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Australia



Iron ores — Determination of Transportable Moisture Limit — Modified Proctor-Fagerberg method for iron ore fines



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Preface

This document was prepared by the Standards Australia Committee MN-002, Iron Ores and Direct Reduced Iron.

The objective of this document is to specify a method for determining the Transportable Moisture Limit (TML) of cargoes containing iron ore fines which may liquefy during transport.

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The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

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1 Scope

This document outlines the modified Proctor-Fagerberg method specified by the International Maritime Organization (IMO) for the determination of the Transportable Moisture Limit (TML) of iron ore fines. These fines are defined in the Iron Ore Fines Schedule of the International Maritime Solid Bulk Cargoes (IMSBC) Code Appendix 1 and Appendix 2, Section 1.4.

WARNING — This procedure may involve hazardous materials, operations and equipment, and does not purport to address all the safety issues associated with its use.

NOTE Local regulatory requirements may apply in relation to health and safety.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents for informative purposes are listed in the Bibliography.

ISO 3082, *Iron ores — Sampling and sample preparation procedures*

ISO 3087, *Iron ores — Determination of the moisture content of a lot*

ISO 11323, *Iron ore and direct reduced iron — Vocabulary*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 11323 and the following apply.

3.1

may

indicates the existence of an option

3.2

optimum moisture content

OMC

moisture content corresponding to the maximum compaction (maximum dry density) under the specified compaction condition

3.3

relevant authority

agency authorized by legislation or regulation to issue determinations, orders, or other instructions in respect of any subject covered by this document

3.4

shall

indicates that a statement is mandatory

3.5

should

indicates a recommendation

3.6 Transportable Moisture Limit TML

moisture content at 80 % degree of saturation

4 Principle

A wet (partially saturated) granular material generally consists of solid particles and void spaces filled with water and air. When a cyclic load is applied to such material, particles of the material may move microscopically, and the volume of the voids may tend to decrease. In such cases, if the voids are filled with water and the water flow through the small voids is resisted, the pore water pressure increases. This can potentially create a failure condition within the granular material through loss of shear strength. This failure condition is characterized by the Transportable Moisture Limit (TML), which for a cargo of iron ore fines is taken as equal to the gross water content at 80 % degree of saturation according to the modified Proctor-Fagerberg test, where saturation corresponds to all voids being filled with water.

The IMSBC Code describes three methods for determining the TML. The procedure outlined in this document is solely concerned with the modified Proctor-Fagerberg (PF) method specifically designed for determining the TML of Iron Ore Fines (refer to IMSBC Code Appendix 2 Section 1.4) as defined in the Iron Ore Fines Schedule in the IMSBC Code (Appendix 1). These are defined as iron ore fines containing 10 % or more of fine particles less than 1 mm ($D_{10} < 1$ mm); and 50 % or more of particles less than 10 mm ($D_{50} < 10$ mm); and a total goethite content less than 35 % by mass. The TML is determined by establishing a complete compaction curve.

The procedure shall be conducted in a room where samples are protected from excessive temperatures, air currents and humidity variations. All phases of the material preparation and testing procedure shall be accomplished in a reasonable space of time to minimize moisture losses. Where possible, suitable sample containers, including plastic sample bags, shall be sealed.

5 Apparatus

The Proctor-Fagerberg apparatus is as follows:

- (a) *Cylindrical mould* — with a removable extension piece (the compaction cylinder) and a compaction tool guided by a pipe at its lower end (the compaction hammer), (see [Figure 1](#) for an example).
- (b) *Compaction hammer*. The required tamping pressure is achieved by using a 150 g compaction hammer that allows a controlled pressure to be applied via a 50 mm diameter tamper head through a guide pipe 0.15 m in length.
- (c) *Drying oven*. The drying oven shall be ventilated, with forced circulation of air or inert gas, typically with a stainless steel interior and capable of maintaining a temperature within the range of $105\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.
- (d) *Weighing balance*. The weighing balance shall be capable of weighing the sample and the container, as received, with an accuracy of at least ± 5 g.
- (e) *Pycnometer*. Preferably water or alternatively gas pycnometry equipment to determine the density of the solid material in accordance with a recognized standard, e.g. AS 1289.3.5.1, NZS 4402.2.7.2 and ASTM D5550.
- (f) *Container for hand mixing*. A flat non-absorbent plastic or metallic tray or a heavy duty ($>200\text{ }\mu\text{m}$ film) plastic bag with a capacity of ≥ 5 l for hand mixing samples that is capable of being sealed after mixing to minimize moisture loss. Spatulas can be used for mixing. Check that the mixing process does not reduce the particle size by breakage or increase the particle size by agglomeration of the test material.