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Iron ore and direct reduced iron — Vocabulary

Minerais de fer et minerais de fer préréduits — Vocabulaire

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 11323 was prepared by Technical Committee ISO/TC 102, *Iron ore and direct reduced iron*.

This third edition cancels and replaces the second edition (ISO 11323:2002), which has been technically revised.

Iron ore and direct reduced iron — Vocabulary

1 Scope

This International Standard gives the definitions for terms used in TC 102 standards for sampling, sample preparation, moisture and particle size analysis and physical testing of iron ore and direct reduced iron. Some specific analytical terms used in the relevant International Standards are also included.

2 Normative references

The following reference documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated dated references, the latest edition of the reference document (including any amendments) applies.

ISO 565:1990, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings*

ISO 3310-1:2000, *Test sieves — Technical requirements and testing — Part 1:Test sieves of metal wire cloth*

ISO 3310-2:1999, *Test sieves — Technical requirements and testing — Part 2:Test sieves of perforated metal plate*

3 Natural and processed iron ore

3.1

iron ore
any rocks, minerals or aggregates of minerals, natural or processed, from which iron can be produced commercially

NOTE The principal ferriferous minerals occurring in iron ore either singly or severally are the following:

a) red, brown and specular hematites, martite and maghemite;

b) magnetite;

c) hydrated iron oxides, including goethite, limonite and limnite;

d) iron carbonates, including siderite or chalybite, ankerite and other mixed carbonates;

e) roasted iron pyrites or pyrite cinders;

f) ferrites (e.g. calcium ferrite) occurring sometimes in natural ores, but mainly in fluxed pellets and sinters.

Also included are manganiferous iron ore and concentrates that contain not more than 8 % manganese by mass (dry basis after heating to 105 °C).

Excluded are finely ground ferriferous minerals used for pigments, glazes, dense medium suspension and other materials not related to iron- and steel-making.

3.2

natural iron ore
ores as extracted from mines and not subjected to any processes of beneficiation other than sizing

NOTE Such ores are also called direct shipping ores or run-of-mine ores.

3.3
lump ore
ore lump
ores consisting of coarse particles, with a specified lower size limit in the range of 10 mm to 6,3 mm

3.4
sized ores
ores that have been prepared to meet specific size limits

3.5
fine ores
ore fines
ores consisting entirely of small particles, with specified upper size limits in the range of 10 mm to 6,3 mm

3.6
processed ores
ores treated by physical or chemical processes to make them more suitable for the subsequent production of iron and steel

NOTE The main purposes of processing include the following:

a) raising the iron content;

b) decreasing slag-forming constituents;

c) decreasing harmful impurities, such as phosphorus, arsenic or sulfur compounds;

d) adjusting size distribution;

e) improving metallurgical behaviour of the metallic furnace burden.

3.7
concentrates
processed ores (3.6) in which the percentage iron content has been raised

3.8
agglomerates
processed ores (3.6) formed into coherent pieces which are substantially larger than the original **particles** (6.1)

NOTE The industrial processes for making agglomerates include sintering and pelletizing.

3.9
sinter
type of **agglomerates** (3.8) made from **fine ores** (3.5) by means of forced draught combustion of an admixed fuel

NOTE Sinter forms through adhesion between particles due to superficial melting, diffusion and recrystallization. Sinters may be acid, fluxed or super-fluxed according to their acid and basic oxide contents.

3.10
pellets
spherical **agglomerates** (3.8) formed by balling **fine ores** (3.5), usually finer than 100 µm, with various additives followed sometimes by hot or cold bonding induration

NOTE Pellets may be acid, partially fluxed, fluxed or super-fluxed, according to their acid and basic oxide contents.

3.11
hot bonded pellet
fired pellet
pellets (3.10) hardened by sintering at temperatures higher than 1 200°C

NOTE Pellets hardened with cement without sintering are termed cold bonded pellets.

4 Direct reduced iron

4.1
direct reduced iron
DRI
high grade feed for iron- and steel-making obtained from the reduction of natural or processed iron ores, without reaching the melting temperature

NOTE DRI includes metallized products that have been further processed by hot or cold briquetting.

4.2
briquettes
product formed by compressing **direct reduced iron** (4.1) in moulds

4.3
hot briquetted iron
HBI
direct reduced iron (4.1) briquetted at a temperature greater than 650 °C and having an **apparent density** (7.1.2) greater than 5 g/cm^3

4.4
cold briquetted iron
CBI
direct reduced iron (4.1) briquetted at a temperature lower than 650 °C and having an **apparent density** (7.1.2) lower than 5 g/cm^3

5 Sampling

5.1
lot
discrete and defined quantity of **iron ore** (3.1) or **direct reduced iron** (4.1) for which quality characteristics are to be assessed

5.2
strata
approximately equal parts of a **lot** (5.1) based on time, mass or space

NOTE Examples of strata include production periods (e.g. 5 min), production masses (e.g. 1 000 t), holds in vessels, wagons in a train, containers and trucks representing a lot.

5.3
sample
relatively small quantity of **iron ore** (3.1) or **direct reduced iron** (4.1), so taken from a **lot** (5.1) as to be representative in respect of the quality characteristics to be assessed

5.4
gross sample
sample (5.3) comprising all **increments** (5.9), entirely representative of all quality characteristics of a **lot** (5.1)

5.5

partial sample

sample (5.3) comprising less than the complete number of **increments** (5.9) needed for a **gross sample** (5.4)

5.6

test sample

sample (5.3) prepared to meet all specific conditions for a test

5.7

test portion

part of a **test sample** (5.6) that is actually and entirely subjected to the specific test

5.8

reserve sample

spare sample kept for use in case of additional tests or umpire judgment

5.9

increment

quantity of **iron ore** (3.1) or **direct reduced iron** (4.1) taken in a single operation of a device for sampling or **sample division** (5.16)

5.10

cut

amount of material taken in a single traverse of a sample cutter through a stream, bed or stratum of **iron ore** (3.1) or **direct reduced iron** (4.1), or such movement of the sample cutter

5.11

sampling regime

collection plan for constituting a **sample** (5.3) that defines the number of, mass of and interval between **increments** (5.9)

5.12

sampling scheme

methodical and detailed sequence of all **sampling stages** (5.14), defining successive sampling operations and all associated steps of preparation and division

5.13

sampling procedure

instructions specifying the operational requirements of a particular **sampling scheme** (5.12)

5.14

sampling stage

single **sample division** (5.16) operation, together with any associated **sample preparation** (5.15)

5.15

sample preparation

process of rendering a **sample** (5.3) suitable for the determination of specified quality characteristics

NOTE Preparation can include various processes, such as drying, mixing, sieving, sample division or comminution, which may be employed at several stages of sampling.

5.16

sample division

any procedure, without comminution, to decrease the mass of any **sample** (5.3) or **increment** (5.9) retained at any **sampling stage** (5.14)

NOTE Division should be controlled so that each divided sample or the total sum of the divided increments remains representative of the lot for the specific purposes of the tests.

5.17
proportional mass division
division of **samples** (5.3) or **increments** (5.9) such that the mass of each retained divided portion is a fixed proportion of the mass being divided

5.18
constant mass division
division of **sample** (5.3) or **increments** (5.9) such that the retained divided portions are of almost uniform mass, irrespective of variations in mass of the **samples** or **increments** divided

NOTE 1 This method is required for sampling on a mass basis.

NOTE 2 "Almost uniform" means that variations in mass are less than 20 % in terms of the coefficient of variation.

5.19
minimum mass of divided gross sample
minimum mass of a **gross sample** (5.4) necessary for determining its quality characteristics to a certain **precision** (5.36), dependent on the **particle size** (6.2) of the sample and the required measurement precision

5.20
split use of sample
separate use of parts of a **sample** (5.3), as **test samples** (5.6) for separate determinations of quality characteristics

5.21
multiple use of sample
use of a **sample** (5.3) in its entirety for the determination of one quality characteristic, followed by the use of the same sample in its entirety for the determination of one or more other quality characteristics

5.22
interleaved samples
samples (5.3) constituted by placing consecutive primary **increments** (5.9) alternately into two sample containers

5.23
manual sampling
collecting **samples** (5.3) or **increments** (5.9) by human effort

5.24
mechanical sampling
collecting **samples** (5.3) or **increments** (5.9) by mechanical means

5.25
in-situ sampling
direct extraction of a sample from a wagon, hold or stockpile

5.26
stratified sampling
sampling of a **lot** (5.1) carried out by taking **increments** (5.9) from specified positions and in appropriate proportions from **strata** (5.2)

5.27
stratified random sampling
sampling (5.26) of a **lot** (5.1) carried out by taking one or more **increments** (5.9) at random within each stratum

5.28
systematic sampling
sampling carried out by taking **increments** (5.9) from a **lot** (5.1) at regular intervals

5.29
mass-basis sampling

sampling carried out so that **increments** (5.9) are taken at equal mass intervals, increments being as near as possible of uniform mass

NOTE “Uniform mass” means that variations in mass are less than 20 % in terms of the coefficient of variation.

5.30
time-basis sampling

sampling carried out so that **increments** (5.9) are taken from falling streams, or from conveyors, at uniform time intervals, the mass of each increment being proportional to the mass flow rate at the instant of taking the increment

5.31
spear

sampling tool of a spear-like shape, used to sample a stationary lot or part of a lot, capable of being driven down to the bottom of the lot and extracting a sample from the complete depth of the lot

5.32
auger

sampling tool involving an auger mechanism, used to sample a stationary lot or part of a lot, capable of being driven down to the bottom of the lot and extracting a sample from the complete depth of the lot

5.33
reference method

method that serves as an agreed-upon reference for comparison, and which is derived from scientific principles, experimental work of a national or international organization, or collaborative experimental work under the auspices of a scientific or engineering group

5.34
reference sample

sample taken by a **reference method** (5.33)

5.35
quality variation

measure of the heterogeneity of the lot, defined as σ_w, the standard deviation of the quality characteristics within strata for mass-basis systematic sampling

5.36
precision

closeness of agreement between independent test results (obtained in a manner not influenced by any previous result on the same or similar test object) obtained under stipulated conditions

NOTE The measure of precision is computed as the standard deviation (σ) of the test results, and is usually expressed in terms of imprecision, β (=2σ), within which the true value of measurement exists with a probability of 95 %. Less precision is reflected by a larger standard deviation.

5.37
repeatability limit

the value below which the absolute difference between two test results obtained under repeatability conditions may be expected to be with a probability of 95 %

NOTE The repeatability limit is generally expressed as r, rejecting the use of any measured value outside this range for reporting; when duplicate measurements are made, it may be expressed as $r = \sqrt{2}\beta$.

5.38
Grubbs' test
one of the statistical methods used to detect outliers in a series of data

NOTE 1 ISO 3086 defines any value beyond the limit value at the 5 % significance level as an outlier.

NOTE 2 The procedure of Grubbs' test is given in ISO 5725-2.

6 Particle size analysis/Moisture determination

6.1
particle
discrete and coherent piece of **iron ore** (3.1) or **direct reduced iron** (4.1), regardless of size, shape or mineral content

6.2
particle size
practical size definition, irrespective of **particle** (6.1) shape, obtained by **sieving** (6.10)

NOTE The particle size may be defined by the size of the smallest sieve aperture through which the particle has passed and the size of the largest sieve aperture on which the particle has been retained ($-a+b$ mm). Particle size may be less precisely defined by stating only one sieve aperture size ($+x$ mm) or ($-z$ mm).

6.3
specification size
sieve aperture size (or sizes) chosen to define a percentage mass limit (or limits) for any size fraction (or fractions) considered to be significant

NOTE A specification sieve has the aperture size that corresponds to the specification size; e.g. a pellet feed may be specified as not more than m % $+x$ mm, or a sinter feed as not more than n % $-z$ mm.

6.4
nominal top size
particle size (6.2) expressed by the smallest aperture size of the test sieve (from a square opening, comprising the R20 and R40/3 series in ISO 565), such that no more than 5 % by mass of **iron ore** (3.1) or **direct reduced iron** (4.1) is retained on the sieve

NOTE This definition applies to iron ore and crushed hot briquetted iron HBI, but not to HBI prior to crushing.

6.5
size fraction
sample portion separated by using one sieve, or two sieves of different aperture sizes

6.6
oversize fraction
coarsest portion of a **sample** (5.3), comprising all **particles** (6.1) that are retained on the sieve of aperture x mm, designated as $+x$ mm and quoted as a percentage of the total mass of the sample

6.7
intermediate size fraction
sieved sample portion specified by two sizes, i.e. the smallest sieve aperture (a mm) through which it has passed and the largest sieve aperture (b mm) on which it has been retained, designated as $-a+b$ mm and quoted as a percentage of the total mass of the **sample** (5.3)

6.8
undersize fraction
finest portion of a **sample** (5.3), comprising all **particles** (6.1) that have passed the sieve of aperture z mm, designated as $-z$ mm and quoted as a percentage of the total mass of the sample

6.9
size distribution

in size analysis by **sieving** (6.10), the proportion of **particles** (6.1) according to the sizes of sieve apertures used and expressed as percentage masses, passed or retained on sieves of selected apertures, relative to the total mass of all **size fractions** (6.5)

6.10
sieving

process for separating particulate **iron ore** (3.1) or **direct reduced iron** (4.1) into two or more **size fractions** (6.5), using one or more sieves

6.11
test sieve

sieve, satisfying the requirements of ISO 3310-1 (metal wire cloth) or ISO 3310-2 (perforated metal plate), used for screening tests of powdery or granular matter

6.12
charge

quantity of **iron ore** (3.1) or **direct reduced iron** (4.1) to be treated at one time on one sieve or on a set of sieves

NOTE The permissible mass of a charge depends on the size and aperture of sieves used.

6.13
mass of sample used for sieving

quantity of **iron ore** (3.1) or **direct reduced iron** (4.1) actually sieved for one complete size analysis

NOTE This may comprise several separate **charges** (6.12); in which case it is expressed as the sum of all charges used.

6.14
hand placing

sieving (6.10) method that may be used when a **sample** (5.3) contains relatively coarse **particles** (6.1), usually 40 mm or larger in size, each particle being individually presented to a sieve aperture by hand and turned until it can either pass through, without force being applied, or can be classed clearly as oversize

6.15
hand sieving

sieving (6.10) operation in which a sieve or a set of sieves is supported and agitated manually

6.16
assisted hand sieving

sieving (6.10) operation in which a sieve or a set of sieves is supported mechanically, but is agitated manually

6.17
mechanical sieving

sieving (6.10) operation, in batch or continuous sieving, in which one or more sieves are supported and agitated by mechanical means

6.18
batch sieving

sieving (6.10) operation in which a specific mass or volume of sample is presented to one or more sieves which are agitated either by hand or by mechanical means

NOTE Oversize fractions remain within the frames of the retaining sieves until the end of the sieving operation. The number of presentations of the particles to the sieve apertures depends on the length of sieving time.

6.19
continuous sieving

mechanical sieving (6.17) operation in which the sample is fed continuously over one or several consecutive sieving surfaces which are mechanically agitated, rotated or inclined

NOTE The ore particles travel over each sieving surface until they either pass through or pass over as oversize. There is continuous discharge of all oversize fractions and of the final undersize product. Usually, numbers of presentations of particles to the sieve apertures depend on the length of sieving time.

6.20
dry sieving

sieving (6.10) without the application of water

6.21
wet sieving

sieving (6.10) with a sufficient application of water to ensure the passage of undersize particles through the sieve apertures

6.22
sieving amplitude

maximum displacement of a sieve from its mean position during the motion of sieving

NOTE In sieving with a straight-line motion, the amplitude is half of the total linear movement. With an elliptical motion, it is half of the major axis of the ellipse. With a circular motion, it is the radius of the circle.

6.23
end point

elapsed time after which further sieving does not yield sufficient additional mass of undersize particles to significantly change the result

6.24
dry basis

[size analysis] a calculation basis for expressing a test result from a **test portion** (5.7) or **size fractions** (6.5) resulting from the sieving operation, that have been dried to **constant mass** (6.26)

6.25
natural basis

⟨size analysis⟩ calculation basis for expressing a test result from a **test portion** (5.7) or **size fractions** (6.5) that have been tested as received, using dry sieving and without drying the resulting size fractions

6.26
constant mass

⟨moisture determination⟩ criterion for ending a drying operation where the mass loss by drying at 105 °C for 1 h is less than 0,05 % of the initial mass

6.27
partial drying

drying not resulting in **constant mass** (6.26)

6.28
average particle size

APS

particle size (6.2) representing the mean, weighted by **size fraction** (6.5), of a **size distribution** (6.9)

6.29
moisture of a lot

water adhering to the iron ore surface and **open pores** (7.1.4), expressed as a mass fraction (%), of mass loss by the sample after drying to a constant mass relative to the original mass of the sample

7 Physical testing

7.1 Bulk density and apparent density

7.1.1
bulk density
mass in air of a unit volume of **particles** (6.1) of **iron ore** (3.1) or **direct reduced iron** (4.1) as aggregate, which includes the voids between and within the **particles**

NOTE 1 Bulk density is referred to as ρ_b and expressed in kilograms per cubic metre.

NOTE 2 In industrial practice, the bulk density of iron ore or direct reduced iron is expressed as the ratio of the mass to the volume of a measuring container filled under specified conditions.

7.1.2
apparent density
ratio of the mass in air of a **particle** (6.1) of **iron ore** (3.1) or **hot briquetted iron** (4.3) to its **apparent volume** (7.1.3)

NOTE Apparent density is referred to as ρ_a and expressed in grams per cubic centimetre.

7.1.3
apparent volume
volume of **iron ore** (3.1) or **hot briquetted iron** (4.3), including the volume of any closed and open pores

7.1.4
open pores
voids within a **particle** (6.1) connected with its outside environment

7.1.5
closed pores
voids within a **particle** (6.1) not connected with its outside environment

7.1.6
water absorption
mass of water at a specified temperature that is absorbed into the **open pores** (7.1.4) of dry **hot briquetted iron** (4.3)

NOTE In ISO 15968, water absorption is referred to as a, expressed as a percentage of the dry mass.

7.1.7
air-dried sample
sample whose **moisture** (6.29) is nearly equilibrated with the laboratory atmosphere

7.1.8
oven-dried sample
sample that has been dried to constant mass at 105 °C in an oven

7.2 Sinter tests

7.2.1
ore mix
blend of ores and other iron-bearing materials, such as mill scale, basic oxygen steel-making slag, dust, etc., used for a sinter test

NOTE This term does not include **return sinter fines** (7.2.13), fluxes, coke breeze or other solid fuels.

7.2.2
sinter mix
materials charged into a sintering apparatus, including the **ore mix** (7.2.1), fluxes, coke breeze or any other solid fuels, **return sinter fines** (7.2.13) and water

7.2.3
mixing time
time, in minutes, used for blending and granulating a **sinter mix** (7.2.2)

7.2.4
bulk density of sinter mix
bulk density (7.1.1) of a **sinter mix** (7.2.2), as charged into a sintering apparatus

7.2.5
hearth layer
layer of previously made and sized sinter or other material, placed on the grate of a sintering apparatus before a **sinter mix** (7.2.2) is charged

7.2.6
net bed height
height of the bed of **sinter mix** (7.2.2) above the **hearth layer** (7.2.5), prior to application of **suction** (7.2.7) and prior to ignition

7.2.7
suction
differential pressure, in kilopascals, measured across the sinter bed

7.2.8
ignition intensity
quantity of heat supplied during ignition, per unit of grate area per unit of time, expressed in megajoules per square metre per minute

7.2.9
ignition temperature
maximum temperature, in degrees Celsius, attained during ignition at or immediately above the surface of a sinter bed

7.2.10
sintering time
time (t) in minutes elapsed from the start of ignition, until the exhaust gas temperature reaches a maximum

7.2.11
sinter cake
sinter produced, including the **hearth layer** (7.2.5)

7.2.12
sinter handling treatment
tumbling and shatter treatments given to a **sinter cake** (7.2.11) obtained in a sinter pot test, to simulate the effects of the handling and transportation in a sinter plant

7.2.13
return sinter fines
undersize sintered fines separated from a **sinter cake** (7.2.11) by sieving after **sinter handling treatment** (7.2.12)

7.2.14
sinter product
sinter of acceptable **particle size** (6.2)

7.2.15

sinter productivity

mass of **sinter product** (7.2.14) produced per unit of grate area per unit of time, after deducting the mass of the **hearth layer** (7.2.5), referred to as P and expressed in tonnes of sinter per square metre per hour

7.2.16

fuel consumption

dry mass (or masses) of solid fuel (or fuels) consumed per unit of mass of **sinter product** (7.2.14), after deducting the mass of the **hearth layer** (7.2.5), expressed in kilograms per tonne

7.2.17

sinter yield

percentage (Y) of **sinter product** (7.2.14) in relation to the **sinter cake** (7.2.11) after deducting the mass of the **hearth layer** (7.2.5)

7.2.18

return sinter fines balance

ratio (B) of the mass of **return sinter fines** (7.2.13) added to the **sinter mix** (7.2.2), to the mass of **return sinter fines** generated

7.2.19

basicity

ratio between basic and acid oxides contents of sintered ore, denoted by binary system: CaO/SiO_2; or quaternary system: $(CaO+MgO)/(SiO_2+Al_2O_3)$

7.3 Strength tests

7.3.1

tumble strength

resistance of **lump ore** (3.3), **agglomerates** (3.8) or **hot briquetted iron** (4.3) to size degradation by impact and abrasion, when subjected to tumbling in a rotating drum under specific conditions

NOTE In ISO 3271 and ISO 15967, tumble strength is referred to as the tumble and abrasion indices:

a) the **tumble index** is a relative measure of the resistance of **lump ore** (3.3), **agglomerates** (3.8) or **hot briquetted iron** (4.3) to size degradation by impact, referred to as TI and expressed as the percentage by mass of the +6,30 mm fraction generated in the **test portion** (5.7) after tumbling;

b) the **abrasion index** is a relative measure of the resistance of **lump ore** (3.3), **agglomerates** (3.8) or **hot briquetted iron** (4.3) to size degradation by abrasion, referred to as AI and expressed as the percentage by mass of the –500 µm fraction generated in the **test portion** (5.7) after tumbling.

7.3.2

crushing strength

value of the compressive load applied to individual **pellets** (3.10) to cause breakage in a compression test

NOTE In ISO 4700, the crushing strength (CS) is expressed as the mean value, in decanewtons, of all the measurements on the **pellets** (3.10) of the **test portion** (5.7).

7.4 Heating and reduction tests

7.4.1

decrepitation

breakage of **lump ore** (3.3), occurring as a result of rapid heating

NOTE In ISO 8371, decrepitation is referred to as the **decrepitation index** ($DI_{-6.3}$) and expressed as the percentage by mass of the –6,3 mm fraction in the **test portion** (5.7) after the thermal treatment.

7.4.2
reduction

removal, by means of reductants, of the oxygen combined with iron in **lump ore** (3.3) or **agglomerates** (3.8)

7.4.3
degree of reduction

extent to which oxygen has been removed, under specific reduction conditions, from iron oxides, expressed as the ratio of oxygen removed by reduction to oxygen originally combined with iron

NOTE 1 ISO 7215, applicable to blast furnace feedstocks, determines for a reduction time of 3 h the degree of reduction referred to as the final degree of reduction (R_{180}) expressed as a percentage by mass.

NOTE 2 ISO 11258, applicable to direct reduction feedstocks, determines for a reduction time of 90 min the degree of reduction referred to as the final degree of reduction (R_{90}) expressed as a percentage by mass.

NOTE 3 The final degree of reduction is generally denoted by R_f.

7.4.4
reducibility

ease with which oxygen combined with iron can be removed by reductants over time from **lump ore** (3.3) or **agglomerates** (3.8)

NOTE 1 ISO 4695, applicable to blast furnace feedstocks, determines the reducibility index ($\mathrm{d}R/\mathrm{d}t$) for the 40 % degree of reduction (O/Fe = 0,9), expressed as a percentage per minute.

NOTE 2 ISO 11258, applicable to direct reduction feedstocks, determines the reducibility indices $\mathrm{d}R/\mathrm{d}t_{(R\,=\,40)}$ for the 40 % degree of reduction (O/Fe = 0,9) and $\mathrm{d}R/\mathrm{d}t_{(R\,=\,90)}$ for the 90 % degree of reduction, expressed as a percentage per minute.

7.4.5
degree of metallization

relative measure of the amount of **metallic iron** (8.5) in the total iron content of **direct reduced iron** (4.1)

NOTE 1 ISO 11257, applicable to direct reduction feedstocks, determines the degree of metallization, referred to as M, expressed as the ratio of the **metallic iron** (8.5) content at a reduction time of 300 min, to the **total iron** (8.6) content, as a percentage by mass.

NOTE 2 ISO 11258, applicable for direct reduction feedstocks, determines the **degree of metallization** (7.4.5) referred to as M_R, expressed as the ratio of the **metallic iron** (8.5) content at a reduction time of 90 min, to the **total iron** (8.6) content, as a percentage by mass.

7.4.6
reduction-disintegration

size degradation of **lump ore** (3.3) or **agglomerates** (3.8) during reduction

7.4.7
low-temperature reduction-disintegration

size degradation of **lump ore** (3.3) or **agglomerates** (3.8) resulting from reduction under low-temperature reduction conditions resembling those prevailing in the upper part of the blast furnace or in various direct reduction reactors

NOTE 1 In ISO 4696-1, applicable to blast furnace feedstocks, low-temperature reduction-disintegration is referred to as the reduction-disintegration index, RDI-1, expressed by three indices: the percentage by mass of the +6,3 mm (RDI-$1_{+6,3}$), −3,15 mm (RDI-$1_{-3,15}$) and −0,5 mm (RDI-$1_{-0,5}$) size fractions of the **test portion** (5.7) obtained when tumbled after reduction over 60 min under static conditions.

NOTE 2 In ISO 4696-2, applicable to blast furnace feedstocks, low-temperature reduction-disintegration is referred to as the reduction-disintegration index, RDI-$2_{-2,8}$, expressed by the percentage by mass of the −2,8 mm size fraction of the **test portion** (5.7) obtained when tumbled after reduction over 30 min under static conditions.

NOTE 3 In ISO 13930, applicable to blast furnace feedstocks, low-temperature reduction-disintegration is referred to as the low-temperature reduction-disintegration index, LTD, expressed by three indices: the percentage by mass of the +6,3 mm ($\text{LTD}_{+6,3}$), −3,15 mm ($\text{LTD}_{-3,15}$), and −0,5 mm ($\text{LTD}_{-0,5}$) size fraction of the **test portion** (5.7) obtained after being tumbled during reduction over 60 min.

NOTE 4 In ISO 11257, applicable to direct reduction feedstocks, low-temperature reduction-disintegration is referred to as the reduction-disintegration index, RDI_{DR}, expressed by the percentage by mass of the −3,15 mm size fraction of the **test portion** (5.7) obtained after being tumbled during reduction over 300 min.

7.4.8
free swelling

increase in volume of fired **pellets** (3.10) that occurs during reduction under unconstrained conditions

NOTE In ISO 4698, free swelling is referred to as the free-swelling index, V_{FS}, expressed as the percentage increase in volume of the pellets after being reduced for 60 min.

7.4.9
reduction under load

structural stability of **lump ore** (3.3) or **pellets** (3.10) during reduction under load

NOTE In ISO 7992, the structural stability is expressed by the following indices:

a) $\Delta p80$: the differential pressure of the reducing gas at an 80 % degree of reduction;

b) $\Delta h80$: the percentage change in the height of the test bed at an 80 % degree of reduction.

7.4.10
cluster

two or more **particles** (6.1) of reduced **pellets** (3.10) stuck together

7.4.11
clustering

formation of **cluster** (7.4.10) of **pellets** (3.10) when reduced under conditions that resemble those prevailing in the direct reduction processes

NOTE In ISO 11256, clustering is referred to as the clustering index (CI) and expressed as a percentage by mass of the aggregate materials remaining in the 95 % reduced test portion after tumbling operations.

7.4.12
static method

method of reducing the sample in a stationary condition

7.4.13
dynamic method

method in which the test portion is reduced under movement (usually rotation)

NOTE This method provides a relative measure for evaluating the degree of size degradation of iron ores when reduced under conditions resembling those prevailing in the blast furnace or direct reduction reactor.

8 Chemical analysis

8.1
hygroscopic moisture
HM

absorbed water content of an ore (equilibrated with the laboratory atmosphere) that can be removed by heating for 2 h at 105 °C

8.2
predried sample for chemical analysis
sample (5.3) that has been dried at 105 °C, to a constant mass

8.3
combined water
water content of an ore that can be driven off by heating up to 950 °C after the removal of **hygroscopic moisture** (8.1)

8.4
loss on ignition
change in mass of an ore held at 1 000 °C, excluding the loss due to **hygroscopic moisture** (8.1)

8.5
metallic iron
iron present in its non-oxidated state, with zero oxidation number

8.6
total iron
all iron present in any form, free and combined with oxygen or other elements

8.7
acid-soluble iron
iron(II) present in an ore as a divalent iron oxide (FeO) which is soluble in hydrochloric acid

8.8
water-soluble chloride
chloride content of an ore extractable by leaching with aqueous solution at 90 °C to 95 °C, at neutral pH conditions

8.9
certified reference material iron ore
CRM iron ore
certified reference material prepared from an iron ore for the purpose of chemical analysis

NOTE The definition of CRM in ISO Guide 30:1992 is “Reference material, accompanied by a certificate, one or more of whose property values are certified by a procedure which establishes its traceability to an accurate realization of the unit in which the property values are expressed, and for which each certified value is accompanied by an uncertainty at a stated level of confidence”.

8.10
laboratory sample
a sample of 100 µm (or 160 µm) ground particles for chemical analysis, from which a test portion is taken

8.11
dry basis
a basis for calculation of sample quality characteristics, in which the mass of the **oven-dried sample** (7.1.8) is used

NOTE For ores which are oxidized easily or have high moisture absorbency, the method in ISO 2596, in which the sample mass is corrected by hygroscopic moisture content, is applied.

8.12
air-dry basis
basis for calculation of sample quality characteristics, in which the mass of the **air-dried sample** (7.1.7) is used

8.13
blank test

test performed without sample in the same manner as, and parallel with, a test using an analytical sample

8.14
check test

test of a reference sample performed in the same manner as, and parallel with, a test using an analytical sample

8.15
oxide factor

factor used for expressing the content of a stoichiometric element into one of its oxides

8.16
standardization experiment

international test conducted with the purpose of standardization of an analytical method, in which participating laboratories are permitted to make some modification to improve its performance

8.17
precision experiment

international test conducted with the purpose of evaluating the precision of the standardized analytical method, in which participating laboratories must follow exactly the prescribed analytical procedure to be tested

8.18
internal reference material

in-house reference material prepared for quality control

NOTE The definition of reference material in ISO Guide 30:1992 is "Material or substance one or more of whose property values are sufficiently homogeneous and well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials".

Annex A
(informative)

General statistical terms in TC 102 standards

A.1 Introduction

This annex contains the glossary of statistical terms used for TC 102 International Standards, Technical Specifications (TS) and Technical Reports (TR). Though this annex is attached for the sake of TC 102 standards users' convenience, it is recommended that one should conform to the standards published by ISO/TC 69 when it comes to exact definitions.

A.2 Statistical terms

A.2.1
bias
difference between the expectation of the test results and an accepted reference value

NOTE The test results, not an expectation of the test results, is used in TC 102 standards for practical use.

A.2.2
estimated bias
difference between the mean value, as determined by the international test, and the accepted (certified) value attached to the sample

A.2.3
variance
measure of dispersion, which is the sum of the squared deviations of observations from their average divided by one less than the number of observations

A.2.4
trueness
closeness of agreement between the average value obtained from a large series of test results and an accepted reference value

NOTE The measure of trueness is usually expressed in terms of bias.

A.2.5
between-laboratory standard deviation
expression of the pure standard deviation component between laboratories after the residual error variation is deducted from the overall variability of analytical results

NOTE Between-laboratory standard deviation is represented by σ_L.

A.2.6
reproducibility standard deviation
standard deviation of test results obtained under **reproducibility conditions** (A.2.7)

NOTE Reproducibility standard deviation is represented by σ_R.

A.2.7
reproducibility conditions
conditions where test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment

A.2.8

permissible tolerance between laboratories

value below which the absolute difference between two means of duplicate test results produced by different laboratories, each under **independent duplicate conditions** (A.2.12), may be expected to have a 95 % probability

NOTE Permissible tolerance between laboratories is represented by P and is used in analysis for umpire judgment.

A.2.9

repeatability standard deviation

expression of precision of analytical results, obtained under **repeatability conditions** (A.2.11), as defined in the analytical method

NOTE Repeatability standard deviation is represented by σ_r.

A.2.10

repeatability limit

value below which the absolute difference between two single test (analysis) results, obtained under **repeatability conditions** (A.2.11), may be expected to have a 95 % probability

A.2.11

repeatability conditions

conditions under which mutually independent test results are obtained with the same method on identical material in the same laboratory by the same operator using the same equipment within a short period of time

A.2.12

independent duplicate condition

conditions under which mutually independent test results are obtained with the same method on identical material in the same laboratory by the same operator using the same equipment on two different days

A.2.13

independent duplicate limit

value below which the absolute difference between two single test (analysis) results, obtained under **independent duplicate conditions** (A.2.12), may be expected to have a 95 % probability

A.2.14

independent duplicate standard deviation

expression of precision of analytical results, obtained under **independent duplicate conditions** (A.2.12), as defined in the analytical method

NOTE Independent duplicate standard deviation is represented by σ_d.

Annex B
(informative)

List of equivalent terms in English, French, Japanese, Chinese and Portuguese

NOTE In addition to terms used in two of the three official ISO languages (English and French), this document gives the equivalent terms in Japanese, Chinese and Portuguese; these are published under the responsibility of the member bodies for Japan, China and Brazil (JISC, SAC and ABNT) and are given for information only. Only the terms and definitions given in the official languages can be considered as ISO terms and definitions.

In Table B.1:

(F)	means French;
(J)	means Japanese;
(C)	means Chinese;
(P)	means Portuguese.

Table B.1

Term	Remarks
B.1 **Acid-soluble iron(II)** (F) fer(II) soluble dans l'acide (J) 酸可溶性鉄(II) (C) 酸溶亚铁 (P) ferro(II) solúvel em ácido	ISO 9035 specifies a titrimetric method for the reducibility test methods specified in ISO 4695 or ISO 7215.
B.2 **Agglomerates** (F) minerais agglomérés (J) 塊成鉱 (C) 人造块矿 (P) aglomerados	
B.3 **Briquettes** (F) briquettes (J) ブリケット (C) 压块 (P) briquetes	
B.4 **Bulk density** (F) masse volumique apparente (J) かさ密度 (C) 体积密度 (P) densidade a granel	ISO 3852 specifies two methods: Method 1 for ores having a maximum particle size of 40 mm or smaller. Method 2 for any ores.
B.5 **Chemical analysis** (F) analyse chimique (J) 化学分析 (C) 化学分析 (P) análise química	ISO/TC 102/SC 2 is in charge of preparing International Standards relating to chemical analysis of iron ore and direct reduced iron.
B.6 **Cold briquetted iron (CBI)** (F) fer briqueté à froid (J) コールドブリケットアイアン (C) 冷压铁块 (P) ferro briquetado a frio	CBI is outside the field of activities of TC 102 for development of any test methods.

Table B.1 (*Continued*)

Term	Remarks
B.7 **Combined water** (F) eau de constitution (J) 化合水 (C) 化合水 (P) água combinada	ISO 7335 specifies a Karl Fischer titrimetric method for 0,05 % to 10 % (mass fraction): pre-drying of the test portion at 105 °C, then heating up to 950 °C.
B.8 **Concentrates** (F) minerais concentrés (J) 精鉱 (C) 精矿 (P) concentrados	
B.9 **Constant mass division** (F) division à masse constante (J) 定量縮分 (C) 定量缩分 (P) divisão a massa constante	
B.10 **Crushing strength** (F) résistance à l'écrasement (J) 圧かい強度 (C) 压溃强度 (P) resistência à compressão	ISO 4700 specifies a method for the determination of the crushing strength of fired iron ore pellets. Number of pellets to be tested: 60 or more.
B.11 **Decrepitation** (F) décrépitation (J) 熱割れ (C) 热裂 (P) crepitação	ISO 8371 specifies a method for the determination of the decrepitation index of lump ore.
B.12 **Degree of metallization** (F) degré de métallisation (J) 金属化率 (C) 金属化率 (P) grau de metalização	

Table B.1 (*Continued*)

Term	Remarks
B.13 **Direct reduced iron (DRI)** (F) fer de réduction directe (J) 直接還元鉄 (C) 直接还原铁 (P) ferro esponja	
B.14 **Dry sieving** (F) tamisage à sec (J) 乾式ふるい分け (C) 干式筛分 (P) peneiramento a seco	
B.15 **Fine ores; ore fines** (F) fines de minerai (J) 粉鉱石 (C) 粉矿 (P) minérios finos; finos de minério	
B.16 **Free swelling** (F) gonflement libre (J) ふくれ (C) 自由膨胀 (P) inchamento livre	ISO 4698 specifies a method for the determination of the free-swelling index during unconstrained reduction of fired iron ore pellets. Test portion: 18 pellets per test
B.17 **Gross sample** (F) échantillon global (J) 大口試料 (C) 大样 (P) amostra global	
B.18 **Hand sieving** (F) tamisage à la main (J) 手動ふるい分け (C) 手工筛分 (P) peneiramento manual	

Table B.1 (*Continued*)

Term	Remarks
B.19 **Hot briquetted iron (HBI)** (F) fer briqueté à chaud (J) ホットブリケットアイアン (C) 热压铁块 (P) ferro briquetado a quente	
B.20 **Hygroscopic moisture** (F) humidité hygroscopique (J) 吸湿水分 (C) 吸湿水 (P) umidade higroscópica	ISO 2596 specifies four methods: Method 1 – Gravimetric method Method 2 – Karl Fischer volumetric method Method 3 – Karl Fischer coulometric method Method 4 – Mass-loss method
B.21 **Increment** (F) prélèvement élémentaire (J) インクリメント C) 份样 (P) incremento	
B.22 **Iron ore** (F) minerais de fer (J) 鉄鉱石 (C) 铁矿石 (P) minério de ferro	
B.23 **Loss on ignition (LOI)** (F) perte au feu (J) 強熱減量 (C) 灼烧减量 (P) perda ao fogo	Heating at 1 000 °C for 60 min.
B.24 **Lump ore; ore lump** (F) minerais en roches (J) 塊鉱石 (C) 块矿 (P) minérios granulados	

Table B.1 (*Continued*)

Term	Remarks
B.25 **Manual sampling** (F) échantillonnage manuel (J) 手動式サンプリング (C) 手工取样 (P) amostragem manual	
B.26 **Mass-basis sampling** (F) échantillonnage à masse constante (J) 質量基準サンプリング (C) 定量取样 (P) amostragem base massa	
B.27 **Mechanical sampling** (F) échantillonnage mécanique (J) 機械式サンプリング (C) 机械取样 (P) amostragem mecânica	
B.28 **Metallic iron** (F) fer métallique (J) 金属鉄 (C) 金属铁 (P) ferro metálico	ISO 5416 specifies a bromine-methanol titrimetric method for metallic iron in direct reduced iron (DRI).
B.29 **Nominal top size** (F) dimension supérieure nominale (J) 最大粒度 (C) 最大粒度 (P) tamanho máximo nominal	
B.30 **Pellets** (F) boulettes (J) ペレット (C) 球团 (P) pelotas	The following International Standards specify the physical test methods specifically applicable to pellets. ISO 4698 for the swelling test ISO 4700 for the crushing test