DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%)

Description

Direct reduced iron (DRI) (D) is a porous, black/grey odourless metallic material generated as a by-product of the manufacturing and handling processes of DRI (A) hot-moulded briquettes and/or DRI (B) lumps, pellets and cold-moulded briquettes, which has been aged for at least 30 days prior to loading.

Characteristics

Physical properties			
Size	**Angle of repose**	**Bulk density (kg/m^3)**	**Stowage factor (m^3/t)**
Fines and small particles with an average size less than 6.35 mm, particles larger than 12 mm not to exceed 3% by weight	Not applicable	1,850 to 3,300	0.30 to 0.54
Hazard classification			
Class	**Subsidiary hazard(s)**	**MHB**	**Group**
Not applicable	Not applicable	SH and/or WF	A and B

Hazard

Temporary increase in temperature of about 30°C over ambient, due to oxidation and consequent self-heating, may be expected after material handling in bulk.

There is a risk of overheating, fire and explosion during transport due to the fact that this cargo reacts with air, fresh water and seawater to produce hydrogen and heat. Hydrogen is a lighter than air, flammable gas, that can form an explosive atmosphere when mixed with air in concentrations above 4% by volume.

Oxygen in cargo holds and in enclosed adjacent spaces may be depleted. Flammable gas may also build up in these spaces.

This cargo may liquefy if shipped at a moisture content in excess of its transportable moisture limit (TML). See sections 7 and 8 of this Code.

Stowage and segregation

"Separated from" goods of classes 1 (division 1.4S), 2, 3, 4 and 5, and class 8 acids in packaged form (see the IMDG Code).

"Separated from" solid bulk materials of classes 4 and 5.

Goods of class 1, other than division 1.4S, shall not be carried in the same ship.

Boundaries of compartments where this cargo is carried shall be resistant to fire and passage of liquid.

Hold cleanliness

The cargo spaces shall be clean, dry and free of salt and residues of previous cargoes. Prior to loading, wooden fixtures such as battens, loose dunnage, debris and combustible materials shall be removed.

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%) *(continued)*

Weather precautions

Storage in the open air shall be permitted prior to loading, subject to any requirements of the competent authority of the port of loading. During storage, the material shall be piled such as to allow the greatest possible exposure to the atmosphere and thus facilitate its natural ageing.

When a cargo is carried in a ship other than a ship complying with the requirements in 7.3.2 of this Code, the following provisions shall be complied with:

.1 the moisture content of the cargo shall be kept less than its TML during loading operations and the voyage;

.2 unless expressly provided otherwise in this individual schedule, the cargo shall not be handled during precipitation;

.3 unless expressly provided otherwise in this individual schedule, during handling of the cargo, all non-working hatches of the cargo spaces into which the cargo is loaded, or to be loaded, shall be closed; and

.4 the cargo in a cargo space may be discharged during precipitation provided that the total amount of the cargo in the cargo space is to be discharged in the port.

Loading

Prior to loading this cargo, the shipper shall provide the master with a certificate issued by a competent person recognized by the competent authority of the port of loading stating that the cargo does not meet the criteria for class 4.2 materials.

As the density of the cargo is extremely high, the tank top may be overstressed unless the cargo is evenly spread across the tank top to equalize the weight distribution. Due consideration shall be given to ensure that the tank top is not overstressed during the voyage and during loading by a pile of the cargo.

Prior to loading, the cargo shall be prepared and aged naturally for a minimum of 30 days. Prior to loading this cargo, the shipper shall provide the master of the ship with a certificate issued by a competent person recognized by the competent authority of the port of loading stating that the cargo has been prepared and aged naturally for a minimum of 30 days.

Prior to loading, the temperature of the cargo in the stockpile to be loaded shall be measured by the shipper for three consecutive days and recorded in a log. Measurements shall be taken 20 to 30 cm below the surface and at 3-metre intervals over the length and width of the stockpile. The cargo shall not be loaded if its temperature is in excess of 65°C.

Care shall be taken by all parties concerned to ensure that particles coarser than 6.35 mm are, as far as is practicable, evenly distributed throughout the entire cargo, in order to avoid build-up of concentrations of coarse material.

Trim in accordance with the relevant provisions required under sections 4 and 5 of this Code.

The cargo temperature shall be monitored during loading and recorded in a log detailing the temperature of each lot of cargo loaded, a copy of which shall be provided to the master.

Hatch covers shall, weather permitting and subject to the absence of precipitation, remain open after completion of loading of the respective holds and placement of thermocouples, in order to allow cooling of the cargo, stabilization of cargo temperature and natural ventilation of the hold. Otherwise, hatches shall be closed and sealed immediately upon completion of loading and placement of thermocouples. Monitoring of temperature and hydrogen concentration shall then be commenced.

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%) *(continued)*

On completion of loading, the ship shall wait for 24 hours (or longer as may be required) before sailing, in order to ensure that:

.1 all loaded cargo holds are correctly closed and sealed;

.2 the temperature of the cargo at all measuring points is stable and does not exceed 65°C for at least 12 consecutive hours; and

.3 that the concentration of hydrogen in the head space of the holds has stabilized and does not exceed 1% by volume (25% of the lower explosive limit (LEL)) for at least 12 consecutive hours.

If after loading and before sailing any cargo temperatures are found to be in excess of 65°C, the material so affected shall be allowed to cool naturally to 65°C or less, or be cooled by mechanical intervention prior to sailing, for example with a front end loader, subject always to proper monitoring and safety precautions being in place. Other measures may be specified by the competent authorities concerned.

On completion of loading and before sailing, a certificate shall be issued by a competent person recognized by the competent authority of the port of loading, stating that:

.1 the proportion of material larger than 12 mm is no more than 3% by weight;

.2 the moisture content of the cargo loaded is at least 2% and below the TML; and

.3 the temperature of the cargo loaded does not exceed 65°C.

Precautions

It is recommended that an experienced cargo technician appointed by the shipper be on board the ship during loading and throughout the voyage.

Prior to loading, the shipper shall provide the master with comprehensive information on the risk of hydrogen evolution and the factors which may affect the rate thereof.

Such risk assessment may include, but not be limited to:

.1 expected weather conditions;

.2 such information as is then available on the hydrogen evolution rate;

.3 planned speed of the ship;

.4 availability and accessibility of ports of refuge en route; and

.5 distance to the port of discharge.

It is strongly recommended that weather routing be utilized in the above-mentioned risk assessment.

Prior to shipment, the master, with the aid of the shipper and/or the cargo technician if appointed, shall ensure that all concerned crew members have been informed about and understand the potential risks associated with the carriage of this cargo. Such knowledge exchange shall be recorded in the ship-shore safety checklist.

The shipper shall ensure that expert advice is available at all times during the voyage and shall provide relevant contact details to the master prior to sailing.

Any material that has become wetted, for example, due to precipitation, shall not be loaded unless such material has been rectified regarding its moisture content.

In the event that a hold carrying this cargo has to be closed prior to completion, for example, due to precipitation, such hold shall be monitored for hydrogen concentration as frequently as required and ventilated to keep the hydrogen concentration less than 1% by volume (25% LEL).

The ship's cargo holds shall be provided with the means of reliably measuring the temperatures at several points within the stow and the concentrations of hydrogen and oxygen in the cargo hold atmosphere during the voyage without entering the cargo holds. Such measuring devices shall be suitable for use in an oxygen-depleted atmosphere and of a certified safe type for use in an explosive atmosphere.

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%) *(continued)*

Holds carrying this cargo and adjacent spaces may become oxygen-depleted. No person shall enter a loaded cargo space or enclosed adjacent space unless such space has been ventilated and the atmosphere tested and found to be gas-free and to have sufficient oxygen to support life.*

Ventilation

During the voyage, mechanical surface ventilation shall be provided in each cargo hold carrying this cargo, in order to keep the hydrogen concentration less than 1% by volume (25% LEL). The mechanical surface ventilation system shall be of a certified safe type for use in an explosive atmosphere, capable of ventilating the cargo surface, as stipulated in 3.5 of this Code. Suitable wire mesh guards shall be fitted over inlet and outlet ventilator openings.

Mechanical surface ventilation shall be available at all times, either by compliance with the Load Line Convention, Annex I, regulation 19(3), or by adopting measures to avoid a situation whereby the cargo hold mechanical ventilation system could not be used due to rough seas, such measures to be in keeping with good seamanlike practices as for similar cargoes emitting intermittent combustible gases and advice from weather routing service providers.

Ventilation shall be such as to provide surface ventilation and to avoid the possibility of the build-up of flammable gas/air mixtures. Ventilation other than surface ventilation shall not be applied and on no account shall air be directed into the body of the cargo.

In order to minimize the possibility of the introduction of oxygen and moisture into the cargo holds, periods of surface ventilation shall be limited to the time necessary to remove hydrogen which may have accumulated in the cargo holds and maintain the hydrogen concentration below 1% by volume (25% LEL).

Mechanical ventilation shall be such as to enable an airflow of at least 1.2 m^3 per hour per tonne of cargo in each hold carrying this cargo when needed, and in any case shall have an adequate capacity to ventilate down to a concentration of 0.2% hydrogen by volume (5% LEL) or less.

Prior to loading, an inspection of the mechanical ventilation system shall be conducted to ensure that it is functioning properly.

Two spare sets of ventilation equipment of a certified safe type for use in an explosive atmosphere shall be available on board the ship during the voyage. A crew member or other person with the ability to install the spare fans shall be available on board throughout the voyage.

In addition, natural ventilation shall be provided in enclosed cargo holds intended for the carriage of this cargo.

The operating period and frequency of the ventilation system shall be determined based on the measured hydrogen concentration and the indicated rate of increase/decrease thereof over time. It is therefore very important to establish a time-based gas prediction curve (see the appendix to this schedule). Such curve shall be first determined prior to sailing and, recognizing that conditions can change during the voyage, be updated from time to time during the voyage as may be appropriate, for example in the case of seawater intrusion into a hold carrying this cargo.

Based on the time-based gas prediction curve(s), the risk assessment shall as soon as possible be updated accordingly, and the voyage plan shall be optimized to avoid a situation where the cargo hold mechanical ventilation system might not be able to be used due to rough seas for periods greater than the estimated time for the concentration of hydrogen to reach 1% by volume (25% LEL). The port authorities at planned ports of refuge shall be advised in advance and a confirmation that access would be granted shall be obtained prior to adding such port to the voyage plan.

The risk assessment, voyage plan, and weather routing, if adopted, shall be updated as frequently during the voyage as updates on the weather become available, as well as actual hydrogen evolution rates.

* Refer to the *Revised recommendations for entering enclosed spaces aboard ships* (resolution A.1050(27)).

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%) *(continued)*

Gases in the cargo holds carrying this cargo shall be removed by extraction, rather than by blowing in the air from outside. Mechanical ventilation exhaust shall be directed to a safe location, away from personnel. All inherent risks associated with the location of the ventilation exhaust openings shall be considered and risk mitigation measures shall be taken to address any such identified potential risk, as appropriate. Ventilation shall be such that exhaust gases cannot enter living quarters in hazardous concentrations.

In the event that mechanical ventilation cannot be operated for whatever reason (for example in the event of mechanical breakdown or electrical failure):

.1 continuous natural ventilation shall be applied until mechanical ventilation is restored; repairs to the non-functioning ventilator shall, if practicable and safe, be carried out away from cargo holds containing this cargo; a ventilator which cannot readily be repaired shall be replaced with a spare one;

.2 if necessary and practicable, use other available means of forced ventilation, preferably in extraction mode;

.3 weather routing advice, if available, shall be updated as soon as possible and, where appropriate, consideration shall be given to re-routing and/or adjusting speed to avoid heavy weather;

.4 the frequency of monitoring of hydrogen concentration and cargo temperature shall be increased;

.5 subject to the discretion of the master, during heavy seas, consideration shall be given to leaving open one or more of the natural vents on the leeward side that are situated in locations protected from the serious effects of the heavy weather, in order to provide some useful dissipation of hydrogen gas from the holds;

.6 mechanical ventilation shall be restarted as soon as possible and operated continuously until the concentration of hydrogen falls to or below 0.2% by volume (5% LEL), and thereafter operated, as necessary, to sustain the hydrogen concentration below 1% by volume;

.7 due care shall be exercised in restarting the ventilation, both mechanical and natural, so as not to create an ignition source; and

.8 seek advice from the shipper or other suitably qualified expert, as appropriate.

In all cases, mechanical ventilation shall be operated for an appropriate period of time prior to discharge.

Carriage

The concentrations of hydrogen and oxygen and cargo temperature in holds carrying this cargo shall be measured daily during the voyage in the presence of or by the ship's designated crew member or representative, or by or under the supervision of the cargo technician, if appointed, and the results of such measurements shall be recorded in a log, given to the master, and kept on board for a minimum of two years.

The frequency of monitoring shall be determined on the basis of the information provided by the shipper, the advice of the cargo technician if appointed, and the information obtained through the analysis of the atmosphere in the cargo holds. Consideration shall be given to increasing the frequency of cargo monitoring following periods of bad weather or following mechanical breakdown of the ventilation system.

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%) *(continued)*

As soon as the results of monitoring indicate that the hydrogen concentration is approaching or has reached 1% by volume (25% LEL), the following precautionary measures shall be taken:

.1 verify proper operation of the mechanical and natural ventilation systems;

.2 maintain, and if possible, increase mechanical and natural surface ventilation until the hydrogen concentration falls to or below 0.2% by volume (5% LEL);

.3 take care to prevent any spark generation or other potential source of ignition in the vicinity of the cargo holds, adjacent spaces, or open decks; and

.4 increase the frequency of monitoring of the hydrogen concentration in the cargo holds with the proper equipment, preferably to hourly, provided always and to the extent that prevailing conditions permit.

If the hydrogen concentration remains above 1% by volume after such increased monitoring and ventilation, seek expert advice. Other than in the case of last resort, opening the hatches for the purpose of additional ventilation shall be undertaken only following receipt of relevant expert advice. Personnel shall under no circumstances enter the affected cargo spaces.

A cargo temperature of 65°C in a cargo hold is an indicator of a potential emergency situation and is, therefore, a trigger for increased monitoring and vigilance, as well as preparation for dealing with the emergency. In such cases, the following precautionary measures shall be taken:

.1 if possible, increase the rate of mechanical and natural ventilation to dissipate heat and any hydrogen;

.2 monitor temperatures every 2 to 3 hours and hydrogen concentration every hour if possible, but in any event not less frequently than every 4 hours, provided always and to the extent that prevailing conditions permit;

.3 do not use CO_2, water or steam on the cargo;

.4 monitor hydrogen and oxygen levels in adjacent cargo holds and spaces and if possible, ventilate them;

.5 if possible, check for bulkhead heating in adjacent cargo holds; if significant bulkhead heating is detected from within an empty cargo hold, spray with water from the empty cargo hold side, provided the bulkheads are mechanically sound (water shall not be allowed to enter into contact with this cargo);

.6 check for signs of abnormal heat in affected sounding pipes and air pipes; and

.7 if and when the temperature returns sustainably to 65°C or less, regular monitoring procedures shall be resumed.

In the event that the cargo temperature reaches or exceeds 100°C, follow the emergency procedures given in the appendix to this schedule.

Bilge wells shall be checked regularly for the presence of water. If water is found, it shall be removed by pumping or draining the bilge wells.

In the event that during the voyage the ship begins to exhibit motions indicative of cargo shifting, the appearance of the surface of this cargo shall be checked, subject always to the provisions for safe entry given in the section for "Precautions" hereof. If free water above the cargo or fluid state of the cargo is observed, the master shall take appropriate actions to prevent cargo shifting and potential capsize of the ship and give consideration to seeking emergency entry into a place of refuge.

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%) *(continued)*

Discharge

The hydrogen concentration in the relevant cargo hold atmospheres shall be measured immediately before any action to open the hatch covers is undertaken. If the hydrogen concentration is greater than 1% by volume (25% LEL), hatch covers shall not be opened. Additional ventilation shall be applied until the hydrogen concentration falls to or below 1% by volume. Special attention shall be given to the opening of hatch covers, in order to avoid sparks being generated. If in doubt, expert advice shall be sought.

The cargo in a hold may be discharged during precipitation, provided that the total amount of the cargo in such hold is: (1) to be discharged in the port; and (2) not to be transferred to another ship. Otherwise, during precipitation, all cargo operations shall be suspended and hatches of holds containing this cargo shall be closed. Monitoring of the hydrogen concentration in those holds containing this cargo shall be resumed.

Clean-up

Accumulations of dust from this cargo on deck or in proximity to cargo holds shall be removed as quickly as possible. Hosing with seawater shall be avoided. Consideration shall be given to carefully cleaning exposed radio communications equipment to which dust from the cargo might adhere, such as radar, radio aerials, VHF installations, AIS and GPS.

Emergency procedures

Special emergency equipment to be carried
Self-contained breathing apparatus.
Emergency procedures
As provided by the shipper.
Emergency action in the event of fire
The specific procedures provided by the shipper should be consulted and followed, as appropriate.
Do not use CO_2. Do not use water. Do not use steam.
Medical first aid
Refer to the *Medical First Aid Guide* (MFAG), as amended.

Appendix

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%)

Precautions to be taken by the shipper prior to and during loading

1 The cargo temperature shall be monitored by the shipper for the three days prior to loading to verify temperature stability. Measurements shall be recorded in a log detailing the temperature for each lot of cargo loaded, a copy of which shall be provided to the master prior to sailing.

2 Material exhibiting temperature instability beyond the temporary increase of up to about 30°C or with a temperature above 65°C shall not be loaded.

3 If necessary, once the pre-shipment moisture content has been determined, each pile of cargo to be loaded may be covered with tarpaulins and during loading, the tarpaulins progressively removed as the pile is loaded. In the event of precipitation during loading such that a pile becomes wet, loading from such a pile shall be suspended and, weather permitting, loading shall be resumed from a different pile which has been tested for moisture content. The wet material shall be resampled for moisture content pursuant to 4.5.2 of the IMSBC Code and, such moisture content to be certified as suitable for loading by a competent person recognized by the competent authority of the port of loading.

4 Prior to loading and after loading has been stopped due to precipitation, the shipper shall ensure that the conveyor belts and all other equipment used for loading this cargo contain no accumulations of water or other substances.

5 Each time loading operations are commenced or resumed, all conveyor belts shall be operated unladen, but not over a cargo hold.

Additional precautions to be taken

1 Where practical, ballast tanks adjacent to the cargo holds containing this cargo, other than double-bottom tanks, shall be kept empty.

2 Bilge wells shall be clean, dry and protected from ingress of the cargo with non-combustible material. Bilge wells shall be checked regularly for the presence of water. If water is found, it shall be removed by pumping or draining the bilge wells.

3 The introduction of moisture and accumulation of condensation in the cargo holds shall be avoided.

4 Appropriate precautions shall be taken to protect machinery and accommodation spaces from the dust of the cargo. Due consideration shall be given to protect sensitive equipment such as radars and exposed telecommunications equipment from the dust of the cargo.

5 Persons who may be exposed to the dust of the cargo shall wear protective clothing, goggles or other equivalent dust eye-protection and dust filter masks, as necessary.

6 During any handling of this cargo, "NO SMOKING" signs shall be posted on decks and in areas adjacent to cargo holds, and no naked light shall be permitted in these areas. Smoking, burning, cutting, chipping, grinding or other sources of ignition shall not be allowed in the vicinity of cargo holds containing this cargo at any time.

7 All electrical equipment within any cargo hold in which this cargo is carried shall be of a certified safe type for use in explosive atmospheres or effectively isolated from the electrical supply.

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%) *(continued)*

8 Prior to loading, an ultrasonic test or another equivalent method shall be conducted to ensure weathertightness of the hatch covers and closing arrangements, and all readings shall confirm weathertightness.

Development of time-based gas prediction curve

A time-based gas prediction curve is an important tool for understanding the likely rate of evolution of hydrogen from this cargo. In order to develop such a curve, a cargo hold shall be ventilated until the hydrogen concentration falls to or below 0.2% by volume (5% LEL), then ventilation (both natural and mechanical) to such hold shall be stopped, and the hydrogen concentration measured every 2 hours thereafter for at least 24 hours or until it reaches 1% by volume, whichever occurs first. If the concentration reaches or exceeds 1% by volume, the respective cargo holds shall be ventilated and measurements continued to ensure that the concentration of hydrogen has stabilized and remains sustainably at or below 0.2% by volume (5% LEL). Based on this data, the length of time needed to reach a concentration of 1% by volume in the absence of ventilation shall be calculated and employed for updating the voyage plan and optimizing the weather routing.

Emergency measures in case of high cargo temperature

1 In the event that the cargo temperature in a hold reaches or exceeds 100°C, the first step is to seek expert advice, in order to determine the best course of action, taking into account the prevailing circumstances and history of the cargo in question; for example, the rate of temperature increase, the remaining sailing time to the scheduled discharge port, etc.

2 Depending on the expert advice received, the following two solutions may be considered:

.1 deviation to a port of refuge to discharge the affected cargo if the cargo temperature exceeds 120°C, in which case preparations should be made for grab discharge; and

.2 as a last resort and only if safe, flooding the affected cargo holds with water, always taking into account the stability and strength of the ship.

3 The temperatures mentioned in this section, i.e., emergency measures in case of high cargo temperature, are indicative only, and the advice of the appointed surveyor or expert shall be followed.

Duties of the cargo technician

1 The cargo technician, if appointed, shall:

.1 Monitor the loading operations and provide advice as appropriate.

.2 Advise on and supervise the installation of thermocouples in the cargo holds for temperature monitoring, monitor the performance of the thermocouples, and keep the master informed accordingly; if a cargo technician is not appointed, the shipper shall advise on and supervise the installation of the thermocouples in the cargo holds.

.3 Monitor and report on the cargo parameters, namely temperature and hydrogen and oxygen concentrations, as well as other data or information relating directly to cargo behaviour, such duty to include taking readings in conjunction with designated crew members and ensuring that readings are communicated on a regular and frequent basis to the master, or their designated representative, who shall forward them to the shipper to seek appropriate advice.

.4 Assist and advise the master and crew in the development of the time-based gas prediction curve and the frequency of updating thereof.

.5 Advise and coordinate with the master and crew, as appropriate, in connection with the operation of the ventilation systems.

DIRECT REDUCED IRON (D)
(By-product fines with moisture content of at least 2%) *(concluded)*

.6 Provide advice and assistance to and cooperate with the master and crew in case of an emergency pertaining to the cargo.

2 In carrying out such duties the cargo technician shall act in an advisory capacity and be subject to the authority and decision of the master of the ship.

3 In the absence of the appointment of a cargo technician, the master or their designated representative shall seek advice from the shipper or other competent person.