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September 2023

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

भारतीय मानक

लौह आक्साइड (पाउडर के रूप में) के मृदुकरण बिंदु का निर्धारण: गांठ अयस्क, सिंटर और छर्रों - पद्धति

(आई एस 11283 का *दूसरा पुनरीक्षण*)

Draft *Indian Standard*

DETERMINATION OF SOFTENING POINT OF IRON OXIDES (IN POWDER FORM): LUMP ORE, SINTER AND PELLETS — METHOD

(First Revision of IS 11283*)*

ICS 77.100

Ores and Feed Stock for Iron and Steel Industry Sectional Committee, MTD 13	Last date for receipt of comments are 27 October 2023

FOREWORD

This Indian Standard (First Revision) subject to its finalization is to be adopted by the Bureau of Indian Standards on recommendation of Ores and Feed Stock for Iron and Steel Industry Sectional Committee and approval of Metallurgical Engineering Division Council.

This standard was published in 1985. This revision (First 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 addition, the following changes have been made:

a) Reference clause has been added;
b) In clause 9.5, Editorial change has been made.

The increasing importance of the cohesive zone in blast furnace iron making in controlling the quality of hot metal and productivity of blast furnaces has recently become abundantly clear. One of the important characteristics governing geometry of the cohesive zone is the softening characteristics of the iron oxide feed. This standard attempts to propose a standard method for determining the softening characteristics of iron oxides (in powder form); lump ore, sinter and pellets.

It is to be noted that in this text all the iron oxides are crushed to a fine size in order to make a relative assessment of all three types of oxide feeds. In the case of IS 9660 applicable only to pellets, a feed size of 9 to 16 mm, covering almost the entire range of pellets actually used in blast furnaces, are tested. The two standards are thus complementary.

This method is based on the method evolved at CRM laboratories, Belgium.

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*

DETERMINATION OF SOFTENING POINT OF IRON OXIDES (IN POWDER FORM): LUMP ORE, SINTER AND PELLETS — METHOD

(*First Revision of* IS 11283)

1 SCOPE

This standard prescribes the method for the determination of softening point of iron oxides (in powder form); lump ore, sinter and pellets.

2 REFERENCE

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 460	Test sieves — Specifications:
(Part 1) : 2020	Wire cloth test sieve (*fourth revision*)

3 TERMINOLOGY

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

3.1 Softening Start Temperature — It is a temperature at which 3 percent contraction in the initial bed height occurs instead of continuing the test till the material is fully molten.

3.2 Softening Finish Temperature — It is a temperature at which 10 percent contraction in the initial bed height occurs instead of continuing the test till the material is fully molten.

4 PRINCIPLE OF TEST

For a bed of given height of any solid material when heated, the height of the bed initially increases because of thermal expansion. This behaviour continues with increasing temperature till a point is reached when the solid starts softening. At this temperature, the expansion tendency of the bed is more than compensated by the collapse of the bed because of softening and the bed height starts to decrease. With any further rise in temperature, the bed height continues to decrease till the solid is fully molten after which the bed height remains more or less unaltered. This test involves compacting the crucible inside a tubular furnace preheated to a temperature and the plunger and dial gauge arc mounted on the sample. The temperature is gradually increased and the dial gauge reading is noted at regular intervals. The test is discontinued when the contraction in the initial bed height reaches a level of 10 percent.

5 NUMBER OF TEST

The test shall be carried out in duplicate on material in the size range of 1.4 mm to 2.0 mm.

6 SAMPLES

6.1 The softening point test samples may be taken either from the physical test or pre-reduced to the required degree.

6.2 The total mass of the softening test sample shall be approximately 40 g crushed to a size according to **5**.

7 HEATING

7.1 After placing the sample in the crucible, it is placed in the furnace, preheated to 800 ± 10°C. The temperature is increased at the rate of 4°C/min. The heating is continued until the softening finish temperature is reached according to **3.2** and **4.**

7.1.1 In case a pre-reduced sample is taken for the test, then heating shall be done under nitrogen atmosphere to avoid oxidation of the sample on heating.

8 PRESSURE APPLIED

A constant pressure of 2 kg/cm^2 shall be applied throughout to the sample by a lever arrangement.

9 APPARATUS

9.1 The softening test apparatus consist of a test crucible shall be of heat resistant steel with a detachable bottom. The sample is first placed in the crucible and compacted by dropping a fixed weight on it three times. It is ensured that the initial compactness of the bed remains the same in all the tests. The crucible is then suspended inside an electrically heated tubular furnace, preheated to a temperature of 800 ± 10°C and the sample is exposed to a fixed load applied through a plunger rod. The dilatation and contraction in the bed height of the sample is measured by a dial gauge. A typical arrangement of the apparatus is shown in Fig. 1.

9.2 The crucible shall be made of heat resisting non-scaling steel with a detachable bottom which is pinned to the lower part of the crucible. The crucible is so suspended inside the furnace that the lower part where the sample is kept should lie near the central heating zone of the furnace. A typical illustration of the crucible is shown in Fig. 1.

9.3 Furnace

The furnace shall be an electrically heated tubular type. The uniform rise in temperature should be monitored by an external temperature controller and the furnace shall be capable of raising the temperature up to 1 400°C. The accuracy of the temperature controller shall be ± 5°C.

9.4 Dial Gauge

The dial gauge shall be of 0.10 mm with a least count of 0.01 mm.

9.5 Sieves

The test sieves used shall be in accordance with size range of l.4 mm to 2.0 mm wire sieves conforming to IS 460 (Part 1) shall be used.

10 PROCEDURE

10.1 Approximately 40 g of sample should be put into the crucible and subsequently compacted by means of dropping three times a 6 kg weight from a height of 65 mm in order to have same initial sample bed height of 30 mm. The plunger rod is then placed on top of the sample. The crucible and the plunger rod assembly is suspended inside an electrically heated tubular furnace preheated to 800 ± 10°C. A load of 2 kg/cm^2 is applied to the sample through the plunger rod by means of a lever arrangement. The dial gauge is mounted on the plunger to measure the dilation and contraction of the bed height.

10.2 After keeping the crucible inside the furnace, the temperature is allowed to stabilize at 800 ± l0°C, subsequently the temperature of the furnace is raised at the rate of 4°C/min under a nitrogen atmosphere if a pre-reduced sample is taken for the test. The dial gauge reading is noted at regular intervals with every 40°C rise in temperature. The contraction of the bed occurs after the initial expansion with the movement of the dial gauge needle in the opposite direction.

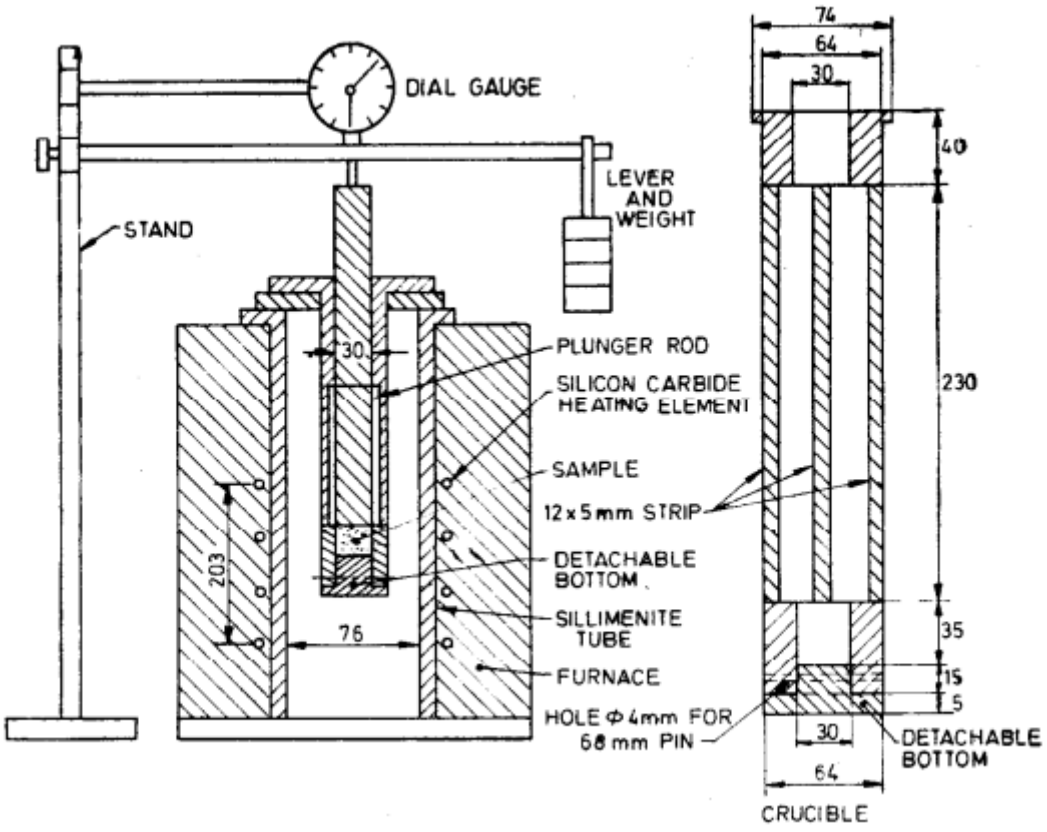


Fig. 1 Test Apparatus for the Determination of Softening Point of Iron Ore, Sinter and Pellet

10.3 The test shall be performed until the contraction in the initial bed height reaches a level of 10 percent.

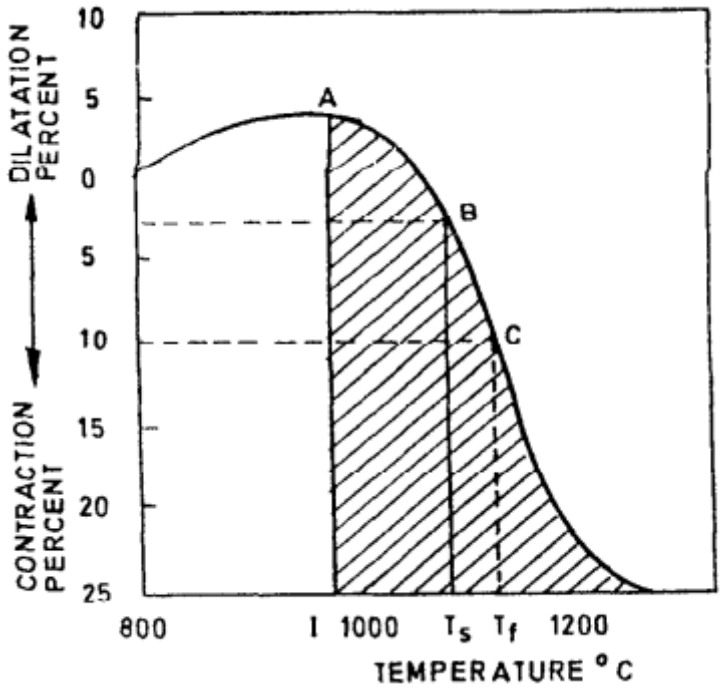
10.4 The softening finish temperature is taken at 10 percent contraction in the initial bed height because at higher degrees of softening, the difficulties are encountered with sticking of the softened material in the crucible.

11 EXPRESSION OF RESULTS

11.1 The following data shall be reported:

a) The softening start temperature (T_S),
b) The softening finish temperature (T_f), and
c) The temperature (T) at which the contraction of the bed begins.

11.2 The reading obtained are plotted as dilatation/contraction on the Y-axis against the temperature on the X-axis. The difference of the softening finish temperature and the softening start temperature would indicate the nature of the width of the softening zone. A schematic diagram for such plot is shown in Fig. 2.



A = bend contraction starts;

B = 3 percent contraction from initial bed height;

C = 10 percent contraction from initial bed height;

T_S = Softening start temperature; and

T_t = Softening finish temperature.

FIG. 2 SCHEMATIC DIAGRAM SHOWING THE DILATATION AND CONTRACTION IN INITIAL BED HEIGHT OF THE SAMPLE DURING A SOFTENING TEST