Hot Briquetted Iron Association (HBIA) Ltd. presents

Hot Briquetted Iron*

Guide for Transporting and Handling at Terminals

Best Available Practice

"* described as Direct Reduced Iron (A) – Briquettes, hot-moulded in The International Maritime Solid Bulk Cargoes (IMSBC) Code published by the International Maritime Organization (IMO)".

HBIA

HOT BRIQUETTED IRON ASSOCIATION

HBI – Steel's Versatile Metallic

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DISCLAIMER

The information presented in this guide is intended for general information only and should not be used in relation to any specific application without independent examination and verification of its applicability and suitability by professionally qualified personnel. Those making use thereof or relying thereon assume all risks and liability arising from such use or reliance.

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FOREWORD

The purpose of the HBI Association Ltd. (HBIA) is threefold:

- To promote HBI as steel's most versatile metallic
- To inform ship owners/operators, charterers, and terminal operators of the handling, shipping, and storage benefits of HBI
- To assist iron and steel producers in the effective use of HBI

One way to achieve this is by sharing our collective experiences to improve the general understanding of the characteristics, properties, quality assurance methods, uses, and behavior of HBI under different conditions.

The HBIA Technical and Transportation Committees have drawn from the practical experience of our members in sampling, transporting, handling, and using HBI over the last 35 years and the expertise of DBTG members in preparing this guide.

I recommend this guide to terminals operators, ship owners and charters, and seafarers as a means to develop a broader understanding of the methods, techniques, and procedures for safely and efficiently transporting and handling HBI at terminals worldwide.

Respectfully,

Alberto Hassan
President
HBI Association Ltd.

PREFACE

The transportation of HBI by sea and land is a very important link in the supply chain from the producer to the end user. Therefore, the HBIA has decided to publish a guide for terminal operations based on actual, practical experiences during the last 35 years.

The preparation of this guide has involved numerous technical discussions between major HBI producers and terminal and ship operators about the physical and chemical properties of HBI and their impact on safe transporting and handling at terminals and during maritime carriage. Each group contributed its insights and experiences on the characteristics and behavior of HBI under various conditions and in different environments.

We hope these guidelines will help make the workplace safer for people involved in transporting, loading, and unloading HBI at terminals around the world and will serve as a useful reference guide for properly determining the risks and hazards associated with this bulk cargo.

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PART I
DEFINITIONS

1.1 BLU Code

Code of practice for the safe loading and unloading of bulk carriers published by the International Maritime Organization (IMO).

1.2 Direct Reduced Iron

The product of iron oxide pellets, lump ores, and/or fines that have been reduced (i.e., oxygen removed) in a direct reduction process at temperatures in excess of 900° Celsius, thereby increasing the percentage (by weight) of total iron in the reduced product. All other oxides in the ore remain in their natural state.

The International Maritime Organization (IMO) describes direct reduced iron as DRI (A) Hot-moulded briquettes, DRI (B) Lumps, pellets, and cold-moulded briquettes, and DRI (C) By-product fines.

1.3 Direct Reduced Iron (A) Briquettes, hot-moulded

The compacted form of DRI produced from pellets/lumps or fines or pellets/lumps and molded while hot (650 ºC minimum) but in solid state to achieve a minimum density of 5 g/cm^3, which greatly improves product stability against re-oxidation and facilitates handling, shipping and storing.

1.4 Direct Reduced Iron (B) Pellets, lumps, and cold-moulded briquettes

The product of iron oxide pellets, lump ores, and/or fines that have been reduced (i.e., oxygen removed) in a direct reduction process at temperatures in excess of 900° Celsius, thereby increasing the percentage (by weight) of total iron in the reduced product. All other oxides in the ore remain in their natural state.

1.5 Direct Reduced Iron (C) By-product fines by IMO description

The result of physical degradation of DRI (A) and DRI (B) during the reduction process caused by the rubbing, crepitation, shear stresses, etc. Fines also can be generated during the handling and screening of DRI (A) and DRI (B).

The typical size distribution depends on the feedstock and will range from 0 to 12 mm, with metallic iron content in the range of 1 to 75 percent by weight. Moisture content can be up to 0.3 percent.

1.6 DRI Fines – High Moisture

An undersize particulate material generated as a by-product during the production and handling process of Direct Reduced Iron (A) Briquettes, hot-moulded or Direct Reduced Iron (B) pellets or lumps. The density of DRI Fines is less than 5,000 Kg/m³. DRI Fines have moisture content of over 0.3 percent and up to 12 percent. Because DRI Fines differ from DRI (C) in moisture content, it is not a listed cargo in the IMSBC Code.

Normal size distribution depends on the feedstock and can range from 0 to 12 mm. Metallic iron content is in the range of 1.0 to 75.0 percent by weight, and moisture content over 0.3 percent and up to 12 percent by weight.

Mixtures of fines sometimes are prepared. The water present in some of these mixtures will accelerate the natural passivation process and result in total iron content similar to sinter feed quality iron ore.

DRI Fines have been known by various names when traded, such as HBI Fines, Orinoco Remet, Orinoco Concentrate, Settling Pond Fines, Quench Tank Fines, Metallized Fines, Remet, Process Fines, Sedimentation Fines, Chips, etc. These different names are used to identify the source of the fines (i.e., how they were generated or collected).

1.7 Ignition Temperature

The point at which the heat of reoxidation exceeds the heat losses in a DRI (A) or (B) storage pile (from 150° to 230° Celsius). In this temperature range, DRI B, and DRI (A) to a lesser extent, could ignite and burn.

1.8 IMSBC Code

The International Maritime Solid Bulk Cargoes Code, as published by the International Maritime Organization (IMO), which contains the amplified provisions governing the carriage of solid bulk cargoes and the carriage of dangerous goods in solid form in bulk. It will supersede the IMO Code of Safe Practice for Solid Bulk Cargoes (BC Code), 1994 Edition, on January 1, 2011. Until then, use of the IMSBC Code is voluntary.

1.9 Inert Condition

A condition in which the oxygen content throughout the atmosphere of a hold has been reduced to 5 percent or less by volume by the addition of inert gas (see 1.10).

1.10 Inert Gas

A gas or a mixture of gases, such as nitrogen, containing insufficient oxygen to support the combustion of flammable gases.

1.11 Inerting

The introduction of inert gas into a cargo hold with the objective of attaining an inert condition (see 1.9).

1.12 International Maritime Organization (IMO)

IMO was created in 1958 to to deal with international treaties and to keep conventions related to shipping, including safety up to date. It also was given the task of developing new conventions as and when the need arose. IMO is now responsible for nearly 50 international conventions and agreements and has adopted numerous protocols and amendments. It publishes the Internaitonal Maritime Solid Bulk Cargoes (IMSBC) Code, which provides guidelines used by the shipping and maritime insurance industries.

1.13 Overheating

The effect when a heavily wetted pile of DRI (A) or (B) exceeds 150° Celsius. The pile should be spread out and allowed to cool naturally. Do not spray water on a steaming pile of DRI (A) or (B).

1.14 Partial Briquettes/HBI Chips

Pieces ranging from 6 to 25 mm particle size that are produced during DRI (A) processing, handling, and screening operations. Pieces over 25 mm are considered DRI (A) for shipping purposes. As per IMO guidelines, fines and small particles (< 6.35 mm) shall not exceed 5 percent in a DRI (A) shipment.

1.15 Passivation (Natural Air)

The process whereby DRI (A) and (B) are allowed to react with the oxygen in the air following quenching or cooling after discharge from the reduction furnace or briquetting machine. The temperatures are about 44° Celsius and less than 100° Celsius for DRI (B) and DRI (A), respectively.

The fresh products are placed into piles in the storage yard and allowed to react with the oxygen in the air. After about five days, the DRI (A) or DRI (B) might show some steaming. Temperatures readings should be taken on a regular basis or daily if in a climate subject to frequent heavy rain.

In the case of DRI fines and DRI (C), natural air passivation normally is acceptable for a period of 30 to 120 days.

1.16 Pyrophoric

Defined as: 1. Igniting spontaneously or 2: Emitting sparks when scratched or struck especially with steel. DRI is not pyrophoric.

1.17 Reactivity

The natural tendency of to react with oxygen in the air and in water to form iron oxide. The loss of iron is slow in the presence of oxygen in the air. However, oxygen in water causes more rapid reoxidation and the release of hydrogen gas. This effect is accentuated when seawater comes into contact with DRI (B) and (C) and to a lesser extent with DRI (A).

1.18 Self-Heating

Tendency of all types of DRI to increase temperature for exothermic chemistry reaction in the presence of oxygen either in the air or in water (i.e., reoxidize). All types of DRI will release water vapor when heavily wetted (see 1.14 Steaming). When the DRI temperature increases to over 150 degrees Celsius, overheating occurs (see 1.6 Ignition Temperature).

1.19 Sponge Iron

Term sometimes used to describe non-briquetted Direct Reduced Iron (see 1.2); particularly used in India.

1.20 Steaming

Occurs when any pile of DRI has been heavily wetted and a new surface is exposed. Heat from the process of re-oxidation generates water vapor, which is released into the air.

1.21 Sweat

The condensation that forms in a ship's hold either on the cargo or on the ship's steelwork. (Source: Cargo Ventilation published by North England P&I Association Ltd.).

PART II
REACTIVITY CHARACTERISTICS OF DIRECT REDUCTION PRODUCTS

This section includes a brief analysis of existing data on the reactivity of the various types of Direct Reduced Iron (DRI), as defined in the IMO IMSBC Code. Available data from technical literature and reports submitted to IMO by DRI producers in the late 1970s and more recently from 2006-2009 were reviewed under the UN concepts and industry testing procedures.

2.1 DRI Production

HBI and DRI, classified by IMO as DRI (A) and DRI (B), respectively, are produced in either shaft furnace or fluidized bed processes. Shaft furnace processes use as feedstock 100 percent iron oxide pellets or a mixture of pellets and lump iron ores. The fluidized bed process uses iron ore fines (<1 to 12 mm particle size). The reduction temperature of both is about 900° Celsius. The product of both processes is metallized to 93 to 94 percent and has 1.5 to 2.0 percent carbon. The HBI temperature after quench cooling is below 100° Celsius. DRI is cooled prior to discharge to below 50° Celsius.

During the reduction process, some physical degradation of the pellets, lumps, and iron ore fines takes place. This action produces small pieces of the original feedstock (>6.35 mm) that have been metalized (i.e., metalized fines).

Fines also can be produced during handling, screening, and carriage of HBI and DRI. The particle size distribution depends on the feedstock and will range from <1 to 12 mm.

Broken pieces and chips of HBI can be produced during handling, screening, and carriage. The normal size distribution depends on the feedstock and will range from 6.35 to 20 mm (see Figure 1 below). Partial briquettes and chips are shipped as HBI according to the IMO IMSBC Code schedule for DRI (A).

The particle size ranges of all direct reduction products are shown in Figure 1.

All direct reduction products undergo natural air passivation prior to temporary storage or vessel load out.

2.2 DRI Product Descriptions

DRI is a highly porous, black/grey metallic material formed by the reduction (removal of oxygen) of iron ore at temperatures below the fusion point of iron.

HBI is an enhanced form of DRI that has been compacted at temperature at or above 650° C and has a density greater than 5.0 grams per cubic centimeter (g/cm^3).

DRI Fines are a highly porous, metallic material generated as a by-product of the manufacturing and handling processes of DRI and HBI having a density of less than 5000 kg/m^3.

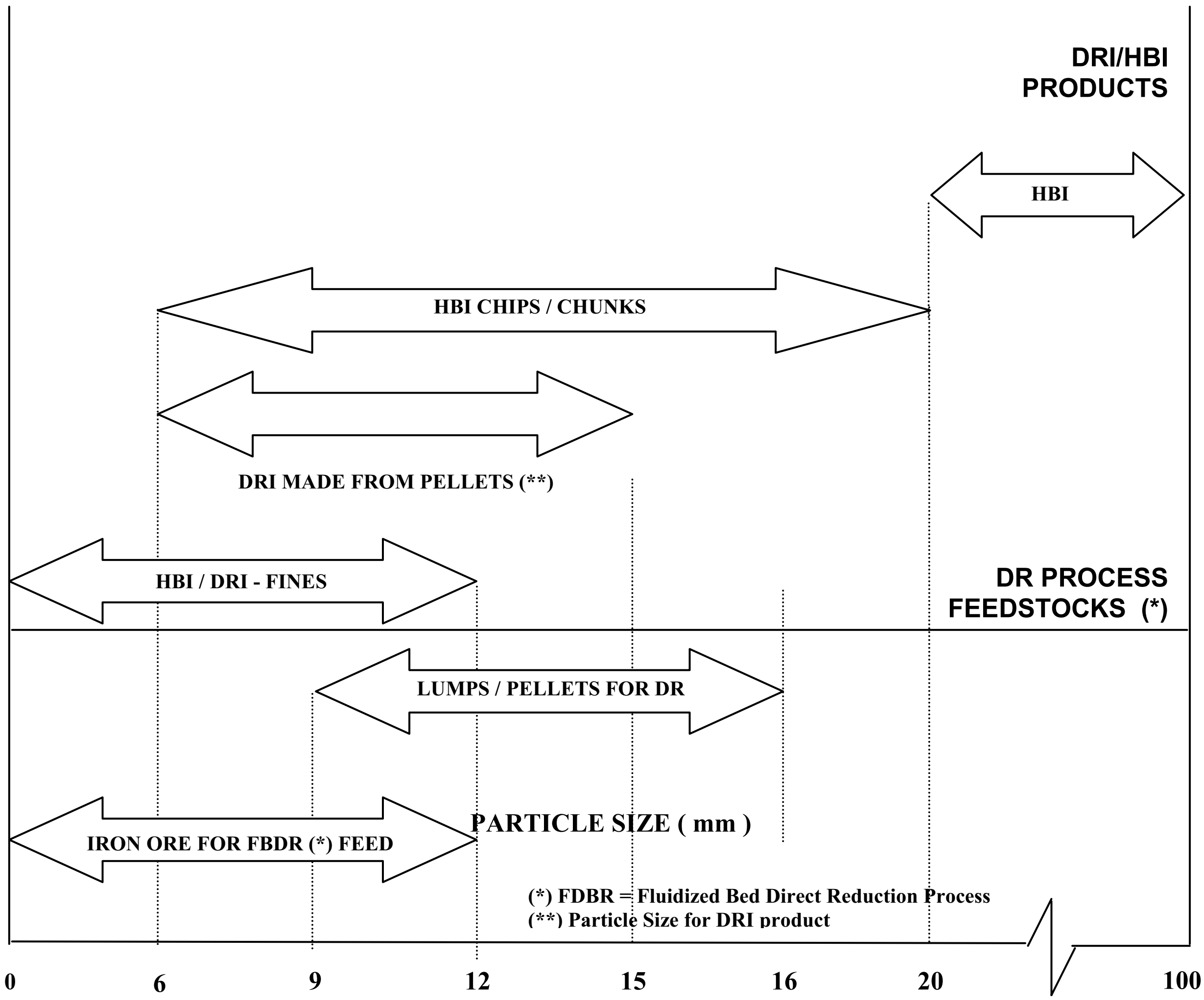


Figure 1 - Particle Size Range for Direct Reduction Processes and Their Products

Table I shows the typical chemical and physical characteristics of HBI. Actual chemical and physical characteristics may vary from shipper to shipper. A preliminary certificate of analysis of the product should be supplied to the Master before sailing.

Typical Chemical Characteristics	(%)	Physical Characteristics	
Total Iron (T Fe)	90 - 94	Bulk density (kg / m³)	2,500 - 3,300
Metallic Iron (°Fe)	83 - 88	Approximate Stowage factor (m³ / mt)	0.3 to 0.4
Carbon	0.8 - 2.0	**Size:**	
Phosphorus (P)	0.02- 0.11	Length: 50 to 140 mm Width: 40 to 100 mm Thickness: 20 to 50 mm Weight: 0.2 to 3.0 Kg Fines: under 6.35 mm	
Sulfur (S)	0.003 - 0.03		
Total Gangue (SiO_2, $Al2O_3$, CaO, MgO, MnO)	1.95 - 5.10		

Table I - Typical Chemical and Physical Characteristics of HBI

2.2.1 DRI (A) Briquettes, hot-moulded

See 1.5 for the definition of HBI in the IMSBC Code, 2009 Edition. A photo of DRI (A) in a cargo hold is shown in Figure 2.

The DRI (A) schedule contains the following remarks:

- As per IMSBC Code: MHB
- Hazards: Hydrogen Generation
- Surface ventilation required
- Safe for sea carriage
- No special precautions
- Golden rule: Avoid excessive contact with water

Figure 2 – DRI (A) in Cargo Hold

2.2.2 DRI (B) (pellets, lump, cold-moulded briquettes)

See 1.2 for the definition of non-briquetted DRI in the IMSBC Code, 2009 Edition. A photo of DRI (B) is shown in Figure 3.

The DRI (B) schedule contains the following remarks:

- Grain Size: Greater than 12 mm and less than 25 mm
- As per theIMSBC Code: MHB
- Inerting required for sea transportation
- No ingress of water in holds

Figure 3 – DRI (B) pellets and lumps

2.2.3 DRI Fines - High Moisture

This product is not listed in the IMSBC Code; however, it is similar to DRI (C) Byproduct fines (see 1.5) except for moisture content and recommended method of carriage (see 1.6). It is recommended to ship DRI Fines – High Moisture according to Section 1.5 of the IMSBC Code, which states that an exemption must be granted in the form of a tripartite agreement including the maritime authority of the port of loading, the maritime authority of the receiving port, and the vessel's flag country.

A photo of DRI Fines – High Moisture in a cargo hold is shown in Figure 4.

The following characteristics describe a typical commercial cargo of DRI Fines:

- Grain size: up to 12mm
- Moisture Content: up to 12 percent
- As per the IMSBC Code: MHB
- Hazards: Hydrogen generation
- Suggested ventilation requirements: Surface and mechanical
- Two changes of air per hour (minimum)
- Duration: from continuous to 1 hr. every 4 hrs
- Ventilation operating under all weather condition
- No ingress of water in holds
- Fan drives explosion proof

Figure 4 – DRI Fines – High Moisture in Cargo Hold

2.3 DRI Reactivity

Direct reduction products have an affinity for oxygen, which is known as reactivity. In early days of exporting DRI, the product showed a strong tendency to react with water, especially sea water.

HBI was introduced in 1976 as a response to the safety issues of shipping DRI in pellet and lump form. HBI has the same low residual chemical characteristics of DRI but is much safer to transport as a bulk cargo due to its compacted physical structure, which makes it less reactive with water and much less prone to self-heating. More than 80 million metric tons (tonnes) of merchant HBI have been shipped worldwide, more than 65 million tonnes of which by water, with an outstanding safety record.

For this reason, prior to loading DRI classified by IMO as DRI (B), a dry, inert gas must be introduced at tank top level to purge the air from the cargo and fill the free volume above. Nitrogen is preferred for this purpose. All vents, accesses, and other openings that could allow the inert atmosphere to be lost from the cargo spaces must be closed and sealed, and the ship must have the means to maintain the oxygen concentration in the cargo spaces below 5.0 percent throughout the voyage.

Figure 5 shows that HBI is the least reactive of all direct reduction products.

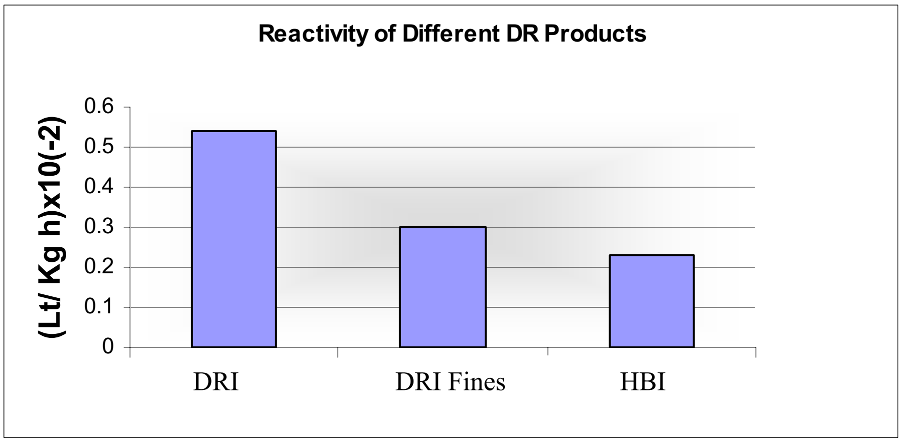


Figure 5 – Reactivity of DRI Types

2.4 DRI Reactivity Stages.

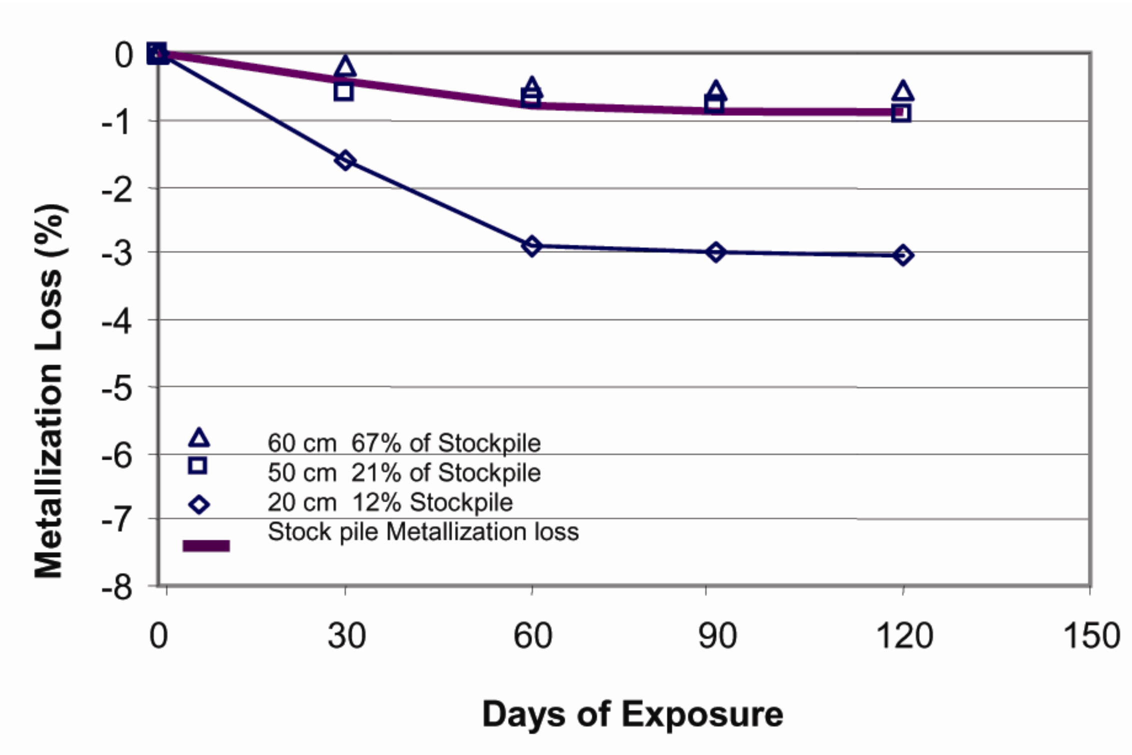
Industry experience has shown that the DRI reactivity mechanism consists of the following stages:

1. Reoxidation
2. Steaming
3. Water Effects
4. Auto Ignition

The reactivity stages are similar for all direct reduction products. However, the following description of the stages will focus on HBI, or DRI (A), which is the subject of this guide.

2.4.1 Reoxidation

HBI will slowly re-oxidize in storage in the same way as scrap. The HBI weatherability test shown in Figure 6 was conducted over an 8-month period in tropical conditions (27° C and 70 percent relative humidity). The average metallization loss was measured at the pile surface and at 0.5 m in the pile.



Courtesy of Orinoco Iron S.C.S. (Test developed by BHP Research – Newcastle)

Figure 6 - Metallization Loss for HBI Stored in Open Yard

Because any direct reduction product will react with water, HBI should be stored in an area with adequate drainage to avoid standing water. However, it is not necessary to cover storage piles because the relatively inert characteristics of HBI prevent rapid reoxidation.

Metallization losses can be minimized when stockpiled in an open yard by following these recommendations:

- Build tent-shaped piles up to 6 meters high
- Build piles slightly above ground level to provide a slope for better water drainage

2.4.2 Steaming

When rain falls on HBI piles, the material will absorb some water (about 3 percent by weight) due to capillary effects on the exposed surfaces and will release water vapor. This effect is called "steaming."

At a temperature above 50° Celsius, HBI will re-oxidize when heavily wetted and create heat, which in turn results in evaporation of the water. HBI piles will steam until the water is evaporated, the reoxidation reaction stops, and the material cools to ambient temperature. Therefore, water should not be sprayed on steaming piles of HBI.

2.4.3 Water Effects

When water is present during or after reoxidation, corrosion (i.e., "rusting") occurs. This effect is stronger when seawater is in contact with HBI. Hydrogen gas can evolve when water is present during oxidation reactions. This gas is highly explosive and detrimental to breathing in enclosed spaces.

2.4.4 Auto Ignition

HBI is classified in the IMO IMSBC Code as MHB (material hazardous only in bulk). An MHB classification is given to a substance that is neither Class 4.2 (substances that can self-heat or are liable to spontaneous combustion) nor Class 4.3 (substances that emit flammable gases after contact with water) and therefore, not considered dangerous.

However, HBI piles can reach the ignition point under certain conditions:
- Sustained re-oxidation
- Excessive fines content in the pile
- Briquetting density below 5.0 gm/cm^3
- Accumulated hot product
- Presence of excess water

Under such conditions, the pile will ignite locally if the temperature of the pile exceeds 200º C (ignition temperature).

The auto ignition tendency should be monitored closely because hydrogen can be generated under wet conditions, especially in the presence of seawater, and there will be no flame present.

2.5 Hazards

HBI is not a pyrophoric material, but neither is it an inert material. Therefore, hazardous situations, such as overheating and hydrogen gas evolution, can occur if proper precautions are not taken.

The schedule for HBI or DRI (A) in the IMO IMSBC Code lists the following under the heading "Hazards":
- Temporary self-heating of about 30° Celsius may be expected after material is handling in bulk.
- Material may slowly evolve hydrogen after contact with water. Hydrogen is a flammable gas that can cause explosions when mixed with air in concentrations above 4 percent.
- Liable to cause oxygen depletion in cargo spaces.
- This cargo is non-combustible or has a low fire risk.

PART III
PREPARATIONS FOR TRANSPORTING HBI

This section provides information about preparations at the terminal for loading vessels that transport HBI based on operating experience over the last 35 years. Flow sheets that are easy to understand and follow are included.

3.1 BLU Code, Section 2

The Code of Practice for the Safe Loading and Unloading of Bulk Cargoes, or so-called BLU Code, was adopted by resolution of the IMO in 2004 along with the Code of Safe Practice for Solid Bulk Cargoes (BC Code) under chapters VI and VII of the 1974 SOLAS Convention. The BLU Code is specific to bulk cargo terminal operations.

Section 2 of the BLU Code addresses guidelines for the safe handling, storage, and hauling of cargoes such as HBI. The most relevant paragraphs of Section 2 are excerpted as follows:

> (2.1.2) Terminals should determine the suitability of a ship for compatibility with both loading and unloading terminal infrastructure, as appropriate.
>
> (2.1.3) It is important that terminal operators keep their relevant customers informed of current terminal operating standards and terms, as well as limitations and any change to relevant navigational conditions, water depths, and loading and unloading equipment and rates.
>
> (2.2.4) Hatches, hatch operating systems, and safety devices should be in good functional order and used only for their intended purpose.

Other paragraphs relevant to HBI operations include:

> (2.3.2) Terminal equipment certification and maintenance.
>
> (2.3.3) Training personnel.
>
> (3.1.2) Loading and unloading plans.
>
> (4.1.1) Cargo and safety issues for loading and unloading

A check list to verify key issues before commencing unloading between terminal operator and ship master should be included.

3.2 Terminal Operator's Checklist

The representative of the Terminal Operator or other relevant person(s) should ensure, as applicable, that:

> **3.2.1** All ships nominated for loading are suitable in all respects for the purpose, and hold the appropriate certification, including a document of compliance for ships carrying solid dangerous goods in bulk.

3.2.2 All relevant pre-information regarding the ship, the terminal and cargo to be loaded is exchanged between ship and terminal in sufficient time before the ship arrives.

3.2.3 The charterers /shippers provide the stevedores with the loading, stowing, and discharging requirements of the cargo.

3.2.4 Any representative appointed by the charterer/shipper receives full cooperation in ensuring these requirements are strictly followed.

3.2.5 The cargo information provided to the Master and to the stevedores involved in the loading operations is correct in all respects and in accordance with the latest version of the IMSBC Code. Expert advice should be sought if there is any doubt about the cargo information provided.

3.2.6 The master has received:

- **a.** The relevant cargo declaration form from the shipper, in accordance with IMSBC Code requirements
- **b.** Material Safety Data Sheet and Emergency Response procedures for the product
- **c.** A certificate is issued by a competent person stating that the cargo meets the requirements of the IMSBC Code in relation to the carriage of DRI in moisture content, size, fines content and temperature as required for the specific product:
  - Prior to loading to confirm that the cargo is suitable for shipment
  - On completion of loading confirming all relevent details about the cargo loaded.

3.2.7 All relevant personnel are aware of the fact that the Master, at his sole discretion, has the right to reject any the cargo which does not conform with the IMSBC Code.

3.2.8 All relevant personnel involved in loading the cargo should be appropriately trained, commensurate with their reponsibilities, and familiarised with IMSBC Code recommendation for the specific cargo to be handled.

3.2.9 The surveyor representing the ship has safe and reasonabale access to the stockpiles and loading installations for inspection prior to commencement of loading.

3.2.10 The conveyor belts and loading system is dry and safe for the cargo to be loaded.

3.2.11 Cargo is loaded carefully to:

- **a.** Minimise high impact drops on tanktops
- **b.** Minimise dusting

c. Loaded in layers to avoid steep piles which may allow self-segregation of fines and larger pieces

d. Avoid driving over the cargo with tracked machines as it may break and generate fines

3.2.12 Cargo is trimmed evenly in accordance with IMSBC Code guidelines to boundaries of cargo space.

3.2.13 The cargo is sampled and cargo temperature is monitored and recorded during loading.

3.2.14 The cargo is not loaded during rain.

3.2.15 Master receives full cooperation if cargo is loaded wet, or in rain, or at excessive temperatures or fines content, where applicable, and with any reasonable requirements for loading to be delayed or off –spec cargo to be rejected or completly removed from the hold(s).

3.2.16 All hatches except the one being loaded is kept closed at all times.

3.2.17 All personnel involved in loading operations should wear appropriate PPE.

3.2.18 No hot work, smoking, naked lights, or ignition sources permitted on the terminal or on deck during loading.

3.2.19 Good cooperation maintained with Master and competent person appointed by national administration in ensuring holds are correctly sealed with hydrogen levels and cargo temperature within prescribed levels.

3.2.20 No entry to enclosed spaces – holds, hold accesses or mast houses on deck without a risk assessment being carried out and an Enclosed Entry Permit being put in place and /or all relevant spaces and holds confirmed by the master as safe for entry by shore personnel.

3.2.21 Terminal personnel and stevedores at discharge port are provided with training and familiarisation in confined space entry procedures and risks of oxygen depletion and hydrogen gas accumulation in the ship's cargo holds, hold access spaces and adjacent compartments.

3.3 Vessel Suitability

Before the first briquette is loaded, it must be determined that the ship is suitable for the cargo and is in possession of a valid IMO Certificate of Compliance (see Figure 7).

CERTIFICATE OF COMPLIANCE
Recommendations of the "Code of Safe Practice for Solid Bulk Cargoes". Appendix B Cargoes.

Certificate Nª.:

Date of issue:

Issued under the authority of the Government of

Particulars of ship
Name of ship
Distinctive number of latters ________________
Port of registry ________________
Gross tonnage ________________
Deadweight of ship (metric tons) ________________
IMO number ________________

THIS IS TO CERTIFY
That the subject ship is found to comply with the recommendations of Appendix B of IMO's "Code of Safe Practice for Solid Bulk Cargoes", Res.A434(XI) for the carriage of dangerous bulk cargoes as listed in this certicate, provided that stowage requeriments together with other provisions of the Code of Safe Practice for Solid Bulk Cargoes (BC Code) has been observed.

Cargo	IMO Class	Cargo Spaces
Direct reduced iron, briquettes, hot moulded	MHB	All cargo holds 3)4)

This certificate is valid until ________________

Issued at ________________ On ________________

RENEWAL OF CERTIFICATE
THIS IS TO CERTIFY that at the periodical survey required for renewal of the Certificate, the ship was found to comply with the relevant provisions and that this Certificate is reinstated wiht validity until:
(maximun five months), pending the issuance of the new certificate

________________ Plase ________________ Date

________________ Surveyor's signature ________________ Stamp

Figure 7 - IMO Certificate of Compliance

The vessel suitability flow sheet for an HBI cargo is shown in Figure 8.

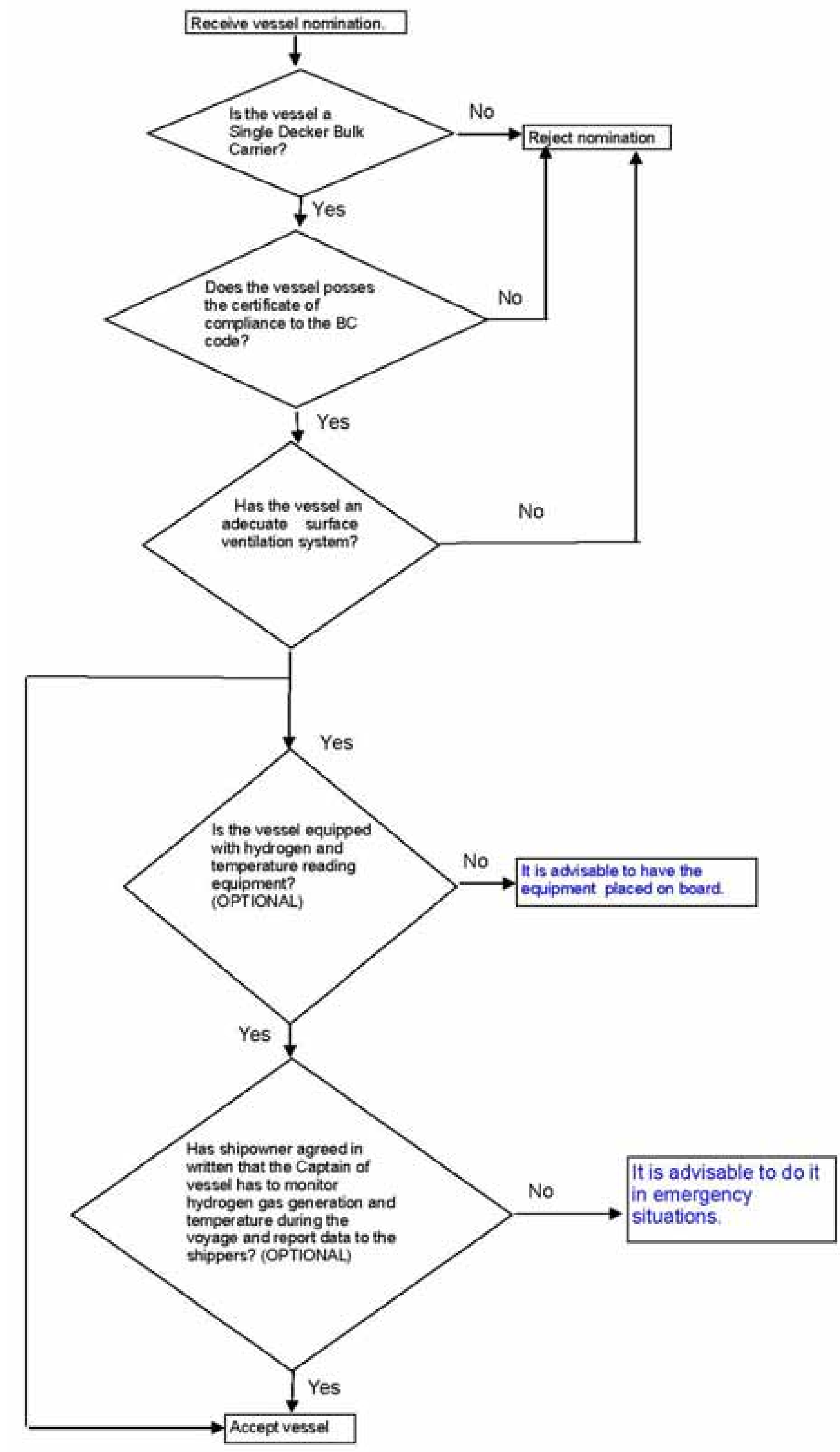


Figure 8 - Vessel Suitability Flow Sheet

3.3.1 Vessel Type

The following types of vessels have been used for ocean transport of HBI:

- Dry bulk carriers: single-deck, handy-size, handy-max, supra-max, or Panamax with hydraulically or mechanically operated type or twin-fold type hatch covers of watertight construction
- OBO with similar hatch covers as above

Double-deck vessels are not recommended for this type of cargo.

3.3.2 Ventilation System Types

Direct reduction products are hygroscopic cargoes because they have a moisture content that can interact with air and condensation (i.e., sweat), can form on the steelwork in a ship's hold. For this reason, surface ventilation, either natural or mechanical, is recommended by the IMO for carriage of HBI, or DRI (A).

According to the IMO IMSBC Code, air should not be directed into the the body of the cargo. When mechanical ventilation is used, the fans must be certified as explosion-proof and equipped to prevent spark generation, thereby avoiding the possibility of igniting any hydrogen gas that might be present in the cargo hold. Suitable wire mesh guards must be fitted over the inlet and outlet ventilation openings, and care must be taken to prevent any escaping gases from entering living quarters in hazardous concentrations.

There are two types of surface ventilation systems available on bulk cargo ships: natural and mechanical (fan-assisted)

a. Natural Ventilation System

Natural ventilation systems typically consist of a pair of ventilators at each end of the hold. However, some ships employ only a single, center line ventilator at each end.

The effect of natural ventilation is assisted considerably by the presence of strong, relative winds. When the relative wind is zero, very little air will enter the ventilators, thereby greatly limiting their effect.

A typical arrangement of natural ventilation on the hatches is shown in Figure 10.

For natural ventilation, it is recommended [4, 9] to equip the hatches of the holds with gravity ventilators (see Figure 9). This would be sufficient to dissipate hydrogen at a sufficient rate to prevent accumulation in an amount that would approach the explosive limit. Hydrogen content in the holds should be less than one percent.

Figure 9 - Natural Ventilation Device on Hatch Covers

b. Mechanical (Fan-Assisted) Ventilation System

Mechanical surface ventilation means power-assisted ventilation and ventilation only of the space above the cargo, as derived from the definitions in Section 3 of the IMO IMSBC Code. A typical arrangement of “mushroom” electric ventilators located on deck between hatch covers is shown in Figure 10.

Figure 10 - Mechanical ventilation device on hatch covers

3.3.3 Arrangement of the Ventilation System

- Vents should be installed on the upper part of the hatch covers.
- Vents and ducts should restrict the ingress of water as much as possible.

- Gases should be extracted from the holds as much as possible rather than blowing in humid air from the atmosphere.

3.3.4 Type of Fan Drive (in Case of Mechanical Ventilation)

Ventilators must have the following characteristics:

- Certified marine explosion-proof in compliance with requirements of classification societies of ships
- Axial flow
- Reversible
- Non-sparking blades
- Variable speed
- Drive mechanisms:
  - Air
  - Water
  - Electrical

PART IV
HBI LOADING PROCEDURES

4.1 Handling and Storage at Loading Port

The flow sheet for handling and storing HBI at the port shown in Figure 11 was developed from actual operations at Compañia Operadora del Puerto de Palúa (COPAL) in Palua, Venezuela. COPAL is the largest and most experienced port in the world for handling, storing, and loading direct reduction products.

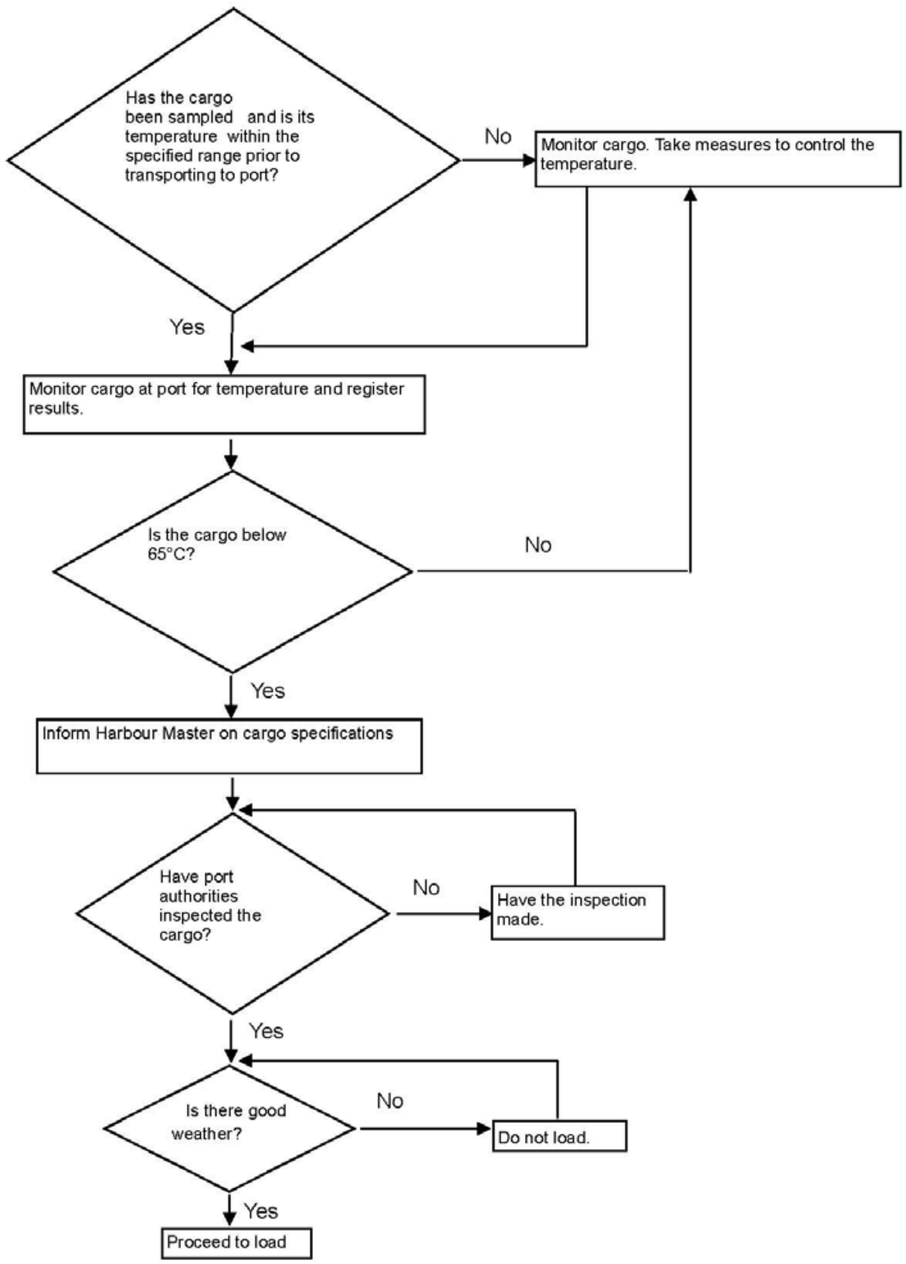


Figure 11 - Handling and Storage at Port Flow Sheet

4.2 Vessel Inspection Prior to Loading

The shipper should provide details regarding the nature of the material to the carrier, and a thorough inspection of the vessel must be carried out following the steps shown in the pre-loading flow sheet shown in Figure 12.

Prior to loading, the shipper or his appointed agent should provide the safety precautions and emergency procedures associated shipping HBI to the Master of the ship. Details of the characteristics and properties, such as chemical hazards (i.e., toxicity and corrosiveness), stowage factor, angle of repose, etc. should be provided so all necessary safety precautions can be put into effect.

The potential for HBI to generate hydrogen gas after contact with water, especially seawater, should be pointed out and extensively discussed in the instructions provided to the carrier. Proof that the instructions were furnished to the carrier, such a signed receipt from the Master, should be obtained by the shipper.

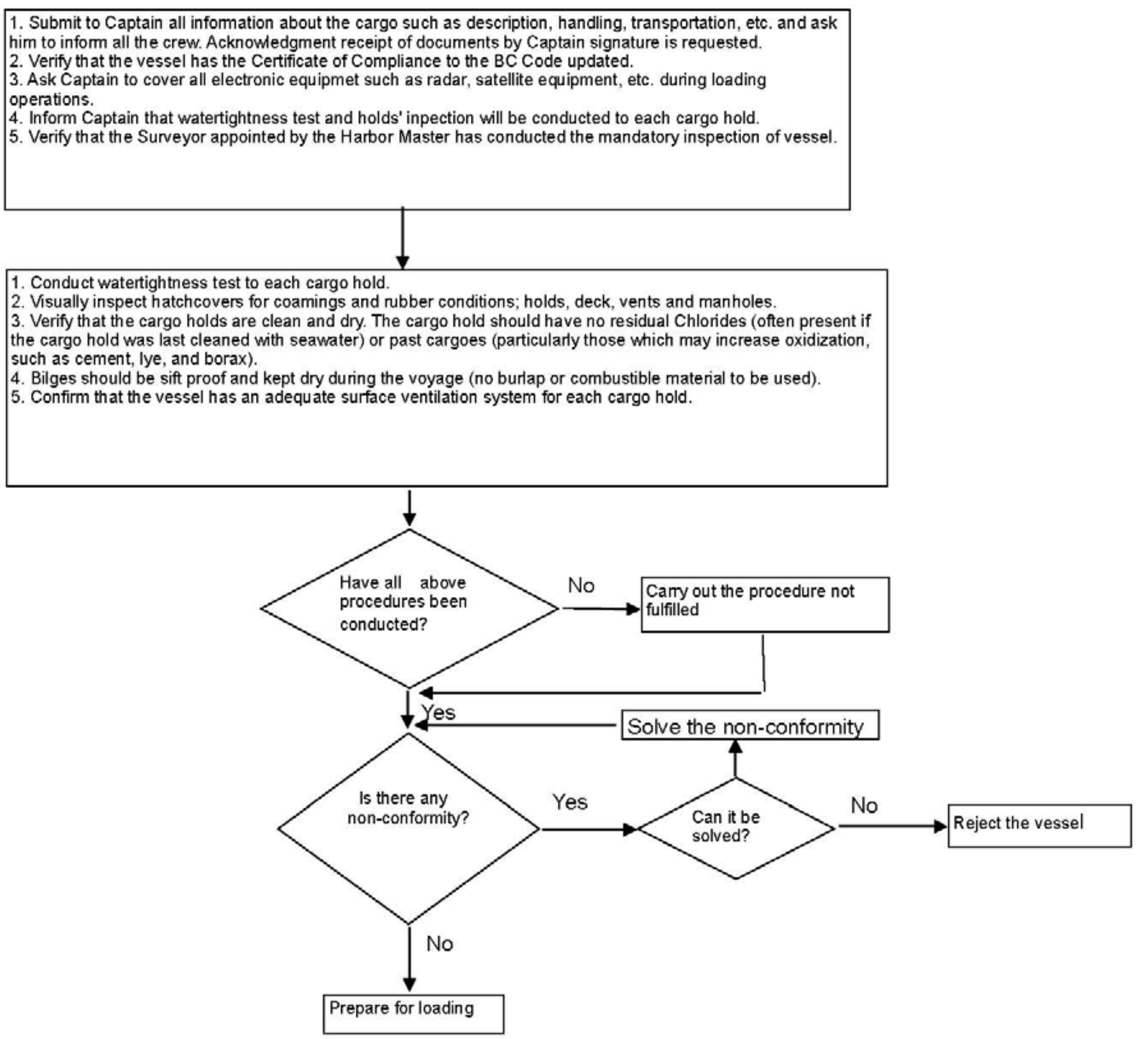


Figure 12 - Vessel Inspection Prior to Loading Flow Sheet

4.3 Cargo Documentation

When shipping HBI, the following instructions are normally given to shipping companies and shipmasters prior to loading:

- Maritime guide for transportation of HBI, or DRI (A)
- Material Safety Data Sheet for HBI, or DRI (A)
- Material Compliance Certificate:
  - Issued by shipper
  - Issued by a competent person recognized by the national administration of the port of loading
- Quantity to be loaded
- Copy of relevant pages of the IMO IMSBC Code
- US Coast Guard Special permits when applicable

4.4 Loading Procedure

The following general information and procedure are derived from experience during the last 35 years regarding the steps to follow for the safe loading of HBI, or DRI (A). See Figure 13 for the vessel loading procedure flow sheet. The procedure also is appropriate for unloading.

HBI, in general, should not be loaded if temperature is in excess of 65° Celsius or during periods of heavy rain.

4.4.1 Moisture Content

Even though the moisture content of the cargo complies with the recommended levels in the IMO IMSBC Code (< 1.0%), condensation might occur in the ship holds as a result of water lost as water vapor by the steaming effect. However, if water vapor is released and either natural or mechanical ventilation is used, no condensation will occur.

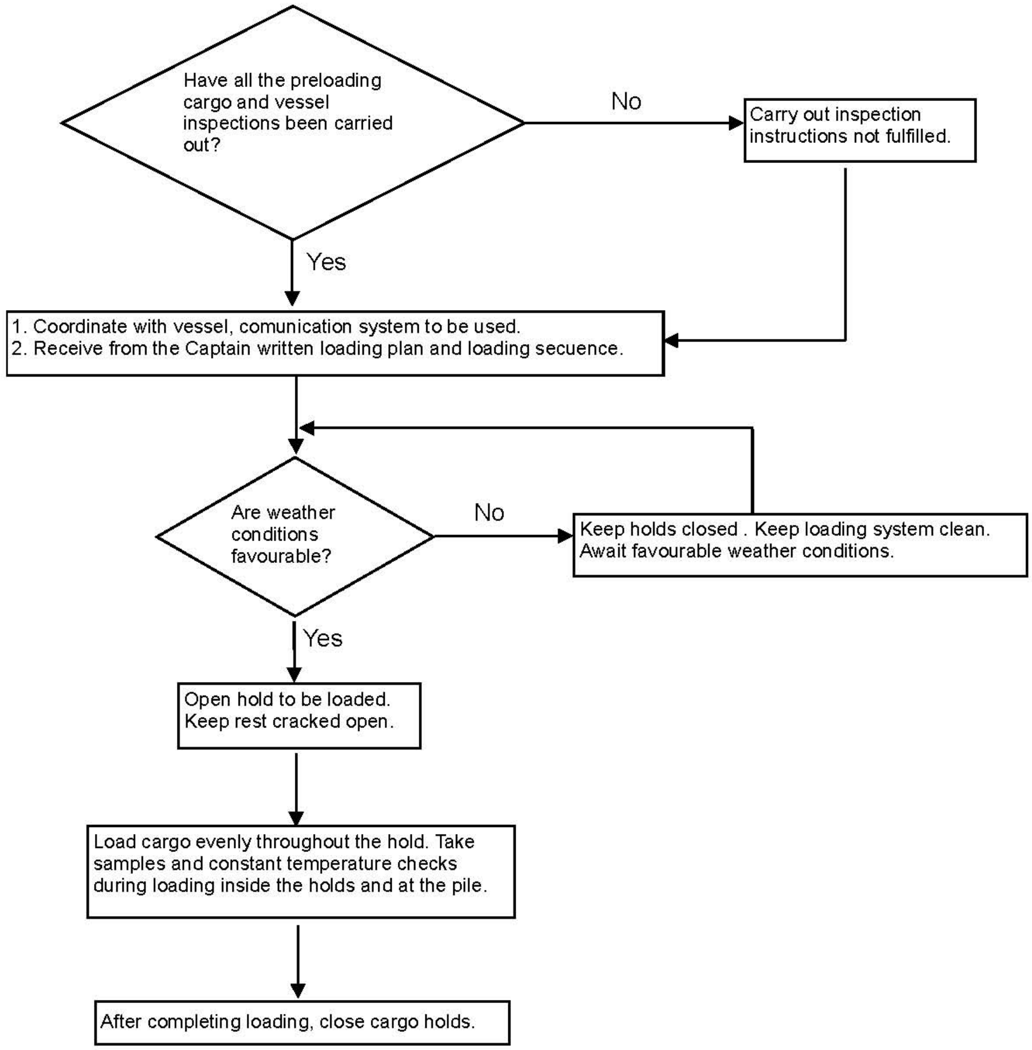
Therefore, although the moisture content of the material at the time of shipment is important, precautions taken by using ventilation will diminish the risks of the cargo.

For this reason, care must be taken to ensure a clean cargo hold before loading. The cargo hold should have no residual chlorides (often present if the cargo hold was last cleaned with seawater) or past cargoes (particularly those that may increase oxidization, such as cement, lye, and borax).

4.4.2 Cargo Temperature

As noted in the previous paragraphs, steaming can occur at time of loading, and temperatures can approach 85° Celsius. Therefore, the temperature of the material at the time of shipment must not exceed 65° Celsius.

The lowest obtained temperature for HBI was with natural ventilation, and the results were in agreement with the temperature readings of recent commercial shipment temperature readings in actual conditions.



WARNING

During cargo handling, "NO SMOKING" signs are to be posted on decks and in areas adjacent to cargo compartments and no naked lights should be permitted in these spaces.

Figure 13 - Vessel Loading Flow Sheet

4.4.3 Hydrogen Gas Evolution

Experiments confirm that hydrogen gas is evolved during re-oxidation when water is present, and that hydrogen evolution occurs after approximately 16 hours. Therefore, it is imperative that cargo holds and adjacent spaces are constantly monitored for hydrogen gas levels that exceed safe values (i.e., LEL 4 percent in air).

If this value is exceeded, immediate actions for dissipating the hydrogen should be taken as per the Emergency Continengies seciton of this guide (PART VII).

Hot work permits should be required on both the jetty and the ship when HBI is being loaded. Masters are advised to ensure a hot work permit is used for any maintenance of other work on deck while the ship is being loaded, unloaded, or underway.

4.4.4 Enclosed Spaces

Enclosed spaces adjacent to cargo areas should be monitored regularly for the presence of hydrogen and/or the depletion oxygen. Such spaces should be adequately ventilated and only equipment safe for use in an explosive atmosphere should be used. Monitoring is especially important prior to permitting personnel to enter enclosed spaces or activiating equipment in such areas.

Before personnel are permitted to enter, enclosed spaces should be thoroughly ventilated and the atmosphere tested and hydrogen and oxygen found to be at safe levels. Absolutely no source of ignition should be allowed in an enclosed space.

See IMSBC Code and IMO Resolution A.864 (20) – Recommendations for Entering Enclosed Spaces on Board Ships for more information.

4.5 Barge Loading

Barges must comply with the following conditions:

- Clean and dry
- Free of chlorides and previous cargoes
- Free of combustible materials
- Covered barges preferred
- Avoid accumulation of water in barges
- Barges should be loaded with a trim by the head
- Portable stripping pumps should be available for removal of water
- Small heaps

Prior to loading, the barges should be inspected to ensure that the bottom is dry and free of rags, wood or other material that could cause heat-up or contamination. Barge should be equipped with a means of removing water from the cargo. The HBI should be evenly distributed in the barge, making the pile as flat as possible and the drop of the briquettes should be minimized, to reduce breakage and production of fines (see Figures 14 and 15).

HBI must be protected at all times from contact with water, and in case of rain, loading should be halted and the hatches closed. During transport, the following precautions should be taken:

- If the transport is by sea, watertight hatch covers have to be used to prevent ingress of salt water into the barge.
- Rainwater should not be allowed to accumulate in the bottom as this will lead to oxidation of the briquettes, which affects the quality. Bilge pumps should be operable.

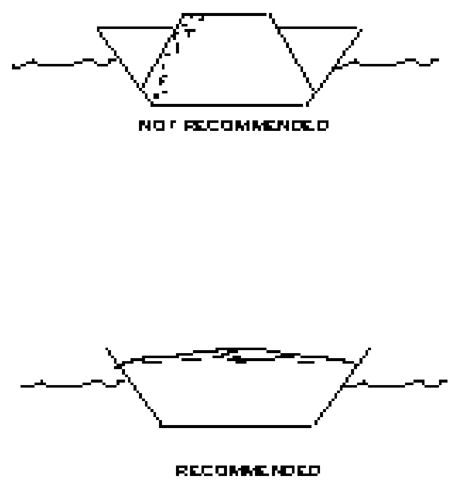


Figure 14 - HBI Loading in Barges

Figure 15 - View of an evenly distributed cargo in barge

4.5.1 Unmanned Barges

The unmanned covered barges used to transport HBI shall be fitted with vents adequate to provide natural ventilation.

After loading, the hatches must be closed at all times until the HBI is unloaded. If at any time the cargo compartment of a loaded barge must be entered, the compartment must be checked for adequate oxygen concentration. Before any person enters a cargo compartment containing HBI, the hatches must be opened for a sufficient length of time to dissipate any accumulated gases.

After unloading, the barge shall be cleaned thoroughly before loading a different cargo.

When HBI is transported by barge, a copy of Coast Guard Special Permit 2-85R, must be on board the tug or towing vessel. When the barge is moored, the shipping paper and a copy of this Special Permit must remain on the barge in a suitable protected location.

4.5.2 Top-Off Operations

In the case of top-off operations with barges, the same precautions taken for loading ocean-going vessels should be followed plus these specific precautions and steps:

Barge cargo hoppers should be clean, dry, and free from salt and residues of previous cargoes. The cargo hold should have no residual chlorides or past cargoes, particularly those that might increase oxidization, such as cement, lye, and borax.

Top-off operations should not be performed during heavy rain.

HBI shall not be loaded if its temperature is in excess of 65° Celsius.

Barges for top-off operations should be provided with covers or the HBI should be covered with appropriate material, such as canvas or tarpaulin, in order to limit water absorption during transfer from the loading dock to the topping-off area.

Additionally, great care should be taken to minimize the entrance and accumulation of water in the hoppers. Barge operators should have portable bilge pumps to remove any water accumulated in the hoppers to avoid excessive wetting of HBI.

Barges should be loaded in such a way as to have adequate trim by the stern (0.3 m minimum) so water accumulates in the aft part of the barge hopper for easier extraction.

HBI should be loaded in the central part of the barge, leaving free space on port and starboard sides for easy drainage of water to the stern and towards the bilge well. There should be about 2 meters of free space from the aft to avoid wetting the cargo with accumulated bilge water.

The HBI should be evenly distributed in small piles as flat as possible. The drop of the briquettes should be minimized to reduce breakage and fines generation.

The loading operations should be started in one end of the barge and continued along the length of the barge hopper.

Once the cargo is evenly distributed in the hoppers, loading personnel should have available space for inspection purposes.

The loading operations should be supervised by personnel familiar with the safety precautions and emergency procedures associated with handling HBI. The loading operators should be trained in the appropriate safety precautions and emergency procedures for handling this product.

Unmanned covered barges used to transport HBI should be fitted with adequate vents to provide natural ventilation.

If the cargo compartment of a covered barge must be entered, first the compartment should be checked for adequate oxygen concentration. Before anyone enters a covered cargo compartment containing HBI, the hatches should be opened for a sufficient length of time to dissipate any accumulated gas.

A photo of a top-off operation is shown in Figure 16.

Figure 16 - Barge Top-Off Operation in Orinoco River

PART V
HBI UNLOADING & TEMPORARY STORAGE

The following general information is derived from experience during the last 35 years of safe unloading of HBI, or DRI (A). In addition to the following guidelines, attention should be given during unloading to the risks posed by hydrogen gas evolution and the depletion of oxygen in enclosed spaces, as outlined in 4.4.3 and 4.4.4.

HBI, in general, should not be loaded if temperature is in excess of 65° Celsius or during periods of heavy rain.

5.1 Actions Prior to Unloading

The following actions should be taken prior to unloading a vessel carrying HBI:

- Check for hydrogen concentration before opening cargo holds
- If hydrogen concentrations in cargo holds approach 4 percent, ventilate then re-check before opening holds
- Verify the cargo temperature inside cargo holds
- If the cargo temperature exceeds 120° C, proceed to unload the cooler cargo in a specially designated area
- If temperature readings are normal (<65° C), proceed to unload cargo in the normal yard area
- Measure oxygen and ensure the oxygen level is > 21 percent before anyone enters the cargo holds
- Ground the cargo holds if possible
- Protect radar, RDF scanner, and other delicate equipment from dust and fines

5.2 Inspection of Holds at Unloading Port

Upon arriving at the unloading port, the holds of a vessel containing HBI should be inspected to determine the condition of the holds and whether or not there are any hot spots in the cargo or evidence of water entry.

The inspection should include the following:

- Weather tightness of the hatch covers. The presence of wetted briquettes on top of the cargo indicates that water has seeped into the hold via the hatch covers
- Entry of water through the double bottom of the hull. This will be indicated by wetted briquettes at the bottom of the pile at the discharging end
- Distribution of the HBI in each hold for later discharge procedures
- Presence of hot spots in any of the holds. Hot spots are defined as areas where the temperature exceeds 100 ° C (212 ° F). If hot spots are detected, this material must be unloaded first.

5.3 Dust

Although briquettes are strong, they will break resulting in chips and fines and generating dust. Therefore, it is important to minimize the height and number of drops while transporting and handling HBI.

Some fine dust will be generated during each material handling transfer stage during the journey from production plant to customer. Therefore, it may be necessary to use a freshwater spray mist to minimize dust clouds. However, this proactice should be limited, as product rusting and corrosion will reduce product metallization and adversely impact the value of the product.

5.4 Equipment for Unloading & Handling HBI

All types of conventional bulk material handling equipment can be used to unload and handle HBI:

- Front-end loaders (Figure 17)
- Scrap yard magnets (Figure 18)
- Cranes with magnet/clamshell-type bucket (Figure 19)
- Conveyor belts (Figure 20)

Figure 17 - Handling HBI with a front-end loader

Figure 18 – Handling HBI with a magnet

Figure 19 - Handling HBI with a clam shell-type bucket and a hopper and conveyor belt system

Figure 20 - Transporting HBI with an installed conveyor

HBI is normally transferred to the scrapyard by barge, rail, or truck. Once unloaded in the storage yard, a front-end loader or a crane using a magnet or clamshell-type bucket can be used (see Figure 21). HBI does not drain out of small openings in buckets and truck beds, as does DRI.

Figure 21 - Truck Loading with Front-End Loader

Care should be exercised when handling HBI with front-end loaders since the bulk density of HBI (2.1-2.8 t/m^3) is often higher than the rated density of buckets used for normal bulk materials, and the machine can become overloaded.

Scrap yard magnets are normally used for charging scrap buckets, and HBI can be handled easily with these magnets. For example, a 2-meter diameter magnet rated at 3.5 tonnes typically can pick up around 2 tonnes of HBI per lift.

5.5 Storage Areas

HBI can be stored in the following areas or containers:

- Yards (covered or uncovered)
- Silos or confined spaces (hydrogen emissions monitoring highly advisable)

The general guidelines for all forms of storage are:

- Clean and dry.
- Free of combustible materials: coal, wood, coke, etc.
- Free of chlorides or past cargoes: avoid cement, lye, borax.
- Care with adjacent cargoes: do not store near coal.

5.5.1 Yards

HBI can be handled by front end loaders and other standard bulk materials handling equipment and systems. When using front end loaders, care should be taken to minimize running them on top of the material to avoid breakage.

The storage area should be easily accessible by loading equipment. Although the HBI has high impact strength, the storage area should be as close as possible to the melt shop to avoid double handling of the product, breakage, and fines generation.

Yard storage of HBI is not affected by water picked up (HBI will pick up only about 3 percent water by weight). However, it is good practice to avoid standing water by providing adequate drainage.

The storage area should be kept reasonably clean, which means free of wood debris, coal or coke residues, and any other combustible material or source. Due to its relatively inert characteristics, it is not necessary to cover HBI storage piles to prevent rapid reoxidation.

Figure 22 shows temporary open yard storage of HBI.

Figure 22 – HBI Storage Piles

When heavily wetted by rain, HBI will release water vapor. This is called "steaming". The HBI will increase in temperature to about 60º Celsius without overheating. An HBI pile must exceed 100º Celsius before overheating occurs.

See 5.10 for the procedure for controlling HBI that becomes overheated.

5.5.2 Silos and Bins

If the HBI is to be loaded into storage silos for use in continuous charging, the receiving hopper should be equipped with a grizzly to remove large pieces of foreign materials or plates of multiple briquettes that may be occasionally encountered in other type of HBI.

If the storage silos discharge directly onto feeder belts, there should be sufficient clearance between the silo discharge and the conveyor belt to avoid jamming of briquettes in the discharge which may result in damage to the belts. No special care such as the use of nitrogen or other inert gas needs to be considered, as it is the case for DRI pellets in silo storage.

Care should be exercised not to mix lime with HBI in the storage silos. During rainy conditions, the lime may become wetted and will then heat up. This may instigate overheating of the HBI up to a hazard condition.

5.6 Inventory Control and Storage.

The HBI should be used or dispatch on a first in first out basis. As pointed out in the previous section, the metallization decreases as a consequence of weather conditions, so that material used on a first in-last out basis will have variable metallic iron, which will affect yield as well as furnace operation.

The storage area should be located so as to be accessible to the loading equipment and should be as close to the melt shop as practical so as to avoid double handling of the product, which may result in an increase of fines.

The HBI should always be stored in an area, which has adequate drainage so that the piles do not become flooded after rainstorms. It is not recommended to allow the piles to be wetted by anything but rainwater, so they should not be located in areas subject to condensation from cooling towers or carryover of water or solution from other plant equipment.

Due to the relative inert character of HBI, it is not necessary to cover the storage piles to prevent rapid reoxidation. It is generally most efficient to pile the HBI in a tent shaped piles 4-5 meters high. Smaller piles waste storage area and result in higher metallization loss due to the increased surface area per unit volume. In order to form piles higher than 4-5 meters with front-end loaders, it is usually necessary to run the loader on top of piled material, which results in increased breakage. Material can be piled higher than 4-5 meters if a stacker is used.

5.7 Quality Loss in Storage.

HBI will slowly reoxidize or rust in storage, which results in a loss of metallic iron and metallization. The losses are higher on the outside layer and diminish towards the center of the pile. This is illustrated in Figure 23, where the average metallization loss of HBI in a storage pile was measured over an 8-month period. In the figure, the HBI average values are lower at the surface than at the 0.5m depth in the pile. The average climatic conditions during the test were 27 degrees C, 70 percent relative humidity, and 56mm of rainfall per month.

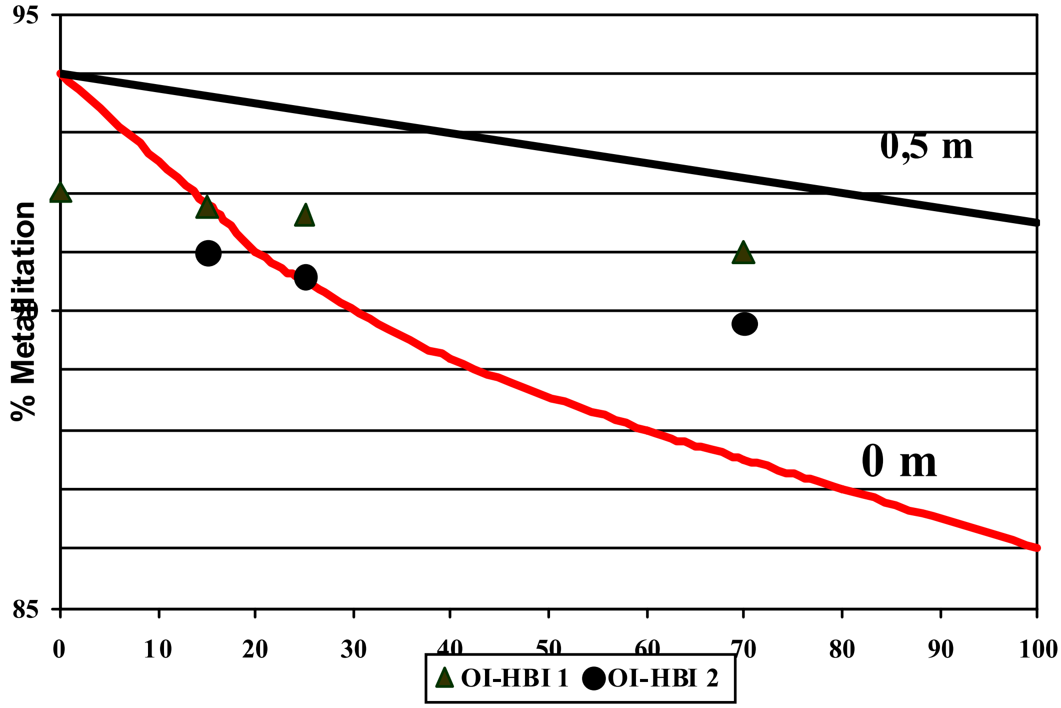


Figure 23 – Metallization Loss in HBI Storage Pile

5.8 Dissipation of Rainwater (Steaming).

HBI will release water vapor in the form of a visible plume after being heavily wetted by rain. This so called "steaming" is often misinterpreted as overheating of the HBI by materials handling personnel, but is in reality only a normal reaction which poses no hazard to the material or the surroundings.

The HBI will warm up to around 60 degrees C as the steaming occurs, but will cool down again to ambient temperature once the free water is driven off. It is not necessary to take any preventive action if the pile is steaming and the temperature does not exceed 100 degrees C. HBI does not overheat as a result of being wetted by rain if it is properly stored.

5.9 Signs of Overheating

After being wetted by rain, HBI piles will release excess water by heating slightly to around 50 to 60 degrees C. Plumes of steam will be seen above the piles. Overheating can be noted by measuring temperatures at the peak of the pile, if there are temperatures in excess of 100 degrees C, this is a serious indication of material overheating. At this stage, no flame will be present.

5.10 Procedure for Controlling Overheated HBI

If overheating to temperatures in excess of 100 degrees C is observed, the material should be removed from the pile and spread out on the ground in a layer of about 0.5 meters using a track equipped bulldozer or front end loader, as shown in Figure 24. The

HBI will warm up to around 60 degrees C as the steaming occurs, but will cool down again to ambient temperature once the free water is driven off. It is not necessary to take any preventive action if the pile is steaming and the temperature does not exceed 100 degrees C. HBI does not overheat as a result of being wetted by rain if it is properly stored.

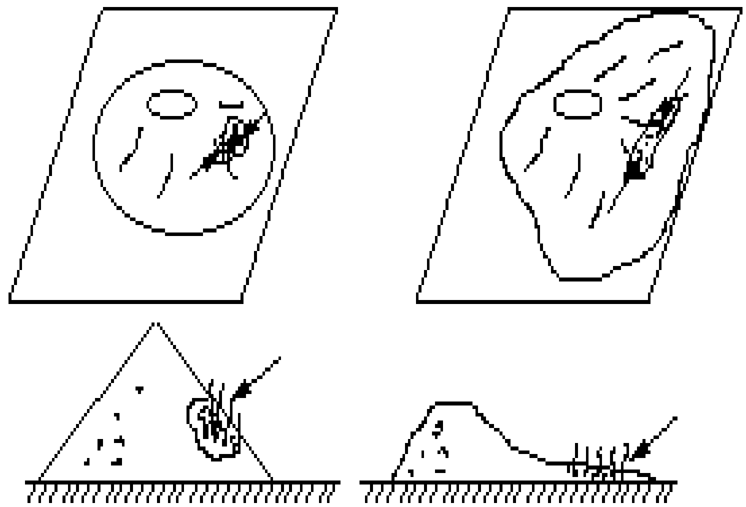


Figure 24 – Method for Controlling Hot Material in Storage Pile

Water should not be sprayed on an overheated pile of HBI. First, water cannot penetrate to the center of the pile where heat is the highest and secondly, hydrogen can be generated by reaction with water, which further increases risk. It should be emphasized that in all instances where HBI has overheated in piles, the material has been cooled and stabilized simply by lowering the height of the pile and allowing the heat to dissipate.

Another method is to bury the pile under sand or other suitable fine material to cut off oxygen supply.

In case the other alternatives are not practical or effective, the material can be flooded with water. However, this should be a last resort because it will result in a significant loss of HBI metallization.

PART VI
HBI LOADING FOR INLAND TRANSPORT

6.1 Equipment for Handling HBI

See 5.4 for description and photos of materials handling equipment suitable for HBI.

6.2 Barge Loading

In the case of inland barges, the same precautions should be taken as for barge top-off operations (see PART IV, Section 4.5). It is very important that the barge hold is dry and should have no residual chlorides (often present if the cargo hold was last cleaned with seawater) or residue from past cargoes (particularly those that may increase oxidization, such as cement, lye, and borax).

Unloading can be conducted under all weather conditions as long as the HBI is outdoors, not in a confined space, and does not have a confined space directly above.

Some hydrogen gas may evolve in the cargo hold during the voyage if the HBI is contacted by water or moisture from previous cargoes. Therefore, it is absolutely essential that the hydrogen gas is ventilated prior to commencing unloading operations.

6.3 Truck Loading

The bulk density of HBI (2.8 t/m^3) must be taken into consideration when loading a truck. Trucks should not be overloaded to avoid loss during transport due to spillage (see Figures 25 and 26). Local regulations regarding use of tarps to cover material should be followed.

Hydrogen gas can evolve during transport if the HBI is in contact with water or residue from a previous cargo. Therefore, the cargo box or freight car should be clean and dry, and the tailgate or car doors/hatches should seal properly. Once loaded, the temperature of the cargo should be checked at several points in the load.

The material should not be sprayed with water to reduce dust generation as it leaves the storage yard. Instead, a tarpaulin should be used to cover the cargo box of the truck, which also helps avoid spillage.

In case a hot spot is located in any area of the cargo box, that area should be unloaded immediately. HBI with a temperature above 65º Celsius should not be transported except to a nearby area for cooling. Hot material should be loaded into trucks only in case of any emergency when a vessel's hold must be cleared immediately and the material transferred to a nearby designated area for cooling.

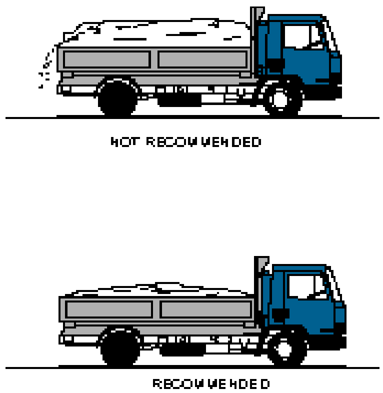


Figure 25 - Truck Loading (Using Front-End Loader)

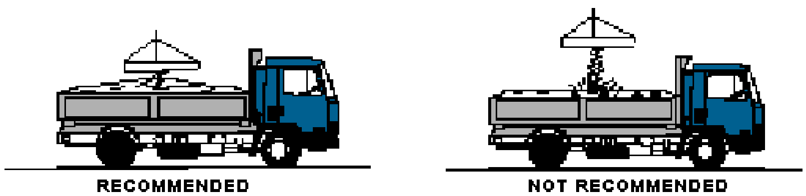


Figure 26 – Truck Loading (Using Grab or Magnet)

6.4 Railroad Car Loading

Railroad cars are loaded in the same manner as trucks; therefore, cautions should be observed as described in 6.3. Figure 27 shows a properly loaded railroad car.

Figure 27 – Railroad Car Loaded with HBI

PART VII
EMERGENCY PROCEDURES

This section provides information about emergency procedures commonly use during the past 35 years.

Basically, there are two types of emergencies:
- Self-heating
- Hydrogen accumulation over the LEL in confined cargo or adjacent spaces

7.1 During Receiving and Loading Operations

The following are instructions developed and implemented by the Port of Palúa, which handles and loads all of the HBI exported by Venezuela.

7.1.1 General Contingencies

The loading operations must be supervised by personnel familiar with the safety precautions and emergency procedures for handling HBI, or DRI (A). The loading operators must be trained in the appropriate safety precautions and emergency procedures.

7.1.3 Action Plan for HBI at Elevated Temperatures

The Operations Supervisor and the Material Handling Operators are responsible for properly executing the action plan if a train or truck arrives at the reception quay of the port carrying HBI at the following temperature levels:

a. Greater Than 65° Celsius but Less Than or Equal to 80° Celsius

Proceed with the following actions:
- Before unloading rail cars or trucks, measure the HBI temperature in each rail car/truck and record the measurements in the temperature log book.
- Unload the HBI in the client's assigned quay and immediately transfer the HBI to the storage yard zone indicated by the client and store it as suggested in 5.5 of this guide.

b. Greater Than 80° Celsius but Less Than or Equal to 150° Celsius

Proceed with the following actions:
- Before unloading the rail cars or trucks, measure the HBI temperature in each rail car/truck and record the measurements in the temperature log book. This should be done every two hours while the contingency is in effect.
- Unload the rail cars/trucks with HBI at temperature less than 65º Celsius first, then those containing HBI between 65º and 100º Celsius. Continue unloading HBI with temperatures between 100º and 150º Celsius in the first vibrating feeder, using the movement sense of the belt as a reference.

- Transfer the HBI from the quayside to the storage yard indicated by the client in the following manner:
  - Transfer the HBI during a maximum of three-minute intervals, and dose (i.e., mix the hotter with the cooler material to have an average temperature lower than the hottest one – no water to be used) the DRI that is at temperatures between 100° and 150° Celsius for a maximum of two minutes. Stop the vibrating feeders for about five minutes, but keep the conveyor belts in motion. Repeat these steps until finished with HBI removal.
  - While transferring the HBI, inspect the belt transfer system for any sign of overheating. In case of belt overheating, stop the HBI dosing and transfer but keep the transfer belts in motion until they cool. Take special care to avoid pouring water into hoppers and other equipment.
  - Use a front-end loader to spread the HBI to a level of approximate 30 centimeter height to stop the reoxidation, as suggested in PART II, Section 5.4 of this guide.
  - Verify that the belts are cooled down, and resume HBI transfer per the previous instructions.

c. Greater Than 150° Celsius

Proceed with the following actions:

- Before unloading the rail cars or trucks, measure the HBI temperature in each rail car/truck and record the measurements in the temperature log book. This should be done every two hours while the contingency is in effect.
- Position the rail cars/trucks containing HBI with temperatures greater than 150º Celsius at the end of the reception area and spray with pressurized water. In this case, there is no option but to momentarily cool down the HBI before being discharged into the quay and then into the conveyor belt system. Otherwise, the belts will burn. Afterward, the HBI is piled in the yard. It then can be spread out for further cooling.
- When the temperature is reduced to between 80° and 150° Celsius proceed with the steps described in 6.1.2.2.

7.2 During Unloading and Storage Operations

Unloading can be conducted under most weather conditions, as long as the HBI remains well ventilated, is not in a confined space, and does not have a confined space directly above.

7.2.1 General Contingencies

The unloading operations must be supervised by personnel familiar with the safety precautions and emergency procedures for handling HBI, or DRI (A). The unloading operators must be trained in the appropriate safety precautions and emergency procedures.

7.2.2 Action Plan for HBI at Elevated Temperatures

The Master of the ship must notify the port authorities if hydrogen gas is detected in the ship holds or if abnormal temperatures are measured in the HBI cargo holds.

The Harbor Master and qualified personnel are responsible for executing the action plan when a ship or barge arrives with HBI at the following temperature levels:

a. Greater Than 65° Celsius but Less Than or Equal to 80° Celsius

Proceed with the following actions:

- Before unloading the vessel, measure the HBI temperature in each hold and record the measurements in the temperature log book.
- Unload the holds in the assigned zone and immediately transfer the HBI to the storage yard zone as described in PART II, Section 5.4 of this guide.

b. Temperature Greater Than 80° Celsius and Less Than or Equal to 150° Celsius

Proceed with the following actions:

- Before unloading the vessel, measure the HBI temperature in each hold and record the measurements in the temperature log book. This should be done every two hours while the contingency is in effect.
- Unload the holds with HBI at temperature less than 65º Celsius first, then those containing HBI between 65º and 100º Celsius. Continue unloading HBI with temperatures between 100º and 150º Celsius in the first transfer station, using the movement sense of the belt as a reference.
- Transfer the HBI from the unloading zone clean and free of debris and flammable material, such as coal, coke and wood to the storage yard indicated by the client as follows:
  - Transfer the HBI during a maximum of three-minute intervals, and dose (i.e., mix the hotter with the cooler material to have an average temperature lower than the hottest one – no water to be used) the HBI that is at temperatures between 100° and 150° Celsius with cooler material for a maximum of two minutes. Stop the vibrating feeders for about five minutes, but keep the conveyor belts in motion. Repeat these steps until finished with HBI removal.
  - While transferring the HBI, inspect the belt transfer system for any sign of overheating. In case of belt overheating, stop the HBI dosing and transfer but keep the transfer belts in motion until they cool. Take special care to avoid pouring water into hoppers and other equipment.
  - Use a front-end loader to spread the HBI to a level of approximate 30 centimeter height to stop the reoxidation, as suggested in PART II, Section 5.4 of this guide.
  - Verify that the belts are cooled down and resume HBI transfer per the previous instructions.

c. Greater than 150° Celsius

Proceed with the following actions:

- Before unloading the holds, measure the HBI temperature in each hold and record the measurements in the temperature log book. This should be done every two hours while the contingency is in effect.
- Position the HBI with temperatures greater than 150° Celsius at the end of the reception area and spray with pressurized water. In this case, there is no option but to momentarily cool down the HBI.
- When the temperature is reduced to between 80º and 150° Celsius proceed with the steps described in 6.3.2.2.

Caution: Do not spray water on hot HBI that is steaming (i.e., emitting water vapor).

7.3 Hydrogen Gas Contingency

Although HBI has the lowest tendency to reoxide when contacted by fresh water or seawater, the ultimate rule is to keep all forms of water from entering the cargo holds. Reoxidation tends to generate hydrogen gas but does not cause spontaneous ignition of the gas unless an ignition source is present.

In case of seawater intrusion into the cargo holds, follow the procedure flow sheet in Figure 14 (see paragraph 4.5 of this guide).

7.3.1 Procedure If Hydrogen Concentration Is Over 1% (25% LEL)

- Inform the shipper immediately and seek expert advice.
- Keep the natural surface ventilation open at all times
- Monitor LEL in the holds continuously until level drops to less than 25 %.
- Avoid any possible ignition source on the vicinity.
- Care shall be taken as to prevent any spark generation.
- Monitor the hydrogen concentration in the holds and keep the surface ventilation (either natural or mechanical) until values fall below 1%.
- When hydrogen levels are within safe values, proceed as normal.
- On the contrary, additional ventilation should be applied to the space if available and re-testing should be conducted after a suitable interval.
- Contact the P & I Club and Shipper and follow the instructions of the appointed expert or surveyor.
- At sea, do not open the troubled hold without explicit instructions from the shipper or appointed expert or surveyor.
- Ensure there are no possible sources of ignition near the cargo spaces, adjacent spaces or open decks.

PART VIII
REFERENCES & SUGGESTED READING

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8.2 Suggested Reading

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8. Pretorius E. B. and Carlisle R. C. - ISS EAF Conf. Proc. 1998, p 276.

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