

BULK MINERAL CARGO LIQUEFACTION

PUBLISHED BY SKULD IN COOPERATION WITH BROOKES BELL
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1) INTRODUCTION

In 2013, Skuld published the first edition of Bulk Mineral Cargo Liquefaction Pocket Book to assist our Members and their crew in identifying the hazards and safeguards against bulk cargoes which may liquefy during carriage. It was reported at the time that between 2010 and 2013 liquefaction casualties cost the marine insurance industry over USD 100 million. Since first publishing this booklet there has been a continued focus on such cargoes and revisions of international conventions to further safeguard against casualties. Unfortunately, there has continued to be serious incidents where the cause has been cargo shift or liquefaction. Intercargo has kindly supplied the Club with updated statistics relating to bulk carrier casualties and between 2008 and 2017 a total of 53 bulk carriers over 10,000 deadweight tons have been identified as total losses, 9 of which have identified cargo failures as a cause. Sadly these losses also accounted for 101 lives lost over the same period.

To continue to highlight and assist our Members and their crew, Skuld has taken this opportunity to revise this booklet with the assistance of Brookes Bell so that it reflects the updated regulations currently in force.

THE PURPOSE OF THIS GUIDE

- Cargoes at risk of liquefaction continue to be shipped.
- The IMSBC (International Maritime Solid Bulk Cargoes) Code started out as the BC Code, first issued in 1965, and became mandatory under SOLAS in January 2011.
- The fully mandatory version, at the time of writing, is the 2016 Edition of the IMSBC Code. The amendments included in the 2018 edition may be applied on a voluntary basis from January 2018, and will be mandatory from 1 January 2019.
- The purpose of the IMSBC Code is to provide guidance on the procedures to be adopted when solid bulk cargoes are to be shipped.

- The Code applies to all ships over 500 gross tonnes, when they are carrying bulk cargoes, regardless of whether or not they are called a 'bulk carrier'.
- The Code **applies to all** solid bulk cargoes, except grain.
- Compliance with the Code is mandatory.

The details of mineral cargoes are listed in Appendix 1 of the IMSBC Code, with advice on their properties, handling and carriage. This listing is not exhaustive, which means that not all types of cargo may be named specifically.

It is a requirement of SOLAS that each ship must comply with IMSBC Code. Therefore a current copy should be kept on board, and the Master should ensure that they are familiar with the contents.

HAZARDS OF SHIPPING BULK MINERAL CARGOES

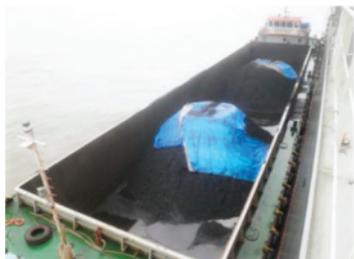
The IMSBC Code draws attention to hazards associated with shipments of wet/damp solid bulk mineral cargoes, as follows:

1. Mineral cargoes are often high density. Therefore their distribution in the holds must be considered, as improper distribution of the cargo may lead to the ship being structurally damaged.
2. They are often loaded at a very fast pace; with the result that loading may stress the hold plating.
3. The loss of, or reduction in, the stability of the ship during the voyage, that may be due to:
 - a) A shift of cargo due to inadequate trimming or improper distribution of the cargo.
 - b) A wet cargo liquefying under the stimulus and vibration or motion of the ship, then sliding or flowing to one side of the cargo compartment.
 - c) Bauxite behaves in a similar way to other mineral cargoes, but the technical description of this behaviour is referred to as 'dynamic separation' (IMO CCC.1/Circ.2/Rev.1 September 2017).

SHIPPERS MUST SUPPLY CORRECT DOCUMENTS

All solid bulk cargoes should have a Bulk Cargo Shipping Name (BCSN – these can be in French, Spanish or English and are listed in the Code in Appendix 4 and 5) given by the shippers and will have a schedule in Appendix 1 of the Code.

- The schedules in the Code are not exhaustive and the properties are given for guidance only.
- It is essential that valid current information is obtained from the shipper before loading is started and that information is given as a declaration, as set out in Section 4 of the Code, on a Cargo Information (or declaration) Form.
- If shippers are offering a solid bulk mineral cargo the name of which is NOT LISTED in the Code, then the 'new' cargo must be assessed, at least by the competent authority of the port of loading (Section 1.3 in the Code).
- In this case, the shipper shall provide details of the characteristics and properties of the proposed cargo and the competent authority will assess the acceptability of the cargo for safe shipment. The competent authority shall provide the Master with a certificate stating the characteristics of the cargo, its required conditions of carriage and handling requirements.
- If the cargo possesses hazards e.g., that it might liquefy, the competent authority of the unloading port and the flag state will become involved to determine the suitable conditions for carriage of the cargo, i.e., either Group A and B, or just Group B. If the cargo presents no specific hazards, the cargo shall be authorized for carriage, by the competent authority, as Group C.
- Once these procedures have been followed and completed satisfactorily, the cargo may be loaded.



Loading from barges is commonly done in many parts of the world.

2) TYPES OF SOLID BULK CARGOES – THE GROUPS

The characteristics of solid bulk cargoes have been divided into three groups; Group A, Group B and Group C.

- **Group A**** - cargoes which may liquefy if shipped at a moisture content in excess of their transportable moisture limit.
- **Group B** - cargoes which possess a chemical hazard which could give rise to a dangerous situation on the ship.
- **Group C** - cargoes which are neither liable to liquefy (Group A) nor possess chemical hazards (Group B).
- Some mineral cargoes can be both Group A and Group B, i.e., they may liquefy, and have a chemical hazard as well.

Transportable Moisture Limit (TML) – the name says it all, it is the maximum moisture content, which is considered safe for carriage of Group A cargoes. It is given as a percentage.

The moisture content of the cargo (which may be referred to as ‘MC’) is also given as a percentage, and must be established by the shipper within 7 days of loading.

Providing the moisture content is less than the TML, the cargo meets the carriage requirements of the Code.

If shippers report a Flow Moisture Point (FMP), the TML will be 90% of this value. It is always worth checking shipper’s calculations on this matter.

Five test methods are used to determine TML in the 2018 edition of the Code, only two of which produce an FMP, but all give a TML. An additional TML method for BAUXITE will be included in future editions of the Code. Shippers should provide the test certificates stating what test method was used to determine the TML. If in doubt, seek advice.

NOTE: the TML test methods for IRON ORE FINES and for COAL only apply to these cargoes and are not applicable to other cargoes unless specified by the IMO/Code.

'Can tests' are often used by Masters to provide further information (see Section 8 of the Code). It must be noted that the 'CAN TEST' is NOT a substitute for laboratory testing, and only provides a 'rough idea' on the state of the cargo.

If 'can tests' fail, then loading should be stopped and the Master should seek advice.

*** The IMO has indicated that some Bauxite cargoes should be treated as Group A cargoes with the BCSN of BAUXITE FINES until the Bauxite schedule is amended in the IMSBC Code (IMO CCC.1/Circ.2/Rev.1 September 2017).*

3) WHY ARE MINERAL BULK CARGOES SUCH AN ISSUE?

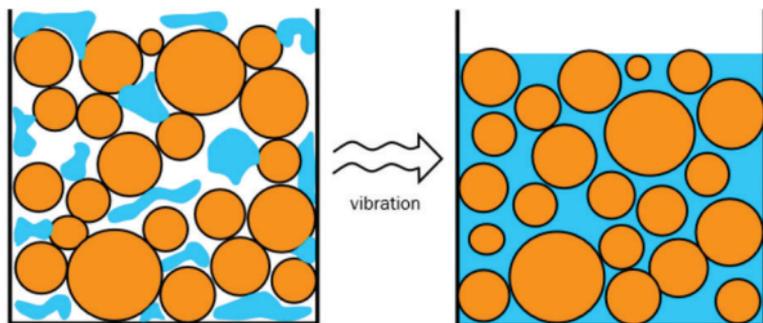
WHY DO SOME MINERAL CARGOES LIQUEFY?

The Code lists a number of mineral cargoes and their properties. Many mineral cargoes are fine-grained and loaded while wet/damp. They may be wet due to the industrial processing conducted by the shippers or stockpiles that have been exposed to rain before loading.

If the particles of the mineral cargo are in contact with each other, friction will hold them together.

Large particles, commonly known as 'lumps' are big enough for contact between them to be maintained regardless of any vibrations and/or ship motions during the voyage. This contact allows water to drain. Therefore, cargoes consisting of lumps often require the bilges to be pumped during a voyage, and are Group C cargoes.

Small particles, commonly known as 'fines' or 'concentrates' often do not drain as quickly as lumps, they may not drain at all. If these cargoes are loaded with a moisture contents above their TML, then they may settle, and become fully saturated. When this happens, they may liquefy.



When particles are in contact with each other, friction between them maintains the cargo structure even when there is water and air mixed in.

When particles are NOT in contact, water can flow between them. This results in fluid flow as the mineral cargo liquefies.

When the particles are surrounded by water and lose contact with each other, the whole cargo can behave like a dense liquid and will flow. This is what makes them Group A.

Some fine-particled cargoes that drain allow a 'wet-base' to form. This should be detailed on the shippers' declaration.

WHY IS LIQUEFACTION DANGEROUS ON A SHIP?

As most mineral cargoes are dense and likely to liquefy when the moisture content is above their TML, they can 'walk up the hold plating' when the vessel rolls, i.e., they flow towards the downside of the roll, but do not necessarily flow back. On each subsequent roll, the cargo might move further to the same side. This is unlike water and grain (which flow back), and may result in a large amount of heavy cargo resting against the hold side plating.

If a liquefied cargo moves during a voyage, the ship might suffer a loss of or reduction in stability due to the cargo shifting. There is a risk that the ship will list as a result of the cargo shift. If the cargo continues to shift to one side, the ship will list more heavily to that side and, if the shift is excessive, there will be down-flooding of sea water into ships tanks and may cause the ship to capsize and sink.

Group A cargoes should only be carried when the moisture content of the cargo is less than, or equal to, the Transportable Moisture Limit of the cargo. The Transportable Moisture Limit (TML) can be calculated as 90% of the Flow Moisture Point (FMP), depending on the test method used.

WHY DOES THE NATURE OF SOME CARGOES CAUSE CONFUSION?

Some people involved with shipping mineral cargoes may not understand the properties of Group A materials and may offer incorrect information. This may be because:

- Many mineral cargoes will 'look OK' even when they are wet – that does not mean they are safe for carriage. Visual appearance can be deceptive.
- Group A cargoes may not always liquefy if the voyage is calm and the movement of the ship does not result in significant energy transfer to the cargo.
- Shippers may use trade or commercial names for the cargo – a BCSN should always be provided for the cargo.
- The cargo may not be listed in the IMSBC Code – shippers should apply for Section 1.3 approval.
- Shippers may not have a copy of the IMSBC Code, they may not have read it or they may not understand it.
- Some shippers think that if a cargo is not listed it is not controlled by the Code. This is not correct. All solid bulk commodities that are put forward for shipment are controlled by the IMSBC Code.

Since the last edition of this Pocket Guide, there have been some additional mineral cargo entries and modifications to existing ones as these relate to liquefaction/dynamic separation and Group A:

Additional mineral cargo entries

IRON ORE FINES

NICKEL ORE

Several 'sand' entries, e.g., TITANOMAGNETITE SAND and OLIVINE SAND

COAL is to be classified as Group A and B unless testing shows it to be only Group B, i.e., all COAL cargoes will have to be tested to ensure they are not Group A.

The Bauxite entry will be split in the next edition of the Code into BAUXITE FINES (Group A) and BAUXITE (Group C), with an additional TML test for this cargo to be included as well (as per the Bauxite circular).

It is advisable to treat all finely granular and damp cargoes as potentially Group A (as per Appendix 3, para 2.1 of the Code) regardless of any shippers' declarations to the contrary.

4) LOADING BULK MINERAL CARGOES SAFELY

While the voyage is being planned, the Master should refer to the procedures set out in the ship's Safety Management System. In addition, the Master and Chief Officer should consult the appropriate IMO publications, including the IMSBC Code, the BLU Code and recommendations on ballast water management.

CHECKLIST FOR MASTERS AND OFFICERS TO FOLLOW BEFORE LOADING

- Ensure that the identity of the cargo to be carried is known and that the name of the cargo is described by using the Bulk Cargo Shipping Name (BCSN), as detailed in the IMSBC Code. A trade name is not a BCSN.
- Ensure that the cargo holds are properly and appropriately cleaned, as well as being prepared for the cargo that is going to be loaded.
- Ensure that all necessary maintenance has been completed before loading starts.
- Plan the loading operation thoroughly, following all SMS and BLU Code requirements and all appropriate instructions.
- Ensure that the appropriate carriage instructions are obtained in advance.

CHECKLIST OF DOCUMENTS REQUIRED BEFORE LOADING

A list of information can be found in IMSBC Code sub-section 4.2, shippers

should give this to the Master for all solid bulk cargoes before loading. This should include:

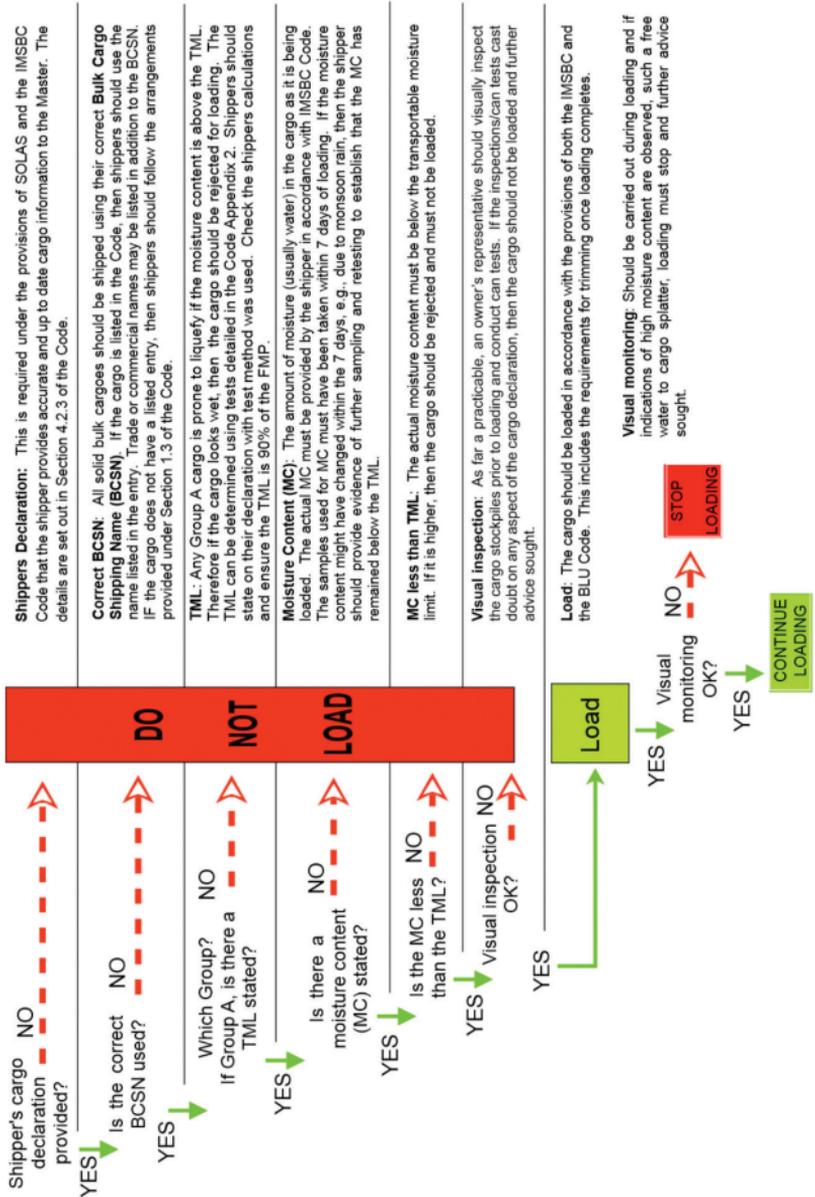
- The Bulk Cargo Shipping Name (BCSN) when the cargo is listed in this Code. Trade or commercial names can be used in addition, but not in substitution to the Bulk Cargo Shipping Name.
- For unlisted cargoes, a certificate from the Competent Authority under Section 1.3 of the Code.
- The cargo Group (A and B, or A, or B, or C).
- If listed as MHB (material hazardous only in bulk), information about the hazard should be included.
- The total quantity of the cargo offered.
- The stowage factor.
- The need for trimming and the trimming procedures.
- The likelihood of shifting.
- Group A - a certificate of the transportable moisture limit (TML). This can be tested up to six months before loading.
- Group A - a certificate on the moisture content of the cargo dated within seven days prior to loading. If it rains after the certificate has been provided the shipper should give an updated moisture value.
- Group A – a certificate from the Competent Authority of the load port confirming approval of the shippers' Moisture Management and Control Procedures (as per para 4.3.3 in the Code).
- Likelihood of a wet base forming (see sub-section 7.2.3 of the Code).
- Toxic or flammable gases that may be generated by cargo.
- Flammability, toxicity, corrosiveness and propensity to oxygen depletion of the cargo.

- Self-heating properties of the cargo, and if trimming is required.
- Properties on the emission of flammable gases that may be in contact with water.
- Radioactive properties.
- A MARPOL statement - Solid bulk cargoes should be classified and declared by the shipper as to whether or not they are harmful to the marine environment (HME). Disposal of cargo residues and hold washings can only be discharged as per the most up to date regulations of MARPOL Annex V (see Section 14 of the current edition of the Code).
- Any other information required by national authorities.



Discharging very wet cargo can be difficult.

FLOW CHART LOADING GROUP A CARGOES



Shippers Declaration: This is required under the provisions of SOLAS and the IMSBC Code that the shipper provides accurate and up to date cargo information to the Master. The details are set out in Section 4.2.3 of the Code.

Correct BCSN: All solid bulk cargoes should be shipped using their correct **Bulk Cargo Shipping Name (BCSN)**. If the cargo is listed in the Code, then shippers should use the name listed in the entry. Trade or commercial names may be listed in addition to the BCSN. If the cargo does not have a listed entry, then shippers should follow the arrangements provided under Section 1.3 of the Code.

TML: Any Group A cargo is prone to liquefy if the moisture content is above the TML. Therefore if the cargo looks wet, then the cargo should be rejected for loading. The TML can be determined using tests detailed in the Code Appendix 2. Shippers should state on their declaration with test method was used. Check the shippers calculations and ensure the TML is 90% of the FMP.

Moisture Content (MC): The amount of moisture (usually water) in the cargo as it is being loaded. The actual MC must be provided by the shipper in accordance with IMSBC Code. The samples used for MC must have been taken within 7 days of loading. If the moisture content might have changed within the 7 days, e.g., due to monsoon rain, then the shipper should provide evidence of further sampling and retesting to establish that the MC has remained below the TML.

MC less than TML: The actual moisture content must be below the transportable moisture limit. If it is higher, then the cargo should be rejected and must not be loaded.

Visual inspection: As far as practicable, an owner's representative should visually inspect the cargo stockpiles prior to loading and conduct can tests. If the inspections/can tests cast doubt on any aspect of the cargo declaration, then the cargo should not be loaded and further advice sought.

Load: The cargo should be loaded in accordance with the provisions of both the IMSBC and the BLU Code. This includes the requirements for trimming once loading completes.

Visual monitoring: Should be carried out during loading and if indications of high moisture content are observed, such a free water to cargo splatter, loading must stop and further advice sought.

WHAT SHOULD THE MASTER AND OFFICERS LOOK OUT FOR DURING LOADING?

- Is it or has it been raining?
- Have shippers provided all the required information on their declaration?
- How does the cargo behave when subjected to a 'can test'?
 - a) Is there any free water on the surface after the 'can test', i.e., does the surface appear shiny with free water?
 - b) Has the sample in the can changed form, i.e., does it flow and form a flat surface?
- If in doubt, seek advice.

DURING THE VOYAGE – WHAT TO LOOK FOR

The purpose of this guide is to help the master/CO/OOW prevent, if possible, an incident from occurring as a result of the cargo properties changing during the voyage.

- The cargo should be checked frequently, looking out for signs of free water on the surface, flattening out of the surface and fluid flow. When entering the holds, safe entry procedures must be used.
- If any of these are seen, contact the vessel DPA immediately as per the company SMS and request expert technical assistance.

BEST PRACTICE AND SEAMANSHIP

Points to be considered include:

- If the cargo has shifted and the list is corrected by ballast operations, what happens if the cargo shifts again?
- The cargo may act like a dense fluid when it flows around the hold(s), therefore ballasting operations may result in significant additional problems.
- What are the prevailing weather conditions?

- Is the vessel rolling? Can this be reduced or minimised by changing of heading and/or speed?
- It is recommended that if there is cargo shift, a reduction in speed will help to minimise rolling and/or pitching, and engine/hull vibrations. In addition, sharp helm movements should be avoided.
- Consider the distance to land (Port of Refuge) along with the current heading and prevailing weather conditions.
- Avoid turning the vessel through the swell and/or wind waves, as this may cause rolling and additional shifting of the cargo.

5) THE LAW

Masters will of course know that their vessel is under the charterer's employment orders and provided the orders are "lawful", the Master should follow them.

The most important factor, however, is the safety of the crew, followed by the vessel's safety. The Master should use his discretion to take any decision that, in his professional judgment, is necessary for safety of life at sea: SOLAS Chapter V, Regulation 34-1. The Master can also refuse, for the security of the vessel, to load cargo and grant access to his vessel: SOLAS Chapter XI-2 Regulation 8.

It is a legal requirement under the provisions of SOLAS Chapter VI, Regulation 2 and the IMSBC Code Section 4.2 for the shipper to provide accurate cargo information.

Furthermore SOLAS Chapter VI, Regulation 6-2 and Regulation 7-7 provide that cargo must not be laden if the actual moisture content exceeds the TML and that the Master has the right to suspend cargo operations if limits are exceeded.



Furthermore, where applicable, the Hague Visby Rules, Article IV Rule 6 states that a Master can seek a Port of Refuge if the cargo on board becomes a danger to the vessel, even if the cargo was carried by consent and with knowledge about its character.

Apart from general law, contractual law and international convention, a Master should always feel able to take steps he feels are necessary to ensure the safety of his crew and the ship.

6) P&I CLUB NOTIFICATION REQUIREMENTS

MANDATORY NOTIFICATION REQUIREMENTS

Whilst it remains the Members' responsibility to ensure full compliance with the IMSBC Code and to take any necessary measures to ensure the safe carriage of nickel ore cargoes from ports in Indonesia and the Philippines, Members who plan to either fix or charter a ship to load nickel ore from these ports or if a ship under an existing fixture is ordered to load such cargo, must contact the Association as soon as possible and provide the following information:

- Ship name.
- Port/anchorage of loading and estimated time of arrival.
- Date of intended loading.
- Charterer/shipper's details.
- Agent's details.
- Copy of the shipper's cargo declaration and supporting certificates.

This will enable the Association to provide members with relevant information on measures that might be taken to reduce risks, e.g., the appointment of a local surveyor to assist the Master, and the appointment of an expert, not necessarily to attend in person but to liaise and supervise the local surveyor.

These measures may reduce the inherent risks in the carriage of nickel ore cargoes but do not guarantee safety.

If the Master is in any doubt at all about the suitability and safety of the cargo, then loading should be stopped.

The member should contact the Association immediately. It is likely there will be problems if loading an unsafe cargo is allowed. For example, it will be difficult to discharge the cargo due to the lack of facilities in the loading port or complications arising from local customs regulations.

POSSIBLE PREJUDICE TO CLUB COVER

Members should be aware that they may prejudice their cover if they fail to notify the Association that they plan to fix or charter a ship, or that a ship has been ordered, to load nickel ore from a port in Indonesia or the Philippines.

The Association would in any event recommend members to make contact if they are planning on carrying cargoes known or suspected to be at risk of liquefaction/dynamic separation.

7) LIST OF RELEVANT REFERENCE DOCUMENTS

- International Maritime Solid Bulk Cargo Code (IMSBC) – current edition.
- Nickel Ore: STOP, THINK, VERIFY. Intercargo Guide for the safe loading of Nickel Ore.
- SKULD web site – www.skuld.com/topics/
- Bauxite Circular issued 20 September 2017 as CCC.1/Circ.2/Rev.1 – draft amendments to IMSBC Code expected to be adopted by MSC (101) in 2019 for the 2020 Edition of the Code.
- The BLU Code – The Code of Practice for the Safe Loading and Unloading of Bulk Carriers (including the BLU Manual).
- Thomas' Stowage.

8) THE IMSBC CODE SECTIONS

- Section 1 General provisions – including application, definitions, related SOLAS regulations.
- Section 2 General loading, carriage and unloading precautions – cargo distribution and loading/unloading procedures.
- Section 3 Safety of personnel and ship.
- Section 4 Assessment of acceptability of consignments for safe shipment – identification of cargoes, and the tests and documentation required for their safe carriage.
- Section 5 Trimming procedures.

- Section 6 Methods of determining angle of repose – does not apply to mineral cargoes.
- Section 7 Cargoes that may liquefy – the dangers of liquefaction, conditions under which liquefaction may take place and precautions to prevent it.
- Section 8 Test procedures for cargoes that may liquefy.
- Section 9 Materials possessing chemical hazards – classification of hazards, stowage and segregation requirements.
- Section 10 Carriage of solid bulk wastes.
- Section 11 Security provisions.
- Section 12 Stowage factor conversion tables.
- Section 13 References to related information and recommendations.
- Section 14 Prevention of pollution by cargo residues from ships.

APPENDICES

- Appendix 1 Individual schedules of solid bulk cargoes.
 - Appendix 2 Laboratory test procedures, associated apparatus and standards.
 - Appendix 3 Properties of solid bulk cargoes.
 - Appendix 4 Index of solid bulk cargoes and some trade names.
 - Appendix 5 Bulk Cargo Shipping Names in three languages (English, French and Spanish).
- Supplement - This contains supporting documents including the BLU Code and IMO circulars (see Appendix 1).

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