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Iron Ore Fines

Iron Ore Fines

CONTENTS

Problems with the Carriage of Iron Ore Fines

In recent years there have been a number of high profile incidents involving suspected liquefaction of iron ore fines. This briefing discusses iron ore fines, the problems it may present during carriage and the response of the international shipping community.

What are Iron Ore Fines?

Iron ore is a natural/raw material that is mined around the world. The material is processed to allow its use in the iron/steel making industry. Initially, this involves crushing followed by screening to separate the ore into lumps and fines. If the iron content of the processed ore is >60% then it can be shipped directly to the plants.

Iron ore fines

The IMSBC Code definition for iron ore refers to cargo in the size range of up to 250mm, and iron ore fines 10% or more of fine particles of less than 1mm and 50% or more of particles less than 10mm. Moisture contents quoted for iron ore fines typically vary between 6 to 12%, with iron ore having lower moisture content.

Our Cargo Wise poster shows the differences between grades of ore cargoes which can be found here: **www.nepia.com/latest/publications**

Incidents in which North has been involved have highlighted various operational problems that can arise when loading an iron ore fines cargo. Liquefaction, the typical problems it brings, and actions that may be taken to avoid the problems arising, are discussed below.

Iron Ore Fines

IMSBC Code Schedule

Due to the problems associated with liquefaction, a specific schedule for the carriage of Iron Ore Fines and an amended schedule for the carriage of Iron Ore have been included since the 2016 version of the IMSBC Code.

What is Liquefaction?

In fine grained moisture laden cargo the spaces between cargo grains are filled with both air and water. Whilst at sea the cargo is subject to forces due to the vibration and rolling of the vessel. These forces cause the inter-grain spaces to contract. The water in the spaces between grains is subject to a compressive force but as it is a liquid it cannot be compressed. This has the effect of reducing the inter-grain frictional force that holds the cargo in a solid state. Where enough moisture is present the reduction in inter-grain friction due to the ship's motion and vibration can be sufficient to cause the cargo flow like a liquid i.e. to liquefy.

Consequences of Liquefaction

The most significant consequence for the vessel resulting from liquefaction is cargo shift leading to loss of stability. This may produce dangerous angles of list and in some instances the resulting loss of stability can be such that the vessel and the lives of those onboard are lost. It is therefore imperative that seafarers are aware of the types and condition of cargo that may give rise liquefaction.

Iron Ore Fines (cont.)

SOLAS Requirements

The International Convention for the Safety of Life at Sea (SOLAS) Chapter VI – Carriage of Cargoes - provides the general framework for the carriage of all cargoes.

Shipper's Duties

In respect of cargoes with particular hazards, such as liquefaction, SOLAS is explicit in requiring the shipper to provide the master, or his representative, with the appropriate cargo information sufficiently in advance of loading to enable the necessary precautions for safe carriage to be put into effect. The format of such information is also supplied in the IMSBC Code. Additionally there are specific provisions for additional information to be supplied for cargoes which may liquefy in the form of a certificate of moisture content and transportable moisture limit (TML).

As such shippers are obliged to provide appropriate cargo information to the master before loading commences.

Master's Duties

Section 7.3.1.1 of the IMSBC Code, states that "Concentrates or other cargoes which may liquefy shall only be accepted for loading when the actual (MC) of the cargo is less than its TML."

Therefore, a master should not accept such a cargo for loading without first receiving the appropriate documentation certifying the moisture content and TML of the cargo with the moisture content shown to be less than the TML.

Terminal Representative's Duties

SOLAS, Chapter VI Part B, Regulation 7, deals with the loading, unloading and stowage of bulk cargoes and introduces the Code of Practice for the Safe Loading and Unloading of Bulk Carriers (BLU Code). The BLU Code is included as a supplement of the IMSBC Code.

The BLU Code, although primarily concerned with arrangements between the terminal and the ship to ensure safe and efficient cargo operations in port, does under section 3.3.3 state that:

"The terminal representative should be satisfied that the ship has been advised as early as possible of the information contained in the cargo declaration as required by chapter VI of SOLAS 1974 as amended."

Terminal representatives bringing commercial pressure on masters to load their vessels before receiving the shippers' cargo declaration are acting in contravention of the BLU Code and therefore SOLAS. Masters are urged to resist such pressures.

It is a master's responsibility to ensure that the vessel is safely loaded; and where the shipper's cargo declaration has not been received the master has no idea of the likely properties of the cargo to be loaded. If such declaration is not forthcoming a master should not commence loading and should immediately notify owners. Members should contact the Association for advice in such circumstances.

Liquefaction and the IMSBC Code

The main reference for any ship operator or master when considering whether or not a cargo is likely to liquefy is to refer to the International Maritime Solid Bulk Cargoes (IMSBC) Code. The dangers associated with commonly shipped cargoes are listed within the Code – Group A cargoes are those that are likely to liquefy. Any cargo listed as Group A should be carried strictly in accordance with the provisions of the IMSBC Code.

Figure 1: Cargo at shipper's stack-yard

However, the Code itself warns in Section 1.2.1 that the schedules for individual cargoes are not exhaustive. Ship operators and masters should not automatically assume there is no risk of liquefaction simply because a cargo does not appear in the IMSBC Code as a 'Group A' cargo. Where a cargo is not listed in the Code then it should only be loaded when an appropriate certificate, as required under Section 1.3, from the Competent Authority has been provided.

Any bulk cargo containing the correct proportion of fine particles and sufficient moisture may liquefy.

It is essential that master's and ship operators are familiar with all sections of the IMSBC Code.

Shipper's Declaration

Section 4 of the IMSBC Code requires the shipper of the cargo to provide the master with appropriate cargo information sufficiently in advance of loading to enable the precautions which may be necessary for the safe carriage of the cargo to be put into effect. The minimum information to be provided is listed in Section 4.2.2. This information includes both the TML of the cargo and its moisture content at shipment.

The vessel should receive this documentation well in advance of loading and masters should resist pressure from shipper or terminal representatives to begin loading in advance of receipt of the certificate. It is better to delay loading whilst awaiting the certificate than to have to discharge unsuitable cargo loaded in advance of receipt of the certificate. Such discharge may be

Iron Ore Fines (cont.)

highly problematic due to the lack of suitable equipment, berths or due to local customs or other regulations. Terminals and shippers may simply be unwilling to accept the discharged cargo. The shipper's cargo declaration should be accompanied by a signed certificate stating the cargo's TML and moisture content. In addition Section 4.3.2 states that 'the certificate of TML shall contain, or be accompanied by, the result of the test for determining the TML'. We understand this to mean that the flow moisture point (FMP) must also be included with the documentation for Flow Table and Penetration Tests and in the case of Iron Ore Fines the TML as determined by the Modified Proctor Fagerberg test. An exemplar declaration extracted from the IMSBC Code is included at page 8 of this briefing.

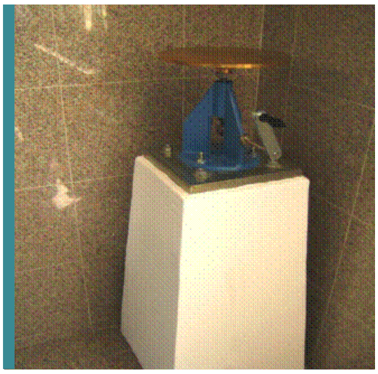

Figure 3: A Flow Table

Shippers are also required, as per Section 4.3.3, to establish procedures for 'sampling, testing and controlling moisture content to ensure the moisture content is less than TML'. These procedures should be approved and their implementation checked by the competent authority of the port of loading. The master must be provided with the documentation issued by the competent authority confirming that the procedures have been approved prior to commencing loading.

Unfortunately there have been many instances where the information provided by the shipper has stated that the moisture content of the cargo has been within the TML but which cargo has later proven to be liable to liquefy.

This can come about through poor testing procedures (despite detailed advice as to the conduct of tests contained within the IMSBC Code), changes in circumstance since testing was carried out e.g. heavy rain (again the Code requires the shipper to retest in these circumstances but often shippers fail to do this), or through lack of understanding by shippers' representatives of the potential dangers posed to the vessel by spurious figures.

As such, even where the certificate states that cargoes are safe to load, masters and their officers must always be vigilant in monitoring the condition of the cargo as it comes onboard. Different stockpiles of cargo can have different characteristics so vigilance throughout the duration of loading operations is necessary.

Should a dispute arise over the properties of the cargo to be loaded we recommend that Members consider appointing an independent surveyor/expert to assist the master. In such circumstances Members should contact the Association for advice.

Sampling and Testing of Cargo

Sampling and testing procedures for bulk cargoes that may liquefy should be carried out to international standards such as the test procedures described in Appendix 2 of the IMSBC Code.

Flow Moisture Point (FMP) and Transportable Moisture Limit (TML)

Flow Moisture Point – the maximum water content, expressed as a percentage, at which a sample of cargo will begin to lose shear strength. Cargoes with moisture content beyond FMP may be liable liquefy.

Transportable Moisture Limit - is defined as 90% of the FMP when used in conjunction with the Flow Table Test (FTT) and Penetration Test. The modified Proctor Fagerberg test method can be used to determine the TML of iron ore fines.

From the ship operators and master's perspective the important figures for the laboratory to determine are the TML of a representative sample of the cargo to be loaded and its actual moisture content. It is a requirement of the International Convention for the Safety of Life at Sea (SOLAS) that the average moisture content of any type of granular cargo in any cargo space must not be higher than the TML.

In order to find the TML, the laboratory must first determine the FMP of the sample using one of the prescribed techniques.

For the Modified Proctor Fagerberg test there is no FMP, the vessel will only be provided with a TML.

Loading a cargo above, at or near its FMP represents an unacceptably high risk for vessels and for this reason a safety margin is allowed – this gives the TML.

After determining the FMP the moisture content of the cargo is obtained by drying samples of the cargo in accordance with Section 4.6.4 of the Code. If the moisture content of the cargo sampled is below the TML then, on the face of it the cargo should be safe to load. However, there is no way for the vessel's operators or master to determine whether or not the sampling and testing procedures used by shippers are adequate and/or accurate.

Iron Ore Fines (cont.)

Can Test

In order that the vessel can make its own assessment of the likelihood of the cargo to liquefy section 8 of the IMSBC Code describes a shipboard method known as the "can test". This involves filling a small can with the material and repeatedly banging it on a hard surface.

Figure 4: Can test of cargo

The appearance of the material at the end of the test can be used to form an opinion regarding 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 may be unsafe for carriage.

Figure 5: Result of can test

Expert advice should then be sought. Where shippers present significant amounts of material that fails the can test (a failed can test with an iron ore fines cargo is pictured), this is an indication that the cargo as a whole may be unsafe, and that any certification to the contrary may be flawed. It should also be borne in mind that a negative result from the can test (i.e. no free moisture or fluid condition is seen) does not necessarily mean that the cargo is safe for shipment.

Shipper's Cargo Declaration Problems

There have been instances where the shipper's cargo declaration has not been presented before loading, where the TML and moisture content certificates are not included with the declaration and where the TML and moisture content certificates are present but do not appear to reflect the characteristics of the cargo presented for loading.

- Loading should not commence until the shipper's cargo declaration is received.
- The cargo declaration must contain the moisture content of the cargo to be loaded, its TML and its FMP where appropriate. Both the moisture content and the TML must be present on the documentation as without both figures the suitability of the cargo for transportation cannot be determined.
- The moisture content of the cargo is particularly susceptible to change due to weather conditions and as such the certificate should not be more than 7 days old. Where there has been significant rain or snow between the time of testing and loading check tests shall be conducted to ensure the moisture content of the cargo is still less than TML (even if this means testing must take place one day after the previous test).
- Where the declaration is not received or where both the moisture content and TML are not included in the certification the master should refuse to load the vessel and should immediately notify the owners.

Additional advice on the steps to be followed when loading a cargo that may liquefy can be found in our Information Sheet on liquefaction at: **www.nepia.com/latest/publications**

Crew Awareness

As the shippers cargo declaration cannot be relied upon in all cases it is essential that masters and Officers remain vigilant throughout the loading process. Failure to identify cargo that may be liable to liquefy onboard the vessel may lead to loss of stability, dangerous listing or capsize. However, this not an easy task as cargo above TML can appear to be dry.

- Heightened crew vigilance at the commencement of, and throughout, loading is essential. The can test should be employed to check the cargo at regular and frequent intervals as it comes aboard. Splattering of the cargo in the hold during loading also indicates that parcels of the cargo are beyond FMP and unsafe to load.
- If the cargo fails the can test, splattering is observed or if the master suspects the cargo may be unsuitable for shipment for any other reason, then loading should be suspended and the vessel should inform owners immediately.

Cargo Unsuitable for Shipment Already Aboard

Suspect cargo should be sampled by an independent laboratory and, if found to be beyond its TML, then the safest option is to discharge the cargo. This sounds simple but unfortunately experience has shown that once a vessel has loaded wet iron ore fines it can be highly problematic for the vessel. A loaded cargo is regarded as being exported by the customs and excise authority, and this immediately creates bureaucratic difficulties for unloading. When combined with

Iron Ore Fines (cont.)

commercial reluctance on the part of the shippers and ports to accept/unload the unsuitable cargo the delays and costs that a vessel can experience may be considerable and can, in the worst cases, last for months. There may also be damage to valuable commercial relationships should such a dispute arise. It is always best for the vessel's safety and in the owner's interest that iron ore fines unsuitable for shipment are identified before they come onboard.

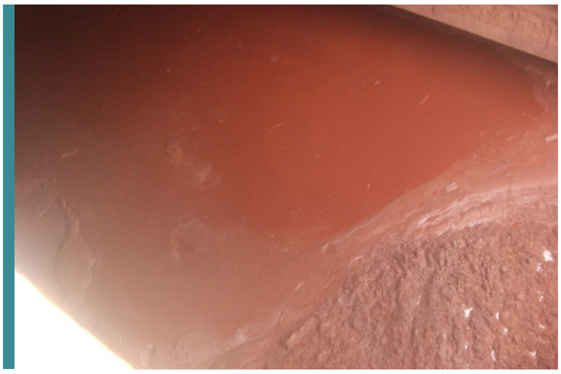

Figure 6: Liquefaction Iron Ore Fines in a Cargo Hold

Cargo Liquefying Whilst at Sea

Despite the provisions of SOLAS, IMSBC and BLU codes it is still the case that cargo unsuitable for transportation is loaded and carried. In recent years there have been a number of incidents involving the loss of vessels and of life that have been attributed to liquefaction of the cargo onboard. There have also been numerous instances of vessels losing stability, but not capsizing, which are known to have been caused by liquefaction.

ISM Code amendments that entered into force on 01 July 2010 require potentially hazardous situations to be risk assessed and procedures to be in place to deal with the situation should it occur. Clearly liquefaction places the vessel in a hazardous situation and procedures to deal with liquefaction should be developed.

Once liquefaction of a cargo has taken place at sea a vessel and its crew may be in very real danger.

Whilst every such situation will have its own unique set of circumstances as a minimum owners/vessels should

- Ensure that detailed stability calculations are carried out before departure from the load port for every cargo loaded. The calculations will then serve as baseline data in the event of a liquefaction incident.
- The master must immediately notify owners. Owners should seek the advice of an expert in these circumstances. The likely effect of ballasting the vessel to correct a vessel's list needs to be calculated and carefully considered before any such operation takes place. Incorrect ballasting may exacerbate the situation causing a further reduction in stability. Even where ballasting has taken place and is successful in returning a vessel upright the cargo onboard is still in a dangerous state.
- It may be necessary to seek the nearest suitable port of refuge.

Best Result

Members should exercise EXTREME CAUTION when fixing to load iron ore fines. Experience has shown that the current testing and certification regime for this cargo may be inadequate in some jurisdictions, such as India and

We would strongly recommend Members to engage the services of a suitably qualified and experienced surveyor to assist the master in determining the suitability of the cargo prior to, and during, loading in these jurisdictions. Always keep in mind that the best result is for unsuitable cargo to be rejected before it is loaded onto the vessel.

Acknowledgements

North is very grateful to Ken Grant of Minton, Treharne & Davies (MTD) and Martin Jonas of Brookes Bell for their advice and guidance in the preparation of this briefing.

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Unless the contrary is indicated, all articles are written with reference to English Law. However it should be noted that the content of this publication does not constitute legal advice and should not be construed as such. Members should contact North for specific advice on particular matters.

Published March 2017.

Iron Ore Fines (cont.)

EXEMPLAR SHIPPERS DECLARATION

Australian Government
Australian Maritime Safety Authority

SHIPPER'S DECLARATION

Note: This form is not applicable if the cargo to be loaded requires a declaration under the requirements of SOLAS 1974, Chapter VII/R4, MARPOL 73/78 Annex III/R4, and the IMDG Code Chapter 5.4 (Documentation).
This form meets the requirements of SOLAS 1974, Chapter VI, Reg 2 (for general cargo, cargo in cargo units, cargo carried in solid bulk) and the IMSBC Code, section 4.2.

General Information

Shipper	Transport document number
Consignee	Carrier
Name/means of transport	Instructions or other matters
Port/place of departure	
Port/place of destination	

Cargo Information

General description of the cargo (For solid bulk cargo – type of material/particle size)	
Gross mass (kg/tonnes) General cargo: Bulk cargo: **Verified gross mass (kg/tonnes)** Cargo unit(s):	Relevant special properties of the cargo (eg highly soluble in water. For solid bulk cargo, see Section 4 of the IMSBC Code)

Solid Bulk Cargo Information

BCSN	
Specification of bulk cargo (if applicable) Stowage factor: Angle of repose: Trimming procedures: If potential hazard - chemical properties*: **eg: Class, UN number or MHB*	Group of the cargo ☐ Group A and B* ☐ Group A* ☐ Group B ☐ Group C ** For cargoes which may liquefy (Group A and Group A and B cargoes)*
Classification relating to MARPOL Annex V ☐ Harmful to the marine environment ☐ Not harmful to the marine environment HME information is for the Master to consider in relation to how cargo residues generated by this cargo may be handled and disposed of after discharge of the cargo.	Transportable moisture limit Moisture content at shipment
Additional certificate(s) (if required) ☐ Certificate of moisture content* ☐ Certificate of transportable moisture limit* ☐ Weathering certificate ☐ Exemption certificate ☐ Approval Certificate for the procedures for sampling, testing and controlling the moisture content for a solid bulk cargo that may liquefy (*see 4.3.3 of the IMSBC Code*) ☐ Other (specify): **May be combined into a single certificate*	

Declaration

I hereby declare that the consignment is fully and accurately described and that the given test results and other specifications are correct to the best of my knowledge and belief and can be considered as representative for the cargo to be loaded.		
Name/status, company/organisation of signatory	Place and date	Signature on behalf of shipper

Shippers' may deliver this declaration by fax or other electronic means. In any electronic transmission, where the signature of the declarant cannot be transmitted, full name of the declarant in capital letters must be provided on the form.

AMSA 268 (3/16)