY OF WORKMANLIKE PERFORMANCE, OR ANY OTHER REASON, SHALL NOT EXCEED IN THE AGGREGATE $10,000. IN NO EVENT SHALL NCB BE LIABLE FOR ANY CONSEQUENTIAL DAMAGES, INCLUDING, BUT WITHOUT LIMITATION, DELAY, DETENTION, LOSS OF USE, OR CUSTOMARY PORT CHARGES TO THE PARTY TO WHOM THIS CERTIFICATE IS ISSUED OR TO ANY OTHER PERSON, CORPORATION OR BUSINESS ENTITY FOR WHOSE BENEFIT THIS CERTIFICATE MAY BE ISSUED.**

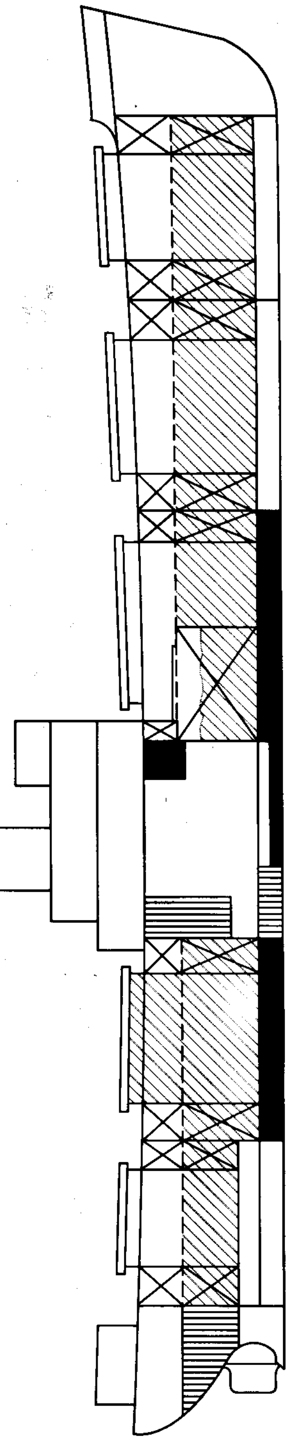
AGENT ______________ *DATE* January 20, *19*94

OPERATOR ______________ *Time passed* 1530

______________ *Surveyor*
T. MOORE

Rev. 11/93

EXAMPLE 3: GENERAL CARGO SHIP



Cargo

Fuel Oil

Fresh Water

See pages:
66 Description of example
84 Excerpts from the Grain Loading Booklet
85 – 88 N.C.B. Grain Stability Calculation forms
89 Certificate of Loading

VOLUMETRIC HEELING MOMENTS (ft4)

HOLD	CAPACITY FT3	VCG FT	LOADED SEPARATELY WITHOUT C/L DIV	LOADED SEPARATELY WITH C/L DIVISION	LOADED SEPARATELY MAXIMUM SLACK	LOADED IN COMBINATION WITHOUT C/L DIV	LOADED IN COMBINATION WITH C/L DIVISION
1LH	60,780	20.2	25,000	18,800	174,500	49,100	47,000
1TD	35,900	39.4	26,500	20,600	178,100		
2LH	112,610	17.5	75,400	51,700	576,300	129,200	112,000
2TD	47,400	36.5	52,200	40,300	299,900		
3LH	51,020	16.8	30,636	17,900	292,300	70,813	58,900
3TD	35,010	35.0	47,400	36,900	271,300		
3DT	50,600	16.8		23,500	75,300		
4LH	96,540	18.5	58,900	41,600	434,000	100,800	91,000
4TD	36,380	36.1	43,000	33,400	254,200		
5LH	42,160	24.3	30,500	21,800	151,900	54,400	50,800
5TD	24,460	37.6	25,700	19,400	168,300		

NOTE:This vessel has permanently installed underdeck centerline divisions. The above table shows heeling moments with or without temporary centerline divisions installed in hatchways.

MAXIMUM ALLOWABLE HEELING MOMENTS (FT.LT.)

DISPLACEMENT LT.	VIRTUAL CENTER OF GRAVITY (KG_v) (FT)						
	21.50	22.00	22.50	23.00	23.50	24.00	KM
14,400	12,764	11,172	9,580	7,988	6,398	4,804	25.38
14,600	13,138	11,525	9,910	8,296	6,682	5,068	25.45
14,800	13,613	11,976	10,339	8,702	7,065	5,428	25.51
15,000	13,905	12,245	10,585	8,925	7,265	5,605	25.57
15,130	14,107	12,433	10,759	9,085	7,411	5,737	25.61

SUMMARYOF TANKS	1DB	CAPACITY LT	VCG FT	FREE SURFACE MOMENT (FT.LT) Slack	98% Full
S.W. BALLAST	1 DB	233	3.5	3,348	
S.W. BALLAST	2 DB P&S	310	2.0	3,883	
S.W. BALLAST	7 DB	53	2.2	489	
S.W. BALLAST	5 DT P&S	239	9.5	504	
S.W. BALLAST	FOREPEAK	308	24.0	296	
FUEL OIL	3 DB P&S	330	2.0	5,690	1.897
FUEL OIL	6 DB P&S	212	2.0	2,208	736
FUEL OIL	SETTLERS	42	34.0	44	
DIESEL OIL	4 DB P&S	161	2.1	1,550	529
FRESH WATER	5 DB P&S	34	2.1	326	
FRESH WATER	FWT P&S	138	17.1	182	
FRESH WATER	AFTERPEAK	200	27.8	817	

NATIONAL CARGO BUREAU, INC.

GRAIN STABILITY CALCULATION

S.S./~~M.V.~~ ATLANTIC		YEAR BUILT 1983 AT Bath
COUNTRY OF REGISTRY U.S.A.	NET TONNAGE 4572	OFFICIAL NO. 303427
AGENT Pacific Steamship Agency		

GRAIN LOADING BOOKLET APPROVED BY National Cargo Bureau

DRAWING NO. GW-348 DATE OF APPROVAL May 21, 1983

APPLICABLE REGULATIONS Int'l. Code for Safe Carriage of Grain

ADDENDUM FOR UNTRIMMED ENDS APPROVED BY None

DRAWING NO. - DATE OF APPROVAL -

LOADING PORT Portland, Oregon

BUNKERING PORTS -

DISCHARGE PORT Valparaiso, Chile

STEAMING DISTANCE 5300 MILES PER DAY 350 TIME 15 Days

DAILY CONSUMPTION: FUEL 30 LT DIESEL 3 LT WATER 12 LT

	DISPLACEMENT	DEADWEIGHT	DRAFT	FREEBOARD
*WINTER				
SUMMER	15,130 LT	11,014 LT	28'0"	10'8"
*TROPICAL				

FRESH WATER ALLOWANCE 7" TPI/TPC (AT SUMMER DRAFT) 52.5

* (If Applicable)

THIS IS TO CERTIFY THAT:

1. THIS CALCULATION IS PREPARED IN ACCORDANCE WITH THE REQUIREMENTS OF THE VESSEL'S GRAIN LOADING BOOKLET AND THE APPLICABLE GRAIN REGULATIONS;
2. THE STABILITY OF THE VESSEL WILL BE MAINTAINED THROUGHOUT THE VOYAGE IN ACCORDANCE WITH THIS CALCULATION.

CALCULATION PREPARED BY:
(TO BE COMPLETED IF FORM PREPARED BY OTHER THAN SHIP'S PERSONNEL)

NAME (PRINT)

COMPANY

SIGNATURE DATE

J. Jones
MASTER

EXAMINED: R. Smith
N.C.B. SURVEYOR

DATE: March 10, 1994

NOTE: ORIGINAL STABILITY CALCULATION AND GRAIN ARRANGEMENT PLAN TO BE SUMITTED TO THE N.C.B. SURVEYOR. ALL TONNAGES USED IN THESE CALCULATIONS SHALL BE SHOWN IN THE SAME UNITS AS USED IN THE GRAIN LOADING BOOKLET.

REV. 1/1/90

PART I

SHIP AND CARGO CALCULATION

TYPE OF GRAIN WHEAT STOWAGE FACTOR (S.F.) 45 CU.FT./L.T. ______ xm3xmxx ______

COMPT. NO.	CARGO (1)	S.F. (1)	GRAIN CUBICS 100%	GRAIN CUBICS ACTUAL (2)	WEIGHT (3)	V.C.G.	MOMENT (3)
1 LH		45	60,780		1351	20.2	27,290
2 LH			112,610		2502	17.5	43,785
3 LH			51,020		1134	16.8	19,051
3 DT			50,600	46,035	1023	16.8	17,186
P&S							
4 LH			96,540		2145	18.5	39,683
4 TD			36,380		808	36.1	29,169
5 LH			42,160		937	24.3	22,769

S.F. CuFt/LT	S.F. M3/MT	DEN. MT/M3
42	1.171	.854
42.5	1.184	.844
43	1.199	.834
43.5	1.212	.825
44	1.226	.815
44.5	1.240	.806
45	1.254	.797
45.5	1.268	.789
46	1.282	.780
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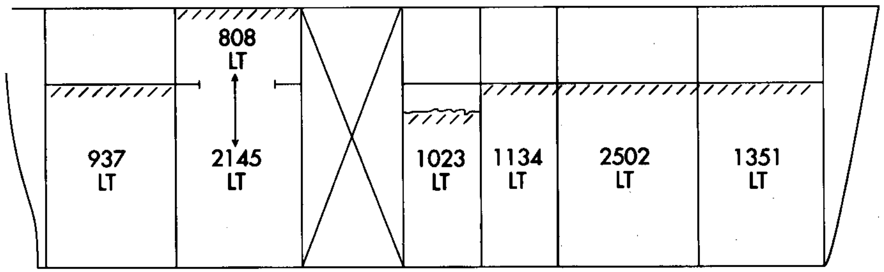
48.5	1.352	.740
49	1.366	.732
49.5	1.380	.725
50	1.393	.718
50.5	1.407	.711
51	1.421	.704
51.5	1.435	.697
52	1.449	.690
53	1.477	.677
54	1.505	.664
55	1.533	.652
56	1.561	.641
57	1.589	.629
58	1.616	.619
59	1.644	.608
60	1.672	.598
61	1.700	.588
62	1.728	.579

THIS CALCULATION IS PREPARED IN:
- ☒ ENGLISH UNITS
- ☐ METRIC UNITS

	WEIGHT	V.C.G.	MOMENT
CARGO TOTALS	9900		198,933
LIGHT SHIP	4116	26.1	107,428
STORES	150	35.0	5,250
SHIP AND CARGO TOTALS	14,166		311,611

(1) COMPLETE THESE COLUMNS IF MORE THAN ONE TYPE CARGO IS LOADED.
(2) FOR PARTLY FILLED COMPARTMENTS, SHOW ACTUAL CUBIC OCCUPIED IN ADDITION TO FULL CUBIC.
(3) WEIGHTS AND MOMENTS SHOULD BE SHOWN TO THE NEAREST WHOLE UNIT.

CARGO PLAN: INDICATE HOLDS, TWEEN DECKS, ENGINE SPACES, FITTINGS, STOWAGE, TONNAGES, ETC.



PART II

FUEL AND WATER CALCULATION

INTERMEDIATE SECTION IS REQUIRED TO BE COMPLETED IF ARRIVAL SECTION SHOWS BALLAST WHICH IS NOT LISTED IN DEPARTURE SECTION. INTERMEDIATE CONDITION IS BEFORE BALLASTING SO IT INCLUDES THE EFFECT OF FREE SURFACE BUT NOT EFFECT OF WEIGHT OF THE BALLAST WHICH IS TO BE TAKEN ABOARD.

		DEPARTURE: NEW ORLEANS				INTERMEDIATE:				ARRIVAL: ANTWERP			
TANK	TYPE LIQUID	WEIGHT	V.C.G.	MOMENT	F.S. MOM.	WEIGHT	V.C.G.	MOMENT	F.S. MOM.	WEIGHT	V.C.G.	MOMENT	F.S. MOM.
F.O.													
3 DB		330	2.0	660	(5,690)					97	2.0	194	5,690
6 DB		212	2.0	424	736					–			–
Sett		42	34.0	1,428	44					42	34.0	1,428	44
D.O.													
4 DB		108	2.1	227	1,550					63	2.1	132	1,550
F.W.													
FWT		138	17.1	2,360	–					56	17.1	958	(817)
5 DB		34	2.1	71	–					34	2.1	71	–
A.P.		100	27.8	2,780	817					–			–

	DEP. WEIGHT	DEP. MOMENT	DEP. F.S. MOM.	INT. WEIGHT	INT. MOMENT	INT. F.S. MOM.	ARR. WEIGHT	ARR. MOMENT	ARR. F.S. MOM.
TOTALS LIQUIDS	964	7,950	8,837				292	2,783	8,101
SHIP AND CARGO	14,166	311,611					14,166	311,611	
GRAND TOTALS DISPLACEMENT	15,130	319,561					14,458	314,394	

DEPARTURE	INTERMEDIATE	ARRIVAL
DEPARTURE KG 21.12	INTERMEDIATE KG ______	ARRIVAL KG 21.75
(1) FREE SURFACE CORR.(+) .58	(1) FREE SURFACE CORR.(+) ______	(1) FREE SURFACE CORR.(+) .56
(2) VERT. S.M. CORR. (+) –	(2) VERT. S.M. CORR. (+) ______	(2) VERT. S.M. CORR. (+) –
KG_V 21.70	KG_V ______	KG_V 22.31
DEPARTURE KM 25.61	INTERMEDIATE KM ______	ARRIVAL KM 25.40
DEPARTURE KG_V 21.70	INTERMEDIATE KG_V ______	ARRIVAL KG_V 22.31
DEPARTURE GM 3.91	INTERMEDIATE GM ______	ARRIVAL GM 3.09
REQUIRED MINIMUM GM ______	REQUIRED MINIMUM GM ______	REQUIRED MINIMUM GM ______

NOTES

(1) FREE SURFACE CORR. = $\frac{\text{SUM OF FREE SURFACE INERTIA MOMENTS}}{\text{DISPLACEMENT}}$ (THIS CORRECTION MUST BE APPLIED TO ALL SHIPS.)

(2) VERT. S.M. CORR. = $\frac{\text{SUM OF VERTICAL SHIFTING MOMENTS FOR CARGO}}{\text{DISPLACEMENT}}$ (THIS CORRECTION APPLIES ONLY WHEN VERTICAL SHIFTING MOMENTS ARE PROVIDED IN THE SHIP'S GRAIN LOADING MANUAL.)

STABILITY SUMMARY

PART III

COMPT. NO.	STOWAGE (1)	GRAIN DEPTH OR ULLAGE FT/M	VOLUMETRIC HEELING MOMENT FT^4/M^4	S.F. OR DENSITY (2)	GRAIN HEELING MOMENT L.T.-FT. M.T.-M.	VERTICAL SHIFTING MOMENT SEE NOTE 2 PART II FT^4/M^4	VERTICAL SHIFTING MOMENT L.T.-FT. M.T.-M.
1 LH	F	0	25,000	45			
2 LH	F	0	75,400				
3 LH	F	0	30,636				
3 DT	PF	2.4	75,300		(MAX)		
4 TD LH	F	0	100,800				
5 LH	F	0	30,500				
		TOTALS	337,636		7,503		

(1) UNDER **STOWAGE** INDICATE "F" FOR FILLED COMPARTMENTS, "F-UT" FOR FILLED COMPARTMENTS UNTRIMMED, "PF" FOR PARTLY FILLED COMPARTMENTS, "SEC" FOR SECURED OR OVERSTOWED COMPARTMENTS.

(2) THE **STOWAGE FACTOR** USED IN PART III SHALL NOT EXCEED THE VOLUME PER UNIT WEIGHT (TEST WEIGHT) OF THE GRAIN. IF STOWAGE FACTOR IS SAME IN ALL COMPARTMENTS, DIVIDE TOTAL VOLUMETRIC HEELING MOMENT BY STOWAGE FACTOR OR MULTIPLY BY DENSITY TO OBTAIN GRAIN HEELING MOMENT. IF STOWAGE FACTOR VARIES, OBTAIN GRAIN HEELING MOMENT FOR EACH COMPARTMENT.

A. FOR VESSELS APPROVED UNDER REGULATION 4, CHAPTER VI, SOLAS 1974 or REGULATION 4, IMCO RESOLUTION A.264(VIII), SOLAS 1960 or REGULATION 4, IMCO RESOLUTION A.184(VI), SOLAS 1960

	DEPARTURE	INTERMEDIATE	ARRIVAL
DISPLACEMENT	15,130		14,458
KG_v	21.70		22.31
TOTAL GRAIN HEELING MOMENT	7503		7503
MAXIMUM ALLOWABLE HEELING MOMENT	13,437		10,283
*ANGLE OF HEEL (12° MAX.)			
*RESIDUAL AREA .075 METER-RADIANS. 14.1 FT° OR 4.3M° MIN.			
*GM (0.3M OR 1 FT. MIN.)			

*TO BE COMPLETED IF VESSEL'S GRAIN LOADING BOOKLET DOES NOT INCLUDE A TABLE OF ALLOWABLE HEELING MOMENTS. IN SUCH CASE, STATICAL STABILITY DIAGRAMS DEMONSTRATING THIS INFORMATION SHALL BE ATTACHED HERETO.

B. FOR SPECIALLY SUITABLE SHIPS APPROVED UNDER SECTION V(B), PART B, CHAPTER VI, SOLAS 1974 or SECTION V(B), PART B, IMCO RESOLUTION A.264(VIII) REGULATION 12, CHAPTER VI, SOLAS 1960

$$\text{ANGLE OF HEEL} = \frac{\text{GRAIN HEELING MOMENT} \times 57.3}{\text{DISPLACEMENT} \times \text{GM}}$$

	DEPARTURE	INTERMEDIATE	ARRIVAL
TOTAL GRAIN HEELING MOMENT			
DISPLACEMENT			
GM (CORRECTED OF LIQUID FREE SURFACE)			
ANGLE OF HEEL (5° MAX.)			

CERTIFICATE OF LOADING
(Bulk Grain Only)
— OF —
NATIONAL CARGO BUREAU, INC.

This is to Certify, *that the* U.S. (Flag), M/V ATLANTIC (Name of Vessel)

whereof J. JONES *is Master, of* 4,572 *Net Tons,*

built at Bath, ME *in 19* 61, *said to be bound for* Antwerp, Belgium

has been under the inspection of a surveyor or surveyors of NATIONAL CARGO BUREAU, INC. at this port from time to time during the course and in respect of the loading of grain in bulk; that so far as said cargo came under the observation of such surveyor or surveyors, the stowage was in accordance with the regulations of the Commandant, United States Coast Guard.

Underdeck cargo said to be:

369,800 Bushels #2 Hard Winter Wheat 9,900 Long Tons

THIS CERTIFICATE IS NOT A CERTIFICATE OF SEAWORTHINESS AND RELATES ONLY TO THE ABOVE CARGO

THIS CERTIFICATE IS NOT A FORM OF INSURANCE, OR GUARANTEE, AND IS ISSUED ON THE FOLLOWING TERMS AND CONDITIONS: This Certificate and performance of services by National Cargo Bureau ("NCB") shall in no way be deemed to be a representation, statement, or warranty of seaworthiness, quality or fitness for a particular use or service, of any vessel, container, cargo, structure, item of material, or equipment. NCB shall not be liable for, and the party to whom this Certificate is issued agrees to indemnify and hold NCB harmless from and against any and all claims, demands, actions for damages, including legal fees, to persons and/or property which may be brought against NCB incidental to, arising out of, or in connection with the services to be performed hereunder, except for those claims caused solely by the negligence of NCB. NCB shall be discharged from all liability for negligent performance or non-performance of any services in connection with issuance of this Certificate, unless the same is discovered prior to and is claimed in writing made to NCB within 180 days and litigation is commenced within one year after performance of survey services. **THE COMBINED LIABILITY OF NCB, ITS OFFICERS, EMPLOYEES, AGENTS OR SUBCONTRACTORS FOR ANY LOSS, CLAIM, OR DAMAGE ARISING FROM NEGLIGENT PERFORMANCE OR NON-PERFORMANCE OF ANY SERVICES IN CONNECTION WITH THE ISSUANCE OF THIS CERTIFICATE, OR FROM BREACH OF ANY IMPLIED OR EXPRESS WARRANTY OF WORKMANLIKE PERFORMANCE, OR ANY OTHER REASON, SHALL NOT EXCEED IN THE AGGREGATE $10,000. IN NO EVENT SHALL NCB BE LIABLE FOR ANY CONSEQUENTIAL DAMAGES, INCLUDING, BUT WITHOUT LIMITATION, DELAY, DETENTION, LOSS OF USE, OR CUSTOMARY PORT CHARGES TO THE PARTY TO WHOM THIS CERTIFICATE IS ISSUED OR TO ANY OTHER PERSON, CORPORATION OR BUSINESS ENTITY FOR WHOSE BENEFIT THIS CERTIFICATE MAY BE ISSUED.**

Issued at New Orleans, LA (Port)

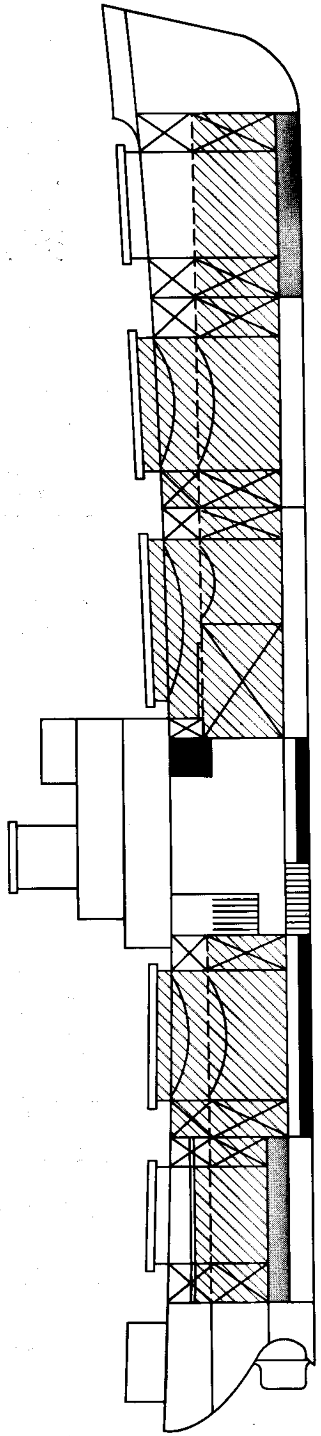
_______ (Time) Jan. 24, 1994 (Date)

_______ _______ *Master* _______ *Surveyor*
A. BAKER

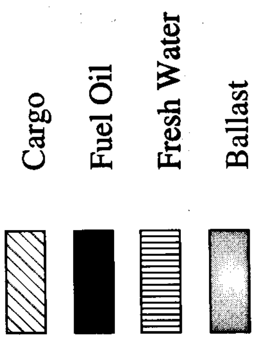
Rev. 11/85

A final Certificate of Loading will be issued in due course.

EXAMPLE 4: GENERAL CARGO SHIP



See pages:
66 Description of example
84 Excerpts from the Grain Loading Booklet
91 – 94 N.C.B. Grain Stability Calculation forms



NATIONAL CARGO BUREAU, INC.

GRAIN STABILITY CALCULATION

S.S/M.V. ATLANTIC		YEAR BUILT 1983 AT Bath
COUNTRY OF REGISTRY U.S.A.	NET TONNAGE 4572	OFFICIAL NO. 303427
AGENT Orleans Shipping Company		

GRAIN LOADING BOOKLET APPROVED BY National Cargo Bureau

DRAWING NO. GW-348 DATE OF APPROVAL May 21, 1983

APPLICABLE REGULATIONS Int'l Code for Safe Carriage of Grain

ADDENDUM FOR UNTRIMMED ENDS APPROVED BY None

DRAWING NO. - DATE OF APPROVAL -

LOADING PORT New Orleans

BUNKERING PORTS -

DISCHARGE PORT Antwerp

STEAMING DISTANCE 5,300 mi. MILES PER DAY 350 TIME 15 Days

DAILY CONSUMPTION: FUEL 30 LT DIESEL 3 LT WATER 12 LT

	DISPLACEMENT	DEADWEIGHT	DRAFT	FREEBOARD
*WINTER				
SUMMER	15,130 LT	11,014 LT	28'0"	10'8"
*TROPICAL				

FRESH WATER ALLOWANCE 7" TPI/TPC (AT SUMMER DRAFT) 52.5

* (If Applicable)

THIS IS TO CERTIFY THAT:

1. THIS CALCULATION IS PREPARED IN ACCORDANCE WITH THE REQUIREMENTS OF THE VESSEL'S GRAIN LOADING BOOKLET AND THE APPLICABLE GRAIN REGULATIONS;
2. THE STABILITY OF THE VESSEL WILL BE MAINTAINED THROUGHOUT THE VOYAGE IN ACCORDANCE WITH THIS CALCULATION.

CALCULATION PREPARED BY:
(TO BE COMPLETED IF FORM PREPARED BY OTHER THAN SHIP'S PERSONNEL)

NAME (PRINT) ____

COMPANY ____

SIGNATURE ____ DATE ____

J. Jones
MASTER

EXAMINED: A. Baker
N.C.B. SURVEYOR

DATE: January 20, 1994

NOTE: ORIGINAL STABILITY CALCULATION AND GRAIN ARRANGEMENT PLAN TO BE SUMITTED TO THE N.C.B. SURVEYOR. ALL TONNAGES USED IN THESE CALCULATIONS SHALL BE SHOWN IN THE SAME UNITS AS USED IN THE GRAIN LOADING BOOKLET.

REV. 1/1/90

PART I

SHIP AND CARGO CALCULATION

TYPE OF GRAIN Barley   STOWAGE FACTOR (S.F.) 55 CU.FT./L.T. ______ m^3/MT ______

COMPT. NO.	CARGO (1)	S.F. (1)	GRAIN CUBICS 100%	GRAIN CUBICS ACTUAL (2)	WEIGHT (3)	V.C.G.	MOMENT (3)
1LH		55	60,780	100%	1105	20.2	22,321
2LH			112,610		2047	17.5	35,823
2TD			47,400		862	36.5	31,463
3LH			51,020		928	16.8	15,590
3DT			50,600		920	16.8	15,456
3TD			35,010		637	35.0	22,295
4LH			96,540		1755	18.5	32,468
4TD			36,380		661	36.1	23,862
5LH			42,160		767	24.3	18,638
5TD			24,460	11,990	218	37.6	8,197

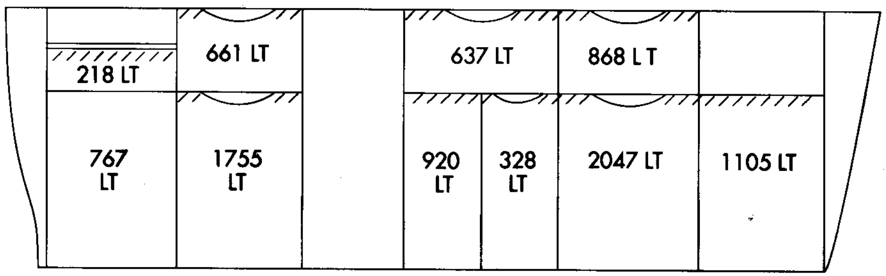
	WEIGHT	V.C.G.	MOMENT
CARGO TOTALS	9,900		226,113
LIGHT SHIP	4,116	26.1	107,428
STORES	150	35.0	5,250
SHIP AND CARGO TOTALS	14,166		338,791

THIS CALCULATION IS PREPARED IN:
☒ ENGLISH UNITS
☐ METRIC UNITS

S.F. CuFt/LT	S.F. M^3/MT	DEN. MT/M^3
42	1.171	.854
42.5	1.184	.844
43	1.199	.834
43.5	1.212	.825
44	1.226	.815
44.5	1.240	.806
45	1.254	.797
45.5	1.268	.789
46	1.282	.780
46.5	1.296	.772
47	1.310	.763
47.5	1.324	.755
48	1.338	.748
48.5	1.352	.740
49	1.366	.732
49.5	1.380	.725
50	1.393	.718
50.5	1.407	.711
51	1.421	.704
51.5	1.435	.697
52	1.449	.690
53	1.477	.677
54	1.505	.664
55	1.533	.652
56	1.561	.641
57	1.589	.629
58	1.616	.619
59	1.644	.608
60	1.672	.598
61	1.700	.588
62	1.728	.579

(1) COMPLETE THESE COLUMNS IF MORE THAN ONE TYPE CARGO IS LOADED.
(2) FOR PARTLY FILLED COMPARTMENTS, SHOW ACTUAL CUBIC OCCUPIED IN ADDITION TO FULL CUBIC.
(3) WEIGHTS AND MOMENTS SHOULD BE SHOWN TO THE NEAREST WHOLE UNIT.

CARGO PLAN: INDICATE HOLDS, TWEEN DECKS, ENGINE SPACES, FITTINGS, STOWAGE, TONNAGES, ETC.



PART II

FUEL AND WATER CALCULATION

INTERMEDIATE SECTION IS REQUIRED TO BE COMPLETED IF ARRIVAL SECTION SHOWS BALLAST WHICH IS NOT LISTED IN DEPARTURE SECTION. INTERMEDIATE CONDITION IS BEFORE BALLASTING SO IT INCLUDES THE EFFECT OF FREE SURFACE BUT NOT EFFECT OF WEIGHT OF THE BALLAST WHICH IS TO BE TAKEN ABOARD.

		DEPARTURE: PORTLAND				INTERMEDIATE: AT BALLAST POINT				ARRIVAL: VALPARAISO			
TANK	TYPE LIQUID	WEIGHT	V.C.G.	MOMENT	F.S. MOM.	WEIGHT	V.C.G.	MOMENT	F.S. MOM.	WEIGHT	V.C.G.	MOMENT	F.S. MOM.
F.O.													
3 DB		330	2.0	660	(5,690)	175	2.0	350	5,690	-			-
6 DB		212	2.0	424	736	212	2.0	424	736	97	2.0	194	(5,690)
Sett		42	34.0	1,428	44	42	34.0	1,428	44	42	34.0	1,428	44
D.O.													
4 DB		108	2.1	227	1,550	92	2.1	193	1,550	63	2.1	132	1,550
F.W.													
FWT		138	17.1	2,360	-	138	17.1	2,360	-	56	17.1	958	-
5 DB		34	2.1	71	-	34	2.1	71	-	34	2.1	71	-
A.P.		100	27.8	2,780	817	38	27.8	1,056	817	-			(817)
BALL													
1 DB		-				-			(3,880)	233	3.5	816	-
5 DT		-				-				239	9.5	2,271	-
TOTALS LIQUIDS		964		7,950	8,837	731		5,882	12,717	764		5,870	8,101
SHIP AND CARGO		14,166		338,791		14,166		338,791		14,166		338,791	
GRAND TOTALS DISPLACEMENT		15,130		346,741		14,897		344,673		14,930		344,661	

DEPARTURE		INTERMEDIATE		ARRIVAL	
DEPARTURE KG	22.92	INTERMEDIATE KG	23.14	ARRIVAL KG	23.09
(1) FREE SURFACE CORR.(+)	.58	(1) FREE SURFACE CORR.(+)	0.85	(1) FREE SURFACE CORR.(+)	.54
(2) VERT. S.M. CORR. (+)		(2) VERT. S.M. CORR. (+)		(2) VERT. S.M. CORR. (+)	
KG_v	23.50	KG_v	23.99	KG_v	23.63
DEPARTURE KM	25.61	INTERMEDIATE KM	25.54	ARRIVAL KM	25.55
DEPARTURE KG_v	23.50	INTERMEDIATE KG_v	23.99	ARRIVAL KG_v	23.63
DEPARTURE GM	2.11	INTERMEDIATE GM	1.55	ARRIVAL GM	1.92
REQUIRED MINIMUM GM		REQUIRED MINIMUM GM		REQUIRED MINIMUM GM	

NOTES

(1) FREE SURFACE CORR. = $\frac{\text{SUM OF FREE SURFACE INERTIA MOMENTS}}{\text{DISPLACEMENT}}$ (THIS CORRECTION MUST BE APPLIED TO ALL SHIPS.)

(2) VERT. S.M. CORR. = $\frac{\text{SUM OF VERTICAL SHIFTING MOMENTS FOR CARGO}}{\text{DISPLACEMENT}}$ (THIS CORRECTION APPLIES ONLY WHEN VERTICAL SHIFTING MOMENTS ARE PROVIDED IN THE SHIP'S GRAIN LOADING MANUAL.)

STABILITY SUMMARY

PART III

COMPT. NO.	STOW-AGE (1)	GRAIN DEPTH OR ULLAGE FT/~~M~~	VOLUMETRIC HEELING MOMENT FT^4/~~M^4~~	S.F. OR DENSITY (2)	GRAIN HEELING MOMENT L.T.-FT. M.T.-M.	VERTICAL SHIFTING MOMENT SEE NOTE 2 PART II FT^4/M^4	L.T.-FT. M.T.-M.
1 LH	F	0	25,000	55			
2 LH	Bundle		51,700				
2 TD	Bundle		40,300				
3 LH	Bundle		17,900				
3 DT's	F		23,500				
3 TD	Bundle		36,900				
4 LH	Bundle		41,600				
4 TD	Bundle		33,400				
5 LH	F		30,500				
5 TD	SEC	–	0				
		TOTALS	300,800		5469		

(1) UNDER **STOWAGE** INDICATE "F" FOR FILLED COMPARTMENTS, "F-UT" FOR FILLED COMPARTMENTS UNTRIMMED, "PF" FOR PARTLY FILLED COMPARTMENTS, "SEC" FOR SECURED OR OVERSTOWED COMPARTMENTS.

(2) THE **STOWAGE FACTOR** USED IN PART III SHALL NOT EXCEED THE VOLUME PER UNIT WEIGHT (TEST WEIGHT) OF THE GRAIN. IF STOWAGE FACTOR IS SAME IN ALL COMPARTMENTS, DIVIDE TOTAL VOLUMETRIC HEELING MOMENT BY STOWAGE FACTOR OR MULTIPLY BY DENSITY TO OBTAIN GRAIN HEELING MOMENT. IF STOWAGE FACTOR VARIES, OBTAIN GRAIN HEELING MOMENT FOR EACH COMPARTMENT.

A. FOR VESSELS APPROVED UNDER REGULATION 4, CHAPTER VI, SOLAS 1974 or
REGULATION 4, IMCO RESOLUTION A.264(VIII), SOLAS 1960 or
REGULATION 4, IMCO RESOLUTION A.184(VI), SOLAS 1960

	'DEPARTURE	INTERMEDIATE	ARRIVAL
DISPLACEMENT	15,130	14,897	14,930
KG_v	23.50	23.99	23.63
TOTAL GRAIN HEELING MOMENT	5469	5469	5469
MAXIMUM ALLOWABLE HEELING MOMENT	7411	5547	6765
*ANGLE OF HEEL (12° MAX.)			
*RESIDUAL AREA .075 METER-RADIANS, 14.1 FT° OR 4.3M° MIN.			
*GM (0.3M OR 1 FT. MIN.)			

*TO BE COMPLETED IF VESSEL'S GRAIN LOADING BOOKLET DOES NOT INCLUDE A TABLE OF ALLOWABLE HEELING MOMENTS. IN SUCH CASE, STATICAL STABILITY DIAGRAMS DEMONSTRATING THIS INFORMATION SHALL BE ATTACHED HERETO.

B. FOR SPECIALLY SUITABLE SHIPS APPROVED UNDER SECTION V(B), PART B, CHAPTER VI, SOLAS 1974 or
SECTION V(B), PART B, IMCO RESOLUTION A.264(VIII)
REGULATION 12, CHAPTER VI, SOLAS 1960

$$\text{ANGLE OF HEEL} = \frac{\text{GRAIN HEELING MOMENT} \times 57.3}{\text{DISPLACEMENT} \times \text{GM}}$$

	DEPARTURE	INTERMEDIATE	ARRIVAL
TOTAL GRAIN HEELING MOMENT			
DISPLACEMENT			
GM (CORRECTED OF LIQUID FREE SURFACE)			
ANGLE OF HEEL (5° MAX.)			

STANDARD BUSHEL WEIGHTS

WHEATS, SOYBEANS, RICE
60 LBS. per Bushel
37.33 Bushels per Long Ton
1,000 Bushels = 26.7857 LT

$$LT = \text{Bushels} \times \frac{3}{112}$$

$$\therefore \text{Bushels} = LT \times \frac{112}{3}$$

CORN, RYE, SORGHUM AND FLAX
56 LBS. per Bushel
40 Bushels per Long Ton
1,000 Bushels = 25 LT

BARLEY
48 LBS. per Bushel
46.67 Bushels per Long Ton
1,000 Bushels = 21.4286 LT

$$LT = \text{Bushels} \times \frac{3}{140}$$

$$\text{Bushels} = LT \times \frac{140}{3}$$

Note: The above are standard Bushel Weight Units used in the Grain Trade and should not be confused with Bushel Volume Units used to determine Test Weights.

AVERAGE TEST WEIGHTS OF THE PRINCIPAL GRAINS LOADED AT UNITED STATES PORTS

The Test Weght of a particular grain is the actual weight in pounds of a U.S. (Winchester) Bushel which is a unit of volume (dry measure) equalling 2,150.42 cubic inches or 1.2445 cubic feet.

	Lbs. per Bushel		Lbs. per Bushel
BARLEY	50	SORGHUM (MILO)	57
CORN	55	SOYBEANS	56
LINSEED	50	SUNFLOWER SEED	28
MILLET	57	WHEAT, AMBER DURUM	61
OATS	40	WHEAT, HARD WINTER	62
PEANUTS	51	WHEAT, NOTHERN SPRING	60
RICE	60	WHEAT, SOFT RED	59
RYE	58	WHEAT, WHITE	61
SAFFLOWER SEED	41	CANOLA/RAPE SEED	51

NOTE: The above test weights are average figures based on information obtained from grain loading ports. The specific test weights of particular grain cargoes may vary from the figures shown. Data on test weights is usually available from grain inspection offices at shipping elevators.

The above test weights when used in conjunction with the stowage factor table on page 97 will give the approximate stowage factor for a conventional general cargo vessel with one tween deck.

The stowage factor for specially suitable bulk carrier will generally be from one to two cubic feet per long ton less due to compaction and the configuration of the holds.

ANGLE OF REPOSE OF VARIOUS GRAINS

BARLEY	46°	RYE	32°
CORN	21°	SAFFLOWER SEED	28°
LINSEED-FLAXSEED		SORGHUM (MILO)	31°
OATS	21°	SOYBEANS	22°
RICE	20°	WHEAT	23°

GRAIN STOWAGE FACTORS

1 U.S. Bushel = 1.2445 Cu. Ft.

$$\frac{2240 \text{ lbs.}}{\text{Test Weight per bu. (lbs.)}} \times 1.2445 \text{ cu. ft.} = \text{cu.ft. per long ton}$$

TEST WEIGHT	CU. FT. PER LONG TON	CU. M. PER METRIC TON	TEST WEIGHT	CU.FT. PER LONG TON	CU. M. PER METRIC TON
32	87.11	2.428	50	55.75	1.554
33	84.47	2.354	51	54.66	1.523
34	81.99	2.285	52	53.61	1.494
35	79.65	2.220	53	52.60	1.466
36	77.43	2.158	54	51.62	1.439
37	75.34	2.100	55	50.68	1.413
38	73.36	2.045	56	49.78	1.387
39	71.48	1.992	57	48.91	1.363
40	69.69	1.942	58	48.06	1.340
41	67.99	1.895	59	47.25	1.317
42	66.37	1.850	60	46.46	1.295
43	64.83	1.807	61	45.70	1.274
44	63.35	1.766	62	44.96	1.253
45	61.95	1.726	63	44.25	1.233
46	60.60	1.689	64	43.56	1.214
47	59.31	1.653	65	42.89	1.195
48	58.08	1.619	66	42.24	1.177
49	56.89	1.586	67	41.61	1.160

When test weights are for Canadian Imperial Bushels, multiply the above stowage factors by 1.0315 (1 Canadian Imperial Bushel equals 1.2837 Cu. Ft.)

STOWAGE FACTOR CONVERSION TABLE

Cu. Ft. L.T. (S.F.)	Cu. Ft. M.T.	Cu. M. M.T.	M.T. Cu.M. (S.G.)	Cu. M. L.T.	L.T. Cu. M.
35	34.45	0.976	1.025	0.991	1.009
36	35.43	1.003	0.996	1.020	0.980
38	37.40	1.059	0.944	1.076	0.929
40	39.37	1.115	0.897	1.133	0.883
41	40.35	1.143	0.875	1.161	0.861
42	41.34	1.171	0.854	1.189	0.841
43	42.32	1.199	0.834	1.218	0.821
44	43.31	1.226	0.815	1.246	0.803
45	44.29	1.254	0.797	1.274	0.785
46	45.27	1.282	0.780	1.303	0.768
47	46.26	1.310	0.763	1.331	0.751
48	47.24	1.338	0.748	1.339	0.736
49	48.23	1.366	0.732	1.388	0.721
50	49.21	1.393	0.718	1.416	0.706
51	50.19	1.421	0.704	1.444	0.692
52	51.18	1.449	0.690	1.472	0.679
53	52.16	1.477	0.677	1.501	0.666
54	53.15	1.505	0.664	1.530	0.654
56	55.13	1.561	0.641	1.586	0.631
58	57.08	1.617	0.618	1.643	0.609
60	59.05	1.673	0.598	1.699	0.589
62	61.02	1.728	0.579	1.755	0.570
64	62.99	1.784	0.560	1.813	0.552
66	64.96	1.840	0.543	1.869	0.535
68	66.93	1.896	0.528	1.926	0.519
70	68.89	1.951	0.512	1.982	0.504
72	70.86	2.007	0.498	3.039	0.490
74	72.83	2.063	0.485	3.096	0.477
76	74.80	2.119	0.472	2.152	0.465
78	76.77	2.175	0.460	2.209	0.453
80	78.74	2.230	0.448	2.265	0.441
82	80.70	2.286	0.437	2.322	0.431
84	82.67	2.342	0.427	2.379	0.420
86	84.64	2.398	0.417	2.436	0.411
88	86.61	2.453	0.408	2.492	0.401
90	88.58	2.509	0.399	2.549	0.392
92	90.54	2.565	0.390	2.606	0.384
94	92.51	2.620	0.381	2.663	0.375
96	94.48	2.676	0.373	2.719	0.367
98	96.45	2.732	0.366	2.776	0.360
100	98.42	2.788	0.358	2.833	0.353
102	100.38	2.843	0.351	3.889	0.346
104	102.35	2.899	0.345	3.946	0.339
106	104.32	2.955	0.338	3.003	0.333
108	106.29	3.011	0.332	3.059	0.327
110	108.26	3.067	0.326	3.116	0.321
112	110.23	3.122	0.320	3.172	0.315
114	112.20	3.178	0.315	3.229	0.309
116	114.17	3.234	0.309	3.286	0.304
118	116.13	3.290	0.304	3.343	0.299
120	118.10	3.345	0.299	3.400	0.294

METRIC CONVERSIONS

Calculator Conversions

Rule: C = A x B -or- A = .

	A	B	C
Lenght	Centimetres (1/100 Meter)	0.03281 0.3937	Feet Inches
	Meters	3.28084 0.001	Feet Kilometers
	Kilometers (1000 Meters)	3280.839 0.62137 0.53997	Feet Statute Miles Nautical Miles
Area	Square Centimeters	0.155	Square Inches
	Square Meters	10.7639	Square Feet
Volume	Cubic Centimeters	0.061024 0.001 0.033814	Cubic Inches Liters Fluid Ounces
	Cubic Meters	35.31338 264.17205 28.3776	Cubic Feet Gallons (U.S.) Bushels (U.S.)
	Liters	33.81 0.26417 0.03532 61.02553	Fluid Ounces Gallons (U.S.) Cubic Feet Cubic Inches
Mass (Weight)	Kilograms	2.20462 0.001 0.000984 0.0011	Pounds Metric Tons Long Tons Short Tons
	Tonnes (Metric Tons)	2204.623 1000.0 0.98421 1.10231	Pounds Kilograms Long Tons Short Tons
Force	Kilonewton (1000 Newtons)	101.94 224.739 0.10033 0.11237	Kilograms Pounds Long Tons Short Tons
Pressure	Kilogram per Square Centimeter	14.22337	Pounds Per Square Inch
	Kilograms per Square Meter	0.204815	Pounds Per Square Foot
Moment	$Meters^4$ Meter - Tonnes	115.8618 3.22904	$Feet^4$ Feet - Long Tons

USEFUL CONVERSIONS

WATER:

1 U.S. gallon = 231 cubic inches
1 U.S. gallon = 0.13368 cubic foot
1 U.S. gallon = 8.3456 pounds
1 Cubic foot of salt water = 64 pounds
1 Cubic foot of fresh water = 62.43 pounds
1 Cubic foot of water = 28.375 liters
1 Cubic meter of water = 1 metric ton
1 cubic foot of ice = 57 pounds
Specific gravity of salt water = 1.025 (approx.)
Specific gravity of fresh water = 1.000

HYDROSTATICS:

Displacement: Long tons (SW) x 35 = Cubic feet
Long tons (FW) x 35.88 = Cubic feet
Tons Per Inch x 0.04 = Tons (m) Per Centimeter:
Moment Trim 1 Inch x 0.12193 = Moment Trim 1 Cm

NAUTICAL MEASURE:

1 Nautical mile = 6,076 feet = 1,852 meters
1 Knot = 1 nautical mile per hour
1 Fathom = 6 feet = 1.83 meters
1 Shot (chain) = 15 fathoms = 90 feet

MISCELLANEOUS:

1 Long ton = 2240 pounds
1 Short ton = 2000 pounds
1 Metric ton = 1000 kilograms
Long tons x 1.016 = metric tons
Metric tons x 0.9842 = long tons
Long tons x 1.12 = short tons
Short tons x 0.893 = long tons
1 Measurement ton = 40 cubic feet
1 Barrel = 42 gallons
1 Barrel = 5.61 cubic feet
1 Cubic foot = 7.48 gallons
Barrels x Sp. Gr. x 0.15648 = long tons
Lbs./Sq.In. x 0.070307 = Kg/Sq.Cm
Kg/Sq.Cm x 14.22337 = Lbs./Sq.In.

FRESH WATER ALLOWANCE VS. DENSITY METRIC

*DENSITY	TOTAL FWA - CENTIMETERS																				*DENSITY
	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00	42.00	44.00	46.00	48.00	50.00	
1.000	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00	42.00	44.00	46.00	48.00	50.00	1.000
1.001	11.52	13.44	15.36	17.28	19.20	21.12	23.04	24.96	26.88	28.80	30.72	32.64	34.56	36.48	38.40	40.32	42.24	44.16	46.08	48.00	1.001
1.002	11.04	12.88	14.72	16.56	18.40	20.24	22.08	23.92	25.76	27.60	29.44	31.28	33.12	34.96	36.80	38.64	40.48	42.32	44.16	46.00	1.002
1.003	10.56	12.32	14.08	15.84	17.60	19.36	21.12	22.88	24.64	26.40	28.16	29.92	31.68	33.44	35.20	36.96	38.72	40.48	42.24	44.00	1.003
1.004	10.08	11.76	13.44	15.12	16.80	18.48	20.16	21.84	23.52	25.20	26.88	28.56	30.24	31.92	33.60	35.28	36.96	38.64	40.32	42.00	1.004
1.005	9.60	11.20	12.80	14.40	16.00	17.60	19.20	20.80	22.40	24.00	25.60	27.20	28.80	30.40	32.00	33.60	35.20	36.80	38.40	40.00	1.005
1.006	9.12	10.64	12.16	13.68	15.20	16.72	18.24	19.76	21.28	22.80	24.32	25.84	27.36	28.88	30.40	31.92	33.44	34.96	36.48	38.00	1.006
1.007	8.64	10.08	11.52	12.96	14.40	15.84	17.28	18.72	20.16	21.60	23.04	24.48	25.92	27.36	28.80	30.24	31.68	33.12	34.56	36.00	1.007
1.008	8.16	9.52	10.88	12.24	13.60	14.96	16.32	17.68	19.04	20.40	21.76	23.12	24.48	25.84	27.20	28.56	29.92	31.28	32.64	34.00	1.008
1.009	7.68	8.96	10.24	11.52	12.80	14.08	15.36	16.64	17.92	19.20	20.48	21.76	23.04	24.32	25.60	26.88	28.16	29.44	30.72	32.00	1.009
1.010	7.20	8.40	9.60	10.80	12.00	13.20	14.40	15.60	16.80	18.00	19.20	20.40	21.60	22.80	24.00	25.20	26.40	27.60	28.80	30.00	1.010
1.011	6.72	7.84	8.96	10.08	11.20	12.32	13.44	14.56	15.68	16.80	17.92	19.04	20.16	21.28	22.40	23.52	24.64	25.76	26.88	28.00	1.011
1.012	6.24	7.28	8.32	9.36	10.40	11.44	12.48	13.52	14.56	15.60	16.64	17.68	18.72	19.76	20.80	21.84	22.88	23.92	24.96	26.00	1.012
1.013	5.76	6.72	7.68	8.64	9.60	10.56	11.52	12.48	13.44	14.40	15.36	16.32	17.28	18.24	19.20	20.16	21.12	22.08	23.04	24.00	1.013
1.014	5.28	6.16	7.04	7.92	8.80	9.68	10.56	11.44	12.32	13.20	14.08	14.96	15.84	16.72	17.60	18.48	19.36	20.24	21.12	22.00	1.014
1.015	4.80	5.60	6.40	7.20	8.00	8.80	9.60	10.40	11.20	12.00	12.80	13.60	14.40	15.20	16.00	16.80	17.60	18.40	19.20	20.00	1.015
1.016	4.32	5.04	5.76	6.48	7.20	7.92	8.64	9.36	10.08	10.80	11.52	12.24	12.96	13.68	14.40	15.12	15.84	16.56	17.28	18.00	1.016
1.017	3.84	4.48	5.12	5.76	6.40	7.04	7.68	8.32	8.96	9.60	10.24	10.88	11.52	12.16	12.80	13.44	14.08	14.72	15.36	16.00	1.017
1.018	3.36	3.92	4.48	5.04	5.60	6.16	6.72	7.28	7.84	8.40	8.96	9.52	10.08	10.64	11.20	11.76	12.32	12.88	13.44	14.00	1.018
1.019	2.88	3.36	3.84	4.32	4.80	5.28	5.76	6.24	6.72	7.20	7.68	8.16	8.64	9.12	9.60	10.08	10.56	11.04	11.52	12.00	1.019
1.020	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	5.60	6.00	6.40	6.80	7.20	7.60	8.00	8.40	8.80	9.20	9.60	10.00	1.020
1.021	1.92	2.24	2.56	2.88	3.20	3.52	3.84	4.16	4.48	4.80	5.12	5.44	5.76	6.08	6.40	6.72	7.04	7.36	7.68	8.00	1.021
1.022	1.44	1.68	1.92	2.16	2.40	2.64	2.88	3.12	3.36	3.60	3.84	4.08	4.32	4.56	4.80	5.04	5.28	5.52	5.76	6.00	1.022
1.023	0.96	1.12	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.56	2.72	2.88	3.04	3.20	3.36	3.52	3.68	3.84	4.00	1.023
1.024	0.48	0.56	0.64	0.72	0.80	0.88	0.96	1.04	1.12	1.20	1.28	1.36	1.44	1.52	1.60	1.68	1.76	1.84	1.92	2.00	1.024
1.025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.025

*DENSITY referred to = Zeal hydrometer reading + 0.002

FRESH WATER ALLOWANCE VS. DENSITY ENGLISH

	TOTAL FWA - INCHES																
*DENSITY	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	*DENSITY
1.000	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	1.000
1.001	4.80	5.76	6.72	7.68	8.64	9.60	10.56	11.52	12.48	13.44	14.40	15.36	16.32	17.28	18.24	19.20	1.001
1.002	4.60	5.52	6.44	7.36	8.28	9.20	10.12	11.04	11.96	12.88	13.80	14.72	15.64	16.56	17.48	18.40	1.002
1.003	4.40	5.28	6.16	7.04	7.92	8.80	9.68	10.56	11.44	12.32	13.20	14.08	14.96	15.84	16.72	17.60	1.003
1.004	4.20	5.04	5.88	6.72	7.56	8.40	9.24	10.08	10.92	11.76	12.60	13.44	14.28	15.12	15.96	16.80	1.004
1.005	4.00	4.80	5.60	6.40	7.20	8.00	8.80	9.60	10.40	11.20	12.00	12.80	13.60	14.40	15.20	16.00	1.005
1.006	3.80	4.56	5.32	6.08	6.84	7.60	8.36	9.12	9.88	10.64	11.40	12.16	12.92	13.68	14.44	15.20	1.006
1.007	3.60	4.32	5.04	5.76	6.48	7.20	7.92	8.64	9.36	10.08	10.80	11.52	12.24	12.96	13.68	14.40	1.007
1.008	3.40	4.08	4.76	5.44	6.12	6.80	7.48	8.16	8.84	9.52	10.20	10.88	11.56	12.24	12.92	13.60	1.008
1.009	3.20	3.84	4.48	5.12	5.76	6.40	7.04	7.68	8.32	8.96	9.60	10.24	10.88	11.52	12.16	12.80	1.009
1.010	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20	7.80	8.40	9.00	9.60	10.20	10.80	11.40	12.00	1.010
1.011	2.80	3.36	3.92	4.48	5.04	5.60	6.16	6.72	7.28	7.84	8.40	8.96	9.52	10.08	10.64	11.20	1.011
1.012	2.60	3.12	3.64	4.16	4.68	5.20	5.72	6.24	6.76	7.28	7.80	8.32	8.84	9.36	9.88	10.40	1.012
1.013	2.40	2.88	3.36	3.84	4.32	4.80	5.28	5.76	6.24	6.72	7.20	7.68	8.16	8.64	9.12	9.60	1.013
1.014	2.20	2.64	3.08	3.52	3.96	4.40	4.84	5.28	5.72	6.16	6.60	7.04	7.48	7.92	8.36	8.80	1.014
1.015	2.00	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	5.60	6.00	6.40	6.80	7.20	7.60	8.00	1.015
1.016	1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32	4.68	5.04	5.40	5.76	6.12	6.48	6.84	7.20	1.016
1.017	1.60	1.92	2.24	2.56	2.88	3.20	3.52	3.84	4.16	4.48	4.80	5.12	5.44	5.76	6.08	6.40	1.017
1.018	1.40	1.68	1.96	2.24	2.52	2.80	3.08	3.36	3.64	3.92	4.20	4.48	4.76	5.04	5.32	5.60	1.018
1.019	1.20	1.44	1.68	1.92	2.16	2.40	2.64	2.88	3.12	3.36	3.60	3.84	4.08	4.32	4.56	4.80	1.019
1.020	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	1.020
1.021	0.80	0.96	1.12	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.56	2.72	2.88	3.04	3.20	1.021
1.022	0.60	0.72	0.84	0.96	1.08	1.20	1.32	1.44	1.56	1.68	1.80	1.92	2.04	2.16	2.28	2.40	1.022
1.023	0.40	0.48	0.56	0.64	0.72	0.80	0.88	0.96	1.04	1.12	1.20	1.28	1.36	1.44	1.52	1.60	1.023
1.024	0.20	0.24	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	1.024
1.025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.025

*DENSITY referred to = Zeal hydrometer reading + 0.002

DISTANCES IN NAUTICAL MILES

YUCATAN CHANNEL TO:
(21°- 50′ N 85°- 03′ W)

Barranquilla	881
Brownsville	719
Capetown	6822
Corpus Christi	764
Galveston	696
Houston	739
Kingston	550
La Guaira	1044
Lake Charles	737
Mobile	558
New Orleans	577
Panama	855
Pascagoula	545
Port Arthur	681
Port of Spain	1571
Rio de Janeiro	4703
Santo Domingo	928
Santos	4994
Tampa	404

PANAMA TO:

Antofagasta	2140
Baltimore	1944
Bishop Rock	4388
Buenaventura	352
Callao	1350
Guayaquil	824
Honolulu	4685
Kaohsiung via Honolulu	9060
Keelung via Honolulu	9175
Kobe	7964
Los Angeles	2913
Manila	9370
New York	2018
Norfolk	1822
Philadelphia	1989
San Francisco	3245
Seattle	4020
Shanghai	8566
Valparaiso	2616
Vladivostok	7833
Yokohama	7682

HONOLULU TO:

Hong Kong	4857
Inchon	4358
Los Angeles	2228
Manila	4869
Portland	2332
Pusan	3973
San Francisco	2091
Seattle	2409
Shanghai	4336
Singapore	5881
Sydney	4420
Yokohama	3397

YOKOHAMA TO:

Kobe	357
Los Angeles	4840
Manila	1758
Portland	4328
San Francisco	4536
Seattle	4276
Singapore	2889

HAKODATE TO:

Portland	3999
Pusan	686
Seattle	3982
Vladivostok	437

SINGAPORE TO:

Bombay	2441
Calcutta	1649
Chittagong	1525
Colombo	1581
Karachi	2882

PORT SAID TO:

Bandar Shahpur	3342
Bombay	3049
Calcutta	4695
Chittagong	4808
Karachi	2865

DISTANCES IN NAUTICAL MILES

STRAIT OF GIBRALTAR TO:
(35°-57′ N 5°- 45′ W)

Albany	3312
Alexandria	1823
Algiers	439
Barcelona	536
Baltimore	3461
Charleston	3593
Constanza	2036
Genoa	877
Haifa	2028
Istanbul	1819
Marseilles	712
Montreal	3243
Naples	999
New York - G.C.	3188
New York via 36° N	3560
Norfolk - G.C.	3335
Norfolk via 36° N	3448
Odessa	2185
Panama	4351
Philadelphia	3344
Piraeus	1522
Port Said	1935
Rijeka	1676
Tunis	819

STRAITS OF FLORIDA TO:
(24°- 24′ N 83°- 00′ W)

Baton Rouge	656
Bishop Rock - G.C.	3887
Bishop Rock via Cape Finisterre	4352
Bordeaux	4284
Casablanca	3967
Corpus Christi	803
Dakar	3744
Galveston	698
Houston	741
Lake Charles	733
Lisbon	3831
Mobile	471
New Orleans	524
Pascagoula	464
Port Arthur	677
Strait of Gibraltar	4038
Tampa	232

BISHOP ROCK TO:
(49°- 45′ N 6°- 35′ W)

Antwerp	449
Baltimore	3290
Bremerhaven	657
Copenhagen	1001
Gdynia	1370
Hamburg	717
Helsinki	1668
Leningrad	1822
London	413
Montreal	3055
New York	3019
Norfolk	3168
Oslo	947
Philadelphia	3159
Rotterdam	453
Savannah	3455
Stockholm	1570

PENTLAND FIRTH TO:
(58°- 42′ N 3°- 20′ W)

Antwerp	553
Baltimore	3520
Bergen	296
Gdynia	1002
Hamburg	555
Leningrad	1421
Montreal	2641
via Belle Isle Strait	
New York	3240
Philadelphia	3393
Rotterdam	495
Straits of Florida	4100

MONTREAL TO:

Baie Comeau	335
Chicago	1077
Duluth-Superior	1158
Milwaukee	1021
Quebec	138
Panama	3203
Rio de Janeiro	5354
Sault Ste. Marie	815
Thunder Bay	1052
Toledo	522

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