H B I
HOT BRIQUETTE IRON
The Ultimate Merchant Steelmaking Metallic

Four Seasons Asia Pacific Ltd
What is HBI (HBI)?

*HOT BRIQUETTES IRON*

Hot Briquettes Iron (HBI) is a premium form of Direct Reduced Iron (DRI)* that has been compacted at a temperature greater than 650° C at time of compaction and has a density greater than 5000 Kilograms per cubic meter (5000 kg/m^3).

*DRI* is a metallic material produced from Iron Oxide fines or iron Oxide pellets and/or lump ores that have been reduced (oxygen removed) without reaching the melting point of iron. Listed by IMO as: Direct Reduced Iron (A) Briquettes, hot-moulded.
**HBI**

**Chemical Analysis**

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fe</td>
<td>92.5 % min</td>
</tr>
<tr>
<td>Metallic Fe</td>
<td>84 %</td>
</tr>
<tr>
<td>C</td>
<td>0.8 - 1.5 %</td>
</tr>
<tr>
<td>P</td>
<td>0.09 % - 0.12 % max</td>
</tr>
<tr>
<td>SiO₂</td>
<td>1.5 % max</td>
</tr>
<tr>
<td>MgO</td>
<td>0.3 % max</td>
</tr>
<tr>
<td>CaO</td>
<td>0.03 % max</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>1.3 % max</td>
</tr>
<tr>
<td>Gangue</td>
<td>3.0 % max (CaO+MgO+SiO₂+Al₂O₃)</td>
</tr>
</tbody>
</table>

**Residual**

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>&lt;=0.002%</td>
</tr>
<tr>
<td>Ni</td>
<td>&lt;=0.006%</td>
</tr>
<tr>
<td>Cr</td>
<td>&lt;=0.008%</td>
</tr>
<tr>
<td>Mo</td>
<td>&lt;=0.002%</td>
</tr>
<tr>
<td>Sn</td>
<td>&lt;=0.002%</td>
</tr>
</tbody>
</table>

**Physical Analysis**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>90 x 58 x 29 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>0.5 - 0.7 Kg</td>
</tr>
<tr>
<td>Bulk Density</td>
<td>2.77 ton/M³ min</td>
</tr>
<tr>
<td>Briquette density</td>
<td>&gt;4 mm: 98%</td>
</tr>
<tr>
<td>Granulometric Distribution</td>
<td>&lt;4 mm: 2%</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.1 % max.</td>
</tr>
</tbody>
</table>

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HBI Advantages:

- High bulk density can hold more quantity on charge bucket in comparison to scrap. Known, consistent chemistry certified by the producer unlike scrap which may vary.
- Minimal trace elements like Cu, Ni, Cr, Mo, Sn, Pb, and V in comparison to scrap.
- High thermal and electrical conductivity.
- Not prone to accident due to self-heating unlike DRI.
- Low reactivity with fresh and salt water (re-oxidation).
- Resistant to degradation due to handling and weathering.
- Compatible with all bulk materials handling equipment.
- Safe, easy to store in all types of weather.
- Reduction in tap-to-tap time while charging to EAF in comparison to scrap.
Venezuela’s major HBI Projects

The Government owned iron ore supplier CVG Ferrominera Orinoco (FMO) is active in the Promotion of new DR projects. Voest Alpine Industrienlagenbau along with two Venezuelan Engineering companies has completed detailed Engineering for the Orinoco Iron plant.

Orinoco, Comsigua and Venprecar Iron Ore Venezuela’s largest merchant Hot Briquette Iron (HBI) Producers in South America.
**HBI - PLANT**

**Orinoco***
The plants uses FINMET® and technology, and is able to produce 2.2 Million MT of HBI per year. The company is present in four continents and its Export experience began in late 1970's already. Orinoco Iron company has been formed to build and operate a 2.2-million mt/y FINMET® plant in Puerto Ordaz, Venezuela. Orinoco Iron is the largest merchant Hot Briquette Iron (HBI) producer in the Americas.

**Comsigua***
The second project is the 1 Million mtpy Comsigua plant which utilizes the MIDREX® technology. The plant is located in the Punta Cuchillo industrial park developed by CVG Ferrominera where a new 3.3 Million mtpy pellet plant is on line. Feed for the plant would be supplied directly from the pellet plant. A new project, Comsigua II, for an additional 1 Million mtpy MIDREX® DR plant at Punta Cuchillo is now being evaluated. Product will be shipped by rail from Comsigua to the Palua port on the Orinoco River.

**Venprecar***
Another pellet based plant, [Posven*renamed] in Venprecar, using previously the HYL III process in Puerto Ordaz. This plant have one steam reformer and two 750,000 HYL III reactors and has produce HBI for the merchant market. The majority were shipped by Posco to Korea, and much of the remaining product was for the US market. The plant, like Comsigua, supplied with San Isidro pellets and lump, with the pellets coming from the adjacent pellet plant. The product will be shipped by rail to Palua, where it will be loaded onto ships for export. The plant has an Investment cost of $326 Million not including port facilities. Since these three plants constructed, they produce HBI for the Export market only. They were increase the Venezuelan HBI availability for Export from the present level of about 1.5 Million mtpy to about 6.5 Million mtpy.
Orinoco Iron Plant

Finmet® Process 2,200,000 MT/Year

Orinoco Iron uses a fluid bed iron ore fines reduction process to produce hot moulded briquettes. The Finmet® process is based upon the reduction of iron ore to metallic iron at high temperature and pressure using reducing gases produced from reforming. The reducing gas utilised has a high content of hydrogen.

The heart of the process is a series of four fluidized bed reactors to convert iron ore fines (12 mm) to HBI. The fines are first preheated in the preheat reactor by the combustion of natural gas in a fluidized bed under non-reducing conditions.

Now at a temperature of 750°C, the fines flow by gravity to the first of three reducing reactors, and pass successively down through the other two. The iron ore is reduced by contact with the reducing gas, and reaches a metallization of 92-93% in the final reactor. Here carbon is formed on the reduced iron ore in the form of iron carbide.

Once the reduction process is completed, the hot iron is transferred to the briquetting machines, where it is compacted between counter-revolving rollers into strings of briquettes. The strings are separated into individual briquettes. The briquettes are passivated and cooled, and then are stored in outdoor storage piles. The briquettes produced in this process are very inert and exhibit little re-oxidation tendency.

An integral part of the process is the quality control, which is applied at each step and thereby ensures that the final product quality meets Orinoco Iron’s standards.

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COMSIGUA PLANT

MIDREX® Direct Reduction Process

Comsigua using MIDREX® Direct Reduction Process reduction by removal of oxygen from iron ore without melting. The MIDREX® Direct Reduction Process is the leading technology for converting iron ore into a high-purity direct reduced iron (DRI) product for use in steelmaking, ironmaking and foundry applications. The MIDREX® Process typically uses natural gas as the reductant and fuel, but also can use coal through gasification which is known as MXCOL®.

The MIDREX® Direct Reduction Process employs a shaft furnace to convert iron ore into DRI using natural gas or syngas from coal (MXCOL®). The MIDREX® Process is energy efficient and flexible, producing 60 percent of the world’s DRI annually. Midrex offers three rotary hearth furnace-based technologies: FASTMET® provides for recycling of steel mill by-products with iron unit recovery; FASTMELT® processes steel mill by-products into hot metal or pig iron for steel mill use; and ITmk3® (pronounced "eye-tee" mark 3) produces high quality pig iron nuggets from iron ore.

This enables HBI to be stored and handled without special precautions as recognised by the International Maritime Organisation (IMO). HBI can be moved using typical scrap handling equipment and easily batch charged to the EAF, thus requiring no capital investment by the steel mill. HBI can be continuously charged with specially-designed systems.

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Venprecar* Plant

**Using HYL Technologies** became part of Techint Technologies in 2005. Techint Technologies is now called Tenova HYL. Technology Solution.

The HYL Process has always had independent reforming and reduction sections. By eliminating the external reformer – the reforming, reduction and carburization occurs within the shaft furnace. This concept, called the ZR Process, has operated successfully since 1998 in smaller, more efficient Plant & Process.

The HYL ZR Process plant is much smaller than a conventional DR plant:
- High pressure operation requires smaller equipment
- No reformer means significant savings
- Efficiencies in fabrication and construction further reduce plant investment cost
- Equipment and structure redesign made possible the HYL Micro-Module

**DRI vs. HBI**

Two different forms of the same product:
- DRI is the traditional form, in either pellet or lump ore form
- HBI is compressed DRI - Two different uses (theoretically):
  - DRI is for onsite production and use in EAF melt shops
  - HBI is for commercial shipment to customers worldwide, usually by Sea. HBI is the form adopted for merchant sale of reduced iron, since it is deemed safer for shipping and handling.

DRI Shipments of product historically includes both DRI & HBI:
- Shipments tend to average 50% for either product form
- Shipments by land or sea are also usually 50% for each
- If DRI can safely be shipped, then the cost of producing HBI has to be justified. Cost of producing HBI is $6/MT higher than for DRI.
HOT IRON BRIQUETTES

How Is it made?

Hot Briquettes Iron (HBI) is a premium form of Direct Reduced Iron (DRI)* that has been compacted at a temperature greater than 650° C at time of compaction and has a density greater than 5000 kilograms per cubic meter (5000 kg/m3).

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HBI is produced by any of several commercially proven direct reduction processes. The direct reduced iron (DRI) is compacted while hot but in a solid state in specially designed roller presses to create a dense, pillow-shaped metallic iron briquette.

Hot Iron Briquettes are produced by reducing iron ore fines in fluid bed reactors with a counter current reducing gas Fluidized Iron Ore Reduction). Due to their high density and metallization, low gangue and residual content, and inert character, Iron HBI is the ideal metallic charge for steelmaking.

At present, direct reduced iron in the form of DRI and HBI is the major source of Scrap Substitutes worldwide. Venezuela has more experience with direct reduction processes than any other country in the world due to the diversity of processes, which have been installed there. Its experience covers more than 30 years, and the country has had seen over 6 Million MT of installed DR capacity on their peak time in order to play an important role as a reliable supplier of HBI.
HBI
Hot Briquettes Iron

Use in Electric Arc Furnaces

- **Batch Charging**  The benefits of DRI/HBI are not limited to its chemical characteristics. In electric furnace steelmaking, the use of high density DRI/HBI can eliminate the need for a second or third scrap charge. This results in lower energy losses, more power on-time and improved productivity. MIDREX® DRI or HBI is mixed with scrap in the bucket. Generally, DRI or HBI can be added at up to 30 percent of the charge.

- **Continuous Charging**  Continuous charging systems can be used to feed up to 100 percent of the required metallics. More commonly, one bucket of scrap is charged and the remainder is continuously fed DRI or HBI. This can reduce back charges and allows the furnace roof to stay on, retaining valuable heat. Maintaining a consistent temperature leads to improved bath heat transfer and faster metallurgical reactions. Continuous charging can be done with cold or hot DRI. Hot DRI can be charged directly using the MIDREX HOTLINK® System, or using a hot transport conveyor or hot transport vessels. Normally, the DRI is charged to the centre of the EAF.

Due to their high density, the briquettes can be used as an alternative metallic source by either charging in buckets (batch charging or continuous feeding through the roof. By charging in buckets, it is possible to reduce the number of back-charges since briquettes are much denser than scrap. Up to 40% briquettes can be used when charging in buckets. In continuous feeding, briquettes are more effective than DRI due to their high density, which allows them to penetrate to the slag/metal interface quickly rather than hang up in the slag. It is possible to continuously charge up to 100% briquettes. One of the melt shops uses an 85% briquette practice. By continuous feeding, all back-charges can be eliminated, which reduces tap to tap time and heat losses due to swinging the roof. This results in a more constant power input, which reduces line losses and improves productivity. Because of the low residual content of the briquettes, they are in increased demand for the production of higher quality steels. The low residual content, compact shape, and high thermal conductivity make briquettes attractive as a coolant for liquid steel in ladle furnaces.
HBI

Hot Briquettes Iron

Use in Blast Furnace

HBI has been used in blast furnaces to increase hot metal production and lower coke consumption. Blast furnace production can be increased by over 20 percent by using HBI in the burden. This increase can be realised with no capital cost expenditures. Its use is cost effective when the steelworks is hot metal short, or if a blast furnace is down for a reline or idled until hot metal demand increases. Use of HBI also decreases CO2 generation.

Using HBI in the burden of blast furnaces allows the productivity to be increased and reduces coke consumption.
**H B I**

**Hot Briquettes Iron**

**Basic Oxygen Furnace (BOF)**

A common practice is to use HBI as a cold charge in the BOF to supplement scrap. It can be loaded in the charging box and charged and melted like scrap. In cases where scrap has high levels of residual metals, HBI is a preferred charge material.

**Other uses**

The HBI are used in smaller quantities in cupolas with good results. Briquettes with up to 3% carbon are being used with excellent results in EAF shops. HBI is a high density ferrous raw material is used in electric arc furnace (EAF) and basic oxygen furnace (BOF) Blast Furnace (BF) for steel making. Due to its high density and compact form, it’s very convenient for handling and storage It has many advantages over scrap, pig iron and DRI as a raw material for making steel.
Raw Materials and Utility Sources

Iron Ore
Iron ore is mined and sold in Venezuela exclusively by CVG FMO, whose mines are located in the Guayana region. The iron ore reserves of CVG FMO are estimated to be around 4.2 billion tons of proven reserves and 14.7 billion tons of total reserves, including estimates for probable and possible deposits. Venezuela can supply its expected metallics demand for more than a century based upon present demand and proven reserves.

The proven reserves for mines with at least 64% iron on a dry basis is 1.7 billion tons. This type of ore is classified as shipping grade, and as such it can be used directly from the mine for steelmaking or direct reduction. There are another 2.5 billion tons of proven ore reserves with 60 to 63% iron. This ore would require a minimal amount of upgrading in order to be used in steelmaking. By comparison, most US ores have less than 50% iron and have to be beneficiated so that iron ore can be used for steelmaking.

In Venezuela, as in many mining regions in the rest of the world, the major part of the ore mined is in the form of fines under 1/2” in size.

Utility Sources

Natural Gas
Natural gas for the Project is provided by PDVSA Gas, the sole supplier in the region. Currently, the gas is produced at wells in the El Tigre area and is transported by pipeline to a gas liquid extraction plant at Jose, on the coast, and then sent by pipeline to the Orinoco Iron Plant.

Venezuela has proven natural gas reserves of 148 trillion cubic feet (Tcf), the second largest in the Western Hemisphere (behind the United States). In addition, new discoveries far exceed increases in consumption. Consumption in the Puerto Ordaz area is in the order of 3.4 billion m³ per year, 12% of total production.

Electricity Power
Electricity is provided by Edelca, which owns and operates all the hydroelectric power supply of the Guayana region. The electricity is supplied by one of the largest and most reliable hydroelectric networks in the world, as its power generation capacity is not vulnerable to adverse changes in rainfall conditions. The Dams - Guri, Macagua I, Macagua II, and Macagua III - provide a combined generating capacity of over 13,500 MW. This will be increased by the construction of new hydroelectric dams in the future. The region’s total hydroelectric capacity is forecasted to be over 18,000 MW in 2010.

Water
Industrial water is supplied from the Caroní River, which has a maximum flow over 10,000 m³/sec. The Orinoco Iron Plant uses 0.2 m³/sec.
Facilities / Supporting Infrastructure

Rail Transportation

There is an existing rail line adjacent to the Orinoco Iron Plant site which connects the Matanzas Industrial Zone to the CVG FMO ore processing facilities at Puerto Ordaz and Palúa. The ore required by Orinoco Iron is delivered by rail car to an unloading station located at the Plant. HBI product from the Plant is transported by conveyor belts to metal storage hoppers located over the rail spur at the rail receiving station inside the Plant site. HBI is an inert material and can be safely stored in uncovered piles or in hoppers. The hoppers will discharge the HBI directly into the rail cars, which deliver the HBI to the shipping port. Capacity of CVG FMO rail line 32 million tpa.

Roads

The Guayana region has one of the best road networks in Venezuela. The Matanzas Industrial Zone has a modern road network which connects it with neighbouring towns. A well maintained four lane highway connects it to both Puerto Ordaz and Ciudad Bolívar. A six lane road connects Matanzas to San Felix, where many of the workers in the heavy industrial plants live.

Orinoco River

The Orinoco River has an estimated maximum shipping capacity of 100 million tpa, or more than five times its present traffic. Vessels of up to 80,000 DWT can load during the period when the Orinoco River draft is high (during May-November) and vessels of around 40-50,000 DWT can make the passage to the Atlantic during the dry season. The draft in the low season is 28-30 feet, while in the high season is 32-38 feet. Most HBI cargoes are being transported in 25-40,000 ton lots.
Facilities / Supporting Infrastructure

Port Facilities

The Palúa facility is located on the mile 184 of the Orinoco River. HBI from the Orinoco Iron Plant is exported from the Palúa facility at San Felix. The Palúa dock has 276.6 meters in length and can berth one vessel. Palúa's ship loading capacity is 1,100 tph for HBI. At present HBI is transported to Palúa and stored at a 150,000 tons store-yard.

The HBI is transported from the plant to the port by rail cars, and stored in piles, then the product is loaded by front end loaders onto a mechanized system which sends it into the ships.

These installations are designed in conformity with the concept of "soft loading", in order to optimize the degradation of the product, which improve the material handling.

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Finally, the sad news ::

Venezuela’s share of world DRI/HBI production has declined steadily since its pre-eminence in 1983...

Initially this was not due to technical problems, but rather through the nationalisation of all Producers since the socialise process in the country take place by destroying entirely output that has further deteriorated dramatically.

Slowly recovering is in sight...!