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# Loss Prevention

# Liquefaction of Mineral Ores and Mineral Concentrates



**Yves Vandeborn**  
**Director of Loss Prevention**  
 T: +65 6506 2852  
 E: yves.vandeborn@ctplc.com

### Introduction

Solid bulk cargoes such as unprocessed mineral ores and refined mineral concentrates may appear to be in a relatively dry granular state when loaded, however, they may still contain sufficient moisture to become fluid under the stimulus of the compaction and vibration that occurs during a voyage. The resulting cargo shift can be sufficient to capsize a vessel.

There are many detailed guides on this subject including The Standard Club's *Standard Cargo* publication on liquefaction which is free to download from our website.

The IMSBC Code categorises cargo into three groups:

- Group 'A' cargoes – cargoes that may liquefy if shipped at a moisture content in excess of their transportable moisture limit (e.g. mineral ores and mineral concentrates);
- Group 'B' cargoes – cargoes that may possess chemical hazards
- Group 'C' cargoes – cargoes that are neither liable to liquefy nor possess chemical hazards.

However, there have been cases where Group C cargoes have exhibited the liquefaction characteristics of group A cargoes. Typically, these cargoes will have a high proportion of fine particles and will not meet the specifications listed in the IMSBC Code.

Members are advised that if the proposed cargo does not meet the properties listed in the IMSBC Code, or if a 'Can Test' raises any doubts about the fluidity of the cargo, the requirements of section 1.3 of the IMSBC Code, 'Cargoes not listed in this Code', should be followed.

### SOLAS/IMSBC Code Regulations

Under the SOLAS/IMSBC Code, the shipper has an explicit duty to provide the master with appropriate information on the cargo sufficiently in advance of loading to enable precautions to be taken for safe stowage/carriage (IMSBC Code – p 23 Section 4.2 – Provision of Information).

Many cargo declaration certificates simply state 'as per Annex 2 of the code' which is an ambiguous statement and should not be accepted, as section 4.1.4 of the IMSBC Code requires an appropriate test to determine properties of the cargo. The method, test procedures and standards should be clarified.

For Group A cargoes, certificates of moisture content must be issued and the interval between sample or testing and loading should not exceed seven days. Certificates of transportable moisture limit must also be issued, with the interval between sample or testing and loading not exceeding six months. Further details on the cargo declaration form for Group A cargoes can be obtained from our [website](#).



**Akshat Arora**  
**Senior Surveyor**  
 T: +65 6506 2809  
 E: akshat.arora@ctplc.com



**Julian Hines**  
**Loss Prevention Manager**  
 T: +44 20 3320 8812  
 E: julian.hines@ctplc.com



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### Test procedures for materials that may liquefy

Unlike the Flow Moisture Point (FMP), which can be determined in the laboratory, the Transportable Moisture Limit (TML) is a parameter that is calculated, rather than measured, as 0.9 times the FMP. The maximum allowed moisture content of a cargo at the time of loading (the TML) is lower than the moisture content at which liquefaction actually occurs (the FMP). This difference between the TML and the FMP is intended to provide a safety margin to protect against variations in moisture or FMP throughout the cargo and to allow for measurement uncertainties in the laboratory determination of moisture and FMP.

Three methods of testing for the FMP and cargo moisture content are listed in Appendix 2 of the IMSBC Code:

- Flow table test;
- Penetration test;
- Proctor-Fagerberg test.

As each method has its advantages, the selection of the test method is determined by local practices or by the appropriate authorities.

#### Flow table test

The flow table test is generally suitable for mineral concentrates and fine material with a maximum grain size of 1mm. It may also be applicable for materials with a maximum grain size up to 7mm, but it will not be suitable for materials coarser than this. In addition, it may not give satisfactory results for some materials with high clay content.

From the club's experience, it seems to be becoming common practice for the loading ports to categorise the cargo into 'lump', i.e. +20mm and 'fines', i.e. -20mm. Generally speaking, the smaller the particle size the greater the risk of liquefaction. The critical size appears to be around 7mm, thus we are particularly concerned with the testing methods of the 'fines'.

Our findings show that a growing number of shippers are using an average reading method, using a composite combining the -7mm and +7mm parts, for a moisture content that generally leads to a figure that is below the TML. However, it is the -7mm fraction that has the propensity to liquefy; therefore the TML of the -7mm fraction should be compared with the MC of the -7mm fraction to get an accurate reflection of how likely the whole cargo is to liquefy.

The use of an average reading, i.e. a composite, for cargo fines is not an acceptable method and is inconsistent with the IMSBC Code. This average reading gives a moisture content on the certificate that is not the actual moisture content of the cargo loaded.

Nickel ore has high clay content and contains a substantial proportion of material coarser than 7mm. In order to obtain an accurate moisture content of the nickel ore cargo, the ship will require separate certificates in accordance with the IMSBC Code and should clearly identify the TML, MC and FMP, and the method of testing:

- for the part of the cargo with fines greater than 7mm;
- for the part of the cargo with fines less than 7mm.

Failure to do so will systematically overstate the safety of the cargo and may lead to cargoes being accepted for loading that are actually unsafe.

#### Penetration test

This test constitutes a procedure where a sample of the material is placed in a cylindrical vessel with a weight on its top. The cylinder is subjected to vibration to test its shear strength. If the sample has sufficiently high shear strength, the weight will not sink; conversely, if the sample has low shear strength, it will liquefy and the weight will sink. This test is an alternative to the flow table test, which is more complex and requires special expertise.

This test procedure is generally suitable for mineral concentrates up to a size of 25mm and coarse cargoes such as coal where the flow table test is not suitable.

#### Proctor-Fagerberg test

This test method is suitable for fine and relatively coarse-grained ore concentrates up to a top size of 5mm. Iron ore fines are generally finer and physically/metallurgically different from metal ore concentrates. The Proctor-Fagerberg test (PFT) is better suited and technically more appropriate for determining the TML for iron ore fines. The premise of this test is that the compaction energy used will create similar densities for given moisture contents as will be found in a ship hold. The compaction energy, applied by varying degrees of hammer weight, drop height and number of drops per layer, is stipulated in the IMSBC Code.



### Can test

The IMSBC Code also describes a shipboard method (the 'can test') for checking whether a cargo may be suitable for shipment. This involves filling a small can with the material and repeatedly banging it on a hard surface. The appearance of the material at the end of the test can be used to suggest the suitability of the material for shipment.

This test should not be a substitute for proper laboratory testing using an appropriate methodology. However, if can tests carried out on a cargo presented for loading indicate a propensity for liquefaction, this is a major warning sign that the cargo as a whole is unsafe for carriage. Expert advice should then be sought.

### New draft schedule for iron ore fines, revised schedule for iron ore and new test procedure for determining the TML of iron ore fines

The IMO DSC meeting in September 2013 introduced a new schedule for iron ore fines with an amendment to the individual schedule for iron ore and an amendment to Appendix 2 to the IMSBC Code to include 'Modified Proctor-Fagerberg test procedure for iron ore fines'.

The new schedule for iron ore fines, (a Group A cargo), is valid for iron ore cargoes containing both 10% or more of fine particles less than 1mm in diameter and 50% or more of particles less than 10mm in diameter. The content of goethite shall be less than 35%.

The existing schedule for iron ore, (a Group C cargo), is amended to be valid for iron ore cargoes containing either less than 10% of fine particles less than 1mm in diameter, or less than 50% of fine particles less than 10mm in diameter, or both, or iron ore fines containing 35% or more goethite.

As stated in the IMSBC Code – p 23 Section 4.2 – Provision of Information, the shipper has an explicit duty to provide the master with appropriate information (including the declaration of the goethite content of the cargo) sufficiently in advance of loading to enable precautions to be taken for the safe stowage/carriage.

Although the new draft schedule will be mandatory in all SOLAS states from 1 January 2017, IMO circular DSC.1/Circ.71 invites SOLAS states to voluntarily implement the new draft schedule and test procedure as soon as possible. Brazil and Australia have already confirmed early implementation of the recent changes to IMSBC Code, but many other states are yet to confirm.

The details of the new iron ore fines schedule and amendment to appendix 2 of the IMSBC Code can be accessed from our [website](#).

### Conclusion

Inaccurate declarations and certificates from shippers appear to be at the heart of the problem with the transport of cargoes liable to liquefy, though it is recognised there are numerous complications.

Based on previous experiences with respect to such cargoes, we recommend that ships loading mineral ores and/or concentrates to:

- clarify the method used to determine the moisture content;
- carefully check the shipper's cargo declaration and stated moisture content;
- check cargo to be loaded in each barge or stockpile for excessive water content;
- if high rainfall occurred in the days prior loading, request new moisture content tests to be carried out;
- ensure that a valid moisture content certificate is issued before loading, in accordance with IMSBC sections 4.3.3 and 4.5.2, and that its validity can be confirmed;
- ensure any document seeking confirmation that the cargo is safe to carry is signed by the shipper not the master or his appointed surveyor;
- consider clausing their charterparty to include that all statutory provisions of the IMSBC are to be followed and stipulate that it is the owner's right to have an independent surveyor in attendance.

If there are any concerns or doubts about the validity of the moisture content:

- further advice and assistance must be obtained from an independent reputable cargo expert;
- the master should not load the cargo until the correct information about the cargo has been received.

The club is able to assist the members with any queries they may have over cargoes that may liquefy, by way of loss prevention advice and/or appointment of correspondents and surveyors. Members should be reminded that it is not within the function of the club to set a standard for approved or rejected cargoes. It is the members' responsibility to ensure full compliance with the IMSBC Code and to take any necessary measures to ensure the safe carriage of subject cargoes. Failure to comply with the Code might prejudice club cover.



## Case study

### A recent loading operation of iron ore concentrates in Sierra Leone

Casualties continue to occur worldwide as a consequence of cargo liquefaction. The lack of understanding of the problem by the parties involved in this trade and the lack of clarity in the regulations, which are not consistently implemented in load port countries, has contributed to a significant loss of life.

The following case study will highlight the main areas of concern arising from our experience in Sierra Leone. Although there were no tragic consequences, the subject case was difficult to resolve. It took several days for a common ground to be achieved between the parties, the ship was unable to resume operations in the meantime, and substantial losses and expenses were involved.

### Background details

The ship, under a long-term time charter on a NYPE form, arrived at Freetown, Sierra Leone to load iron ore concentrate from barges at the ship's anchored position.

Some cargo was rejected by the master and the P&I appointed a surveyor during loading owing to excessive wetness.

A few days later whilst the ship was still loading cargo, one of the holds was found to be emitting a high volume of water and the cargo that had been loaded into the hold was found to have a muddy bottom layer, despite having passed can tests. Subsequently, water was also noted in the other holds.

The ship's bilge records also established that a significant volume of water was pumped from all five holds and thus the cargo was prone to moisture migration.

The shipper's initial reaction was to refuse to discharge the cargo from the holds that emitted water. The shipper contested that the cargo was a 'wet base'/'free draining' cargo, which could be loaded even though the bottom part exceeded the transportable moisture limit. However, section 7.2.3 of the IMSBC Code spells out the danger of 'wet base' cargoes (whose moisture sinks to the bottom layers) being '*dangerous even if the bottom layer is less than the TML*'.

The shipper also insisted that the cargo be accepted on the basis of the 'can test' alone, although it is well known that, whilst the test may indicate if cargo is unfit for shipment, it cannot

determine if a cargo is fit to be loaded—this can only be determined by laboratory testing. Following written consent from the shipper (which initially was opposed), samples of the cargo were dispatched to the UK and tested by an internationally recognised laboratory. The findings verified that the actual moisture content, FMP and TML differed significantly to those advised by the shipper through the certificates provided for the purposes of the IMSBC Code. Essentially, the shipper was presenting a cargo whose TML properties were **not** properly reflected in the certificates.

Following long delays, the shipper agreed to discharge the cargo from the holds and replace it with sound cargo.

The shipper's loading practices which raised concern were:

- Some barges did not have proper water draining facilities;
- Some of the cargo was becoming wet in spite of the tarpaulins covering the cargo whilst on board the barges;
- Wetted cargo rejected by this ship (or other ships in the area) was left at the aft end of the barge, but as the barge started to list, the wetter cargo was transferred forward, becoming mixed with drier cargo;
- In order to reach the ship's grabs, rather than rotating the barge, the drier cargo was moved towards the grabs – resulting in the bottom part of that cargo becoming wet due to the water which had drained onto the barge's surface;
- The shipper was not transferring wet cargo to the shore since there were no storage facilities on shore.

There are some notable considerations with respect to Sierra Leone shipments:

- Infrastructure at load ports is largely rudimentary;
- Mines are located far from suitable test facilities;
- Access to the stockpiles is problematic;
- Local expertise and technology is lacking, thus little reliance can be placed on the results of testing conducted by local mine laboratories;
- There are no independent local laboratories available to the owners;
- Dispatch of samples outside the country, if achieved, can take days;
- Discharge of the cargo, if needed, is difficult due to lack of facilities or complications arising from local customs regulations;
- Communication barriers exist;
- Rain can be frequent, lengthy and extra precaution is needed;
- Appointing a surveyor can be difficult since commercial pressure and intimidation of the surveyors has been frequently reported;
- Cost of surveyor's attendance is very high;
- Gaining the co-operation of some shippers may be challenging.



**Eva Kelesidou**  
Claims Executive

T: +30 210 429 1853  
M: +30 6941 583 682  
E: eva.kelesidou@ctplc.com

**Charterers' hire deduction and their further associated losses**

The charterers claimed that the ship was off-hire during some periods of time at the load port and accordingly deducted a substantial amount from hire. The owners objected that the master's decision and actions were reasonable and within his discretion in accordance with the provisions of the charterparty related to the carriage of dangerous goods and cargo certification and operations were in strict compliance with the Code and the applicable regulations.

in the Bills of Lading. A comprehensive Bulk Mineral Ore Liquefaction Risk clause (such as that addressed by BIMCO) incorporated into the charterparty would also be of paramount importance and assistance.

In this case, the charterparty's provisions ensured the above rights, providing the necessary discretion of loading to the master with any time lost for the account of charterer/shipper. The precautions taken by a master in order to secure the safety of the ship cannot be considered as unreasonable.

**The legal framework**

SOLAS Chapter VI, Regulation 2 and the IMSBC Code section 4.2 require the shipper to provide the master with accurate cargo information.

Moreover, according to SOLAS Chapter VI, Regulation 6-2 and Regulation 7-7, the cargo must not be loaded if the actual moisture content exceeds the TML. The master is entitled to stop loading operations in the event that those limits are exceeded.

Under SOLAS Chapter V, Regulation 34-1, the master has absolute discretion to take any decision which, in his professional judgement, is necessary for safety of life at sea and/or protection of the marine environment.

The Hague Visby Rules, Article IV Rule 6, provide that goods of a dangerous nature to the shipment may, at any time before discharge, be landed at any place or destroyed or rendered innocuous by the carrier, even if the cargo was carried with consent and knowledge of its character. Article IV Rule 6 further entitles the carrier to recover all losses directly or indirectly resulting from the shipment of the dangerous cargo.

Furthermore, the IMSBC Code mandatory provisions require that if a cargo prone to liquefaction has a moisture content that exceeds the TML, it should not be loaded.

Under English law, the carrier's position is empowered and protected against claims as a consequence of the strict liability regime for shipment of dangerous goods and the incorporation of the Hague or Hague Visby Rules

**What members can do**

Before fixing this type of cargo, members should conduct an internal risk management analysis and ensure that appropriate due diligence is performed.

Members should protect themselves contractually by incorporating a Bulk Mineral Ore Liquefaction Risk clause in the charterparty whereby it will be made clear which party a) bears the risk of the cargo being safe, b) has legal and financial responsibility with respect to the cargo operations and c) absorbs the risk, time and cost of pre-loading inspections, testing as well as the attendance of the independent surveyors.

Members are advised to require that certificates be issued by internationally recognised testing authorities (rather than accept 'local laboratories') and secure, in advance, written consent of the shipper for the dispatch of the samples, if needed.

The cargo operations should always be subject to the application of the IMSBC, SOLAS and any other relevant rules, whilst at the same time direct indemnity to the carrier should be established in the event the charterers and/or the shipper is in breach of the above.

If there are any doubts as to the safety of cargo the members are recommended not to load on board, in accordance with the Code. If, however, the cargo already has been loaded on board the ship, then all necessary steps in order to discharge the unsafe cargo should be taken. In any event, it would not be prudent to commence a sea voyage without further analysis and thorough risk assessment. If the ship is already underway, the club is able to advise appropriate risk mitigation measures.

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**Charles Taylor & Co. Limited**  
The Minster Building, 21 Mincing Lane,  
London EC3R 7AG  
Registered in England No. 02561548

Telephone: +44 20 3320 8888  
Emergency mobile: +44 7932 113573  
Email: [pandi.london@ctplc.com](mailto:pandi.london@ctplc.com)  
Website: [www.standard-club.com](http://www.standard-club.com)

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