THE REPUBLIC OF LIBERIA
LIBERIA MARITIME AUTHORITY

8619 Westwood Center Drive
Suite 300
Vienna, Virginia 22182, USA
Tel: +1 703 790 3434
Fax: +1 703 790 5655
Email: Technical@liscr.com
Web: www.liscr.com

12 February 2018

Marine Advisory: 02/2018
(This Marine Advisory supersedes Marine Advisory 01/2016)

SUBJECT: Carriage of Bauxite and other solid bulk cargoes that may liquefy

Dear Shipowner/Operator/Master:

The purpose of this Marine Advisory is to provide guidance for safe transport of bauxite, including the accurate declaration on cargoes; the potential risks associated with the carriage of certain Group A bauxite in bulk due to its potential to undergo dynamic separation.

The investigation into the loss of the M.V. BULK JUPITER in 2015 with a cargo of bauxite, suggested liquefaction of the bauxite cargo led to a loss of stability resulting in the vessels capsizing and sinking. Pursuant to this casualty, the International Maritime Organization (IMO) published CCC.1/Circ.2 on *Carriage of Bauxite that may liquefy*. At the time, bauxite was listed in the IMSBC Code as a Group C cargo (cargoes neither liable to liquefy- Group A or possess chemical hazards- Group B).

In 2016, the Global Bauxite Working Group (GBWG) was established to provide a peer reviewed report on the nature of bauxite cargoes and develop a globally applicable transportable moisture limit (TML) test for bauxite cargoes.

The peer reviewed report of the GBWG indicated that Bauxite Fines containing more than 30% of fine particles less than 1 mm; and more than 40% of particles less than 2.5 mm (Group A) may suffer instability due to moisture content, resulting in dynamic separation and formation of a liquid slurry (water and fine solids) above the solid material, and a free surface effect which may significantly affect the ship's stability. This cargo is not liable to undergo dynamic separation when the cargo is shipped below its TML.

In September 2017, following further discussion at the IMO and having noted that some Bauxite cargoes should be classified as Group A, the following were finalized:

1. the draft Test Procedure for Determining the TML for Bauxite;

2. the draft individual schedule for Bauxite of Group A having the Bulk Cargo Shipping Name "BAUXITE FINES"; and

3. the draft amendments to the individual schedule for Bauxite of Group C.

Pending adoption of the draft amendments referred to in the paragraph above in 2019 and expected entry into force of the draft amendments to the IMBSC Code on 1 January 2021, Shipowners, Operators and Masters should exercise extreme care and appropriate action, taking into account the provisions of relevant IMO instruments when handling and carrying Bauxite in bulk and the conditions in the attached IMO circular, CCC.1/Circ.2/Rev.1.

Below is the link to AMSA website where an explanation of dynamic separation phenomena in bauxite cargoes is outlined and a video is given showing the effect of the free slurry surface on the vessels stability.

https://www.amsa.gov.au/vessels-operators/cargoes-and-dangerous-goods/dynamic-separation-cargoes

The AMSA website may be slow to load the video, so it is now also available on YouTube.

https://youtu.be/zdyrQSypPBQ

Masters are also encouraged to consult section 7 of the IMSBC Code, for additional information on cargoes that may liquefy and may carry out a check test for approximately determining the possibility of flow by the auxiliary method prescribed in section 8 of the IMSBC Code.

For more information, please contact the Technical Department at Technical@liscr.com or telephone +1 703 790 3434.

Enclosure: **CCC.1/Circ.2/Rev.1**

* * * * *

INTERNATIONAL MARITIME ORGANIZATION

E

4 ALBERT EMBANKMENT
LONDON SE1 7SR
Telephone: +44 (0)20 7735 7611 Fax: +44 (0)20 7587 3210

CCC.1/Circ.2/Rev.1
20 September 2017

CARRIAGE OF BAUXITE WHICH MAY LIQUEFY

1 The Sub-Committee on Carriage of Cargoes and Containers (CCC), at its second session (14 to 18 September 2015), considered matters related to the carriage of Bauxite, including some initial considerations of the circumstances surrounding the loss of the 10-year-old Bahamas flag Supramax bulk carrier **Bulk Jupiter** with the loss of 18 lives on 2 January 2015. In this context, the Sub-Committee noted that loss of the aforementioned ship may have been caused by liquefaction of the cargo.

2 Bauxite is described in the International Maritime Solid Bulk Cargoes (IMSBC) Code as a Group C cargo. However, subsequent work undertaken by the industry Global Bauxite Working Group (GBWG) in conjunction with competent Authorities indicate that Bauxite presents a risk caused by moisture. As such some Bauxite cargoes should be treated as Group A cargoes.

3 The Sub-Committee, at its second session, approved CCC.1/Circ.2 to raise awareness on the potential risks posed by moisture in the carriage of Bauxite. The advice provided by this circular has been superseded by the outcome of the research undertaken.

4 The Sub-Committee, at its fourth session (11 to 15 September 2017), having noted that some Bauxite cargoes should be classified as Group A, finalized:

.1 the draft Test Procedure for Determining the TML for Bauxite;

.2 the draft individual schedule for Bauxite of Group A having the Bulk Cargo Shipping Name "BAUXITE FINES"; and

.3 the draft amendments to the individual schedule for Bauxite of Group C,

as set out in annexes 1 to 3, respectively, for submission to the Maritime Safety Committee.

5 The Sub-Committee, noting that:

.1 a Bauxite cargo of Group A is not listed in the IMSBC Code and shall be carried in accordance with subsection 1.3 of the Code; and

IMO WORLD MARITIME DAY 2017
CONNECTING SHIPS, PORTS AND PEOPLE

.2 the draft amendments referred to in paragraph 4 are expected to be adopted by the Maritime Safety Committee (MSC 101, in 2019) and the date of entry into force of these draft amendments to the IMBSC Code is expected to be 1 January 2021,

decided to invite Member States to take the aforementioned draft Test Procedure and draft individual schedules for Bauxite of Group A and Group C into consideration at the time of:

.1 classification of Bauxite cargoes as Group A or Group C; and

.2 setting the preliminary suitable conditions for the carriage of this cargo in accordance with subsection 1.3 of the Code, when the cargo is classified as Group A.

6 Member States are invited to note the following observation by the GBWG:

"That an atypical motion of the ship (wobbling) may also be indicative of cargo instability. The master should take appropriate action."

This atypical motions (or wobble) is caused by the movement of a free surface slurry over the top of the cargo which is out of phase with the roll period of the ship. If left unchecked this movement of cargo has the potential to further reduce stability and the risk of capsize.

7 Member States are also invited to bring the above information to the attention of shippers, terminal operators, shipowners, ship operators, charterers, shipmasters and all other entities concerned, requesting that extreme care and appropriate action be taken, taking into account the provisions of relevant IMO instruments when handling and carrying Bauxite in bulk.

8 This circular supersedes CCC.1/Circ.2.

***

ANNEX 1

DRAFT TEST PROCEDURE FOR DETERMINING THE TML FOR BAUXITE

1.6 Modified Proctor/Fagerberg test procedure for Bauxite

1.6.1 *Scope*

.1 The test procedure specified in this section (this test) should only be used for determining transportable moisture limit (TML) of Bauxite cargoes containing both:

.1 more than 30% of fine particles less than 1 mm (D_{30} < 1 mm); and

.2 more than 40% of particles less than 2.5 mm (D_{40} < 2.5 mm).

.2 The TML of a cargo is taken as equal to the critical moisture content at 80% degree of saturation according to the Modified Proctor/Fagerberg test procedure for Bauxite where the Optimum Moisture Content (OMC) of the Bauxite tested occur at saturation levels greater than or equal to 90%.

.3 The TML of a cargo is taken as equal to the critical moisture content at 70% degree of saturation according to the Modified Proctor/Fagerberg test procedure for Bauxite where the OMC of the Bauxite tested occur at saturation levels less than 90%.

.4 Where moisture freely drains from the sample such that the test sample compaction curve cannot extend to or beyond 70% saturation, the test is taken to indicate a cargo where water passes easily through the spaces between particles. Therefore, the cargo is not liable to liquefy.

1.6.2 Test equipment

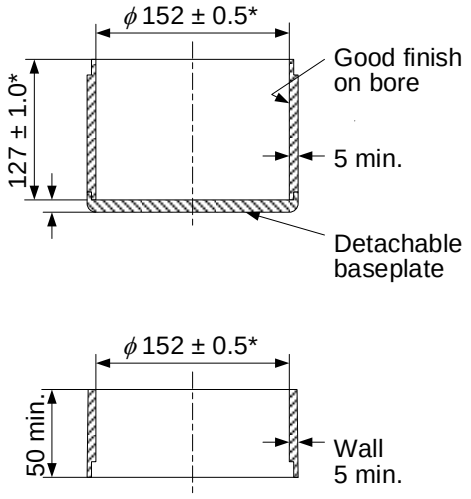
.1 The Proctor apparatus (see figure 1.6.1) consists of a cylindrical iron mould (the CBR mould) with a removable extension piece that screws on the top and a compaction tool guided by a pipe open at its lower end (the compaction hammer).

.2 The weighing balance should be capable of weighing the sample and the container, as received, with an accuracy of better than ± 1 g. For suitable sample containers (see section 3.2 of annex 12 of the IMSBC Code).

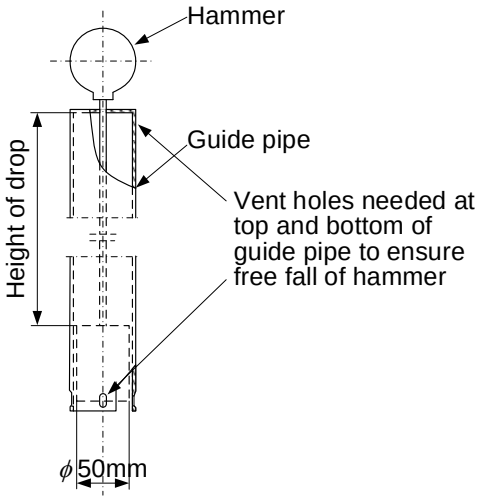
.3 A drying oven with a controlled temperature interval from 100°C to maximum 105°C.

.4 A container for hand mixing. Care should be taken to ensure that the mixing process does not reduce the particle size by breakage or increase the particle size by agglomeration.

.5 A gas or water pycnometry equipment to determine the density of the solid material as per a recognized standard (e.g. ASTM D5550, AS 1289, BS 1377 Part 2).



CBR Mould compaction cylinder and screw-on extension piece (from BS 1377 Part 4. all dimensions in mm)



Compaction hammer

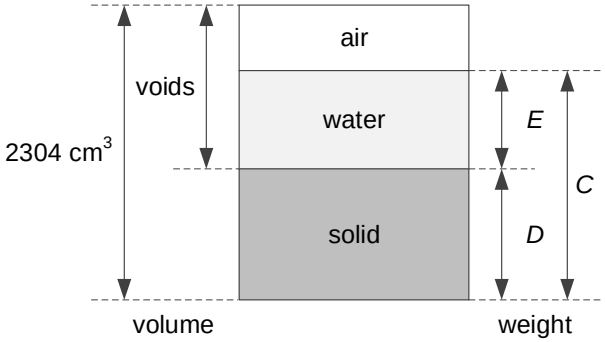


Figure 1.6.1 Equipment and definitions

1.6.3 Temperature and humidity (see 1.1.3 of this appendix)

1.6.4 Procedure

.1 Establishment of a complete compaction curve

A representative sample according to a relevant standard (see 4.7 of this Code) of the test material is utilized.

.2 Sample homogenization and division

Divide the as-received sample into individual subsamples using a sample dividing apparatus as specified in ISO 6140:1991 "Aluminium ores - Preparation of samples". Place these subsamples into heavy-duty plastic buckets that can be sealed to preserve water content.

.3 Reconstituted sample preparation procedure

Reconstitution is required for Bauxites if the amount of material in the representative sample that is coarser than 25 mm is greater than 10% of the total mass (by dry weight). In this case the reconstitution process below

should be applied (see also figure 1.6.2). In this process, particles above 25 mm are removed from the sample and replaced by an equivalent mass of particles in the range 6.3 mm to 25 mm. Note that 6.3 mm is a standard sieve size. If it is not available, a 6 mm sieve may be used instead. Through reconstitution, a final reconstituted sample of sufficient mass for TML testing is generated which contains a maximum particle size of 25 mm, but which better reproduces the compaction characteristics of the full as-received particle size distribution with particles greater than 25 mm.

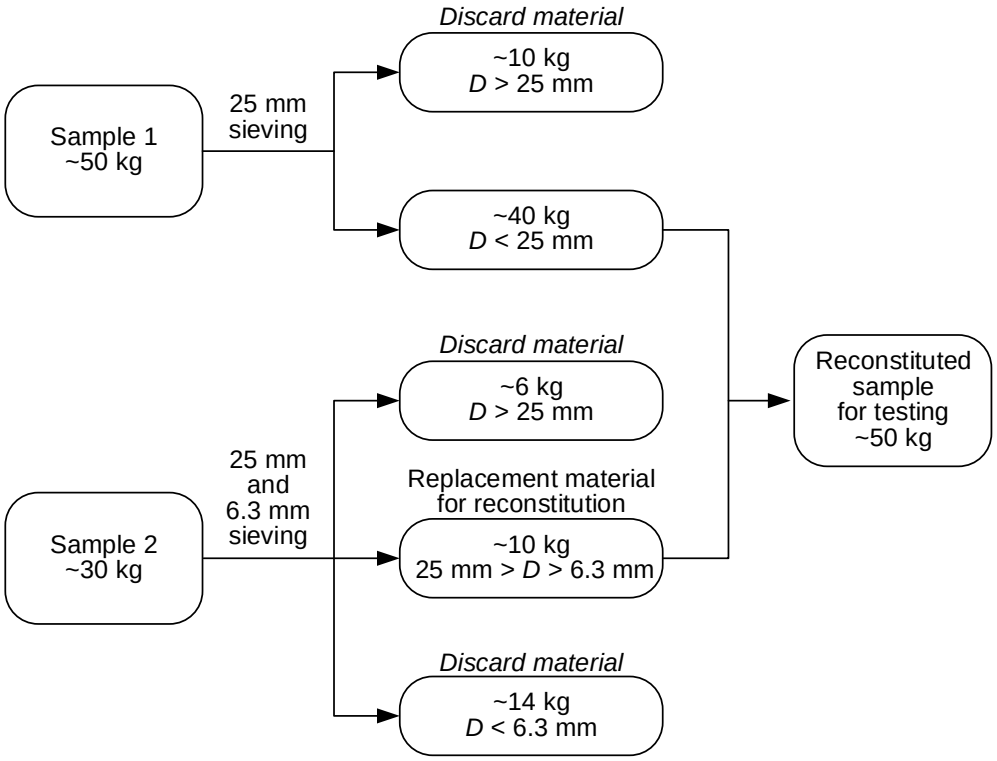


Figure 1.6.2: Schematic diagram of reconstitution sample procedure

Step 1: The first step in sample preparation is to sieve the sample at 25 mm to determine the amount of dry weight that is larger than 25 mm. All material retained on the 25 mm sieve is to be discarded, while material passing 25 mm is to be tested (see figure 1.6.2). Screen about 40 kg of Bauxite for one Proctor/Fagerberg compaction curve if reconstitution is required. If the amount (by dry weight) that is larger than 25 mm is 10% or less, then no reconstitution is required. A total of about 50 kg of 25 mm screened Bauxite is needed for one Proctor/Fagerberg compaction curve. Obtain this and proceed to Step 4 if no reconstitution is required.

Step 2: If reconstitution is required, then from a separate representative subsample of the same ore screen at 25 mm and 6.3 mm and retain the portion between these two sieve sizes. Produce about 15 kg of screened Bauxite between these two sizes for one Proctor/Fagerberg compaction curve (see figure 1.6.2).

Step 3: Add the 6.3 to 25 mm fraction from Step 2 to the <25 mm fraction from Step 1. The amount of 6.3 mm to 25 mm fraction added must be equal to the mass of > 25 mm Bauxite removed and discarded in Step 1.

Step 4: Fully mix the reconstituted or scalped sample.

.4 Compaction

Compaction tests are executed for five to ten (but typically seven) different moisture contents (i.e. typically seven but five to ten separate tests). The number of tests should fully define the compaction curve, including accurately determining the optimum moisture content and conditions near to or at full saturation. A total of about 40 kg to 100 kg of unscreened Bauxite is typically needed for one series of tests, depending on whether reconstitution is required or not.

Divide the screened Bauxite into five to ten subsamples and place each in a sealed plastic bucket. The water content of the subsamples are adjusted by adding a suitable amount of water into each bucket in order to obtain water contents ranging from the as-received water content to almost saturated subsamples.

Typically one test is carried out at the as-received water content. Four to eight tests are carried out at higher water contents. Depending on the as-received water content, one or two tests are carried out at lower water contents than the as-received water content. These lower water content tests are obtained by partially drying the Bauxite subsample at room temperature. Note that full drying of the Bauxite samples is not to be carried out. Note that some Bauxites are not sensitive to pre-drying, but unless this is comprehensively demonstrated for the Bauxite being tested, pre-drying is not permitted.

The subsamples are mixed at the target water contents before being allowed to rest and equilibrate overnight in the sealed plastic buckets. The plastic bucket contents are remixed immediately before compaction to ensure that a homogeneous sample is tested.

The required quantity of prepared Bauxite per compaction test is about 5 kg, so this is the target amount for each subsample. The subsamples will be compacted at the prepared water contents to define a full compaction curve.

Approximately one fifth of the subsample in a plastic bucket is filled into the mould with the extension piece attached (figure 1.6.1) and levelled to form the first layer increment. Bauxites that display plasticity may tend to stick together into clumps at the wetter water contents. It is important to gently disaggregate the clumps by hand into the small particles when loading the mould.

The Bauxite is then tamped uniformly over the surface of the layer. Tamping is executed as per the Proctor/Fagerberg method *D*, by dropping a 150 g hammer 58 times through the guide pipe, 0.15 m each time. The guide tube is held by hand and positioned so that it is just touching with the surface of the ore, but is not resting on it. This allows the hammer to fall the full specified height and compact the Bauxite, while avoiding additional (and excessive) compaction arising from the weight of the guide tube, itself, which should not be compressing the Bauxite.

The performance is repeated for all five layers so that the last layer only just overfills the mould-extension piece junction. The aim is to fill the mould by compacting in five nearly equal layers in order to produce a uniformly compacted sample in which the specified energy has been put into Bauxite that occupies the mould volume.

Bauxite should not extend more than 1 cm in height above the mould into the extension piece. If a height of more than 1 cm of Bauxite is found, the sample has been under compacted and the test should be redone.

When the last layer has been tamped the extension piece is removed and the sample is levelled off along the brim of the mould with care, ensuring to remove any large particles that may hinder levelling of the sample, replacing them with material contained in the extension piece and re-levelling.

The levelling process should be a horizontal cutting action, not a pushing action as that would compress more material into the mould volume than had been compacted by the specified energy input.

After the weight of the cylinder with the tamped sample has been determined, the cylinder is emptied, the full sample is dried at 105°C as per ISO moisture determination standard for Bauxite (ISO 9033:1989 "Aluminium ores - Determination of the moisture content of bulk material") and the weight is determined. The test is then repeated for the other samples with different moisture contents.

.5 Definitions and data for calculations *(see figure 1.6.1)*

- empty cylinder, mass in grams: A
- cylinder with tamped sample, mass in grams: B
- wet sample, mass in grams: C

$$C = B - A$$

- dry sample, mass in grams: D
- water, mass in grams (equivalent to volume in cm^3): E

$$E = C - D$$

Volume of cylinder: 2304.5 cm^3

.6 Calculation of main characteristics

- density of solid material, g/cm^3 (t/m^3): d
- dry bulk density, g/cm^3 (t/m^3): γ

$$\gamma = \frac{D}{2304}$$

- net water content, volume %: e_v

$$e_v = \frac{E}{D} \times 100 \times d$$

- void ratio: e (volume of voids divided by volume of solids)

$$e = \frac{d}{\gamma} - 1$$

- degree of saturation, percentage by volume: S

$$S = \frac{e_v}{e}$$

- gross water content, percentage by mass: W^1

$$W^1 = \frac{E}{C} \times 100$$

- net water content, percentage by mass: W

$$W = \frac{E}{D} \times 100$$

.7 Presentation of the compaction tests

For each compaction test the calculated void ratio (*e*) value is plotted as the ordinate in a diagram with net water content (e_v) and degree of saturation (*S*) as the respective abscissa parameters.

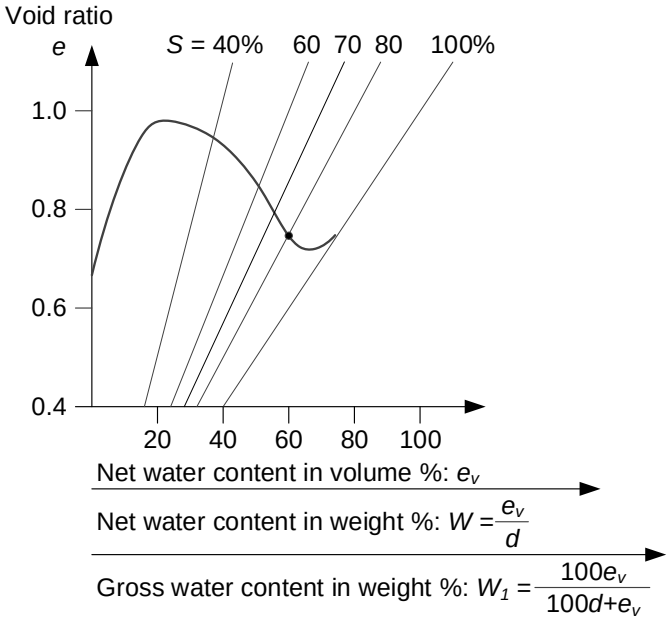


Figure 1.6.3

Form of Bauxite compaction curve when the optimum moisture occurs at a saturation greater than 90%. TML is determined as the critical water content at 80% saturation.

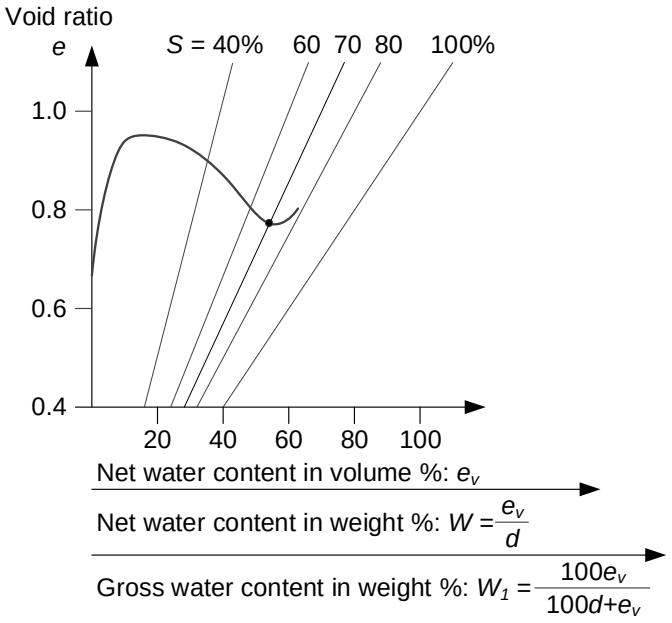


Figure 1.6.4

Form of Bauxite compaction curve when the optimum moisture occurs at a saturation less than 90%. TML is determined as the critical water content at 70% saturation.

.8 Compaction curve

The test sequence results in a specific compaction curve (see figures 1.6.3 and 1.6.4).

Should the optimum moisture content (OMC) of Bauxite occur at or above 90% saturation, the critical moisture content is indicated by the intersection of the compaction curve and the line $S = 80\%$ degree of saturation (see figure 1.6.3). The TML is the critical moisture content.

Should the optimum moisture content (OMC) of Bauxite occur below 90% saturation, the critical moisture content is indicated by the intersection of the compaction curve and the line $S = 70\%$ degree of saturation (see figure 1.6.4). The TML is the critical moisture content.

Where the OMC is not clearly defined by carrying out a sufficient number of tests at water contents close to and either side of the OMC, then a TML based on $S = 80\%$ cannot be adopted. The TML shall be based on $S = 70\%$. This is to guard against the erroneous adoption of a high OMC due to insufficient definition of the compaction curve.

Where moisture very freely drains from the sample at moisture content such that the test sample compaction curve does not extend to or beyond 70% saturation, the test is taken to indicate a cargo where water passes freely through the spaces between particles.

***

ANNEX 2

DRAFT INDIVIDUAL SCHEDULE FOR BAUXITE OF GROUP A

BAUXITE FINES

The provisions of this schedule shall apply to Bauxite cargoes containing both:

.1 more than 30% of fine particles less than 1 mm (D_{30} < 1 mm); and

.2 more than 40% of particles less than 2.5 mm (D_{40} < 2.5 mm).

Notwithstanding the above provision, Bauxite cargo meeting the above criterion may be carried as a Group C cargo in accordance with the provisions of the individual schedule for BAUXITE where the shipper provides the master with a certificate, in accordance with the result of the test approved by the competent authority of port of loading*, stating that the moisture of the cargo freely drains from the cargo so that the degree of saturation is not liable to reach 70%.

Description

A reddish-brown to brownish-yellow clay-like and earthy mineral. Insoluble in water.

Characteristics

Angle of repose	Bulk density (kg/m^3)	Stowage factor (m^3/t)
Not applicable	1,100 to 2,000	0.50 to 0.91
Size	**Class**	**Group**
More than 30% of fine particles less than 1 mm and more than 40% of particles less than 2.5 mm	Not applicable	A

Hazard

This cargo may liquefy if shipped at a moisture content in excess of its Transportable Moisture Limit (TML). See sections 7 and 8 of this Code.

This cargo may suffer instability due to moisture content resulting in dynamic separation and formation of a liquid slurry (water and fine solids) above the solid material, resulting in a free surface effect which may significantly affect the ship's stability. This cargo is not liable to undergo dynamic separation when the cargo is shipped below its TML.
This cargo is non-combustible or has a low fire-risk.

Stowage & segregation

No special requirements.

Hold cleanliness

No special requirements.

Weather precautions

When a cargo is carried in a ship other than a ship complying with the requirements in subsection 7.3.2 of this Code, the following provisions shall be complied with:

* Refer to 1.6 of appendix 2 to this Code.

.1 the moisture content of the cargo shall be kept less than its TML during loading operations and the voyage;

.2 unless expressly provided otherwise in this individual schedule, the cargo shall not be handled during precipitation;

.3 unless expressly provided otherwise in this individual schedule, during handling of the cargo, all non-working hatches of the cargo spaces into which the cargo is loaded or to be loaded shall be closed;

.4 the cargo may be handled during precipitation under the conditions stated in the procedures required in subsection 4.3.3 of this Code; and

.5 the cargo in a cargo space may be discharged during precipitation provided that the total amount of the cargo in the cargo space is to be discharged in the port.

Loading

Trim in accordance with the relevant provisions required under sections 4 and 5 of this Code. When the stowage factor of this cargo is equal to or less than 0.56 m^3/t, the tank top may be overstressed unless the cargo is evenly spread across the tank top to equalize the weight distribution. Due consideration shall be given to ensure that the tank top is not overstressed during the voyage and during loading by a pile of the cargo.

Precautions

Bilge wells shall be clean, dry and covered as appropriate, to prevent ingress of the cargo. The bilge system of a cargo space to which this cargo is to be loaded shall be tested to ensure it is working.

Ventilation

No special requirements.

Carriage

The appearance of the surface of this cargo shall be checked regularly, including at least daily visual inspections where condition permits, during voyage. If free water or a liquid slurry above the cargo or fluid state of the cargo is observed, including the flattening of the cargo, during voyage, the master shall take appropriate actions to prevent cargo shifting, loss of stability due to free surface effect and potential capsize of the ship, and give consideration to seeking emergency entry into a place of refuge. Cargo hold bilges shall be sounded at regular intervals and pumped out, as necessary.

An atypical motion of the ship (wobbling) may also be indicative of cargo instability and the master shall consider appropriate action.

Discharge

No special requirements.

Clean-up

No special requirements.

***

ANNEX 3

DRAFT INDIVIDUAL SCHEDULE FOR BAUXITE OF GROUP C

Note: The new texts are shown in grey shading and the proposed deletions are shown in ~~struck out with grey shading~~, based on the existing individual schedule for bauxite in the IMSBC Code.

BAUXITE

The provisions of this schedule shall apply to Bauxite cargoes

.1 containing either:

.1 30% or less of fine particles less than 1 mm (D_{30} ≥ 1 mm); or

.2 40% or less of fine particles less than 2.5 mm (D_{40} ≥ 2.5 mm); or

.3 both;

or

.2 where the shipper provides the master with a certificate, in accordance with the result of the test approved by the competent authority of port of loading*, stating that the moisture of the cargo freely drains from the cargo so that the degree of saturation is not liable to reach 70%.

Description

A reddish-brown to brownish~~,~~ -yellow clay-like and earthy mineral. ~~Moisture content: 0% to 10%.~~ Insoluble in water.

Characteristics

Angle of repose	Bulk density (kg/m^3)	Stowage factor (m^3/t)
Not applicable	1,100 ~~1190~~ to 2,000 ~~1389~~	0.5 ~~0.72~~ to 0.91 ~~0.84~~
Size	**Class**	**Group**
~~70% to 90% lumps: 2.5 mm to 500 mm~~ ~~10% to 30% powder~~ Typically up to 500 mm	Not applicable	C

Hazard

No special hazards.
This cargo is non-combustible or has a low fire-risk.

Stowage & segregation

No special requirements.

* Refer to 1.6 of appendix 2 to this Code.

Hold cleanliness

No special requirements.

Weather precautions

No special requirements.

Loading

Trim in accordance with the relevant provisions required under sections 4 and 5 of this Code. When the stowage factor of this cargo is equal to or less than 0.56 m^3/t, the tank top may be overstressed unless the cargo is evenly spread across the tank top to equalize the weight distribution. Due consideration shall be given to ensure that the tank top is not overstressed during the voyage and during loading by a pile of the cargo.

Precautions

"Bilge wells shall be clean, dry and covered as appropriate, to prevent ingress of the cargo. The bilge system of a cargo space to which this cargo is to be loaded shall be tested to ensure it is working."

Ventilation

No special requirements.

Carriage

No special requirements.

Discharge

No special requirements.

Clean-up

No special requirements.