# Nickel Ore Liquefaction: The Risk That Still Sinks Ships

## 1. The Impact of Nickel Ore Carriage on the Shipping Industry

Over the last two decades, the carriage of nickel ore has been associated with a number of serious bulk carrier losses, including incidents involving loss of life and total loss of the vessel. In several cases, vessels have been lost suddenly, often in relatively moderate weather conditions, giving rise to significant concern within the industry regarding the risks associated with this cargo. Maritime authorities and industry organisations have consistently identified nickel ore, including lateritic nickel ore primarily shipped from Indonesia and the Philippines, as one of the higher risk bulk commodities, owing to its potential to liquefy and adversely affect vessel stability under certain conditions.

The losses of Jian Fu Star (2010), Nasco Diamond (2010), Hong Wei (2010), Vinalines Queen (2011), Trans Summer (2013), Harita Bauxite (2013), Emerald Star (2017) and Nur Allya (2019), all of which were carrying nickel ore, demonstrate the recurring risk of cargo liquefaction associated with this cargo, where moisture content may have been above the Transportable Moisture Limit[1] (TML) and is understood to have contributed to these losses.

The recurring nature of these accidents demonstrates that the hazard is not merely theoretical, but arises from a combination of the inherent properties of nickel ore as a Group A[2] cargo prone to liquefaction, the conditions under which it is mined and transferred via barges in rainy conditions for loading onto seagoing vessels and failures to comply with the IMSBC Code.

## 2. Nickel Ore Cargo Characteristics and Stability Implications

### 2.1 Physical Properties of Nickel Ore

Nickel ore shipped by sea is typically lateritic ore, composed of fine particles with a high proportion of clay like material. These ores naturally retain moisture within their particle structure. Even when the surface appears dry, significant water may remain trapped between particles.

When shipped with moisture content exceeding a specified limit, nickel ore is susceptible to liquefaction or dynamic separation[3]. During the voyage, ship motion and vibration can result in a loss of shear strength, causing the cargo to behave like a viscous fluid, termed as *flow state*[4]. Once initiated, this process may develop rapidly and can pose a hazard to vessel stability. This change may be sudden and often irreversible with serious consequences.

### 2.2 Geographic and Environmental Factors at Mines

Nickel ore is predominantly exported from tropical regions, notably Southeast Asia and Pacific islands. Disturbance from mining operations increases the movement of sediment and water and periods of rainfall in mine areas can lead to the migration of fine particles and elevated moisture levels within ore stockpiles.

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[1] Transportable moisture limit (TML) of a group A cargo means the maximum moisture content of the cargo which is considered safe for carriage in ships not complying with the special provisions of 7.3.2. It is determined by the test procedures, approved by a competent authority, such as those specified in paragraph 1 of appendix 2.

[2] Group A consists of cargoes which possess a hazard due to moisture that may result in liquefaction or dynamic separation if shipped at a moisture content in excess of their transportable moisture limit.

[3] Dynamic separation means the phenomenon of forming a liquid slurry (water and fine solids) above the solid material.

[4] Flow state means a state occurring when a mass of granular material is saturated with liquid to an extent that, under the influence of prevailing external forces such as vibration, impaction or ship's motion, it loses its internal shear strength and behaves as a liquid.

Climate variability has intensified these risks. Changes in rainfall patterns have shortened dry seasons and increased the frequency of heavy precipitation, thereby reducing the reliability of historical safe loading windows.

### 2.3 How Liquefaction Affects Ship Stability

When nickel ore cargo undergoes liquefaction, it no longer behaves as a solid and instead moves within the ship's hold in a fluid manner. This produces a free surface effect similar to that in partially filled tanks and subsequently cargo may shift and settle unevenly to one side, reducing the ship's righting moment[5] (RM) and limiting its ability to return to an upright position after rolling. The vessel may capsize and sink if the righting moment becomes less than the heeling moment[6](HM).

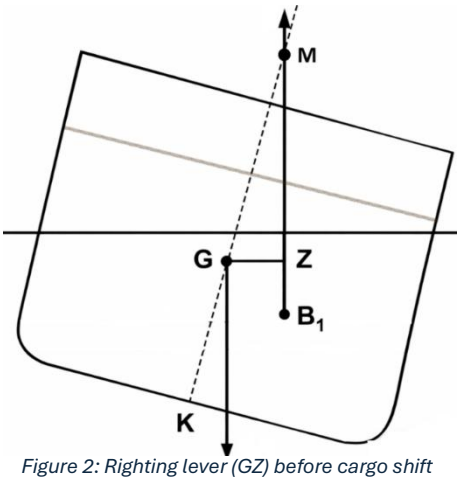


*Figure 2: Righting lever (GZ) before cargo shift*

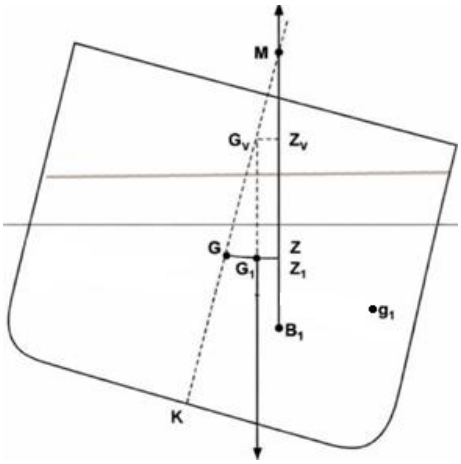


*Figure 1: Reduced righting lever ($G_1Z_1$) after cargo shift ($g_1$)*

### 2.4 Moisture Migration[7]

During the voyage, moisture may migrate within the cargo, causing the cargo at the bottom of the hold to exceed the Transportable Moisture Limit (TML) even where the moisture content at the top of the hold remains below the limit. This wet base can still lead to asymmetrical cargo movement during vessel rolling, increasing list and potentially resulting in a rapid loss of stability.

## 3. Regulatory Framework

### 3.1 SOLAS and IMSBC Code Requirements

The IMSBC Code, which is mandatory under SOLAS, provides the requirements for the shipment of nickel ore under its schedule in Appendix 1. Nickel ore is classified as a Group A cargo and the IMSBC Code specifies the conditions for its carriage, including the requirements in sections 4 and 7, together with the testing procedures in section 8 and Appendix II.

The IMSBC Code requires cargo suitability to be assessed before loading, verified by correct cargo identification, correct cargo information and proper sampling, testing and certifications. Nickel ore is only to be accepted for loading when the actual moisture content is below the Transportable Moisture Limit, unless the cargo is carried on a ship that has been specially designed or approved for this purpose.

These requirements apply to both shippers and shipmasters.

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[5] Righting moment is the force that returns a vessel to its upright position after it has been heeled by external forces.
[6] Heeling moment is the force that causes a vessel to incline or heel from its upright position due to external or internal influences.
[7] *Moisture migration* means the movement of moisture contained in a cargo by settling and consolidation of the cargo due to vibration and ship's motion. Water is progressively displaced, which may result in some portions or all of the cargo developing a flow state.

### 3.2 Shipper Obligations Under IMSBC

Shippers are required to declare the correct Bulk Cargo Shipping Name (BCSN) and to provide valid laboratory test results showing both the Transportable Moisture Limit (TML) and the actual Moisture Content (MC) of the cargo. These results are to be based on representative sampling of the entire consignment and issued by an entity recognised by the competent authority at the port of loading.

The Transportable Moisture Limit is to be evaluated and confirmed within six months before loading. Where the cargo composition or characteristics change, a new test is required once such variation can reasonably be assumed to have occurred.

Sampling and testing for moisture content are to be carried out as close as practicable to the start of loading and in any case not more than seven days before loading commences. Where the cargo is exposed to rain, snow or any other source of moisture before or during loading, the moisture content is to be reassessed and re-certified to confirm that it remains below the Transportable Moisture Limit (TML), with evidence provided to the master as soon as practicable.

### 3.3 Obligations and Authority of the Master

Under SOLAS and the IMSBC Code, the master is required to ensure that cargo accepted for loading is suitable for safe carriage. This includes receiving correct cargo information from the shipper prior to loading, supported by a correct cargo declaration, a certificate for the Transportable Moisture Limit and a separate certificate for the actual moisture content, with moisture content testing carried out not more than seven days prior to loading.

The Transportable Moisture Limit and moisture content are to be evaluated in accordance with the recognised methods as set out in the IMSBC Code. The master is to review the information provided and may decline or suspend loading where the cargo has been exposed to rain or other sources of moisture or where there are reasonable grounds to believe that the cargo may not comply with the IMSBC Code. The IMSBC Code places responsibility on the master to rely on properly issued documentations and to act where information is missing, inconsistent or raises safety concerns.

In addition, the master is responsible for managing shipboard operations to support the safe carriage of the cargo. This includes ensuring the bilge system is fully operational before loading, suspending cargo operations and protecting cargo spaces from water ingress during rain, trimming the cargo evenly, monitoring the cargo surface for signs of liquefaction that may affect the ship’s stability during the voyage, and planning and conducting the voyage with due regard to weather conditions.

## 4. Limitations and Practical Challenges in Testing and Sampling Procedures

### 4.1 Geographical Factors and Remoteness of Loading Areas

Nickel ore is predominantly mined and exported from remote tropical regions, often far from major industrial or laboratory centres. Export ports are often small, with limited infrastructure, or consist of temporary anchorages rather than purpose built bulk terminals. Stockpiles may be located inland, on hillsides, or near river systems, with limited physical access. This creates several constraints such as limited physical access to stockpiles for systematic and representative sampling, long transport times between mine sites, stockpiles, barges and loading points, difficulty in maintaining sample integrity and reduced oversight by competent authorities in isolated locations. As a result, sampling may be carried out under time pressure and logistical constraints that affect representativeness, particularly during periods of rainfall or peak export demand.

Sampling is commonly conducted before loading begins. However, delays, exposure to weather or transport by barge may change the moisture content between testing and loading. In some cases, access to stockpiles is limited, restricting the depth and locations from which samples can be taken. Samples may at times be taken from the surface of the cargo, even though the surface may appear dry while higher moisture levels

remain deeper within the stockpile. These factors can affect the reliability of test results, even where recognised procedures are followed.

For these reasons, compliance with the testing and sampling requirements does not by itself ensure that the cargo will remain safe throughout the voyage. Continued attention during loading and the voyage is therefore necessary for safe carriage.

### 4.2 Availability of Approved Laboratories

Another critical limitation lies in the availability of qualified, independent and well-equipped laboratories capable of performing IMSBC compliant testing. Members are often forced to rely on laboratories located far from the port of loading, resulting in delays between sampling and testing.

### 4.3 Limitations of Test Methods Employed

The IMSBC Code recognises several laboratory methods for determining Flow Moisture Point (FMP) and deriving the TML. However, each method has inherent limitations in determine accurate FMP and TML values for nickel ore due to the ore's natural heterogeneity in particle and clay content, and the crude nature of open-cast mining. These technical challenges are significantly amplified when testing facilities do not strictly adhere to IMSBC standards, increasing the risk of cargo data with an understated moisture profile.

### 4.4 Sampling Challenges and Representativeness

Heterogeneity of stockpiles may affect the moisture content, and it may differ significantly between surface layers, core material and basal zones. Rainwater tends to penetrate downward; this moisture migration leaves surface material deceptively dry while deeper layers remain saturated. Samples taken days before loading may no longer be representative after rainfall or rehandling.

Selective sampling is a risk concern when samples are taken from convenient or visually “dry” locations rather than from across the full consignment.

Barge loading further complicates representativeness, as cargo may be re-handled and exposed to external moisture in the form of rain or seawater before reaching the vessel, altering its moisture profile relative to the original stockpile.

### 4.5 Onboard Screening and Its Limitations

Onboard checks, such as simple “can” tests, are only to be used as a supplementary screening tool. If free moisture or fluid condition appears during can test, arrangements should be made to have additional laboratory tests conducted on the material before it is accepted for loading.

## 5. Operational and Practical Considerations

### 5.1 Supporting Compliance

Compliance with the IMSBC Code provides the framework for the safe carriage of nickel ore. In practical terms, this involves managing sampling, testing, loading and shipboard operations in a manner that takes account of local conditions, weather and logistical constraints that may affect these activities.

### 5.2 Appointment of Expert Surveyors

Member appointed independent expert surveyors play an important role in overcoming the challenges of sampling and testing nickel ore cargoes. Their responsibilities are to include identifying the specific stockpiles designated for shipment, ensuring that samples are collected in accordance with IMSBC Code sections 4.4 and 4.6, and verifying that these samples are actually representative of the entire consignment. Surveyors

should also oversee the collection of samples for laboratory testing, ensuring that procedures follow Appendix 2 of the Code. In addition, they should assess stockpile conditions, monitor drainage and exposure to rainfall, witness moisture content testing, review laboratory protocols and supervise loading operations to detect any rain exposure or deterioration of the cargo. The surveyor should liaise and assist the master to comply with his obligations under the IMSBC Code and local regulations.

### 5.3 Shipboard Operational Controls

The master is responsible for managing shipboard operations in a manner that supports the safe carriage of the cargo. This includes ensuring bilge systems are operational before loading, suspending cargo operations and protecting cargo spaces from water ingress during rainfall and trimming cargo evenly. During the voyage, the cargo surface should be monitored for signs of liquefaction or uneven movement that may affect stability, and the voyage planned and conducted with due regard to prevailing and forecast weather conditions. These operational controls form part of the overall management of risk during loading and carriage and support the safe transport of nickel ore.

## 6. P&I Club Support and Member Actions

The Club remains committed to supporting Members in managing the risks associated with the carriage of nickel ore from Indonesia and the Philippines. Members are required to notify the Club at the earliest opportunity when they plan to fix or charter a vessel for loading nickel ore from these regions or where a vessel under an existing fixture is ordered to load such cargo, as failure to do so may prejudice Club cover. Members should also refer to the Club any contractual, operational or safe carriage concerns they may have so that appropriate guidance can be provided, including advice on compliance with the IMSBC Code and any considerations relating to shippers' documentation. While compliance with the IMSBC Code remains the sole responsibility of the Member and Master, the Club can assist by supplying relevant information on risk mitigation measures, such as the appointment of a reputable local surveyor to support the Master during loading and an independent expert to supervise or liaise with the surveyor as required. These steps can reduce, though not eliminate, the inherent dangers associated with carrying nickel ore. If the Master has any doubt whatsoever regarding the condition, suitability or safety of the cargo, loading must be stopped immediately and the Club informed. Members should remain vigilant and ensure full transparency with the Club at all stages prior to the carriage of nickel ore.

## 7. Conclusion

The carriage of nickel ore presents risks arising from cargo characteristics, environmental conditions, and operational decision making influenced by commercial pressure, which may increase the likelihood of loss of cargo stability if not properly managed. The international regulatory frameworks concerning nickel ore shipments are comprehensive and unambiguous, and it can be safely carried if these requirements are adhered to without any exceptions. On the other hand, failure to fully comply with them increases the likelihood of serious consequences, such as loss of life and the vessel. Safe carriage therefore depends on consistent compliance with applicable requirements and the appropriate exercise of authority in assessing cargo suitability.

## Supportive Information

For further information on this or other Loss Prevention topics please contact the Loss Prevention Department, Steamship Insurance Management Services Ltd.
Tel: +44 20 7247 5490
Email: loss.prevention@simsl.com

## Resources

IMSBC Code

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