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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 4885

Ferrous materials — Heat treatments — Vocabulary

Matériaux ferreux — Traitements thermiques — Vocabulaire

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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The document was prepared by Technical Committee ISO/TC17, Steel.

Ferrous materials — Heat treatments — Vocabulary

1 Scope

This document defines important terms used in the heat treatment of ferrous materials.

[Annex A](#) provides an alphabetical list of terms defined in this document, as well as their equivalents in French, German, Russian, Chinese and Japanese.

[Table 1](#) shows the various iron-carbon (Fe-C) phases.

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. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18203:2016, *Steel — Determination of the thickness of surface-hardened layers*

3 Terms and definitions

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

There are 3 types of terms specified in this document, preferred terms, admitted terms and deprecated terms. Preferred terms are the primary terms for a given concept. The preferred term is the form which is used throughout the main body of the text. If there is more than one preferred term, only one of the preferred terms shall be used except in the case where both a full form and an abbreviated form are preferred terms (in which case they may be used interchangeably). Preferred terms are written in bold type (with the exception of symbols, which shall be presented as used in running text). Admitted terms are accepted synonyms for the preferred term. They are written in regular type. Deprecated terms are synonyms of the preferred term, which are no longer in use or whose use is discouraged. They are written in regular type.

There can be more than one term of each type. An abbreviated term or a symbol can constitute a term.

EXAMPLE

3.1 General terms

3.1.1

accelerated cooling

method of cooling in the rolling process and which aims at conditioning the crystal structure of steels and improving the mechanical properties by means of rolling followed by cooling down through the temperature range for transformation with a greater speed than that of air-cooling

Note 1 to entry: This does not include the cooling method for quenching which merely cools rapidly on a rolling line using the accelerated cooling equipment.

Note 2 to entry: Cooling for equipment protection, capability compensation of cooling bed, etc are not included in the accelerated cooling because they do not affect mechanical properties of steel.

Note 3 to entry: Accelerated cooling is frequently used for tubes, forgings and thick plates.

3.1.2**austenitizing**

heating (3.1.37) a ferrous material above A_1 or A_3 temperature and *soaking* (3.1.57) for enough time to form partial or complete austenite

Note 1 to entry: Complete austenitizing takes place above A_3 temperature, while partial austenitizing takes place between A_1 and A_{cm} temperatures.

Note 2 to entry: The minimum temperature and the length of the soaking time required depend on the steel composition, the initial microstructure and the heating conditions used.

3.1.3**austenitizing temperature**

temperature at which the ferrous material is maintained during *austenitizing* (3.1.2)

3.1.4**bake hardening steel**

steel with the ability to gain an increase of yield strength after a plastic pre-strain and a subsequent *heat treatment* (3.1.35) in the usual industrial paint processes (in the region of 170 °C for 20 min)

Note 1 to entry: These steels have a good suitability for cold forming and present a high resistance to plastic straining (which is increased on finished parts during *heat treatment* (3.1.35) and a good dent resistance.

3.1.5**cast iron**

alloy of iron, carbon and silicon where the carbon content is approximately more than 2 %

3.1.6**characteristic cooling curve**

diagram showing the variations of cooling rate in the core of a specimen with temperature

Note 1 to entry: Characteristic cooling curve reflects the cooling capacity of a specimen in a cooling medium at different temperatures.

3.1.7**controlled atmosphere**

furnace atmosphere (3.1.31) of which composition may be controlled for the purpose of oxidation or reduction, carbonization or decarbonization

Note 1 to entry: The main purpose of controlled atmosphere is to effectively carry out thermo-chemical treatment such as carburizing and carbonitriding, and to prevent oxidation or decarburization of ferrous materials during heating.

3.1.8**controlled atmosphere heat treatment**

heat treatment carried out in a controlled atmosphere to achieve non-oxidation and non-decarburization, or carburizing (nitriding) as required

Note 1 to entry: Heat treatment in a protective atmosphere or inert gas is also called protective atmosphere heat treatment.

3.1.9**controlled cooling**

cooling according to the predetermined cooling schedule during heat treatment

3.1.10**controlled rolling**

rolling process where rolling temperature and reduction are controlled to achieve enhanced mechanical properties

Note 1 to entry: Examples of controlled rolling are normalizing rolling (3.1.73), *thermomechanical rolling* (3.1.64).

Note 2 to entry: Controlled rolling is used for fine grain ferritic steels and for dual-phase steel for obtaining fine-grain structure.

3.1.11

cooling

decreasing of the temperature of a hot ferrous material, either continuously, discontinuously, gradually, in one or more steps or interrupted

Note 1 to entry: The medium in which cooling takes place should be specified, e.g., air, oil, water, etc. See also *quenching* (3.3.19).

3.1.12

cooling conditions

cooling schedules

condition(s) (temperature and kind of cooling medium, relative movements, agitation, etc.) under which the *cooling* (3.1.11) of the ferrous material takes place

3.1.13

cooling function

cooling curve

temperature change at a defined point of a ferrous material or in a furnace load as a function of time during cooling

Note 1 to entry: The cooling function may be shown as a graph or written in a mathematical formula.

3.1.14

cooling rate

variation in temperature as a function of time during *cooling* (3.1.11)

Note 1 to entry: A distinction is made between an instantaneous rate corresponding to a specific temperature, and an average rate over a defined interval of temperature or time.

3.1.15

cooling time

cooling duration

interval of time separating two characteristic temperatures of the *cooling function* (3.1.13)

Note 1 to entry: It is always necessary to specify precisely what the temperatures are.

3.1.16

critical cooling

cooling necessary to avoid transformation to an undesired microstructure

Note 1 to entry: The cooling course may be characterized by the gradient of temperature or of the *cooling rate* (3.1.14) in general or at given temperatures or times.

3.1.17

critical cooling rate

cooling rate (3.1.14) corresponding to the *critical cooling* (3.1.16)

3.1.18

critical diameter

diameter (d) of a cylinder with a length $\geq 3d$, having a structure of 50 vol.-% of *martensite* (3.8.22) at the centre after *quench hardening* (3.3.18) with defined conditions

3.1.19

decomposition of austenite

decomposition of austenite into *ferrite* (3.8.11) and *pearlite* (3.8.26) or into ferrite and *cementite* (3.8.8) or into *bainite* (3.8.5) with decreasing temperature

3.1.20

differential heating

heating that generates temperature gradient in a ferrous material purposely

3.1.21

endogas

gas mixture produced by incomplete combustion of hydrocarbons

Note 1 to entry: Composition of endogas is usually: by using methane, about 20 vol.-% of carbon monoxide, about 41 vol.-% of hydrogen and residual nitrogen; by using propane, about 24 vol.-% of carbon monoxide, about 31 vol.-% hydrogen and residual nitrogen; by using vaporised methanol with 60 vol.-% of methanol and 40 vol.-% of nitrogen, resulting in 20 vol.-% of carbon monoxide, 40 vol.-% of hydrogen and residual nitrogen.

Note 2 to entry: The endogas is used as a basic or carrier gas. *Carbon level* (3.7.9) of the ferrous material is usual about 0,4 wt.-%. For higher carbon levels of the ferrous material, it is necessary to add a gas to donate carbon, e.g., for carburizing.

3.1.22

endothermic atmosphere

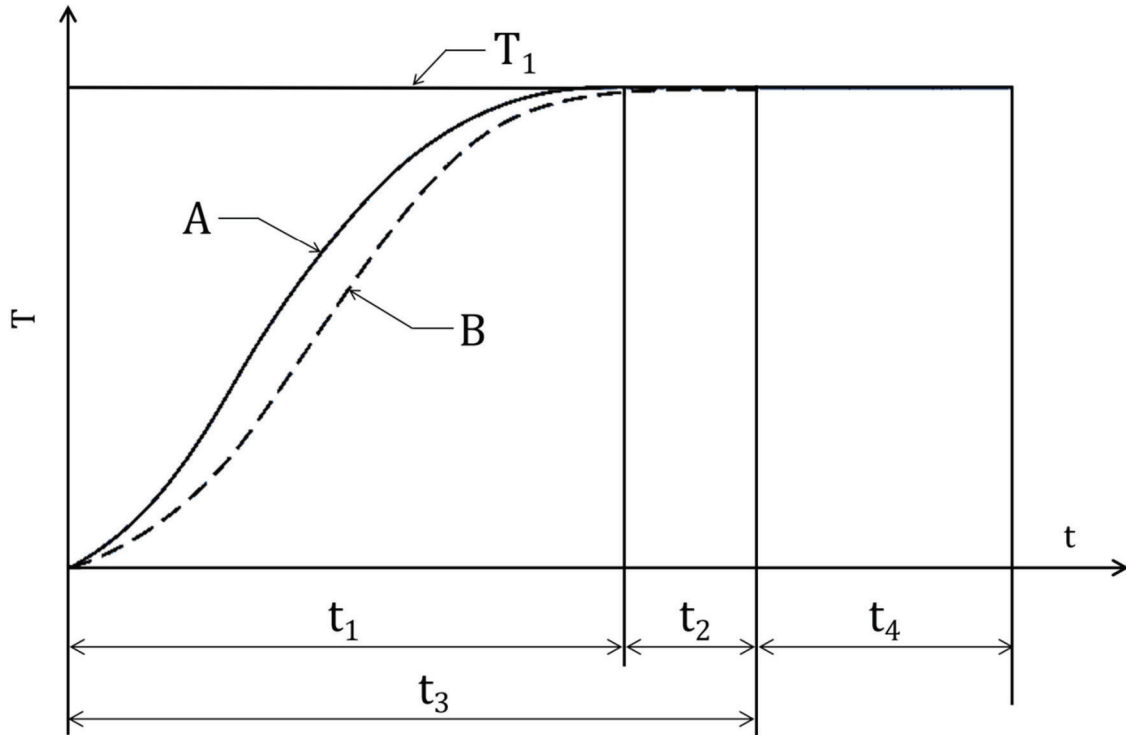
furnace atmosphere (3.1.31) produced endothermically and with a carbon potential capable of being matched to the carbon content of the ferrous material under *heat treatment* (3.1.35) in order to reduce, increase or maintain the *carbon level* (3.7.9) at the surface of the ferrous material

Note 1 to entry: Endothermic means that heat energy is transferred to the atmosphere.

3.1.23

equalization

second stage of *heating* (3.1.37) of a ferrous material whereby the required temperature is obtained at the surface throughout its section (see [Figure 1](#))

**Key**

A	heating curve of surface
B	heating curve of core
t_1	heating up time
t_2	equalization time
t_3	heating time
t_4	soaking time
T_1	austenitizing or quenching temperature

Figure 1 — Schematic representation of heating during an austenitizing treatment

3.1.24 equilibrium diagram

graphical representation of the temperature and composition limits of phase fields in an alloy system

3.1.25 equivalent diameter

equivalent diameter of cooling rate
ruling section

diameter (d) of a cylinder of the same steel (of length $\geq 3d$) in which the *cooling rate* (3.1.14) in the core is identical to the slowest cooling rate recorded in the considered ferrous workpiece with an irregular shape, under the same *cooling conditions* (3.1.12)

Note 1 to entry: The determination of the equivalent diameter is described in ISO 683-1[2] and ISO 683-2[3]

3.1.26 eutectoid transformation

reversible transformation of *austenite* (3.8.4) into *pearlite* (3.8.26) (ferrite + cementite) that occurs at a constant temperature

Note 1 to entry: Temperature for eutectoid transformation of pure iron is 723 °C. Alloying elements or cooling speed influence this temperature.

3.1.27

exogas

gas mixture produced by complete combustion of hydrocarbons

Note 1 to entry: Composition of exogas is usually 6,8 vol.-% to 10 vol.-% of carbon dioxide, 2,4 vol.-% to 7,4 vol.-% of carbon monoxide, 2,5 vol.-% to 9,5 vol.-% of hydrogen, small amounts of oxygen, water vapor, residual nitrogen.

Note 2 to entry: Exogas is used to protect ferrous material surfaces from oxidation and has a decarburizing effect.

3.1.28

exothermic atmosphere

furnace atmosphere ([3.1.31](#)) produced exothermically and controlled not oxidizing the ferrous material

Note 1 to entry: Exothermic means that heat energy is transferred from the atmosphere.

3.1.29

ferrous material

metals and alloys with iron as the principal element

Note 1 to entry: Ferrous materials include products and workpieces of steel and cast iron.

3.1.30

fluidized bed

heat treatment ([3.1.35](#)) medium made by a ceramic powder fluidized by a gas into a furnace heated from the outside

Note 1 to entry: The fluidizing gas may be inert to protect the surface of heat-treated ferrous materials or a reactive gas for a *thermochemical treatment* ([3.7.56](#)) such as *carburizing* ([3.7.13](#)).

3.1.31

furnace atmosphere

gaseous filling of a furnace, used for *heat treatment* ([3.1.35](#))

Note 1 to entry: Gaseous filling may be pure gas or gas mixture, the atmosphere may be inert or reactive.

Note 2 to entry: The purpose of furnace atmospheres is to prevent *oxidation* ([3.9.11](#)) or *decarburization* ([3.9.2](#)) or to be the carrier or reactive gas in a *thermochemical treatment* ([3.7.56](#)).

3.1.32

heat conduction

spontaneously heat flow from a body at a higher temperature to a body at a lower temperature and/or within a ferrous material with locally different temperatures, e.g., between surface and core

Note 1 to entry: In the absence of external drivers, temperature differences decay over time, and the bodies approach to thermal equilibrium.

Note 2 to entry: See Reference [\[5\]](#).

3.1.33

heat convection

transfer of heat from one place to another by movement of fluids

Note 1 to entry: Convection is usually the dominant form of heat transfer in liquids and gases, see Reference [\[5\]](#).

Note 2 to entry: Heat convection during *quenching* ([3.3.19](#)) may be single phase (as in *gas quenching* ([3.3.7](#))) or dual phase (as in water quenching with water and *vapor film* ([3.3.28](#)) at the same time). Usually, single-phase convection has a lower heat transfer than dual-phase convection.

3.1.34

heat radiation

thermal radiation

emission of electromagnetic waves from all matter that has a temperature greater than absolute zero

Note 1 to entry: Heat radiation represents a conversion of thermal energy into electromagnetic energy; see Reference [\[5\]](#)

3.1.35

heat treatment

series of operations in the course of which a solid *ferrous material* ([3.1.29](#)) is totally or partially exposed to *thermal cycles* ([3.1.62](#)) to bring about a change in its properties and/or structure

Note 1 to entry: The chemical composition of the *ferrous material* ([3.1.29](#)) may be modified during these operations. See *thermochemical treatment* ([3.7.56](#)).

3.1.36

heat treatment cycle

entire heat treatment process involving heating, soaking and cooling

3.1.37

heating

increasing of the temperature of a ferrous material, either continuously, discontinuously or gradually, in one or more steps

Note 1 to entry: The medium in which heating takes place should be specified, e.g., in protective atmosphere, inert gas, noble gas, vacuum, air, etc.

3.1.38

heating conditions

heating schedules

condition(s) (temperature, time and method of heating, etc.) under which the *heating* ([3.1.37](#)) of the ferrous material takes place

3.1.39

heating function

heating curve

temperature change at a defined point of a ferrous material or in a furnace load as a function of time during *heating* ([3.1.37](#)).

Note 1 to entry: The heating function may be shown as a graph or written in a mathematical formula.

3.1.40

heating rate

variation in temperature as a function of time during *heating* ([3.1.37](#))

Note 1 to entry: A distinction is made between an instantaneous rate corresponding to a specific temperature, and an average rate over a defined interval of temperature or time.

3.1.41

heating time

heating duration

interval of time separating two characteristic temperatures of the *heating function* ([3.1.39](#))

Note 1 to entry: It is always necessary to specify precisely what the temperatures are.

Note 2 to entry: Heating time is the sum of heating up time and equalization time.

3.1.42

heating up time

time for the surface of a ferrous material to reach the specified temperature during heating

3.1.43

high energy beam heat treatment

heat treatment using different high power density energy sources, such as laser, electron beam or plasma, to heat ferrous materials

3.1.44

hot forming

forming of steel products in a temperature range usually between 780 °C up to 1 300 °C depending on the chemical composition of the workpiece

Note 1 to entry: Hot forming includes hot-rolling, hot-forging, hot-bending, etc.

Note 2 to entry: Forming between the temperatures of hot forming and cold forming is called warm forming.

3.1.45

hypereutectoid steel

steel containing more carbon than the eutectoid composition

3.1.46

hypoeutectoid steel

steel containing less carbon than the eutectoid composition

3.1.47

ideal critical diameter

diameter of a cylinder having a structure of 50 vol.-% of martensite at the center after cooling in a medium with ideal condition of *quenching intensity* ([3.3.20](#))

3.1.48

impulse heating

method of *heating* ([3.1.37](#)) by short repeated bursts of energy, giving rise to a local increase in temperature

Note 1 to entry: Various sources of energy may be used, e.g., condenser discharge, lasers, electron beams, etc.

3.1.49

induction heat treatment

heat treatment using electromagnetic induction to generate eddy current within a ferrous material to heat the ferrous material

3.1.50

isoforming

thermomechanical control process ([3.1.63](#)) of steel consisting of plastic deformation carried out during the transformation of *austenite* ([3.8.4](#)) to *pearlite* ([3.8.26](#))

3.1.51

normalizing rolling

controlled rolling ([3.1.73](#)) process in which the final deformation is carried out within a certain temperature range, leading to a material condition equivalent to that obtained after *normalizing* ([3.2.17](#)), such that the specified mechanical properties are still met in the event of any subsequent normalizing

3.1.52

plasma heat treatment

ion bombardment heat treatment

glow discharge heat treatment

heat treatment using glow discharge generated between a ferrous material (as cathode) and anode in a specific atmosphere with pressure lower than 0,1 MPa (usually 10^{-1} Pa - 10^{-3} Pa)

3.1.53

preheating

heating of a ferrous material with one or more temperature levels and suitable soaking time until the desired heat treatment temperature is reached

3.1.54

protective atmosphere

protective gas

gas to avoid the change of composition of the surface layer of ferrous materials during *heat treatment* (3.1.35), usually used to produce a protective *furnace atmosphere* (3.1.31)

Note 1 to entry: Protective gas is usually used to avoid *oxidation* (3.9.11) or *decarburization* (3.9.2).

Note 2 to entry: The composition of protective gases depends on the purpose of its use.

Note 3 to entry: Best protection is treatment in vacuum furnaces.

3.1.55

recovery

change in structure and properties from *annealing* (3.2.1) a cold-worked ferrous material associated with residual stress removal and strain-free region formation

Note 1 to entry: Recovery is carried out at a temperature below that of *recrystallizing* (3.1.56).

Note 2 to entry: Recovery is due to dislocation climb and glide produced by the movement of vacancies and atoms.

3.1.56

recrystallization

change in structure and properties from *annealing* (3.2.1) a cold-worked ferrous material associated with frequent formation of new fine grains

Note 1 to entry: *Grain growth* (3.8.17) may occur in the ferrous material under critical degree of deformation.

Note 2 to entry: Recrystallization usually decreases strength and increases ductility.

3.1.57

soaking

part of the *thermal cycle* (3.1.62) during which the temperature is held constant

Note 1 to entry: It is necessary to stipulate whether the temperature concerned is that of the surface of the ferrous material, the core or any other particular point on the ferrous material or on the furnace load.

3.1.58

spheroidal graphite iron

cast iron (3.2) containing spherical graphite

Note 1 to entry: It differs from the grey cast iron with lamellar graphite in its chemical composition, merely due to the addition of magnesium (from 0,04 % to 0,06 %), cerium and other rare earth elements that influence the formation of graphite spheres

Note 2 to entry: Usually nodular cast iron will be heat treated, e.g. *austempering* (3.3.3), *normalizing* (3.2.17), *quenching* and *tempering* (3.4.8).

3.1.59

stabilization of retained austenite

phenomenon which reduces or prevents the possibility of the transformation of *retained austenite* (3.8.31) into *martensite* (3.8.22) during *cooling* (3.1.11) to a temperature below ambient temperature

Note 1 to entry: This stabilization occurs during low temperature tempering or holding at ambient temperature after *quenching* (3.3.19).

3.1.60

stabilizing

heat treatment (3.1.35) of a ferrous material intended to prevent subsequent geometrical, dimensional, microstructural and property changes with time

Note 1 to entry: Generally, stabilizing itself may cause those changes to occur, which at a later date may be undesirable.

3.1.61**steel**

ferrous material with iron as the principal element and carbon content not more than 2 wt.-%

Note 1 to entry: The presence of large quantities of carbide-forming elements can modify the upper limit of the carbon content.

Note 2 to entry: The nomenclature for unalloyed steels suitable for *heat treatment* (3.1.35) and for alloyed steels is defined by ISO 4948-1 and ISO 4948-2.

3.1.62**thermal cycle**

variation of temperature as a function of time during *heat treatment* (3.1.35)

3.1.63**thermomechanical control process**

TMCP

hot forming (3.1.44) process in which the final deformation is carried out in a certain temperature range followed by air cooling or accelerated cooling

Note 1 to entry: Leading to a material condition with certain properties which may not be achieved or repeated by *heat treatment* (3.1.35) alone, thermomechanical control process may include *tempering* (3.4.8), including *self-tempering* (3.4.1) but excluding *direct quenching* (3.3.6), quenching and *tempering* (3.4.8).

Note 2 to entry: The target of thermomechanical control process is to produce a fine grain, tough and high tensile structure which may not be achieved or repeated by *heat treatment* (3.1.35) alone and improve weldability and formability of a steel product.

3.1.64**thermomechanical rolling**

TMR

rolling process in which the final deformation is carried out in a certain temperature range leading to a material condition with certain properties which cannot be achieved or repeated by heat treatment alone

Note 1 to entry: Subsequent heating above 580 °C may lower the strength values. If temperature above 580 °C is needed reference should be made to the supplier.

Note 2 to entry: Thermomechanical rolling leading to the delivery condition TMCP may include processes with an increasing cooling rate with or without *tempering* (3.4.8) including *self-tempering* (3.4.1) but excluding direct quenching and quenching and tempering.

Note 3 to entry: In some publications, TMR is also considered as a process of TMCP.

3.1.65**thermo-mechanical heat treatment**

coupled heat treatment by combining plastic deformation and thermal heat treatment to improve mechanical properties of a ferrous material

Note 1 to entry: Thermo-mechanical treatment includes *hot forming* (3.1.44), *controlled rolling* (3.1.10), etc.

3.1.66**through heating**

method of heating that enables the whole workpiece to reach a uniform temperature

3.1.67**transformation diagram**

presentation of *austenite* (3.8.4) transformation of ferrous materials in dependence on time and temperature for a given steel composition

Note 1 to entry: Set of curves may be drawn in a semi-logarithmic coordinate system with temperature as function of logarithmic time which define, for each level of temperature, the phase transformation of austenite as beginning and the transformation to other *phases* (3.8.27) as ending.

Note 2 to entry: At the end of transformation, the amount of constituents of the microstructure and the hardness may be determined.

Note 3 to entry: There is distinction between transformation diagrams in relation to the heating and soaking period called *time-temperature austenitization diagram (TTA diagram)* (3.1.67.1) and diagrams in relation to the cooling period called *time temperature transformation diagram (TTT diagram)* (3.1.67.4).

3.1.67.1

time-temperature austenitization diagram

TTA diagram

diagram which presents austenitization of the initial structure of ferrous material in dependence on time and temperature for a given steel composition and initial microstructure

Note 1 to entry: There is distinction between *isothermal austenitization diagrams* (3.1.67.2) and time-temperature austenitization diagrams.

Note 2 to entry: Set of curves may be drawn in a semi-logarithmic coordinate system with logarithmic time/temperature coordinates which define, for each level of temperature, the phase transformation of *ferrite* (3.8.11), *pearlite* (3.8.26), carbide as beginning and the transformation to *austenite* (3.8.4) as ending.

3.1.67.2

isothermal austenitization diagram

IA diagram

diagram which presents transformation of an initial microstructure to austenite at a given temperature in dependence on time

Note 1 to entry: For a given temperature, the graph is read from left to right following the horizontal temperature line to find out the required time for transforming each component of the microstructure as beginning and the achieved austenite microstructure as ending.

Note 2 to entry: Differences in the initial microstructure may modify the diagram.

3.1.67.3

continuous austenitization diagram

diagram which presents transformation of an initial microstructure to austenite at a given heating rate in dependence on time

Note 1 to entry: Set of curves for different heating rates may be drawn in a semi-logarithmic coordinate system with logarithmic time/temperature coordinate.

Note 2 to entry: For a given heating rate along the curve, the time and temperature of begin and end of the change of each component of the initial structure and the austenitic structure may be obtained.

Note 3 to entry: Differences in the initial microstructure may modify the diagram.

3.1.67.4

time-temperature-transformation diagram

TTT diagram

isothermal transformation diagram

IT diagram

diagram which presents isothermal transformation of *undercooled austenite* (3.8.39)

Note 1 to entry: TTT-diagrams may be used to determine the vol.-% of each *phase* (3.8.27) and its hardness after the transformation.

3.1.67.5

continuous-cooling-transformation diagram

CCT diagram

diagram which presents continuous cooling transformation of *austenite* (3.8.4)

Note 1 to entry: At the 500 °C line, the cooling parameter, λ , divided by 100 or directly in seconds for the temperature range between 800 °C and 500 °C may be determined.

3.1.68**transformation point**

transformation temperature between one microstructures to another

Note 1 to entry: The term shall be completed by indication of the kind of the microstructure, e.g., transformation point of the martensitic stage, pearlitic stage, etc.

3.1.69**transformation range**

interval of temperature within which a ferrous product undergoes a change of *phase* (3.8.27)

3.1.70**transformation temperature**

critical point

temperature at which a change of *phase* (3.8.27) occurs and, by extension, at which the transformation begins and ends when the transformation occurs over a range of temperatures

Note 1 to entry: The following principal transformation temperatures may be distinguished in steels:

- A_1 , equilibrium temperature defining the lower limit of existence of *austenite* (3.8.4);
- A_3 , equilibrium temperature defining the upper limit of existence of *ferrite* (3.8.11);
- A_{cm} , equilibrium temperature defining the upper limit of existence of *cementite* (3.8.8) in *hypereutectoid steels* (3.1.45);
- M_s , temperature at which the austenite begins to transform into *martensite* (3.8.22) during cooling ;
- M_f , temperature at which the austenite has almost completely transformed into martensite during cooling;
- M_x , temperature at which x vol.-% of the austenite has transformed into martensite during cooling.

3.1.71**ultrafast cooling**

method of cooling which is carried out mainly in the quenching process of thin plates and which aims at obtaining finer microstructure of steels and improving the mechanical properties by means of high pressure water cooling with a much greater speed than that of water-cooling

3.1.72**vacuum heat treatment**

heat treatment in a vacuum environment with pressure below 0,1 MPa (usually 1×10^{-1} Pa - 1×10^{-3} Pa)

3.1.73**strain hardening**

work hardening

strengthening of a ferrous material by deformation

Note 1 to entry: This strengthening occurs because of dislocation movements and dislocation generation within the crystal structure of the ferrous material.

Note 2 to entry: Work hardened structure may be removed by recrystallization.

3.2 Terms related to annealing and normalizing**3.2.1****annealing**

heat treatment (3.1.35) consisting of *heating* (3.1.37) and *soaking* (3.1.57) at a suitable temperature followed by *cooling* (3.1.11) under conditions such that, after return to ambient temperature, the ferrous material is in a microstructural state closer to that of equilibrium

Note 1 to entry: Since this definition is very general, it is advisable to use an expression specifying the aim of the treatment. See e.g., *bright annealing* (3.2.4), *full annealing* (3.2.8), *softening/soft annealing* (3.2.21) *inter-critical annealing* (3.2.13), *isothermal annealing* (3.2.14) and subcritical annealing.

3.2.2**bainitizing**

austenitizing (3.1.2) and *quenching* (3.3.19) to a temperature above Ms and isothermal soaking to ensure a transformation of the *austenite* (3.8.4) to upper or lower *bainite* (3.8.5)

Note 1 to entry: Bainitizing may result in both upper and lower bainites, while austempering usually results in lower bainite.

3.2.3**batch annealing**

box annealing

annealing (3.2.1) of strip in tight coil form within a protective atmosphere for a predetermined time-temperature cycle

3.2.4**bright annealing**

annealing (3.2.1) in a medium preventing the oxidization of the surface to maintain the original surface quality

3.2.5**continuous annealing**

annealing (3.2.1) of strips and bars moving continuously through a furnace

Note 1 to entry: The atmosphere used in the furnace should be specified.

3.2.6**diffusion annealing**

annealing (3.2.1) of ferrous materials to reduce *segregation* (3.9.14) and promote homogeneity by *diffusion* (3.7.25)

Note 1 to entry: To reduce segregation of metallic alloying elements in steel making or in bar rolling a diffusion annealing with temperatures between 1,000 and 1,300 °C is required.

Note 2 to entry: To reduce segregation of non-metallic alloying elements (e.g., carbon, nitrogen or sulfur) in ferrous materials a diffusion annealing at a temperature below 1,000 °C is usually done.

3.2.7**ferrite-pearlite annealing**

FP annealing

annealing (3.2.1) consisting of *austenitizing* (3.1.2) and *cooling* (3.1.11) down at a relatively slow rate until *decomposition of austenite* (3.1.19) is completed

Note 1 to entry: The purpose of ferrite-pearlite annealing is to attain a microstructure with ferrite and pearlite, and to improve machinability.

3.2.8**full annealing**

critical annealing

annealing (3.2.1) to achieve *spheroidites* (3.8.35) consisting of complete or partial *austenitizing* (3.1.2) followed by slow *cooling* (3.1.11)

Note 1 to entry: The austenitization of hypoeutectoid steel (C < 0,77 wt.-%) takes place above A₃ temperature (the microstructure is then fully austenitic), however hypereutectoid steels (C > 0,77 wt.-%) between A₁ and A_m temperatures (the microstructure is partially austenitic).

3.2.9**graphitization**

precipitation of carbon in the form of graphite

3.2.10**graphitizing**

annealing (3.2.1) applied to *cast irons* (3.1.5) or *hypereutectoid steels* (3.1.45) to bring about *graphitization* (3.2.9)

3.2.11**homogenizing**

prolonged high-temperature *annealing* (3.2.1) to make the distribution of the chemical composition uniform in a ferrous material

Note 1 to entry: also called high-temperature diffusion annealing

3.2.12**baking**

hydrogen removal annealing

annealing (3.2.1) below A_1 temperature for a certain soaking time permitting the release of hydrogen absorbed in a ferrous material without modifying its structure

Note 1 to entry: The soaking time depends on the size of the ferrous material and the hydrogen content.

Note 2 to entry: In quench hardened or case-hardened steels, the hydrogen is usually removed at a tempering temperature of 230 °C up to 300 °C, with some hours of soaking time.

Note 3 to entry: The treatment is generally carried out following an electrolytic plating or pickling, or a welding operation.

3.2.13**inter-critical annealing**

inter-critical treatment

annealing (3.2.1) of a *hypoeutectoid steel* (3.1.46) involving *heating* (3.1.37) to and soaking at a temperature between A_1 and A_3 , followed by *cooling* (3.1.11) adapted to the characteristics required

3.2.14**isothermal annealing**

annealing (3.2.1) consisting of *austenitizing* (3.1.2) and *cooling* (3.1.11) down to a certain temperature which is held constant until *decomposition of austenite* (3.1.19) is completed

EXAMPLE Isothermal pearlite transformation or isothermal bainitizing (3.3.3)

3.2.15**isothermal normalizing**

normalizing in which austenitized ferrous workpieces are fast cooled by a forced air blowing to and soaking at a certain temperature in the pearlitic transformation zone in order to obtain the pearlitic microstructure, and then cooled in air

Note 1 to entry: Isothermal normalizing is differentiated by cooling rate and form of pearlite attained with isothermal annealing.

3.2.16**malleablizing**

long-time *annealing* (3.2.1) at high temperatures to change the structure of white *cast iron* (3.1.5) to produce malleable cast iron

Note 1 to entry: If the annealing is done in a *decarburizing* (3.7.20) atmosphere, the malleable cast iron is called “white malleable cast iron”. If the annealing atmosphere is not decarburizing so that elementary carbon is formed as graphite, the iron is called “black malleable cast iron”.

3.2.17**normalizing**

heat treatment (3.1.35) intended to attain both grain refinement and homogenization of a ferrous material, consisting of *heating* (3.1.37) it to a temperature slightly above A_3 (A_1 for *hypereutectoid steels* (3.1.45)), and then *cooling* (3.1.11) it in air to a temperature substantially below the transformation range to obtain a fine ferrite-pearlite structure

Note 1 to entry: Normalizing leads to the formation of new grains and acts as a refinement of the microstructure.

3.2.18**patenting**

heat treatment (3.1.35) consisting of *austenitizing* (3.1.2) followed by *cooling* (3.1.11) under conditions suitable for producing pearlite with a fine interlamellar spacing for subsequent wire-drawing or cold-rolling

Note 1 to entry: The cooling medium in which patenting takes place should be specified, e.g., air, salt bath, etc.

Note 2 to entry: The patenting method should be specified with the word “continuous” if the operation is to be carried out continuously on the unwound ferrous material, or “batch” (discontinuously) if the material is to be handled as one load and remains in the form of a coil or bundle. In the case of continuous processing, it is also called “inline patenting”.

3.2.19**recrystallization annealing**

annealing (3.2.1) to remove strengthening after cold forming leading to the formation of new grains by nucleation without any change in *phase* (3.8.27)

Note 1 to entry: *Grain growth* (3.8.17) may occur in the ferrous material under critical degree of deformation.

3.2.20**repeated normalizing**

normalizing on ferrous materials for two or more times

Note 1 to entry: Repeated normalizing is mainly applied for castings and forgings.

3.2.21**soft annealing**

softening

annealing (3.2.1) intended to reduce the hardness of the ferrous material to a given level

Note 1 to entry: Soft annealing slightly below A_1 temperature is called subcritical annealing.

3.2.22**solution annealing**

solution treatment

annealing (3.2.1) consisting of *austenitizing* (3.1.2) at a high temperature for a sufficient *soaking* (3.1.57) time to dissolve precipitates, followed by sufficiently rapid *cooling* (3.1.11) to avoid new precipitations on return to ambient temperature, e.g., applied to austenitic stainless steels and maraging steels

3.2.23**spheroidizing**

spheroidizing annealing

annealing (3.2.1) just below the A_1 temperature of steels for sufficient long soaking time to bring the cementites in the form of spheroids

Note 1 to entry: See also *precipitation growth* (3.8.29).

Note 2 to entry: To accelerate the carbide transformation, the annealing temperature may be oscillated around the A_1 temperature.

3.2.24**stabilizing annealing**

annealing (3.2.1) at around 850 °C intended to obtain precipitation or spheroidization of compounds, e.g., carbides, in stabilized austenitic stainless steels

3.2.25**stress relieving**

process annealing

annealing (3.2.1) at a temperature below A_1 to reduce the internal stresses without substantially modifying the structure of a ferrous material down to a level, at which internal stresses may be minimized, followed by slow *cooling* (3.1.11)