

Liquefaction of Bulk Cargoes

***- Introduction of the ClassNK Activities
for the Safe Carriage of Nickel Ore -***

*Hull Department, ClassNK
7 November 2013*

1. Background

2. Approach

- ✓ *How to Enhance the Safe Carriage of Nickel Ore*
- ✓ *Concept to determine NEW Requirements*

3. Introduction for 2nd Version of

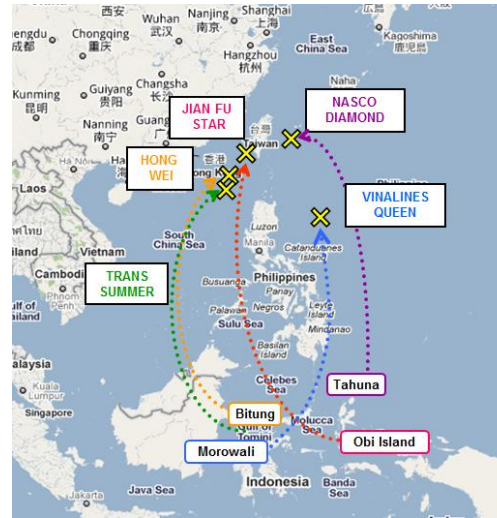
“Guidelines for Safe Carriage of Nickel Ore”

- ✓ *Contents of this Guidelines*
- ✓ *What is the “Specially Constructed Cargo Ship”*

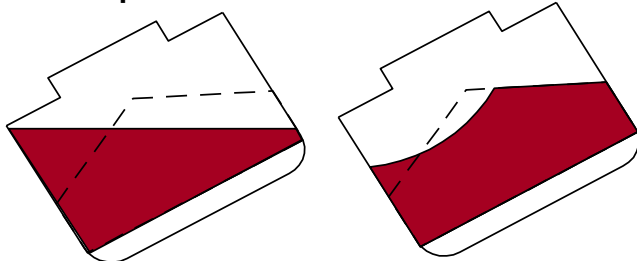
4. Conclusion

1. Background

◆ Main Features of Nickel Ore



Major marine casualties have been reported in recent years, the main cause of which appears to be **loss of stability by liquefaction** of Nickel Ore and consequent behavior assumed as either of followings during her voyage,



Under such circumstances, **NICKEL ORE** is newly being categorized as **Group A Cargo** in the Appendix 1 of IMSBC Code and entered into force on 2015.

1. Background

◆ Transportation of Nickel Ore (1)

■ Definition of Group A Cargo

Cargoes which may **liquefy** if shipped at a moisture content (MC) in excess of the transportable moisture limit (TML) [Ref. IMSBC Code 1.7.12]

- *Moisture Content (MC)* [Ref. IMSBC Code 1.7.20]

Moisture content means that portion of a representative sample consisting of water, ice or other liquid expressed as a percentage of the total wet mass of that sample.

- *Transportable Moisture Limit (TML)* [Ref. IMSBC Code 1.7.27]

TML of a cargo which may liquefy means the maximum moisture content of the cargo which is considered safe for carriage in ships not complying with the special provisions of subsection 7.3.2 of IMSBC Code.



MC > TML



Liquefaction

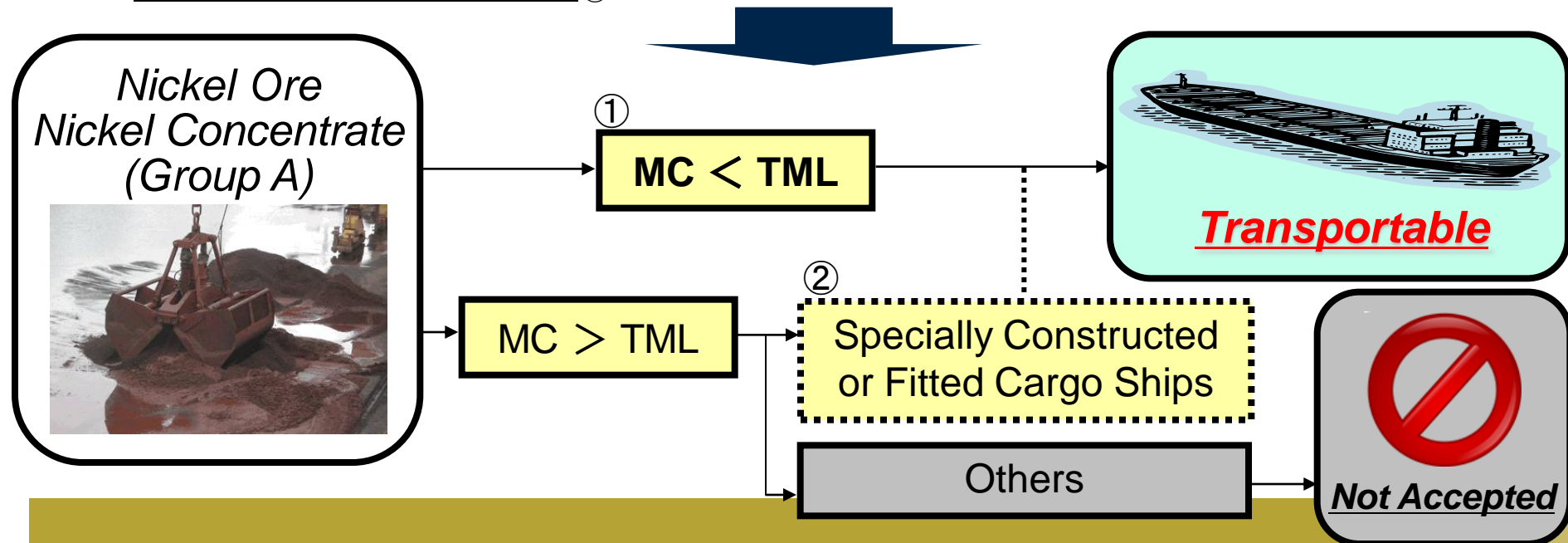
1. Background

◆ Transportation of Nickel Ore (2)

■ *IMSBC Code 7.3.1.1*

Concentrates or other cargoes which may liquefy shall only be accepted for loading when the actual moisture content of the cargo is less than its TML ①

Notwithstanding this provision, such cargoes may be accepted for loading on specially constructed or fitted cargo ships even when their moisture content exceeds the TML ②



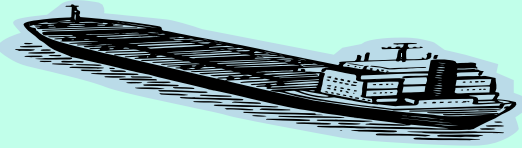
1. Background

◆ How to Enhance the Safe Carriage of Nickel Ore (1)

Nickel Ore
Nickel Concentrate
(Group A)



MC < TML



Transportable

MC > TML

Specially constructed
or fitted cargo ships

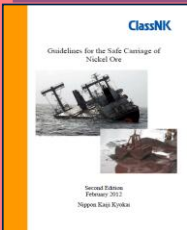
Prompt and Immediate Effect

Step 1

Operational Phases to keep
its MC less than the TML

**Summarize the past
findings/knowledge**

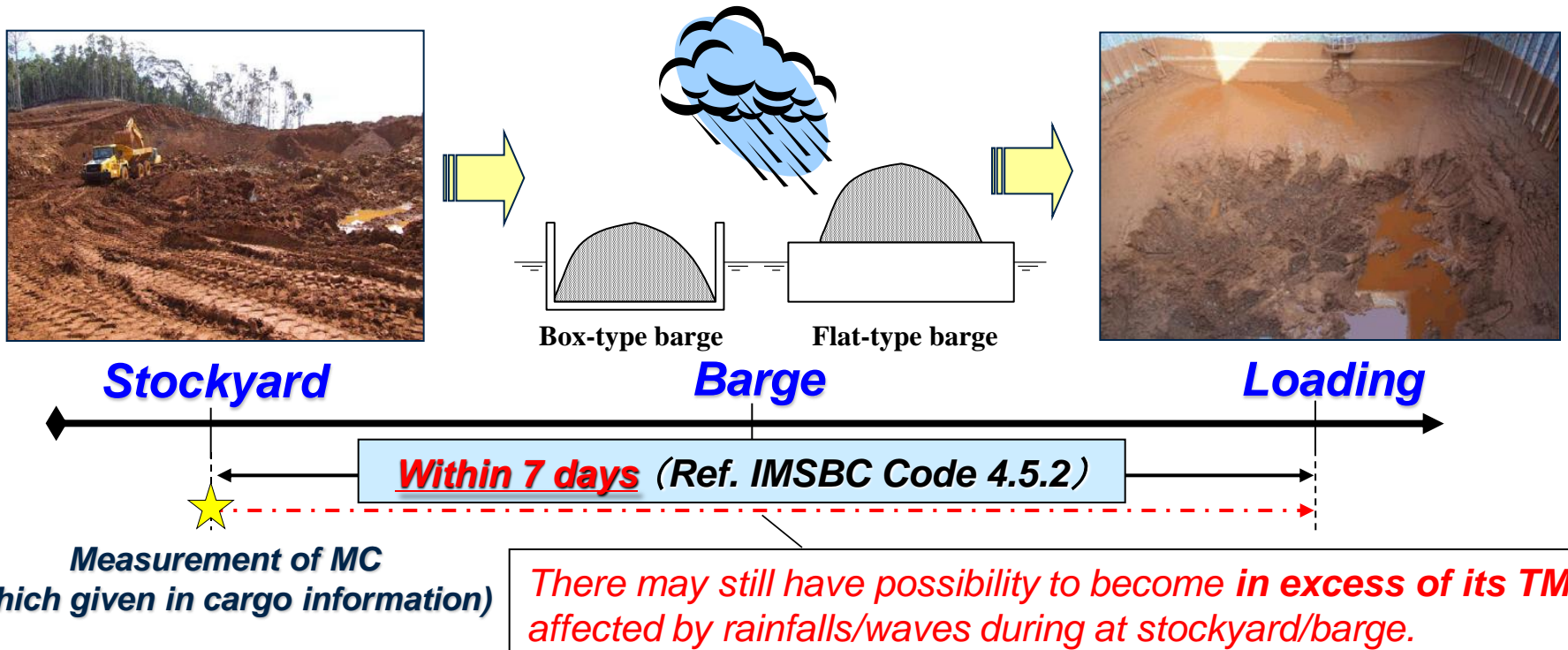
MC < TML



- ✓ First Edition has already been published in **May 2011**.
- ✓ Establish the guidelines to recommend **appropriate operation**

1. Background

◆ Needs for realization of “Specially Constructed Cargo Ship”



- Test to determine the moisture content of a solid bulk cargo has been conducted ***within 7 days*** of the date of loading the cargo. (Ref. IMSBC Code 4.5.2)

→ ***Unavoidable*** to carry such liquefied cargoes at any cost because of ***business pressure from Shipper*** based on difficulties to control moisture at huge stockyard.

1. Background

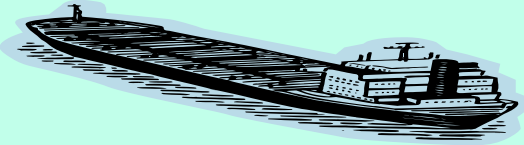
◆ How to Enhance the Safe Carriage of Nickel Ore (2)

Nickel Ore
Nickel Concentrate
(Group A)



MC < TML

(※ already established)



Transportable

MC > TML

Specially Constructed
or Fitted Cargo Ships

Further Enhancement

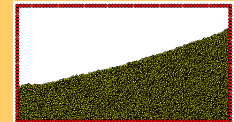
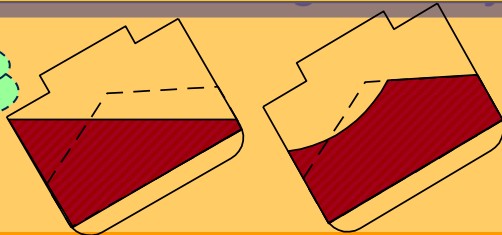
Step 2

Hull Structural Phases to ensure
entire safety in any case even if its MC
exceeds the TML during her voyage

Propose NEW
standards of Stability
& Hull Strength

MC > TML

Properties ?
Behavior ?



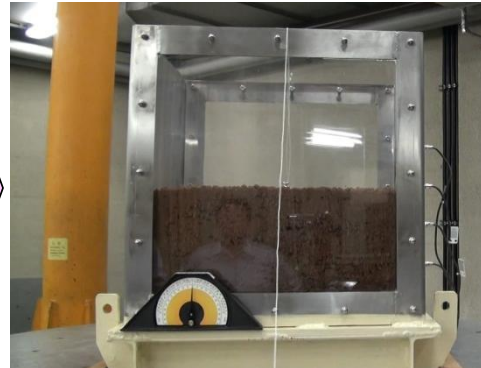
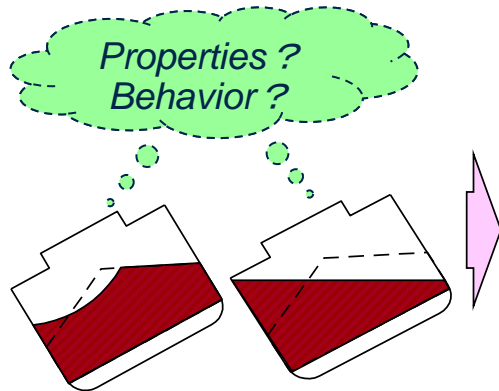
Verified by our Research

2. Approach

◆ Laboratory Test with the Use of Nickel Ore

→ to grasp the actual cargo properties & behavior at the different MC

Test Name	Outline of Tasks
Weight Intrusion Test	<i>Alteration of Cargo Properties induced by Vibration</i>
Rolling Test	<i>Cargo behavior at Rolled Condition</i>
Static Inclining Test	<i>Cargo behavior at Heeled Condition, Pressure Measurement</i>

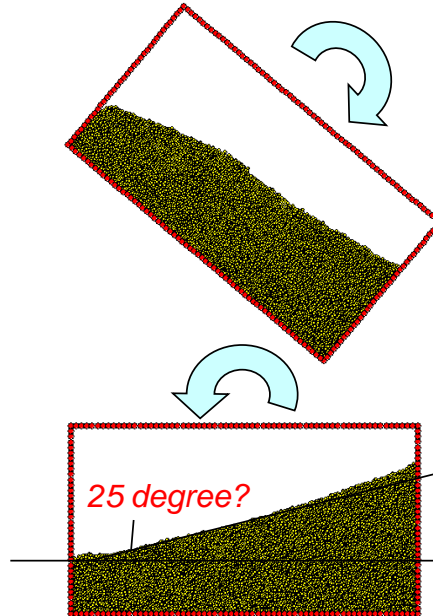
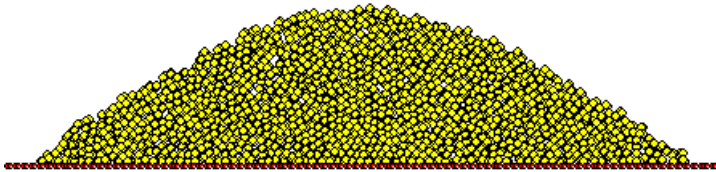


- ✓ No significant Property Alteration is found by Vibration, Rolling or Heeling
- ✓ MC arises, cargo behavior gradually come close with Liquid

2. Approach

◆ Numerical Analysis (Further verification by Discrete Element Method)

- considering the scale effect, cargo behavior at real scale is verified by Discrete Element Method
- to examine the difference of behavior between Nickel Ore and Grain



• Condition

Max. Rolling Angle	$\pm 40^\circ$
Rolling Period	10 sec.

Ex.) Sample Movie

Nickel Ore	Grain

✓ No significant difference of behavior is found between Nickel Ore & Grain as an influence which induces Stability

2. Approach

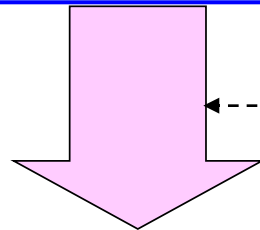
◆ Concept to Determine Stability Requirements

1. *Laboratory Test with the use of Nickel Ore*
2. *Numerical Analysis (Further verification by Discrete Element Method)*

- ✓ MC arises, cargo behavior gradually come close with Liquid
- ✓ No significant difference of behavior is found between Nickel Ore & Grain as an influence which induces Stability



- In case of “**High**” Moisture Contents
→ synchronized with ship motion such as Liquid cargo
(**Free Surface Effect** is to be considered)
- In case of “**Middle** (liquid with Viscosity)” and “**Low**” Moisture Contents
→ Maximum angle of cargo shifting induced by rolling is **25 degree**







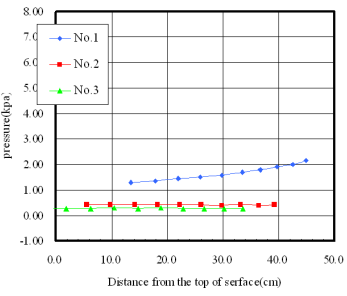
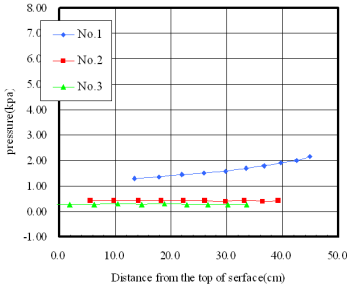
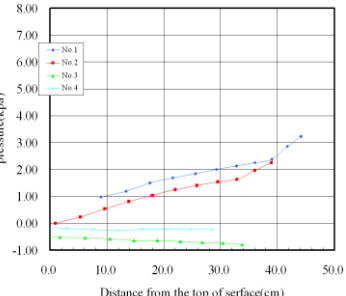
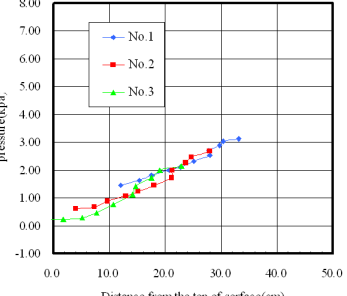
Applying the rational criterion on the basis of relevant international codes which has been recognized widely and safely

Establish Stability Requirements (P14, 15)

2. Approach

◆ Concept to Determine Hull Strength Requirements

During Static Inclining Test, pressure acting on wall is measured at various MC

MC	23.6%	33.6%	38.6%	43.6%
Test Piece				
Pressure X-axis: Height Y-axis: pressure				

● It is sufficient to regard the pressure acting on BHD by Liquid behavior

Establish Hull Strength Requirements (P17)

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

◆ Contents of this Guideline

Chap.6

**TECHNICAL SERVICES
OFFERED BY CLASSNK**

*Approval of Drawings,
Issuance of Certificate*

Chap.5

**SPECIAL REQUIREMENTS OF SPECIALLY
CONSTRUCTED SHIP FOR THE
CARRIAGE OF NICKEL ORE**

*New Requirements
(Stability & Hull Strength)*

Chap.4

**PRECAUTIONS DURING THE
CARRIAGE OF NICKEL ORE AND
RECOMMENDATIONS**

*Organize the Recommended
Operation (incl. Check List)*

Chap.3

NICKEL ORE

*Features of Nickel Ore
(incl. Properties, Report etc.)*

Chap.2

**CARGOES WHICH MAY
LIQUEFY**

*Organize the General
Requirements in IMSBC Code
(Definition, Scheme etc.)*

Chap.1

**GENERAL REQUIREMENTS FOR
THE CARRIAGE OF SOLID BULK
CARGOES**

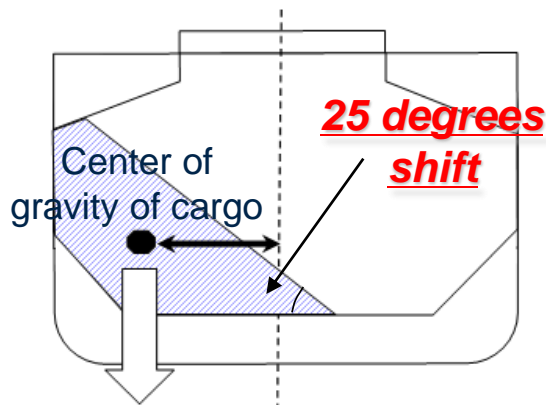
(※ Inside the Thick Frame with bold letter indicates the Modification from Ver.1)

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

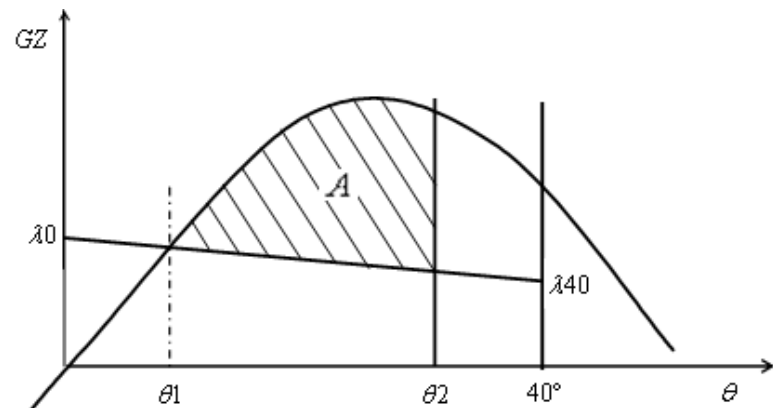
Chap.5 SPECIAL REQUIREMENTS OF SPECIALLY CONSTRUCTED CARGO SHIP FOR THE CARRIAGE OF NICKEL ORE

(a)-1 Stability

- In case of “High” Moisture Contents
 - synchronized with ship motion such as Liquid cargo (Free Surface Effect is to be considered)
- In case of “**Middle** (liquid with Viscosity)” and “**Low**” Moisture Contents
 - **Maximum angle of cargo shifting induced by rolling is 25 degree**



Transverse Heeling Moment



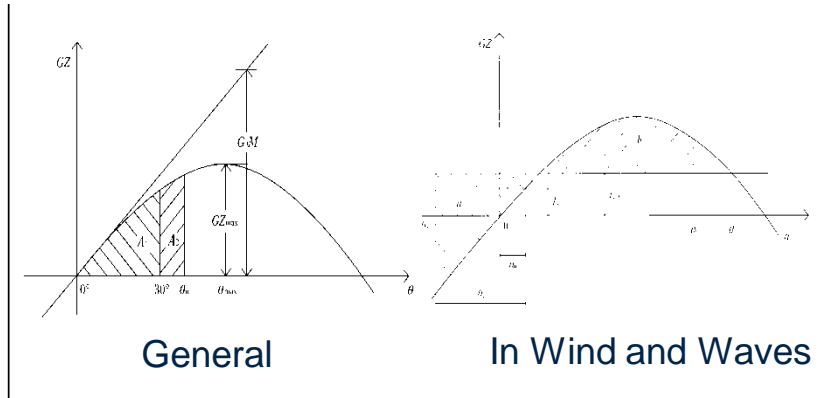
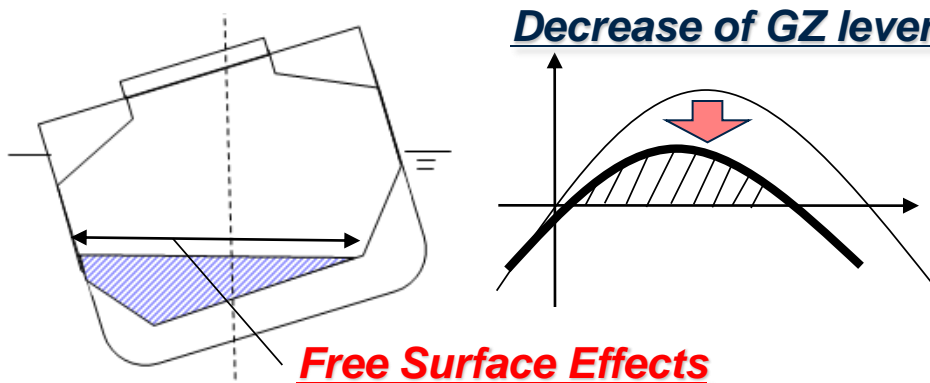
Evaluate applying International Grain Code considering with heeling moment with cargo shifting at 25 degree

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

Chap.5 SPECIAL REQUIREMENTS OF SPECIALLY CONSTRUCTED CARGO SHIP FOR THE CARRIAGE OF NICKEL ORE

(a)-2 Stability

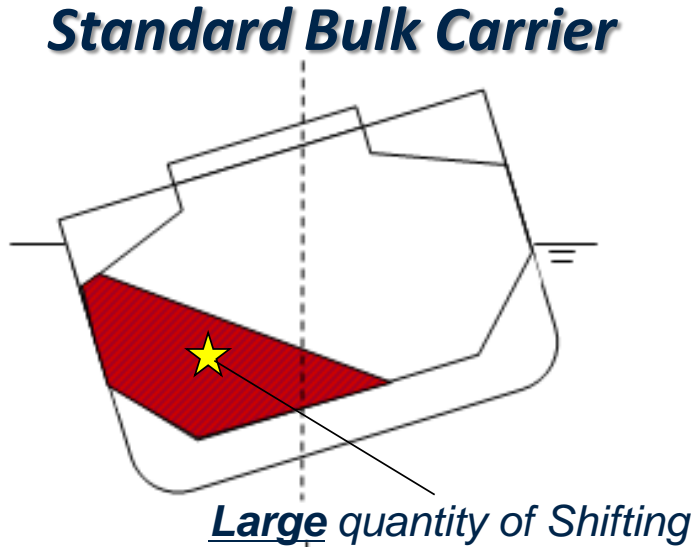
- In case of “**High**” Moisture Contents
 - synchronized with ship motion such as Liquid cargo (**Free Surface Effect** is to be considered)
- In case of “Middle (liquid with Viscosity)” and “Low” Moisture Contents
 - Maximum angle of cargo shifting induced by rolling is 25 degree



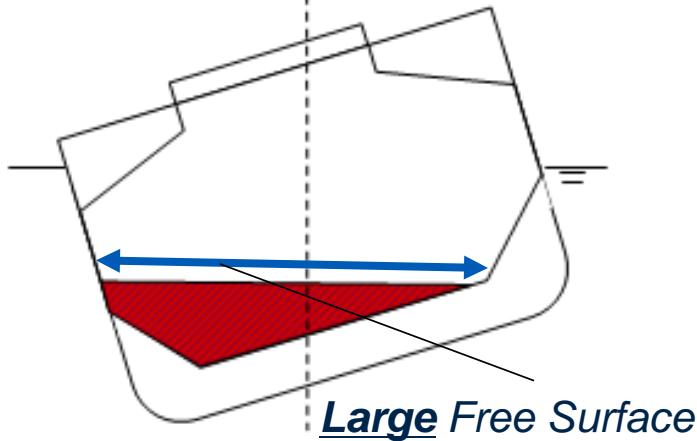
Evaluate applying 2008 IS Code considering with motion such as Liquid cargo including Free Surface Effect

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

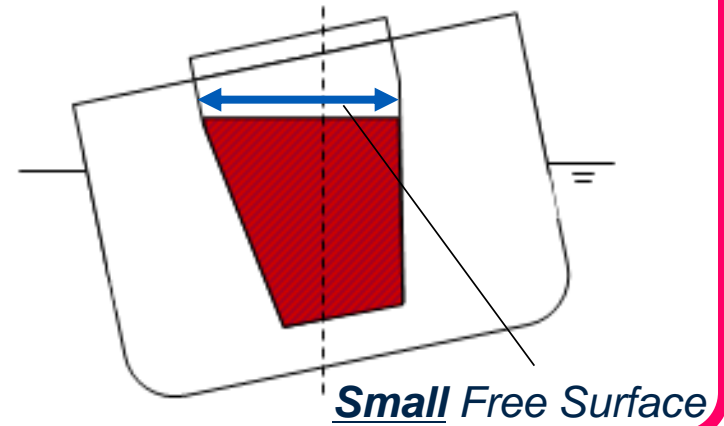
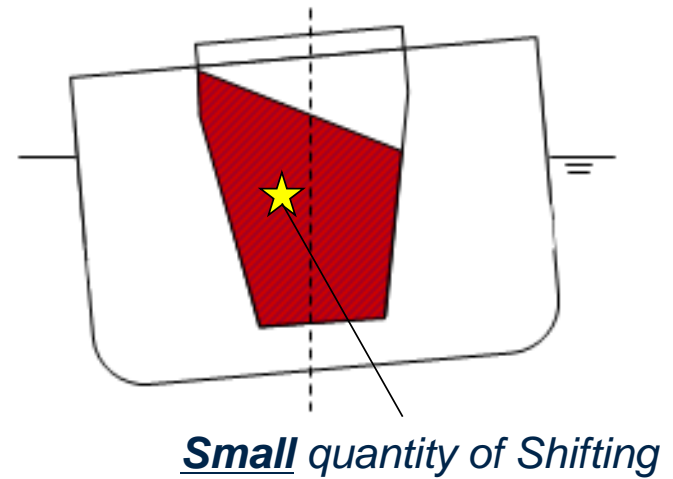
(a)-1
Heeling Moment
(P10)



(a)-2
Free Surface Effect
(P11)



Ore Carrier



Difficult for Standard Bulk Carrier to satisfy with NEW requirements

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

Chap.5 SPECIAL REQUIREMENTS OF SPECIALLY CONSTRUCTED CARGO SHIP FOR THE CARRIAGE OF NICKEL ORE

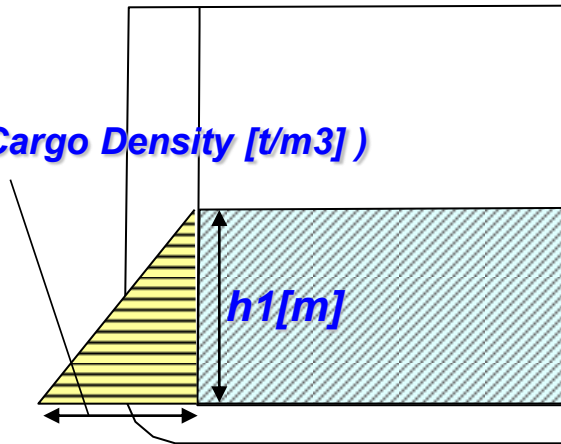
(b) Hull Strength

- It is sufficient to regard the pressure acting on BHD by Liquid behavior

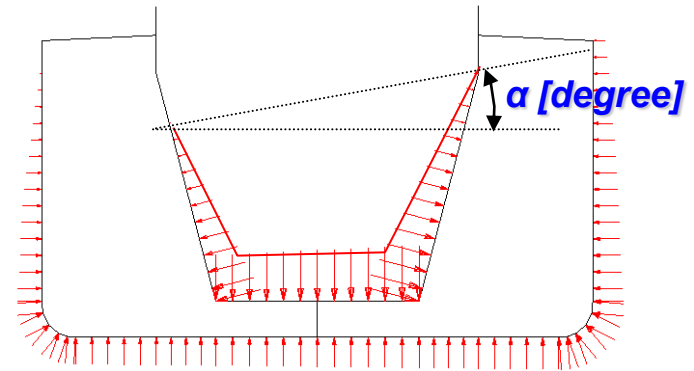
Load → Equivalent to the pressure induced by Liquid Cargo

$$P = \rho h1$$

(ρ : Bulk Cargo Density [t/m³])



Shape → Considering the angle of heel (α) obtained as a result of Stability Calculation



Evaluate hull scantlings applying appropriate regulations (Part C/ Part CSR-B of NK Rules) with use of these Load and Shape

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

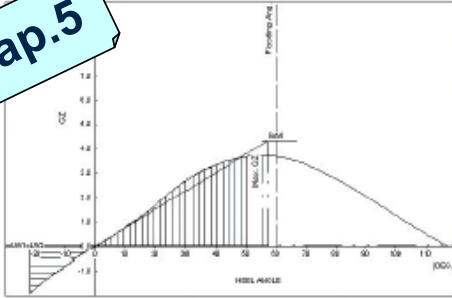
Chap.6

TECHNICAL SERVICES OFFERED BY CLASSNK

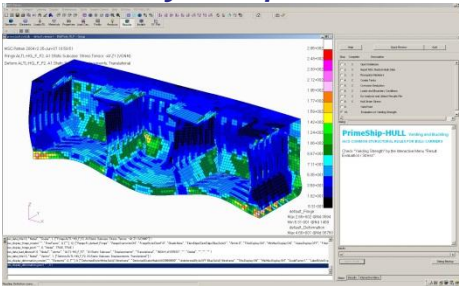
Approval work for Specially Constructed Cargo Ship for the Carriage of Nickel Ore

✓ *Distinction* as a vessel which satisfies with all requirements in Chap.5

Chap.5



Stability Requirements



Hull Strength Requirements

shows the standards for approval



➤ Notation: **SCCS**
 ➤ Descriptive Note: **Designed for Carriage of Liquefied Nickel Ore having a Moisture Content in excess of Transportable Moisture Limit**

(a) Approval of relevant drawings

(b) Issuance of Certificate

(c) Affix Class Notation

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

◆ What is the “Specially Constructed Cargo Ship” ?

■ IMSBC Code 7.3.2.2 (& 7.3.2.3)

Specially constructed (fitted) cargo ships shall have permanent (portable) structural boundaries, so arranged as to confine any shift of cargo to an acceptable limit. The ship concerned shall carry **evidence of approval by the Administration**.
** Description in () means the regulation in 7.3.2.3.*

■ IMSBC Code 7.3.2.4

A submission made to an Administration for approval of such a ship shall include:

- .1 relevant **structural drawings**, including scaled longitudinal and transverse sections;
- .2 **stability calculations**, taking into account loading arrangements and possible cargo shift, showing the distribution of cargo and liquids in tanks, and of cargo which may become fluid; and
- .3 any other information which may assist the Administration in the assessment of the submission.

*However, it is difficult to issue such approval by the administration because **no concrete standards/criteria for approval** has been established in any international codes.*

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

◆ Our Effort to realize “Specially Constructed Cargo Ship”

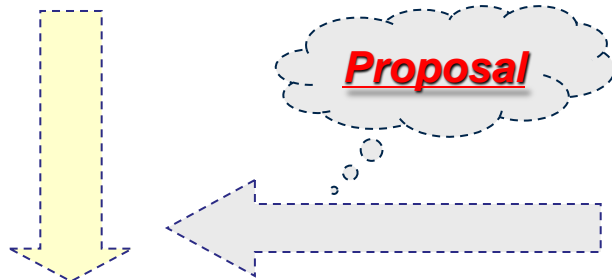
Cargoes having a moisture content in excess of the TML shall only be carried in Specially Constructed Cargo Ships (IMSBC Code Reg.7.3.2.1)



The ship concerned shall carry Evidence of Approval by the Administration

However...

NO Standard/Criteria in IMSBC Code



for Ver.2



Vessels satisfying with New Requirements for Safe Carriage of Nickel Ore

We would like to get an acceptance of this from each Administration as standards to issue Evidence of Approval for the carriage of Nickel Ore.

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

◆ Response of Each Administration at Present

◆ 17 October 2011

With our technical assistance, **Panama Maritime Authority** approves **first** vessel for the Carriage of Nickel Ore.
(MV JULES GARNIER II)

Panama approves new bulker design aimed at tackling liquefaction

Adam Corbett

London

Panama has given the first flag-state approval to a new bulker design intended to allow vessels to sail safely even with a dry-bulk cargo that has liquefied.

The 27,200-dwt ship, the first of its kind, has been ordered by Naikai Shipbuilding for owner Nissho Shipping and will be delivered in the autumn of 2012.

Naikai intends to use the vessel for trading nickel ore, a cargo that has been known to liquefy and affect ship stability if it exceeds its

transportable moisture limit.

Japanese classification society ClassNK was involved in the ship design. A spokesperson for its hull department said: “The vessel will be able to transport cargoes such as nickel ore even if unexpected rain or waves increase the moisture level past the limits laid out in the International Maritime Solid Bulk Cargoes Code.”

But the design is unlikely to provide an immediate short-term solution to the growing industry problem of liquefying dry-bulk cargoes. Carrying cargoes with too

much moisture content has proved catastrophic for conventional vessels with four losses last year. The hazardous cargoes also include iron-ore fines and sinter fines.

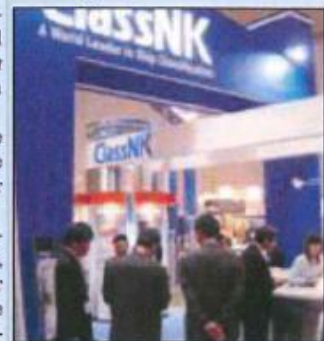
Most ships rely on shippers loading cargoes with a suitable moisture level, although pressure is often put on vessel personnel to take on cargoes that exceed the moisture limit.

Up to four ships are believed to be currently laid up with problems related to a liquefied cargo, including the 206,000-dwt *BW*

Odel (built 2007), which continues to be stuck off Mauritius, and the 76,300-dwt *Red Gardenia* (built 2005), which is laid up in Mobile, Alabama.

ClassNK is hopeful that the move by Panama to approve the design will lead to more orders for the new design.

“By establishing clear guidelines for the use of these elements, ClassNK hopes to make it easier for flag administrations to approve such new designs and in turn contribute to the safety of the world’s bulker fleet,” it said.



CLASSNK: Involved in developing the new design
Photo: ClassNK

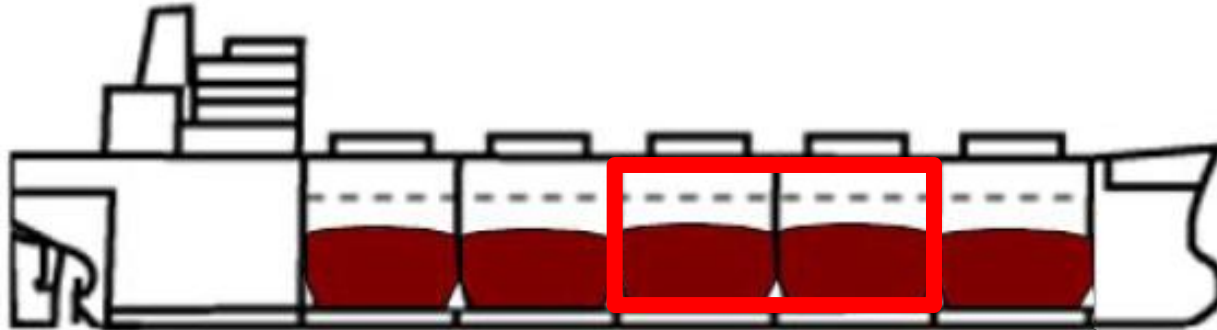
As an example of Panama, we have continued to discuss with Japan, Liberia and Marshall Islands etc.
(We already have received a voice of favor in this concept)

3. Introduction for 2nd Edition of “Guidelines for Safe Carriage of Nickel Ore”

◆ Other Information

Basically, we apply these new requirements (Stability & Hull Strength) into ALL cargo holds.

→ Difficult for Bulk Carrier to satisfy these requirements



*For Bulk Carrier, we could support to get **evidence of approval** from Administrations with some condition/restriction (Ex. Nickel Ore is just being carried in 1 or 2 Cargo Holds).*

4. Conclusion

- ClassNK published “Guidelines for the Safe Carriage of Nickel Ore <1st Edition>” in May 2011 which includes the appropriate “**Operation**” to avoid the liquefaction (keep its MC less than the TML).
- ClassNK established NEW requirements of “**Stability**” and “**Hull Structure**” for the carriage of Nickel Ore having a MC in excess of TML and published them into 2nd Edition of the Guidelines in February 2012.
- To realize “**Specially Constructed Cargo Ship**” defined in IMSBC Code 7.3.1.1 for the carriage of Nickel Ore, ClassNK aggressively continues to offer technical explanations of these NEW requirements to various Administrations and make a platform for owners to get “**Evidence of Approval**” smoothly.

Thanks for your kind Attention

ClassNK

A World Leader in Ship Classification

“Guidelines for the Safe Carriage of Nickel Ore” can be downloaded on our website (<https://www.classnk.or.jp>)