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IS 11284 : XXXX

DRAFT FOR P-CIRCULATION

भारतीय मानक ब्यूरो

भारतीय मानक **प्रारूप**

स्पंज लौह / प्रत्यक्ष रिड्यूस्ड आयरन (डीआरआई) के निर्माण के लिए लौह बियरिंग सामग्री के लिए घूर्णी नलिका परीक्षण - पद्धति

(*पहला पुनरीक्षण*)

Draft *Indian Standard*

ROTARY TUBE TEST FOR IRON BEARING MATERIALS FOR THE MANUFACTURE OF SPONGE IRON/DIRECT REDUCED IRON (DRI) - METHOD

(*First Revision*)

ICS 77.100

Ores and Feed Stock for Iron and Steel Industry Sectional Committee, MTD 13

Last date for receipt of comments are 18 Oct 2023

FOREWORD

(Formal clause will be added to be later)

This standard was originally published in 1985. This 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.

a) In addition, the following change have been made:
b) Reference clause has been updated;
c) Sample preparation clause has been modified

For the past few decades, sponge iron has gained prominence as a feed stock for steel making in electric arc furnace or in oxygen steel making processes. Suitability of any of the proposed raw material combination plays a significant role during the production of sponge iron. For ensuring, whether the proposed combination of ore and coal, in principle, is suited for direct reduction in rotary kiln process, it was felt necessary to formulate this standard covering a method of testing of raw materials to determine the reducibility of ore and degradation of iron ore and coal during sponge iron manufacture.

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

Draft Indian Standard

ROTARY TUBE TEST FOR IRON BEARING MATERIALS FOR THE MANUFACTURE OF SPONGE IRON/DIRECT REDUCED IRON (DRI) - METHOD

(*First Revision*)

1 SCOPE

This standard prescribes the rotary tube test method to determine the reducibility of iron ore and degradation behavior of iron ore and coal during sponge iron production by simulating the reduction conditions of rotary kiln.

2 REFERENCE

The following Indian Standards 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 agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in given below:

IS No.	*Title*
IS 460	Test Sieves — Specification
Part 1 : 2020	Wire Cloth Test Sieves (*fourth revision*)
Part 2 : 2020	Perforated Plate Test Sieves (*fourth revision*)
Part 3 : 2020	Methods of examination of apertures of test sieves (*fourth revision*)
IS 1350	Methods of test for coal and coke
Part 1 : 1984	Proximate analysis (*second revision*)
Part 2 : 2022/ ISO 1928 : 2020	Determination of gross calorific value (*third revision*)
Part 3 : 2022/ ISO 334 : 2020	Determination of total sulphur eschka method (*second revision*)
Part 4/Sec 1 : 1974	Ultimate analysis, section 1 determination of carbon and hydrogen (*first revision*)
Part 4/Sec 2 : 1975	Methods of test for coal and coke: Part 4 ultimate analysis, section 2 Determination of nitrogen (*first revision*)
Part 5 : 2017	Determination of special impurities (Carbon Present As Carbonate, Chlorine And Phosphorus) (*second revision*)
IS 1493 : 1959	Methods of chemical analysis of iron ores
IS 1607 : 2013	Methods of test sieving (*second 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*)

3 SAMPLE PREPARATION

The raw materials shall be reduced to the size normally applied in industrial plants The iron ore lumps shall be crushed to a size below 20 mm in a jaw crusher and the coal to a size below 15 mm in a roll crusher. After crushing, the lump ore shall be screened at 6 mm and ore of 5 mm -20 mm

fraction used for test. The coal shall be screened at 3 mm and the fraction of 3 mm - 15 mm used for the test. Detail screen analysis for the coal 3mm - 6 mm, 6 mm - 10 mm, 10 mm - 15 mm and screen analysis of the ore at 6mm - 10 mm, 10mm - 15 mm and 15 mm - 20 mm shall be reported along with the results. Iron Ore and coal shall be chemically analyzed, in accordance with the methods given in IS 1493 and the relevant parts of IS 1350. However, the methods not given in IS 1493 and the relevant parts of IS 1350, the referee method shall be as agreed to between the manufacturer and purchaser.

4 TEST SIEVES

Test sieves shall be of the square mesh type and shall conform to the requirements given in IS 460 (Part 1) or IS 460 (Part 2). As the standard test sieve will become less accurate after period of time, the sieve shall therefore be periodically checked according to IS 460 (Part 3) and the correction factor shall be determined and applied to the result.

5 TEST EQUIPMENT

5.1 Rotary Tube

The laboratory type rotary tube consists of a heat resistant steel tube with an inside diameter of 150 mm and a reaction zone length of 650 mm. Its total length shall be 1 450 mm. The rotary tube tapers on its both ends to 90 mm inside diameter. The rotary tube is provided with arrangement of rotating it at a variable speed of 3 rev/min - 27 rev/min (normally operated at constant speed of 8 rpm) and admitting inert gas during the cooling period.

5.2 Furnace

The furnace shall be heated electrically having the heating elements in the spiral form, inserted in the refractory lining of the heating chamber. The external dimension of the heating chamber and furnace shall be as follows:

Furnace width, approx	— 1 200 mm
Furnace height, approx	— 1 400 mm
Total length, approx	— 2 870 mm
Supply voltage	— 415 V 50 Hz
Power	— 20 kW
Maximum current	— 28 A
Maximum operating temperature	— 1 150°C

5.2.1 Both front sides of the furnace shall have a gas tight sealing. For charging and discharging of the sample, the stationary head of the inlet side shall be equipped with a rubber gasket. A thermocouple shall be provided at the center of the reaction zone through the sealing flange and shall be connected with a temperature controller to control the temperature in the rotary tube.

5.3 A typical test equipment has been given in Fig. 1, for illustration.

6 TEST PROCEDURE

6.1 Test Conditions

The test condition shall be as follows:

a) Kiln Charge	
Mass of Iron ore	1 000 g
Ore size	5 mm - 20 mm
Reductant	Coal to be tested
Coal size	3 mm - 15 mm
Fixed C/Fe ratio	0.5 (This ratio shall determine the mass of the coal to be charged)

b) Kiln Conditions	
Temperature of kiln at start of test	Room temperature
Reduction temperature	1 000 ± 10°C
Heat-up time for reduction temperature	120 minutes, *Max* (recommended rate 10°C/min)
Reduction time	180 minutes
Kiln speed	8 rev/min
Kiln atmosphere	Nitrogen gas

6.2 Procedure

Place the cold tube with the sample in the furnace at room temperature and start rotating it at 8 rev/min. Switch on the furnace and raise the temperature of the sample at the rate of 10°C per minute to the predetermined temperature (1 000°C) under a neutral atmosphere by passing nitrogen at 3 liters / minutes. Maintain this temperature for a defined period of reduction time (180 minutes).

6.2.1 After the required retention time (180 minutes), cool the sample with nitrogen to 300°C in the furnace, continue rotating at 8 rev/min. For further cooling to room temperature, the tube shall be taken out of the furnace or retained in the furnace.

6.2.2 After the sample cools down to room temperature, it shall be subjected to magnetic separation. The magnetics and the non-magnetics shall be screened according to IS 1607, and their respective mass determined.

7 TEST REPORT

The test report shall contain the following informations:

a) Reference to this Indian Standard IS 11284;
b) Screen analysis of feed ore and coal;
c) Screen analysis of magnetics and non-magnetics;
d) Grain size wise metallization and chemical analysis of the product -1 mm and -3 mm fraction must be reported; and
e) Reduction degradation behavior of magnetic product.

7.1.1 The reduction degradation of ore, suitable for sponge iron manufacture should be minimum. The criterion for the ore degradation is the proportion of 1 mm in the reduced product in accordance with IS 10823.

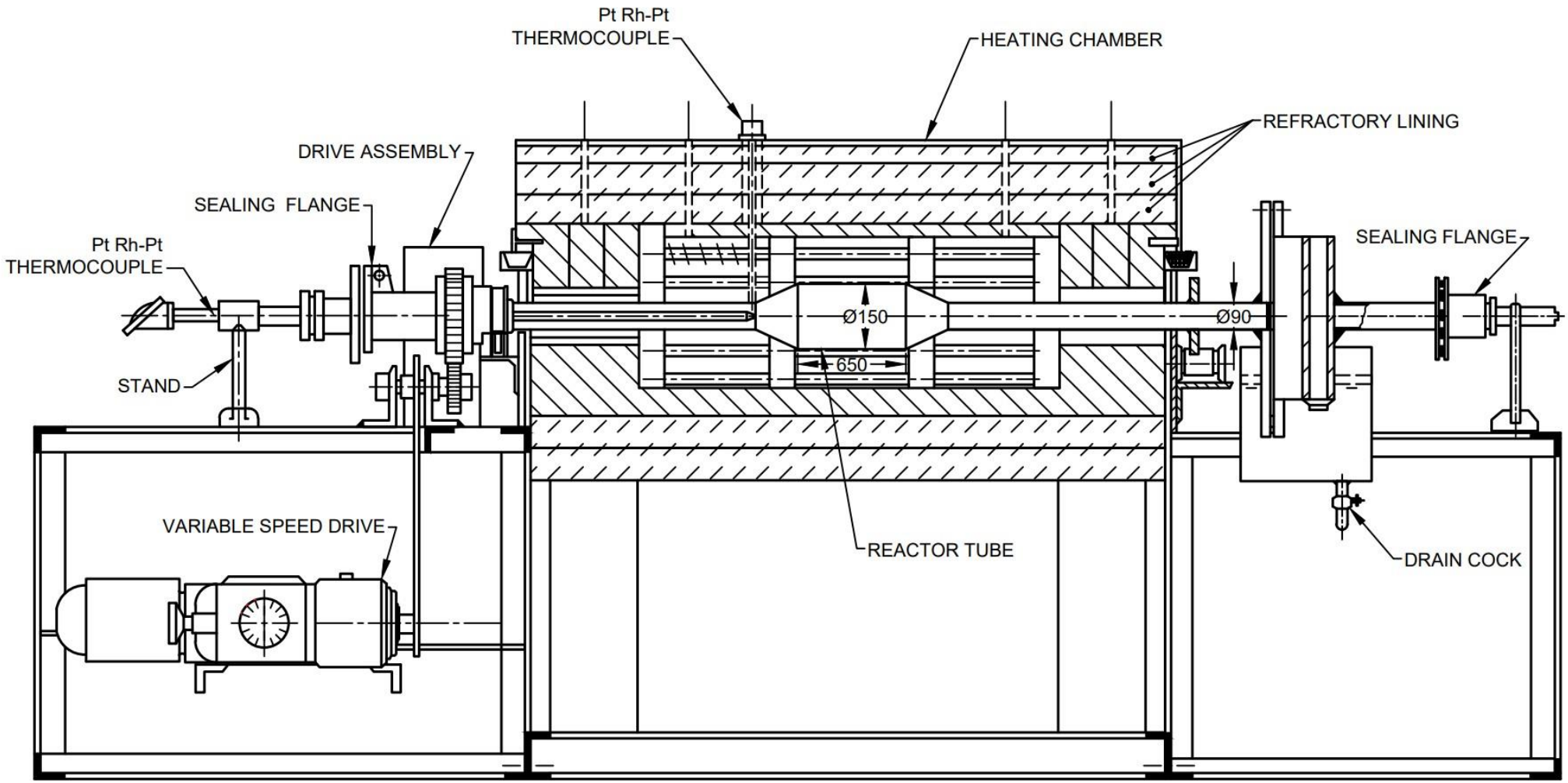

FIG. 1 LABORATORY ROTARY FURNACE