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BUREAU OF INDIAN STANDARDS

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भारतीय मानक

लौह अयस्क फाइन के लिए प्रयोगशाला पॉट-ग्रेट सिंटरिंग परीक्षण – दिशानिर्देश

(आई एस 11282 का *दूसरा पुनरीक्षण*)

Draft *Indian Standard*

LABORATORY POT-GRATE SINTERING TESTS FOR IRON ORE FINES - GUIDELINES

(Second Revision of IS 11282*)*

ICS 77.100

Ores and Feed Stock for Iron and Steel Industry Sectional Committee, MTD 13	Last date for receipt of comments are 25 October 2023

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Ores and Raw Materials Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1985 and subsequently revised in 2000. This revision (Second Revision) has been brought out to bring the standard in the latest style and format of the Indian Standards. It also incorporates 1 amendments issued to the last version of the standard.

In additional following change have been made;

a) In clause 2, Reference clause has been updated;
b) In clause 3, Editorial change has been made;
c) In clause 4, Editorial change has been made;
d) In clause 5.3, Return Sinter fines is substituted by Sinter returns;
e) In clause 6.2, Return Sinter fines is substituted by Sinter returns; and
f) In ANNEX A to E, Editorial change has been made in table;
g) Annex D is modified as per the best practice which is referred in ISO 8263

Pot-grate sinter test is a method by which input and operating parameters for sintering of given raw materials can be established. The test data are useful in design of sinter plants and optimization of e existing plant practices for improving sinter productivity as well as quality. Several procedures exist for sintering on a pot-grate and the purpose of this guideline is to

evolve a common test procedure which will facilitate comparison of results obtained by tests done at different laboratories.

In the revision of the standard, assistance have been drawn from ISO 8263 : 1992 ‘Iron ore fines -Method for presentation of the results of sintering tests’.

For the purpose of deciding whether a 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 : 2022 ‘Rules for rounding off numerical values (second revision)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Draft *Indian Standard*

LABORATORY POT-GRATE SINTERING TESTS FOR IRON ORE FINES - GUIDELINES

(*Second Revision of* IS 11282)

1 SCOPE

This standard gives the guidelines for the method for sintering tests in the laboratory using a pot-grate unit and is applicable for sintering of iron ore fines. These guidelines have been formulated to facilitate comparison of test data from various organizations on the same sinter mix. For individual organizations, the parameter may be varied as required.

2 REFERENCES

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

IS	*Title*
IS 6495 : 2019	Method of tumbler test for iron oxides : lump ores, sinter and pellets (*second revision*)
IS 8167 : 1989	Method for determination of reducibility index of iron ore oxides, lumps ore, sinter and pillets (*first revision*)
IS 10823 : 2018	Methods for determination of thermal degradation index (TDI) and reduction degradation index (RDI) of iron oxides: lump ores, sinter and pellets (*second revision*)
IS 11283 : 1985	Method for determination of softening point of iron oxides (In Powder Form); lump ore, sinter and pellets
IS 11292 : 1985	Method for determination of relative reducibility of iron oxides: lump ores, sinter and pellets
IS 12550 : 1988	Methods of determining particle size distribution of iron ore fines

3 TEST SAMPLE

3.1 The raw materials for test sample for sintering tests shall have the following size ranges:

Iron ore, iron bearing materials and other materials of -10 mm or (-8 mm if -8 mm classifying fines are used) = 95 percent, *min* (with a mean size not in excess of 3 mm);

Fluxes, coke breeze and other additives of -3.2 mm = 90 percent, *Min* and -1 mm fraction in coke breeze: 75 percent, *Max*.

3.2 Sinter mix components that is iron ore fines, coke breeze, limestone fines, dolomite fines, sinter returns, and metallurgical waste shall be mixed in dry condition in a mixer by rotating for 2 min. Water is to be added to sinter mix for 1 min duration so that the moisture content of sinter mix attain pre-determined value. After moistening the mixer is to be rotated for 2 min for granulation.

3.3 In case of double layer charging, only 70 - 80 percent of coke breeze shall be added during initial mixing. After balling half of the mix, it shall be removed and charged into the sinter pot.

The balance of coke breeze shall be added to the sinter mix in the mixer and mixer shall be rotated further for 1 min.

4 APPARATUS

4.1 The test apparatus consists of a square pot of 400 mm x 400 mm size so that at least 50 - 60 kg of net sinter (+ 6.3 mm) may be produced so that it is sufficient for shatter, tumbler, reducibility, low temperature breaks down, softening tests, chemical analysis, screen analysis, etc. A typical layout is given in Fig. 1.

4.2 The bed height of sinter should generally be kept at 300 mm (excluding the hearth layer).

4.3 In case ignition is obtained by using a gas flame, the ignition intensity for gaseous fuels shall be 35 MJ/m^2, *Min* and an ignition time of 90 secs shall be allowed.

4.4 During ignition of the mix, suction may be maintained at 300 mm WG, *Min*. After ignition either suction below grate say 800 mm is to be kept constant by manipulating leakage in waste gas track or maintaining constant air flow through the bed.

4.5 The permeability of the sinter bed shall be monitored throughout the experiment. Green permeability of sinter mix is to be measured before ignition at various levels of suction that is, 300 mm WG, 500 mm WG, 800 mm WG.

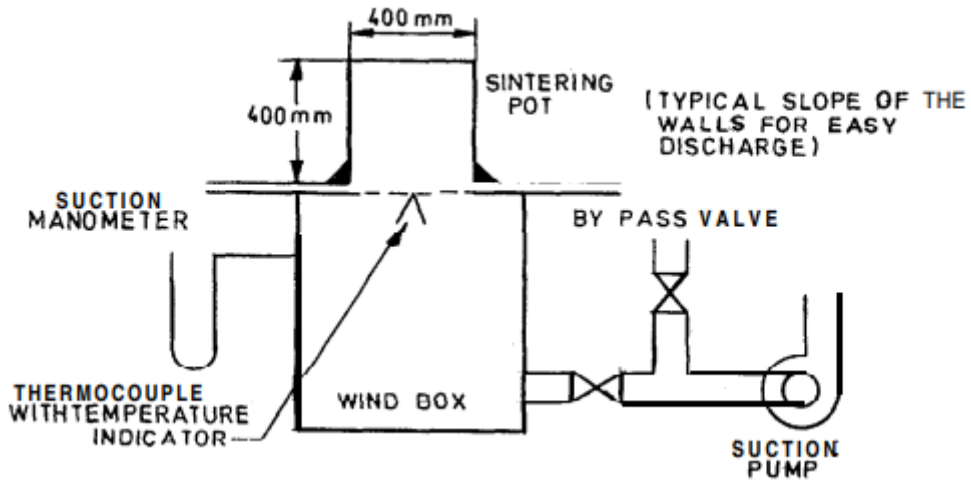

FIG. 1 SCHEMATIC ARRANGEMENT OF LABORATORY POT SINTERING UNIT

4.5.1 The permeability (*P*) shall be estimated by using the relation

$$U = P\ (S/H)\ 0.6$$

Where,

U is the linear air velocity in m/min at suction *S* in mm of WG; and

H is bed height in mm.

4.5.2 A typically 20 mm square screen should be placed over the pot for charging of green mix and the charge should be uniformly distributed over the screen.

4.5.3 Hearth layer height and size should be chosen depending on the bed height and commercial practice.

4.6 The bed temperature and the waste gas temperature below the grate may also be measured continuously.

4.7 In case the sintering is done under different conditions of pot size, bed height, ignition and suction conditions, the same shall be indicated along with the results.

5 PROCEDURE

5.1 This mix shall be transferred carefully in the pot containing about 25 mm thick hearth layer of S-20 mm size sinter to get the desired bed height. The ignition of the top layer of the bed by red hot coke breeze, saw dust and gaseous/liquid fuel flame, shall be started and desired suction achieved in 30 s.

5.2 The temperature of the waste gases shall be monitored and suction continued till 1 min after the maximum waste gas temperature is achieved. Often during the sintering experiments, two temperature peaks are observed and hence temperature monitoring should be continued up to 5 min after the appearance of the first peak. Sintering time should be taken as the time at which the maximum temperature is recorded.

5.3 The sinter then shall be allowed to cool to room temperature in the port itself. The sinter cake shall be dislodged after cooling and weighed. The cake shall then be stabilized. Stabilization should be determined depending upon a practice so as to generate similar proportion of return fines as in the plant. The -6.3 mm fraction shall be reported as 'sinter returns' and +6.3 mm fraction shall be taken for various physical/chemical tests as per the relevant Indian Standards.

6 REPORTING OF TEST RESULTS

6.1 All additions shall be reported based on percentage of green ore mix.

6.2 A minimum of 4 tests shall be conducted under any given set of conditions. Out of these 4 tests at least in two tests, sintering times match within ± l0 percent and sinter returns balance comes within ±5 percent. The average of these two tests should be taken as representative values for all parameters.

6.3 Sintering conditions and sinter properties shall-be reported as follow:

a) Pot dimensions;
b) Mix granulometry before mixing and after balling as per the format given in Annex A;
c) Chemical composition of feed, as per format given in Annex B;
d) Moisture content;
e) Sinter mix composition including coke breeze as per format given in Annex C;
f) Ignition condition (time of ignition, ignition intensity, etc);
g) Bed height;
h) Suction;
j) Maximum temperature reached in the bed;
k) Maximum waste gas temperature;
m) Sintering time;
n) Return fines generation;
p) Sinter composition; and
q) Screen analysis of sinter.

6.4 The sinter test data shall be reported as per the format given in Annex D. The tests for various properties indicated in Annex E shall be conducted as per the relevant Indian Standards.

ANNEX A

(*Clause* 6.3)

CHEMICAL ANALYSIS (DRY BASIS) AND SIZE DISTRIBUTIONS OF THE VARIOUS ORES INCLUDED IN THE ORE MIX

A-l The chemical analysis (dry basis) and size distribution of the various ores included in the ore mix shall be determined as per IS 12550, shall be reported as follows:

Sl No.	Mineral Type (Percent)	Ore A	Ore B	Ore C	Ore D	Sinter Mix	Mill Scale and/or other	Test Ore
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	Fe (total)							
2.	FeO							
3.	SiO_2							
4.	Al_2O_3							
5.	CaO							
6.	MgO							
7.	MnO							
8.	S							
9.	P							
10.	Na_2O							
11.	K_2O							
12.	C							
13.	Loss on ignition							
14.	Combined Water							
Moisture Content								

	Size Distribution	Mass (Percent)
1.	-8.0 mm	
2.	-8.0 to +5.6 mm	
3.	-5.6 to +4.0 mm	
4.	-4.0 to +2.0 mm	
5.	-2.0 to +1.0 mm	
6.	-1.0 to +0.5 mm	
7.	-0.5 to +0.25 mm	
8.	-0.25 mm to +0.125µm	
9.	-0.125 µm to +0.063 µm	
10.	-0.063 µm	

Method of size analysis:
Dry sieving

ANNEX B

(Clause 6.3)

CHEMICAL ANALYSIS (DRY BASIS) AND SIZE DISTRIBUTION OF lRON ORE, FLUXES, FUEL AND RETURN SINTERED FINES

B-l The chemical analysis (dry basis) and size distribution of iron ore, fluxes, fuels and return sintered fines shall be determined as per IS 12550, shall be reported as follows:

Sl No.	Mineral Type (Percent)	Iron Ore	Coke or Other Fuel	Limestone	Dolomite	Siliceous Material	Other Fluxes	Return Sinter Fines	Steel Plant Waste Material
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.	Fe (total)								
2.	FeO								
3.	SiO_2								
4.	Al_2O_3								
5.	CaO								
6.	MgO								
7.	MnO								
8.	S								
9.	P								
10.	Na_2O + K_2O								
11.	C								
12.	Ash								
13.	Volatile matter(VM)								
14.	Combined water								
15.	Loss on ignition								
Moisture Content									

	Size Distribution	Mass (Percent)
1.	-8.0 mm	
2.	-8.0 to +5.6 mm	
3.	-5.6 to +4.0 mm	
4.	-4.0 to +2.0 mm	
5.	-2.0 to +1.0 mm	
6.	-1.0 to +0.5 mm	
7.	-0.5 to +0.25 mm	
8.	-0.25 mm to +0.125µm	
9.	-0.125 µm to +0.063 µm	
10.	-0.063 µm	

Method of size analysis:
Dry sieving

Granulometry of dry mix
Granulometry of green mix

ANNEX C

(*Clause* 6.3)

COMPOSITION OF THE SlNTER FEED

C-1 composition of the sinter feed shall be reported as follows:

Sl No.	**Constitution of Sinter Feed , Dry Basis**	**Test 1**	**Test 2**	**Test 3**	**Test 4**
(1)	(2)	(3)	(4)	(5)	(6)
1.	Ore mix				
2.	Return sintered fines				
3.	Siliceous material				
4.	Limestone				
5.	Dolomite				
6.	Other fluxes (if any)				
7.	Coke (or alternate fuel)				
8.	Other additions (if any)				

ANNEX D

(*Clause* 6.4)

SINTERINC TEST DATA SHEET

D-1 The sintering test data shall be reported as follows:

Sl. No.	Item	Test 1	Test 2	Test 3	Test 4
(1)	(2)	(3)	(4)	(5)	(6)
a)	Sinter to be charged 1. Mass of hearth layer, M_2 (kg) 2. Mass of sinter feed charged wet (kg) 3. Moisture content of feed (percent) 4. Percent moisture content for maximum permeability 5. Bulk density of feed wet (t/m3)				
b)	Condition of Sinter Test 1. Mixing time — 1st stage (min) — 2nd stage (min) 2. Pot-grate area, (m^2) (A) 3. Height of hearth layer (mm) 4. Net bed height (mm) 5. Suction (mm WC) — During ignition — During sintering 6. Ignition time (min) 7. Cooled - In sinter pot - Discharged hot 8. Sinter stabilization treatment — Tumble: No. of revolutions : Drum size length (mm) x dia (mm) — Shatter: No. of drops : Height dropped (mm) 9. Sieving aperture size for separating return sintered fines (mm) 10. Ignition intensity (mcal/m^2/mm) 11. Ignition temperature (°C)				
c)	Sintering Test Results				
	1. Productivity (tons/m^2/h)				
	2. Coke consumption (kg/ton) of sinter or (kg/ton) contained Fe in sinter				
	3. Sinter return balance *B*				
	4. Sinter returns (percentage)				
	5. Percent Yield				

NOTES

1. Productivity P, is calculated from the equation

$$P = \frac{M_1 - M_2/1\,000}{\text{Pot area in m}^2 \text{ x Sintering time in hours}}$$

Productivity may also be reported in terms of tonnes of iron contained in Sinter of acceptable size per Square metre per hour, to reflect changes in the grade of the Sinter product.

The productivity, in tonnes of iron in Sinter per Square metre per hour, is calculated from the equation

$$P_{Fe} = \frac{P \times W_{Fe}}{100}$$

2. Coke consumption (C) is calculated [in terms of kg/ton of sinter (or) kg/ton contained Fe in sinter] using the formula given below:

$$C = \frac{M_3}{M_1 - M_2} \times 1\,000$$

3. The return sintered fines balance B is calculated from the equation

$$B = \frac{\text{Sinter return generated}}{\text{Smter return output}} = \frac{M_5}{M_6}$$

In a Sinter pot test, this is normally maintained within limits of 1 + 0.05, for results to be representative of actual practice.

4. The percentage of return sintered fines F may also be recorded, and is calculated from the equation

$$F = \frac{M_4 - M_1}{M_4 - M_2} \times 100$$

5. The yield Y, as a percentage by mass, is calculated from the equation:

$$Y = \frac{M_1 - M_2}{M_4 - M_2} \times 100$$

Where,

M_1= Mass of sinter produced of acceptable size, (Kg)

M_2= Mass of the hearth layer, (kg)

M_3= Dry mass of solid fuel/coke in the Sinter mix consumed, (kg)

M_4= Mass of sinter cake produced, (kg)

M_5= Mass of sinter returns charged (input), (kg)

M_6= Mass of undersize sinter returns produced (output), (kg)

t = Sintering time, t (in hours)

ANNEX E

(*Clause* 6.4)

SlNTER QUALITY DATA

E-l The sinter quality data shall be reported as follows:

Sl. No.	Item	Test 1	Test 2	Test 3	Test 4
(1)	(2)	(3)	(4)	(5)	(6)
1.	Tumble strength +6.3 mm (*As per* IS 6495)				
2.	Reduction degradation (*As per* IS 10823)				
3.	Reducibility (*As per* IS 8167)				
4.	Relative reducibility (*As per* IS 11292)				
5.	Softening tests (*As per* IS 11283)				
6.	Chemical analysis of Sinter Product, percent Fe (total) FeO SiO_2 Al_2O_3 CaO MgO MnO S P $Na_2 + K_2O$ Loss on ignition				
7.	Basicity: CaO/SiO_2 or $\frac{CaO + MgO}{SiO_2 + Al_2O_3}$				
8.	Sieve Analysis, percent + 40 mm + 25 mm + l5 mm + 10 mm + 5 mm - 5 mm				
9.	Sinter return consumption (kg/t of sinter)				