Exporting DRI
LIBYAN IRON AND STEEL COMPANY

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Our steel complex at Misurata, Libya consists of two MIDREX® DRI Series 500-Modules and one MIDREX HBI Series 500-Module. Our first DRI module was commissioned in 1989, the second in 1990, and our HBI unit was commissioned in 1997. The production of DRI is primarily intended for in-house consumption in two steel meltshops, SMS-1 and SMS-2, with total annual liquid steel production of 1.3 million metric tons (Mt). HBI production is mainly for export. To date LISCO has produced over 14 Mt of DRI.

We decided to export our surplus DRI to prospective buyers. Our first DRI consignment of 25,000 t was shipped to India in April 2006. The voyage took 14 days. As per IMO Guide Lines,

LISCO

we took extra precautions in the production of DRI, regarding its passivation, storage, loading, and shipment as detailed below.

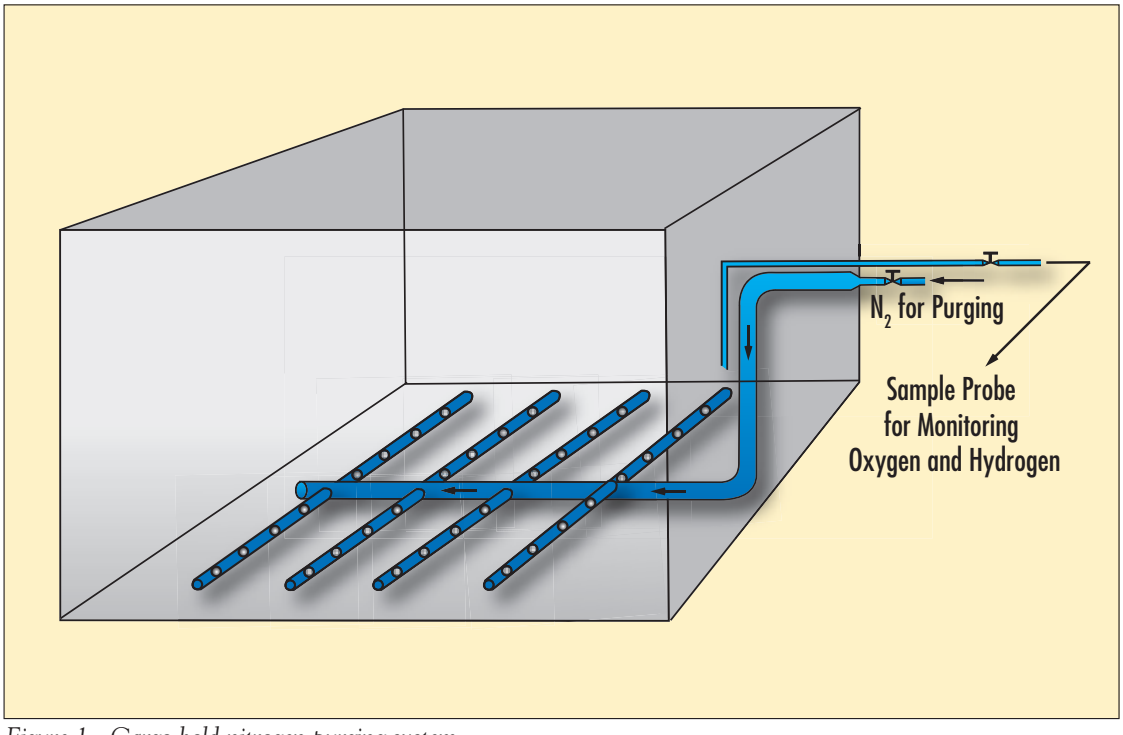

Figure 1 - Cargo hold nitrogen purging system

Production Precautions

We used 100 percent feed mix of CVRD, LKAB, and Samarco pellets – a mix we have consistently used over the years. We started lime coating of pellets at 1 kg/t oxide feed and operated the reduction furnace at a maximum bustle temperature of 900° C. This was achieved without oxygen injection because currently LISCO does not have surplus oxygen. The produced DRI has more than 93 percent metallization and 1.6 percent carbon with a maximum temperature of 40° C at furnace discharge. The full batch of DRI for export was discharged via a

remet hopper, as the product screens downstream of product bins were being used to feed DRI to the steel meltshops.

Natural Passivation by Air

The DRI discharged through the remet hopper was stored in small heaps of approximately 50 t on a dry concrete surface. The temperature of each small heap was monitored. After about three to four days of air passivation, the smaller heaps were accumulated into larger heaps of about 1,000 t, with a maximum pile height of three meters. Pile temperatures were recorded by inserting thermocouple probes with temperature gauges. The readings were recorded daily with a maximum temperature reading of 55° C. About 12,000 t of air-passivated DRI was stored inside the product warehouse before loading for shipment. Storage inside the product warehouse was arranged in piles of about 2,000 t within each section. Again, the pile temperatures were measured by inserting thermocouples in each pile. The product warehouse was naturally ventilated, and the DRI stored outside was protected against rain with tarpaulins.

DRI Loading

DRI was shipped in a vessel with five cargo holds, each roughly 19 m x 14.4 m x 15.6 m. Before loading the DRI, all cargo holds were inspected to make sure they were clean and dry. At the bottom of each hold, a perforated pipe was installed for purging the hold with nitrogen after loading of the DRI was completed.

LISCO has its own captive port with specialized facilities, such as a telescopic ship-loading conveyor for loading HBI into ships. The conveying system extends from the HBI plant to the port, about 1,500 meters away.

The loading of DRI was done through the existing conveyor. Because of the specialized facilities, about 8,000 to 9,000 t could be loaded per day by deploying three pay loaders to feed the conveyor. No feeding was done during rain.

The cargo loading sequence was decided by the Shipmaster. Feeding in each hold was about 3,000 Mt. A network of portable thermocouples (immersion probe J-type of 316 stainless steel) was placed over the heap in four different locations to measure the temperature of the cargo during voyage. The remaining DRI cargo was fed into individual holds after installation of thermocouples with extended wiring. No thermocouple was placed on the floor or on top of the cargo. DRI volume in each hold was maintained at less than 50 percent of the hold volume.

When the total DRI cargo had filled four holds and HBI cargo was fed into a fifth, the hatch covers on all cargo holds were closed. Nitrogen purging devices were installed in all four DRI cargo holds. A common sampling probe to measure oxygen and hydrogen concentration during purging, as well as during the voyage, was also installed in each hold.

The hold hatches were then properly sealed; sealant was applied to all leaking points when nitrogen purging began. Purging of the DRI cargo holds was done by supplying compressed nitrogen gas in tankers at 15 bar pressure. Two tankers were deployed for transporting the gaseous nitrogen. Each hold required about 10,000 Nm^3 of nitrogen for purging to less than five percent of oxygen in the hold. Monitoring cargo temperature started eight hours after filling was completed.

While loading and unloading DRI, ship instruments such as radar and telecommunication systems were protected against dust.

Measurements While Sailing

As determined from the readings of variable oxygen concentration in the cargo space, there was a gradual increase in oxygen concentration during the voyage even though the hatches were closed and sealed. All ventilators and other hold openings were also closed before disconnecting nitrogen purging. Hydrogen concentration was not detectable throughout the journey. There was marginal change in cargo temperatures during the voyage. The oxygen and hydrogen concentrations were measured with a hand-held portable monitor by drawing samples from the sample probe of the cargo space. Temperatures were measured with a portable digital thermometer.

Safety Precautions for DRI Cargo

Before sailing, a final set of reading of temperature, oxygen and flammable gas concentrations (hydrogen) were taken. Acceptable criteria were:

Temperature	< 65° C
Oxygen	5.5% (max.) in all holds
Flammable gas	Nil

During the voyage, temperature and oxygen measurements were taken in all holds containing DRI at least three times a day, weather and sea conditions permitting. All readings were reported to the Master and the shipper daily.

In case of heavy weather, the frequency of readings must be increased temporarily. Also, all weather-tight doors must be properly closed and secured after readings are taken.

Atmosphere in the holds will warm up during the day and cool down during the night, and air may be drawn into the hold while taking readings at night and early morning. Therefore, a good seal around the probe is essential to prevent loss of inert atmosphere and inaccurate readings.

The inert gas in the holds may leak into the crane-houses in which the sampling points are located, thereby rendering the atmosphere dangerous. Therefore, the oxygen level in the crane-houses was confirmed before entering them.

Successful DRI Shipping Experience

A number of factors contributed to the success of our first shipment of DRI. Our plant produced DRI with excellent chemical characteristics and physical attributes, which we carefully passivated and properly stored prior to shipping. As the DRI was loaded, we made certain it was dry and the ship's holds were properly closed, sealed, and purged. During the trip, we routinely checked the oxygen and hydrogen levels in the holds and closely monitored the temperature of the DRI.

At journey's end, we delivered our customer a high quality DRI product and demonstrated that DRI can be safely shipped when proper procedures are put into place and closely followed.