Sponge iron/DRI has gained great prominence in India as a substitute of steel scrap (partially) in steel making in electric arc furnace and in induction furnace.

Direct Reduction is a metallurgical process of producing sponge iron from iron oxides (mainly from lump iron ores or pellets) directly in the solid phase. The product of this solid state route has a honeycomb structure with minute pores. Hence this product is most commonly known as sponge iron/direct reduced iron (DRI). In addition to the metallic iron content sponge iron contains some unreduced iron oxides and gangue. Since there is no separation of impurities in DR process, all the gangue present in the original oxide (silica, alumina, oxides of phosphorous) goes in to the product sponge iron. In fact concentration of these oxides increases due to the removal of oxygen to a level of plus 90%.

Hot DRI in the form of pellets, lumps, fines at a temperature of 650-700 deg C is passed through hot briquetting machine where the product is pressed between the rolls at extremely high pressure to produce highly compacted pillow shaped material called hot briquetted iron (HBI). While producing sponge iron some amount of sponge fines of minus 4mm is also generated. This sponge fines is briquetted in cold condition using binders in hydraulic roll press to produce highly compacted pillow shaped material called as cold briquetted iron (CBI).

HBI/CBI are nothing but densified form of sponge iron with substantial increase in apparent density.

Induction furnace is purely melting unit of steel scrap/sponge iron and no refining of steel can be done for the removal of phosphorous/sulphur. In addition the presence of gangue in sponge iron increases the power consumption and operational problems for deslagging. Hence the specification of sponge iron suitable for use in induction furnace is very stringent. The manufacturer of sponge iron has to be most diligent in selection of iron oxide for phosphorous/gangue content and in process control to offer a consistent product quality for the induction furnace customers.

Sponge iron is being used in induction furnace

Upto 30% of charge mix for the removal of carbon in the liquid metal

Upto 50% of charge mix for carbon removal and control of tramp elements

Upto 80% of charge mix for carbon removal, control of tramp elements and economics of usage.

Accordingly sponge iron has been classified in three grades in this standard to suit the above requirements.

For the purpose of deciding whether particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2:1960 `Rules for rounding off numerical values (revised)`.

The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.
1 SCOPE
This draft standard covers the product specification of sponge iron suitable for steel making in induction furnaces.

2 REFERENCES
The standards listed below contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<table>
<thead>
<tr>
<th>IS No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>228(Part I):1987</td>
<td>Method of chemical analysis of steels:</td>
</tr>
<tr>
<td></td>
<td>Part I Determination of carbon by volumetric method</td>
</tr>
<tr>
<td></td>
<td>(for carbon 0.05 percent to 2.5 percent) (third revision)</td>
</tr>
<tr>
<td>1387:1993</td>
<td>General requirements for the supply of metallurgical materials</td>
</tr>
<tr>
<td></td>
<td>(second revision)</td>
</tr>
<tr>
<td>1405:1982</td>
<td>Methods of sampling iron ores (second revision)</td>
</tr>
<tr>
<td>1493:1959</td>
<td>Method of chemical analysis of iron ores.</td>
</tr>
<tr>
<td></td>
<td>(Part I): 1981 Part I Determination of common constituent (first revision)</td>
</tr>
<tr>
<td>1607:1977</td>
<td>Method for dry sieving (first revision)</td>
</tr>
<tr>
<td>10812:1992</td>
<td>Classification of sponge iron/direct reduced iron (DRI) fines/</td>
</tr>
<tr>
<td></td>
<td>briquettes for steel making – specification</td>
</tr>
<tr>
<td>10852:1984</td>
<td>Guidelines for storage and transportation of sponge iron/direct</td>
</tr>
<tr>
<td></td>
<td>reduced iron (DRI)</td>
</tr>
<tr>
<td>14719:1999</td>
<td>Method for measuring the bulk density of HBI</td>
</tr>
</tbody>
</table>

3 TERMINOLOGY
For the purpose of this standard, the following definitions shall apply.

3.1 Sponge Iron/Direct Reduced Iron - It is the resulting product (with a metallization degree greater than 82 percent) of solid state reduction of iron ores or agglomerates (generally of high grade), the principal constituents of which are Metallic iron, residual iron oxides carbon and impurities such as phosphorus, sulphur and gangue (principally silica and alumina).

3.2 HBI - HBI means briquettes made out of sponge iron/DRI produced in gas based direct reduction processes at elevated temperature by the application of external pressure in a more or less close mould.

3.3 Cold Briquettes - Cold briquettes mean cold bonded sponge iron/DRI briquettes, made from sponge iron/DRI fines only.

3.4 Total Iron - It is defined as:

\[
Fe (T) = Fe (M) + Fe (O)
\]

Where

- \(Fe (T)\) = total iron,
- \(Fe (M)\) = metallic iron, and
- \(Fe (O)\) = iron from residual iron oxides

Present in sponge iron/DRI, HBI and cold briquettes.
3.5 **Metallic Iron** - It is the aggregate quantity of iron, either free or combined with carbon (as cementite) present in sponge iron/DRI, HBI and cold briquettes.

3.6 **Residual Iron Oxides** - These are remaining oxides of iron present in sponge iron either in the form of FeO, Fe₃O₄ or Fe₂O₃, though normally FeO would be the only residual oxides present.

3.7 **Total Carbon** - It is the total carbon present in sponge iron, and is equal to the sum of free and combined carbon (as cementite).

3.8 **Impurities** - These are undesirable elements/compounds in sponge iron, sulphur and phosphorus being the most common among them.

3.8.1 **Gangue** - It is the amount of other impurities present in sponge iron (resulting from the raw materials), in the form of oxides such as Al₂O₃, SiO₂, CaO, MgO, etc.

3.8.2 **Quaternary basicity** - It is the ratio of CaO, MgO, and Al₂O₃, SiO₂, and is expressed as:

\[
B = \frac{\text{Percent CaO} + \text{Percent MgO}}{\text{Percent Al}_2\text{O}_3 + \text{percent SiO}_2},
\]

3.9 **Metallization** - It is a measure of the conversion of iron oxides into metallic iron (either free, or in combination with carbon as cementite) by removal of oxygen due to the action of the reductant used.

3.10 **Degree of Metallization** - It is used to describe the extent of conversion of iron oxide into metallic iron during reduction. It is defined as follows:

\[
\text{Degree of metallization (percent)} = \frac{\text{Mass of metallic iron}}{\text{Mass of total iron}} \times 100
\]

3.10.1 **Equivalent Metallization**

Carbon content in sponge iron at a given degree of metallization is important it has the capacity to remove oxygen from the remaining iron oxides during steel making. This leads to the concept of equivalent metallization, which may be defined as:

Equivalent Metallization (percent) = Degree of metallization (percent) + 5 times the Percent of total carbon in sponge iron

3.11 **Fines**

It refers to cold sponge iron fines with size 0-4 mm obtained during production of sponge iron through solid/gaseous reduction route.

3.12 **Binders**

They refer to additives used in the briquetting process for increasing the strength of the briquette and as lubricants to decrease the roll wear.

3.12.1 **Binder Specification** - It is desirable to use a combination of solid and liquid binders for getting desired strength of cold briquettes.

3.12.1.1 **Solid binder** - Hydrated lime, Ca(OH)₂ should be minimum 80 percent, shall have grain size minus 100 mesh or 0.15 mm.
The typical composition shall be as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO, %</td>
<td>65 - 70</td>
</tr>
<tr>
<td>SiO₂, %</td>
<td>2.5 - 3</td>
</tr>
<tr>
<td>MgO, %</td>
<td>0.5 - 1</td>
</tr>
<tr>
<td>Al₂O₃, %</td>
<td>0.4 - 0.5</td>
</tr>
<tr>
<td>LOI, %</td>
<td>24 - 26</td>
</tr>
</tbody>
</table>

### 3.12.1.2 Liquid binder

**a)** *Sodium silicate*: Sodium silicate (liquid) shall have an apparent density of 1.45 t/m³ and shall have a specific gravity of 1.40.

Typical composition of Sodium silicate:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total soluble silica</td>
<td>26 to 30 percent</td>
</tr>
<tr>
<td>Na₂O</td>
<td>8.8 to 9.4 percent</td>
</tr>
<tr>
<td>Mass ratio of total Na₂O to total SiO₂</td>
<td>3 to 3.4</td>
</tr>
</tbody>
</table>

**b)** *Molasses*: Sp. gravity should be minimum 1.3. Sulphur and phosphorus content should be checked to ensure acceptable limits of the same in the final briquettes.

The liquid binder and solid binder shall constitute about 3-4 percent and 2-3 percent of DRI fines mix respectively.

Powdered pitch can be added to get desired strength of briquettes if the same is not achieved by the above means. The typical specification shall be as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>S percent</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>H₂O</td>
<td>0</td>
</tr>
<tr>
<td>Grain Size</td>
<td>- 0.15 mm</td>
</tr>
<tr>
<td>Softening temp.</td>
<td>°C: 120 ± 25</td>
</tr>
</tbody>
</table>

### 3.12.2 Mixing

Mixing should take place in a suitable mixer with mixing time ranging between 2.5 - 3 minutes.

### 3.12.3 Cold Briquetting

Metallized fines having bulk density in the range of 1.6-1.9 t/m³ mixed with suitable proportion of binders are to be fed into a roll type briquetting machine of suitable capacity. The briquetting force shall range from 1200 - 1500 kN at a hydraulic pressure of 180 - 200 bar. The briquettes obtained shall have size ranging as mentioned in clause 7.

### 3.12.4 Curing

Natural curing of briquettes shall be done for 24 hours for gaining desired strength.

### 4 SUPPLY OF MATERIAL

General requirement relating to supply of sponge iron for use in induction furnaces shall be as laid down in IS 1387.
5. CLASSIFICATION OF SPONGE IRON

Sponge iron shall be classified into three grades based on the percentage of total/metallurgical iron content, the level of impurities gangue and sulphur/phosphorus.

6 CHEMICAL COMPOSITION

6.1 Sponge Iron/DRI (lumps) and HBI - The chemical composition of sponge iron /DRI and HBI shall conform to the requirements given in Table 1.

Table 1 Chemical Composition of Sponge Iron
(Chemical Analysis in Percentage)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Total Iron</th>
<th>Metallic Iron</th>
<th>SiO₂ + Al₂O₃</th>
<th>SiO₂</th>
<th>Sulphur</th>
<th>Phos</th>
<th>Combined total of Pb, Zn, Cu, Sn, Cr, Ni, As</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plus 91</td>
<td>Plus 82</td>
<td>5</td>
<td>4</td>
<td>0.02</td>
<td>0.06</td>
<td>0.015</td>
</tr>
<tr>
<td>2</td>
<td>89-91</td>
<td>78-82</td>
<td>6</td>
<td>4</td>
<td>0.03</td>
<td>0.07</td>
<td>0.015</td>
</tr>
<tr>
<td>3</td>
<td>85-91</td>
<td>76-78</td>
<td>8</td>
<td>6</td>
<td>0.03</td>
<td>0.10</td>
<td>0.015</td>
</tr>
</tbody>
</table>

6.2 Although FeO content/Metallization of sponge iron are important, these can be calculated based on total iron and metallic iron content as specified in the above grades.

6.3 For any given degree of metallization the equivalent metallization would vary depending up on the total carbon content of sponge iron. Normally for sponge iron from coal based rotary kiln process carbon content shall be 0.10-0.20% whereas for gas based sponge iron the carbon content shall be 1.5-2.0%. Accordingly Equivalent Metallization shall be mutually agreed up on between the supplier and the purchaser.

6.4 Chemical analysis of metallic iron shall be determined by the ferric chloride method prescribed in Annex A and a correction factor of + 0.8 percent metallization may be added by the manufacturer in arriving at the actual degree of metallization certified. However, in case of any dispute the purchaser shall only accept the result obtained by the bromine methanol method prescribed in Annex B for the determination of amount of metallic iron present (in this case, no correction factor need be added). Chemical analysis of carbon shall be done by the method as specified in IS 228 (Part I).

7 SIZE RANGE

The grain size of sponge iron depends on the production process and type of iron oxide used as feed. The size range of sponge iron for various products shall be as follows:

Sponge iron Lumps:-4mm:5%max
+4mm-20mm:90%
+20mm-30mm:5%max

Sponge Iron Fines
-1mm:25%max
+1mm-4mm:70%
+4mm:5%max

HBI:
Length:90-130mm
Width:80-100 mm
Thickness:20-50 mm
CBI:
Length: 40-50 mm
Width: 20-30 mm
Thickness: 16-24 mm

Undersize of minus 4 mm shall not exceed more than 5% for HBI/CBI at the time of dispatch.

This size range shall be valid for sponge iron at the dispatched only. The size range at the receiving point shall depend on the transport and handling. Over and above sponge iron may contain a maximum of 1 percent non-metallic which will not be considered in the size distribution nor the chemical analysis of sponge iron.

8 STORAGE AND TRANSPORTATION

Sponge iron needs special care during storage and transportation. Guide line for storage and transportations as per IS 10852:2009 shall be followed.

9 SAMPLING AND SAMPLE PREPARATION

9.1 Sponge Iron/DRI

9.1.1 Representative samples of sponge iron shall be drawn and prepared for chemical test and screen analysis as described in Annex C.

9.1.2 The screen analysis of sponge iron may be carried out in accordance with IS 1607.

9.1.3 The magnetic portion shall only be considered for the purpose of chemical analysis.

9.2 HBI

9.2.1 Representative samples of HBI shall be drawn and prepared for chemical analysis and screen analysis as described in Annex D.

9.2.2 The screen analysis of HBI may be carried out in accordance with IS 1607.

9.3 Cold Briquetted Iron (CBI)

9.3.1 In case of CBI, sampling procedures shall be as per IS 1405.

10 MARKING

10.1 The material shall accompany a test certificate giving the following:

   a) Grade of the material
   b) Chemical composition
   c) Size specification
   d) Manufacturer’s name

10.2 BIS Certification Marking

The material may also be marked with Standard Mark.

10.2.1 The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.
ANNEX A
(Clause 6.4)

METHOD FOR DETERMINATION OF METALLIC IRON IN SPONGE IRON/DIRECT REDUCED IRON (DRI) BY THE FERRIC CHLORIDE METHOD

A-1 FERRIC CHLORIDE METHOD

A-1.1 Outline of the Method

The reaction between ferric chloride and metallic iron proceeds as follows:

$$2\text{FeCl}_3 + \text{Fe} = 3 \text{FeCl}_2$$

The technique involves digestion of the sample in a ferric chloride solution followed by filtration and titration of the ferrous iron in the filtrate. Precautions should be taken to prevent atmospheric oxidation of the ferrous chloride formed.

A-1.2 Reagents

A-1.2.1 Ferric Chloride [10 Percent (m/v)]

Dissolve 100 g of ferric chloride (FeCl$_3$, 6H$_2$O) in water and dilute to one litre.

A-1.2.2 Hydrochloric Acid, rd = 1.16 (conforming to IS 265)

A-1.2.3 Phosphoric Acid rd = 1.75

A-1.2.4 Sodium Diphenylamine Sulphonate Indicator

Dissolve exactly 0.32 of barium diphenylamine sulphonate in 100 ml of hot water. Add 0.5 g of sodium sulphate, stir and filter off the precipitate of barium sulphate. Store the filtrate in a dark-coloured bottle or 0.2% solution of sodium diphenylamine sulphonate indicator in water.

A-1.2.5 Potassium Dichromate Solution (0.1N)

Dissolve exactly 4.903 g of potassium dichromate (dried at 100º to 110ºC) in water in 1,000 ml volumetric flask and make up the volume up to the mark. Mix thoroughly and use as a standard solution.

A-1.3 Procedure

Transfer 1 g of sample in a 500 ml conical flask and add 200 ml of ferric chloride solution. Create an inert atmosphere in the flask obtained through displacement of air by nitrogen, stopper the flask and agitate the solution with polypropylene coated magnetic stirrer for one hour. Filter the solution through medium texture filter paper. Wash the residue with ferric chloride solution. Transfer the filtrate to one litre beaker containing 400 ml water, 25 ml sulphuric acid, 25 ml phosphoric acid, 3 to 4 drops of sodium diphenylamine sulphonate and titrate with potassium dichromate solution (0.1N).

$$1 \text{ml 0.1 N K}_2\text{Cr}_2\text{O}_7 = 0.001862 \text{g of metallic iron Fe (M)}.$$  

A-1.3.1 The above relationship of 1 ml (0.1 N) K$_2$Cr$_2$O$_7$ = 0.001862 Fe (M) is derived as follows:

a) 1000 ml of K$_2$Cr$_2$O$_7$ (1N) = 55.85 g of Fe (T).
 or 1000 ml of K$_2$Cr$_2$O$_7$ (0.1 N) = 5.585 g of Fe (T)
 or 1 ml of K$_2$Cr$_2$O$_7$ (0.1 N) = 0.005 585 g of Fe (T)
b) \( \text{Fe} + 2 \text{FeCl}_3 = 3 \text{FeCl}_2 \)

Therefore three part of \( \text{FeCl}_2 \) corresponds to one part of \( \text{Fe}(\text{M}) \) or one part of \( \text{FeCl}_2 \) corresponds to \( 1/3 \) part of \( \text{Fe} \) (M).

\[
\text{or } 1 \text{ ml of } \text{K}_2\text{Cr}_2\text{O}_7 \text{ (0.1 N)} = \frac{0.005585}{3} = 0.001862 \text{ g of Fe (M)}
\]

**ANNEX B**

*(Clause 6.4)*

**METHOD FOR DETERMINATION OF METALLIC IRON IN SPONGE IRON/ DIRECT REDUCED (DRI) BY THE BROMINE METHANOL METHOD (REFEREE METHOD)**

**B-1 BROMINE METHANOL METHOD**

**B-1.1 Outline of the Method**

The bromine and methanol mixture is added to the sample of sponge iron resulting in the dissolution of the metallic iron. The residue is separated by filtration, hydrochloric acid is added to the residue which contains oxides of \( \text{Fe}^{2+} \) and \( \text{Fe}^{3+} \) and it dissolves the \( \text{FeO} \) present. The addition of stannous chloride, reduces all the \( \text{Fe}^{2+} \) present in the residue \( \text{Fe}^{3+} \). The excess stannous chloride is eliminated by reaction with mercuric chloride (\( \text{HgCl}_2 \)). The amount of combined iron is determined. The difference between total iron and the combined iron is equal to the amount of metallic iron.

\[
2\text{Fe} + 3 \text{Br}_2 = 2 \text{Fe}^{3+} + 6 \text{Br}^- \\
2\text{Fe}^{3+} + \text{Sn}^{2+} = 2\text{Fe}^{2+} + \text{Sn}^{4+} \\
\text{Sn}^{2+} \text{ (excess)} + 2 \text{Hg}^{2+} = \text{Sn}^{4+} + 2 \text{Hg}^+ \\
6\text{Fe}^{2+} + \text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ = 6\text{Fe}^{3+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}
\]

**B-1.2 Reagents**

**B-1.2.1 Bromine Methanol Solution (50ml/1)**

Dissolve 50 ml of bromine in 950 ml of water free methanol. The solution shall be freshly prepared and used immediately.

**NOTE** Proper care should be taken while preparation of solution and during analysis.

**B-1.2.2 Stannous Chloride Solution**

Dissolve by heating 60 g of pure stannous chloride in a mixture of 400 ml of concentrated hydrochloric acid and 600 ml of water until dissolution is completed. Cool and add a few pieces of granulated tin and preserve the solution in air tight amber coloured bottle to prevent oxidation.

**B-1.2.3 Mercuric Chloride Solution**

Prepare a saturated solution of mercuric chloride in water.

**B-1.2.4 Standard Potassium Dichromate Solution (0.1 N)**
Dissolve exactly 4.903 g of potassium dichromate (dried at 100 to 110°C) in water in a 1000 ml volumetric flask and make up the volume to the mark. Mix thoroughly and use as a standard solution or 0.2% solution of sodium diphenylamine sulphonate indicator in water.

B-1.2.5 Hydrochloric Acid, \(rd = 1.16\) (conforming to IS 265)

B-1.2.6 Sodium Diphenylamine Sulphonate Indicator – See A-1.2.4.

B-1.2.7 Sulphuric Acid-Phosphoric Acid Mixture

Add slowly and with stirring 150 ml of sulphuric acid (\(rd = 1.84\)) and 150 ml of phosphoric acid (\(rd = 1.71\)) to 700 ml of water. Destroy any oxidizable impurities by adding potassium permanganate solution (0.1 N) drop by drop until the pink colour of permanganate persists and cool the solution.

B-1.3 Procedure

B-1.3.1 Combined Iron

Weigh 0.5 g of sample into a 500 ml ground glass joint flask. Add 100 ml of bromine methanol solution and fit the flask to reflux condenser. Cool, filter and wash the residue with distilled water, then with methanol and again with distilled water.

B-1.3.2 Carefully remove the residue and wash with hydrochloric acid (1:1). Add 45 ml hydrochloric acid and allow to dissolve covering the flask with a watch-glass. Add stannous chloride to the solution, until the solution becomes colourless. Add 2 drops of stannous chloride in excess. Allow the solution to cool and add 15 ml of mercuric chloride (5 percent). Allow to stand for 2 minutes and add 25 ml of acid mixture. Add 3-4 drops of indicator and titrate with potassium dichromate solution (0.1 N). The solution changes its colour from colourless to yellow, green and end point is purple.

B-1.4 Calculation

Percent, Combined iron

\[
\frac{A \times B \times 0.05585 \times 100}{C}
\]

A = volume in ml of potassium dichromate solution consumed.  
B = strength of the standard dichromate solution, and  
C = mass in g of the sample taken.

B-1.4.1 Total Iron

Total iron shall be determined in accordance with the procedure laid down in IS 1493 (Part 1).

B-1.4.2 Metallic Iron

Metallic iron shall be determined by the difference of total iron and combined iron that is,

Metallic iron = Total iron - Combined iron
ANNEX C

SAMPLING OF SPONGE IRON
(Clauses 9.1.1)

The method for sampling are applicable to the taking of samples of DRI from conveyors, railways wagons or containers (including trucks) and stockpiles, during the loading or discharging of a lot in cases where manual sampling can be carried out safely.

C-1 GENERAL PROCEDURES FOR MANUAL SAMPLING - Sampling shall be carried out while a lot is being transferred. The general sampling procedure shall be as follows:

a) Identify the lot to be sampled
b) Ascertain the nominal lot size
c) Determine the mass of increment considering the nominal lot size

C-2 INCREMENTS

C-2.1 Minimum mass of increment

C-2.1.1 The mass of each increment shall be as specified in Table 1 according to the nominal lot size of the DRI being sampled.

Table 1
(Minimum Mass of Increment)

<table>
<thead>
<tr>
<th>Nominal top size (mm)</th>
<th>Over</th>
<th>Upto &amp; including</th>
<th>Minimum Mass of increment (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>22.4</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22.4</td>
<td>0.8</td>
</tr>
</tbody>
</table>

C-2.1.2 Increments shall be taken in such a manner as to ensure that they are of almost uniform mass.

C-2.2 Number of increments to be taken from a lot shall be as given in Table 2

Table 2
(Minimum Number of Increments)

<table>
<thead>
<tr>
<th>Mass of lot (MT)</th>
<th>Over</th>
<th>Upto &amp; including</th>
<th>Number of increments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30000</td>
<td>-</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>15000</td>
<td>30000</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>5000</td>
<td>15000</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>5000</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>2000</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>500</td>
<td>6</td>
</tr>
</tbody>
</table>

C-2.3 While taking increments, special care shall be taken to obtain representative increments because of the segregation of fine and coarse particles.

C-2.4 The sampling device used should have width of 6 times of the nominal lot size.
The volume of the device in the effective collection area should be sufficient to hold at least twice the minimum mass of increment.

C-3 Methods of manual sampling

C-3.1 Sampling from conveyors

C-3.1.1 When the increment is taken from a stopped conveyor belt, a section of adequate length in the direction of the stream & of the full width and thickness of the DRI stream, should be taken.

C-3.1.2 When the increment is taken from a moving conveyor, the full width and thickness of the DRI stream shall be taken by a mechanically assisted device from the failing stream.

C-3.2 Sampling from wagons or containers

C-3.2.1 The increment shall be taken at random from the new surface of DRI exposed during the loading or the unloading of the wagons or trucks.

C-3.2.2 When it is suspected that there is some bias between strata (between the top and bottom, the front and the rear, or the left and the right) in the DRI in the wagon or truck, it is advisable to take increments from each such stratum.

C-3.3 Sampling from bunker discharge - The sampling of DRI from bunker discharge shall be conducted in accordance with the method specified in C-3.1.

C-3.4 Sampling from Stockpiles - The sampling of DRI from stock piles shall be performed from conveyors either by stopped belt sampling or from a transfer point in accordance with the method specified in C-3.1 while the stockpile is being formed or reclaimed.

The sponge iron should be stacked in geometric shapes preferably 100 MT in quantity. The quantity of sponge iron shall be assessed from bulk density if it is not weighed. The height of the stack should not be more than 1.5 m. A bulk sample from central portion of 1 m to 1.5 m diameter on the top shall be made to expose the bottom of the stack. The trenches of minimum 0.5 m depth shall be made longitudinally on four sides to expose the materials. Samples with the help of double scoops shall be collected in such a manner that the size distribution of the sample shall be proportionate to the size distribution of the stock pile. The scoop should be moved from bottom to the top of the trench.

C-4 PROCEDURE FOR SAMPLE PREPARATION - The preparation of samples of DRI shall be conducted with extreme care to minimize the chance of reoxidation due to dampness, overheating or both. All equipments should be thoroughly cleaned to remove remnants of deleterious material and it is desirable to flush the equipment just prior to use with a small quantity of the same DRI.

C-4.1 CRUSHING AND GRINDING

The crushing & grinding shall be conducted with a crusher and a grinder suitable for the size and mechanical strength of the DRI particles. The crusher and grinder should be purged just before use with DRI from the same source. Precautions shall be taken to minimize overheating and reoxidation and to avoid the production of flakes of metal.

C-4.1.1 - From the gross sample + 10 mm size shall be crushed to - 10 mm with the help of jaw crusher & mixed along with - 10 mm fractions already screened. The mixed material shall be split up for reduction of volume. When the sample quantity attains around 5 kg, then the material is further crushed to - 6mm, mixed thoroughly and divided by splitter till the final quantity is around 1 kg. The sample thus obtained shall be ground in disc grinder to - 150 micron size. Special precautions should be taken to ensure that grinding process does not generate excessive heat which could significantly change the chemical composition.
C-4.2 MIXING - By mixing the sample thoroughly it can be made homogeneous and consequently the errors in sample division can be lessened. The mixing may be conducted either by a mechanical mixer or by hand. The mixer shall be selected to suit the sample and its particle size.

C-5 APPARATUS FOR SAMPLE PREPARATION - The following apparatus which shall be thoroughly cleaned and examined before and after use, shall be provided for sample preparation.

A) Crusher and grinder, e.g. Jaw Crusher, Cone Crusher, Vertical Mill Ring grinder and Agate pestle and mortar.
B) Mixers e.g. double cone mixer
C) Riffles
D) Scoop crusher
E) Disc pulveriser

C-6 Preparation of Test Samples

C-6.1 Preparation of test samples for Size analysis - The test sample for size analysis should be prepared from each increment, each partial sample or the gross sample without mixing.

C-6.2 Preparation of test sample for Chemical Analysis - The test sample for chemical analysis may be prepared from each increment, each partial sample of the gross sample.

C-6.2.1 Mass and size of test sample for Chemical Analysis - A test sample of 100 gr. minimum at minus 150 microns in particle size shall be prepared.

C-6.2.2 Preparation of test sample for Chemical Analysis

C-6.2.2.1 Prepare a sample of 500 g minimum at minus 250 microns in particle size from each increment, each partial sample of the gross sample according to the division methods.

C-6.2.2.2 Grind the above sample to minus 150 microns in particle size and from this sample, prepare a set of not less than four samples each of 100 g minimum by an appropriate division method. Seal the samples and distribute them to the laboratories concerned. Special precautions should be taken to ensure that the grinding process does not generate excessive heat which could significantly change the chemical composition. Precautions may include:

a) Reducing the grinding time by grinding smaller charges.
b) Use a single pass straight through type of grinder.
c) In the grinding of samples, usually some material remain sticking to the surface of the pot especially when the material is of high metallisation. Care should be taken to include this sticky material also while entire lot of powder is taken out after grinding.
d) Some material sticking to the surface of pot should also be included while the entire lot of powder is taken out after grinding.

C-7 Packing and marking of Sample for Chemical Analysis - The chemical analysis sample for distribution shall be tightly sealed in air tight containers. The label and a card placed in the container shall contain the following particulars.

a) Type of DRI and name of lot (Name of ship, train etc.)
b) Mass of lot
c) Sample number
d) Place and date of sample
e) Place and date of sample preparation
f) Any other items (if necessary)

Of the sample prepared, one sample shall be provided for the supplier, one for the purchaser and one for the arbitrator and if required one held in reserve. The reserve samples shall be retained for 6 months.
ANNEX D  
(Clause 9.2.1)  
REPRESENTATIVE SAMPLES OF HBI

D-1 SAMPLING

The sampling of the hot briquetted sponge iron will be done at the following points:

a) On piles,
b) On trucks or wagons, and
c) On conveyor

D-2 SAMPLING FROM PILES

From every 500 t or less hot briquetted sponge iron, a minimum of one gross sample shall be collected. The gross sample shall consist of 10 increments of 10 Kg each. This 100 kg briquettes shall be used for both chemical as well as screen analysis as shown in Fig. 1.

D-3 SAMPLING ON TRUCKS OR WAGONS

From each truck or wagon, one increment of suitable weight shall be drawn. All increments thus drawn shall constitute a gross sample. The total mass of the gross sample shall be 50 kg which shall be used for both chemical as well as screen analysis as shown in Fig. 1.

D-4 SAMPLING OF CONVEYOR

From conveyor increments of suitable weight shall be drawn at regular intervals. All increments thus drawn shall constitute a gross sample. The total mass of the gross sample shall be 50 kg which shall be used for both chemical as well as screen analysis as shown in Fig. 1.

D-5 PREPARATION OF SAMPLE FOR CHEMICAL TESTS AND SCREEN ANALYSIS

The laboratory samples shall be obtained by the procedure given in Fig. 1. The sample shall be stored with the following identification:

a) lot number,
b) Sample number, and
c) Sampling date
Hot Briquetted Sponge Iron
100 Kg (200/250 Briquettes)

Homogenization

↓

75 kg (150/200 Briquettes)
Screen Analysis

25 Kg (50 to 100 Briquettes)

↓

Coarse crushing (-20 mm)

↓

Coning and quartering

↓

6 Kg

↓

Fine crushing (-5 mm)

↓

Homogenization

↓

Riffle sampling

↓

1.5 kg

↓

0.75 kg

↓

Disc pulverizing

↓

Screen 150/212 micron sieves

↓

Homogenization

↓

Coning and quartering

↓

50-100 g
Sample

↓

Homogenization

↓

50-100 g
Test sample

↓

25-50 g
Chemical Analysis

↓

25-50 g
Test Sample

↓

Fig. 1 REDUCTION OF SAMPLE TO FINAL STAGE FOR CHEMICAL/SCREEN ANALYSIS