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Ferrous materials — Heat treatments — Vocabulary (ISO 4885:2017)

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National foreword

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European foreword

This document (EN ISO 4885:2017) has been prepared by Technical Committee ISO/TC 17 “Steel” in collaboration with Technical Committee ECISS/TC 100 “General issues” the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2017, and conflicting national standards shall be withdrawn at the latest by August 2017.

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The text of ISO 4885:2017 has been approved by CEN as EN ISO 4885:2017 without any modification.

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Foreword

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This document was prepared by Technical Committee ISO/TC 17, *Steel*.

This second edition cancels and replaces the first edition (ISO 4885:1996), which has been technically revised.

Ferrous materials — Heat treatments — Vocabulary

1 Scope

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

NOTE The term ferrous materials include products and workpieces of steel and cast iron.

Annex A provides an alphabetical list of terms defined in this document, as well as their equivalents in French, German, Chinese and Japanese.

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

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
acicular structure
structure which appears in the form of needles in a micrograph

3.2
activity
effective concentration of species under non-ideal (e.g. concentrated) conditions; for *heat treatment* (3.108), this means the effective concentration of carbon or nitrogen (or both) in heat treatment media and in ferrous materials

Note 1 to entry: Ratio of the vapour pressure of a gas (usually carbon or nitrogen) in a given state (e.g. in *austenite* (3.12) of specific carbon/nitrogen concentration) to the vapour pressure of the pure gas, as a reference state, at the same temperature.

3.3
ageing
change in the properties of steels depending on time and temperature after hot working or *heat treatment* (3.108) or after cold-working operation due to the migration of interstitial elements

Note 1 to entry: The ageing phenomenon can lead to higher strength and lower ductility.

Note 2 to entry: The ageing can be accelerated either by cold forming and/or subsequent *heating* (3.109) to moderate temperatures (e.g. 250 °C) and soaking (e.g. for 1 h) to create the ageing effects.

3.4
air-hardening steel
DEPRECATED: self-hardening steel
steel, the *hardenability* (3.103) of which is such that *cooling* (3.45) in air produces a martensitic structure in objects of considerable size

3.5
alpha iron
stable state of pure iron at temperatures below 911 °C

Note 1 to entry: The crystalline structure of an alpha iron is body-centred cubic.

Note 2 to entry: Alpha iron is ferromagnetic at temperatures below 768 °C (the Curie point).

3.6
alpha mixed crystal
iron with body-centred cubic lattice structure with alloying elements in interstitially or substitutively solution

Note 1 to entry: The material science for alpha mixed crystal is ferritic.

Note 2 to entry: Alpha mixed crystal is ferromagnetic.

3.7
aluminizing
DEPRECATED: calorizing
surface treatment into and on a workpiece (3.201) relating to aluminium

3.8
annealing
heat treatment (3.108) consisting of *heating* (3.109) and soaking at a suitable temperature followed by *cooling* (3.45) under conditions such that, after return to ambient temperature, the metal will be in a structural 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 *bright annealing* (3.29), *full annealing* (3.89), *softening/soft annealing* (3.186), *inter-critical annealing* (3.122), *isothermal annealing* (3.127) and subcritical annealing.

3.9
ausferrite
fine-grained mixture of *ferrite* (3.85) and stabilized *austenite* (3.12) which should lead to high hardness and ductility of austempered ductile cast iron (ADI)

3.10
ausforming
thermomechanical treatment (3.207) of a workpiece which consists of plastically deforming the metastable *austenite* (3.12) before subjecting it to the martensitic and/or bainitic transformation

3.11
austempering
isothermal heat treatment for producing bainitic (see 3.17 and 3.18) or ausferritic (see 3.9) structure of a workpiece

Note 1 to entry: The final *cooling* (3.45) to ambient temperature is not at a specific rate.

3.12
austenite
solid solution of one or more elements in *gamma iron* (3.91)

Note 1 to entry: See also Table 1.

3.13
austenitic steel
steel structure which is austenitic at ambient temperature

Note 1 to entry: Cast austenitic steels can contain up to about 20 % of *ferrite* (3.85).

3.14
austenitizing
heating (3.109) a workpiece to *austenitizing temperature* (3.15) and holding at this, so that the microstructure is predominantly austenitic

Note 1 to entry: The amount of the minimum required temperature results from the heat speed and the steel composition. The holding period depends on the heating conditions used.

3.15
austenitizing temperature
temperature at which the workpiece is maintained during austenitization

3.16
auto-tempering
self-tempering
tempering undergone by *martensite* (3.137) during *quenching* (3.168) or subsequent *cooling* (3.45)

3.17
bainite
microstructure resulting from the transformation of *austenite* (3.12) at temperatures above *martensite* (3.137) start temperature (M_S) and outside the *pearlite* (3.155) range consisting of ferrite laths and carbides which are dispersed either inside the ferrite laths (lower bainite) or between the ferrite laths (upper bainite)

Note 1 to entry: See also Table 1.

3.18
bainitizing
austenitizing (3.14) and *quenching* (3.168) to a temperature above M_S and isothermal soaking to ensure a transformation of the *austenite* (3.12) to *bainite* (3.17)

3.19
bake hardening steel
steel with the ability to gain an increase of yield strength after a plastic pre-strain and a subsequent *heat treatment* (3.108) 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) and a good dent resistance.

3.20
baking
heat treatment (3.108) permitting the release of hydrogen absorbed in a ferrous product without modifying its structure

Note 1 to entry: The treatment is generally carried out following an electrolytic plating or pickling, or a welding operation.

3.21
banded structure
lines of constituents of the microstructure caused by *segregation* (3.179) during solidification

3.22
blacking
operation carried out in an oxidizing medium at a temperature such that the polished surface of a workpiece becomes covered with a thin, continuous, adherent film of dark-coloured oxide (see 3.151)

3.23
black nitriding
nitriding (3.143) followed by *oxidation* (3.150) of the steel surface

Note 1 to entry: After *nitrocarburizing* (3.144), *blacking* (3.22) will improve the corrosion resistance and the surface properties

3.24
blank nitriding
blank nitrocarburizing
simulation treatment which consists of reproducing the thermal cycle of *nitriding* (3.143)/ *nitrocarburizing* (3.144) without the nitriding/nitrocarburizing medium

Note 1 to entry: This treatment makes it possible to assess the metallurgical consequences of the thermal cycle of nitriding/nitrocarburizing.

3.25
batch annealing
box annealing
process in which strip is annealed in tight coil form, within a protective atmosphere, for a predetermined time-temperature cycle

3.26
blueing
treatment carried out in an oxidizing medium (see 3.152) at a temperature such that the bright surface of a workpiece becomes covered with a thin, continuous, adherent film of blue-coloured oxide

Note 1 to entry: If the blueing is carried out in superheated water vapour, it is also called steam treatment.

3.27
boost-diffuse carburizing
carburizing carried out in two or more successive stages and/or different temperatures with different carbon potentials

3.28
boriding
thermochemical treatment (3.207) of a workpiece to enrich the surface of a workpiece with boron

Note 1 to entry: The medium in which boriding takes place should be specified, e.g. pack boriding, paste boriding, etc.

3.29
bright annealing
annealing (3.8) in a medium preventing the *oxidation* (3.150) of the surface and keeps the original surface quality

3.30
burning
irreversible change in the structure and properties brought about by the onset of melting at the grain boundaries and surface

3.31
carbon activity
effective concentration of carbon under non-ideal (e.g. concentrated) conditions; for *heat treatment* (3.108), this means the effective concentration of carbon in heat treatment media and in ferrous materials.

3.32
carbon mass transfer coefficient
coefficient of the mass of carbon transfer from the carburizing medium into steel (per unit surface area and time)

Note 1 to entry: Also defined as the mass of carbon transferred from the carburizing medium into the steel, per unit surface area per second, for a unit difference between the carbon potential and actual surface carbon content.

3.33
carbon level
carbon content in percent of mass in an austenitized probe of pure iron at a given temperature in the equilibrium with the carburizing medium

Note 1 to entry: The "carbon level" has been defined for practical use, because the carbon potential of steels cannot be measured directly in carburizing media; see Reference [13].

3.34
carbon profile
carbon content depending on the distance from the surface

3.35
carbonitriding
thermochemical treatment (3.207) to enrich the surface layer with carbon and nitrogen

Note 1 to entry: The elements are in solid solution in the *austenite* (3.12), usually the carbonitrided workpiece undergoes *quench hardening* (3.167) (immediately or later).

Note 2 to entry: Carbonitriding is a *carburizing* (3.36) process.

Note 3 to entry: The medium in which carbonitriding takes place should be specified, e.g. gas, salt bath, etc.

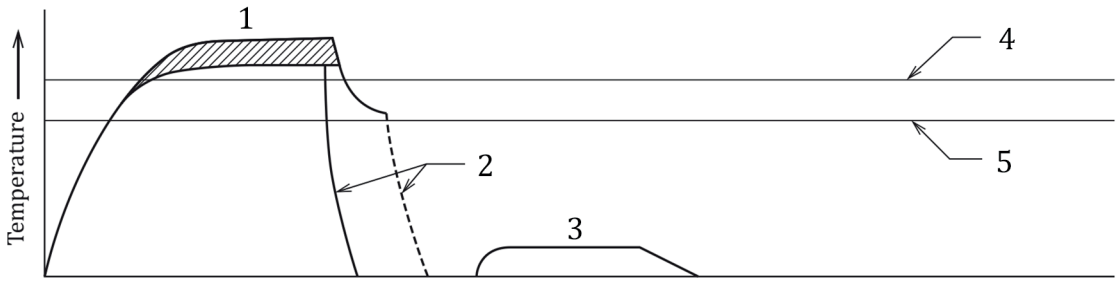
3.36
carburizing
DEPRECATED: cementation
thermochemical treatment (3.207) which is applied to a workpiece in the austenitic state, to obtain a surface enrichment in carbon, which is in solid solution in the *austenite* (3.12)

Note 1 to entry: The carburized workpiece undergoes *quench hardening* (3.167) (immediately or later).

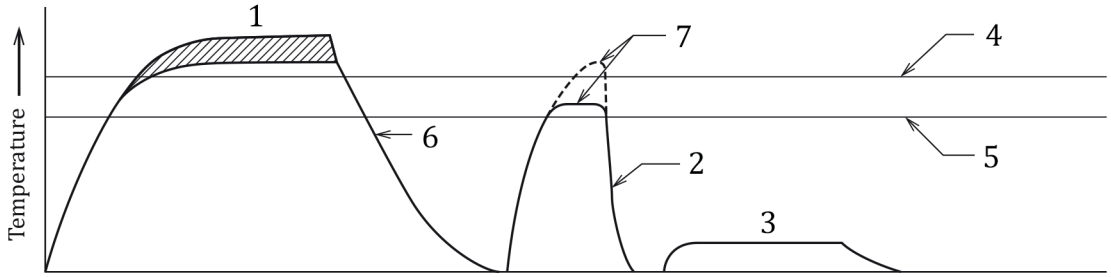
Note 2 to entry: The medium in which carburizing takes place should be specified, e.g. gas, pack, etc.

3.37
case hardening
treatment consisting of *carburizing* (3.36) or *carbonitriding* (3.35) followed by *quench hardening* (3.167)

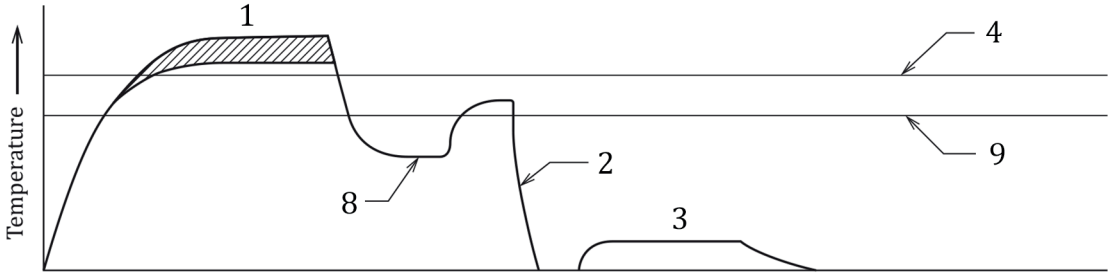
Note 1 to entry: See Figure 1.



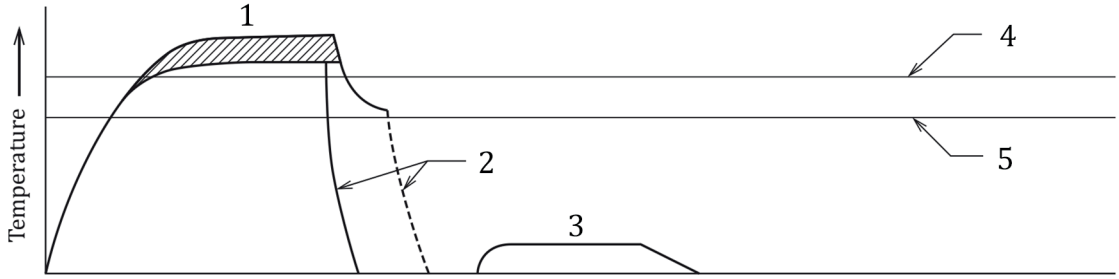
a) Direct-hardening treatment



b) Single-quench hardening treatment



c) Quench-hardening treatment with isothermal transformation



d) Double-quench hardening treatment

Key

1 carburizing, carbonitriding
2 quenching
3 tempering
4 Ac_3 core
5 Ac_3 surface
6 cooling
7 quench-hardening treatment
8 isothermal transformation
9 Ac_3 surface after carburizing

Figure 1 — Schematic representation of the possible thermal cycles of various case-hardening treatments

3.38
cast iron
alloy of iron, carbon and silicon where the carbon content is approximately more than 2 %

3.39
cementite
iron carbide with the formula Fe_3C

Note 1 to entry: See Table 1.

Table 1 — Iron-carbon (Fe-C) phases

Phase	Crystal structure	Properties	Typical hardness
Ferrite, α	bcc	soft, tough, magnetic	60 HBW to 90 HBW
Austenite, γ	fcc	fair strength, non-magnetic	150 HBW (1,5 % C)
Cementite, Fe_3C	rombic	hard, brittle chemical composition	820 HBW
Pearlite with coarse lamellas (0,4 µm)	α + Fe_3C, lamellar	combination of tough ferrite and hard cementite	200 HBW
Pearlite with fine lamellas (0,1 µm)	α + Fe_3C, lamellar	harder than pearlite with coarse lamellas	400 HBW
Spheroidite	α + globular Fe_3C	soft	120 HBW to 230 HBW, depending on carbon and alloy content
Upper bainite	precipitations of Fe_3C on surface of α	properties such as pearlite with fine lamellas	400 HBW
Lower bainite	precipitations of Fe_3C inside of α	strength near martensite, but tougher than tempered martensite	600 HBW
Martensite, α', non-tempered	bcc, slightly tetragonic	hard, brittle	250 HV to 950 HV, depending on carbon content
Martensite, α', tempered	bcc, slightly tetragonic	softer and tougher than non-tempered martensite	250 HV to 650 HV, depending on carbon content and tempering temperature

3.40
chromizing
surface treatment into and on a workpiece (3.201) relating to chromium

Note 1 to entry: The surface layer can consist of practically pure chromium (on low-carbon steels) or of chromium carbide (on high-carbon steels).

3.41
compound layer
DEPRECATED: white layer
surface layer formed during *thermochemical treatment* (3.207) and made up of the chemical compounds formed by the element(s) introduced during the treatment and certain elements from the base metal

EXAMPLE The surface layer may consist of the layer of nitrides formed during *nitriding* (3.143), the layer of borides formed during *boriding* (3.28), the layer of chromium carbide formed during the *chromizing* (3.40) of high-carbon steel.

Note 1 to entry: In English, the term "white layer" is improperly used to designate this layer on nitrided and nitrocarburized ferrous products.

3.42
continuous annealing
process in which strip is annealed by moving continuously through an oven within a protective atmosphere

3.43
continuous-cooling transformation diagram
CCT diagram
see 3.210.2

3.44
controlled rolling
rolling process where rolling temperature and reduction are controlled to achieve enhanced mechanical properties, e.g. normalizing rolling, thermomechanical rolling

Note 1 to entry: Controlled rolling is used for fine-grain *ferritic steels* (3.86) and for dual-phase steel for obtaining fine-grain structure.

3.45
cooling
reduction (or operation to reduce) of the temperature of a hot workpiece continuous, discontinuous, gradually or interrupted

Note 1 to entry: The medium in which cooling takes place should be specified, e.g. in furnace, air, oil, water. See also *quenching* (3.168).

3.46
cooling condition
condition(s) (temperature and kind of cooling medium, relative movements, agitation, etc.) under which the *cooling* (3.45) of the workpiece takes place

3.47
cooling function
reduction of the temperature as a function of time of a determined point of a workpiece

Note 1 to entry: This function could be shown as a graph or written in a mathematical form.

3.48
cooling rate
variation in temperature as a function of time during *cooling* (3.45)

Note 1 to entry: A distinction is made between

— an instantaneous rate corresponding to a specified temperature, and

— an average rate over a defined interval of temperature or time.

3.49
cooling time
interval of time separating two characteristic temperatures of the *cooling function* (3.47)

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

3.50
core refining
process to get a fine grain and a homogenous microstructure in the core, often done by hardening of carburized workpieces

Note 1 to entry: See Figures 1 b), c) and d).

3.51
critical cooling course
cooling course to avoid transformation in undesired microstructure

Note 1 to entry: The cooling course can be characterized by the gradient of temperature or of the *cooling rate* (3.48) in general or at given temperatures or times.

3.52
critical cooling rate
cooling rate (3.48) corresponding to the *critical cooling course* (3.51)

3.53
critical diameter
diameter (d) of a cylinder with a length ≥3 d, having a structure of 50 % by volume of *martensite* (3.137) after *quench hardening* (3.167) with defined conditions at its centre

3.54
decarburization
depletion of carbon from the surface layer of a workpiece

Note 1 to entry: This depletion can be either partial (partial decarburization) or nominally complete (complete decarburization). The sum of the two types of decarburization (partial and complete) is termed total decarburization; see ISO 3887.

3.55
decarburizing
thermochemical treatment (3.207) intended to produce *decarburization* (3.54) of a workpiece

3.56
decomposition of austenite
austenite transformation
decomposition into *ferrite* (3.85) and *pearlite* (3.155) or ferrite and *cementite* (3.39) with decreasing temperature

3.57
delta iron
stable state of pure iron between 1 392 °C and its melting point

Note 1 to entry: The crystalline structure of a delta iron is body-centred cubic, identical to that of the *alpha iron* (3.5).

Note 2 to entry: Delta iron is paramagnetic.

3.58
depth of carburizing
carburizing depth
distance between the surface of a workpiece and a specified limit characterizing the thickness of the layer enriched in carbon, which means effective case depth

3.59
depth of decarburization
decarburization depth
distance between the surface of a workpiece and a limit characterizing the thickness of the layer depleted in carbon

Note 1 to entry: This limit varies according to the type of *decarburization* (3.54) and can be defined by reference to a structural state, a level of hardness or the carbon content of the unaltered base metal (see ISO 3887), or any other specified carbon content.

3.60
depth of hardening
distance between the surface of a workpiece and a limit characterizing the penetration of *quench hardening* (3.167)

Note 1 to entry: This limit can be defined starting from a structural state or a level of hardness.

3.61
depth of nitriding
nitriding depth
distance between the surface of a workpiece and a specified limit characterizing the thickness of the layer enriched in nitrogen

3.62
destabilization of retained austenite
phenomenon occurring during tempering which allows the *retained austenite* (3.175) to undergo martensitic transformation within a temperature range where it would not previously have been transformed spontaneously

3.63
diffusion
movement of atoms to new places in ferrous materials

3.64
diffusion annealing
heat treatment (3.108)/*annealing* (3.8) of ferrous products or workpieces to reduce *segregation* (3.179) and promote homogeneity by *diffusion* (3.63)

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

Note 2 to entry: Reducing segregations of non-metallic alloying elements (such as carbon or sulphur) in workpieces usually would be done at a temperature below 1 000 °C.

3.65
diffusion treatment
heat treatment (3.108) to reduce a very high concentration of elements in the surface layer such as carbon or nitrogen after *carburizing* (3.36) or *nitriding* (3.143)

Note 1 to entry: See also *malleablizing* (3.133), which is also a diffusion treatment.

3.66
diffusion zone
surface layer formed by a *thermochemical treatment* (3.207) characterized by enrichment of elements such as carbon or nitrogen

Note 1 to entry: The enriched elements such as carbon or nitrogen are in solid solution and/or precipitated such as carbides or nitrides.

Note 2 to entry: The concentration of the enriched elements decreases from surface to the core of a workpiece.

3.67
direct-quench hardening
quench hardening (3.167) of carburized workpieces immediately after *carburizing* (3.36) or *carbonitriding* (3.35)

Note 1 to entry: The direct-quench hardening should be started directly from the carburizing or a lower temperature, adjusted to the surface carbon content.

Note 2 to entry: Direct hardening from hot forging or hot rolling replaces separate *austenitizing* (3.14) and *quenching* (3.168).

Note 3 to entry: See Figure 1 a).

3.68
direct quenching
quenching (3.168) carried out immediately following hot rolling or hot forging or *solution annealing* (3.188) of stainless steels or after a *thermochemical treatment* (3.207)

3.69
dislocation
crystallographic defect or irregularity, within a crystal structure

EXAMPLE There are two primary types, “edge dislocations” and “screw dislocations”.

Note 1 to entry: Cold forming increases the amount of dislocations and results in higher hardness.

3.70
distortion
any change in the shape and original dimensions of a ferrous workpiece, occurring during *heat treatment* (3.108)

Note 1 to entry: The causes are manifold including not only the heat treatment process but also the workpiece geometry, steel inhomogeneity and the production conditions.

3.71
double-quench hardening treatment
heat treatment (3.108) consisting of two successive quench-hardening treatments, generally carried out at different temperatures

Note 1 to entry: In the case of carburized products, the first *quench hardening* (3.167) could be done immediately after *carburizing* (3.36) from carburizing temperature. The second quench hardening could be carried out from a lower temperature adjusted to the carbon content of core.

Note 2 to entry: Double-quench hardening is also used for grain refining.

Note 3 to entry: See Figure 1 d).

3.72
effective case depth after carburizing
case-hardening hardness depth
carburizing depth
perpendicular distance between the surface of a case-hardened workpiece and the point where the hardness has the limit hardness value

Note 1 to entry: This limit should be specified, e.g. for the total case depth, this limit will correspond to the carbon content of the unaltered base metal.

Note 2 to entry: The term case depth is used in relation to any case-hardening or surface-hardening process.

[SOURCE: ISO 18203:2016, 3.1, modified.]

3.73
effective case depth after nitriding
nitriding hardness depth
perpendicular distance from the surface of a nitrided or nitrocarburized workpiece to the point where the hardness has the limit hardness value

[SOURCE: ISO 18203:2016, 3.4, modified.]

3.74
effective case depth after surface hardening
surface hardening hardness depth
distance between the surface and the point at which the Vickers hardness (HV) is equal to 80 % of the minimum surface hardness required for the workpiece considered

[SOURCE: ISO 18203:2016, 3.5, modified.]

3.75
electron beam hardening
austenitizing (3.14) the surface layer of a workpiece by *heating* (3.109) with an electron beam

Note 1 to entry: *Quenching* (3.168) for hardening could be done by external *quenching media* (3.170) or it takes place by self-cooling.

3.76
embrittlement
severe loss of toughness of a material

Note 1 to entry: Steels can be affected by different forms of embrittlement such as blue embrittlement, *temper embrittlement* (3.202), quench-age embrittlement, sigma-phase embrittlement, strain-age embrittlement, thermal embrittlement and low-temperature or cold embrittlement.

3.77
endogas
gas mixture produced by incomplete combustion of hydrocarbons

Note 1 to entry: Endogas has a conventional composition of 20 % by volume to 24 % by volume of carbon monoxide, 31 % by volume to 40 % by volume of hydrogen and residual nitrogen.

Note 2 to entry: A gas with the composition given in the above Note 1 to entry can also be generated synthetically by a mixture of gaseous methanol and nitrogen.

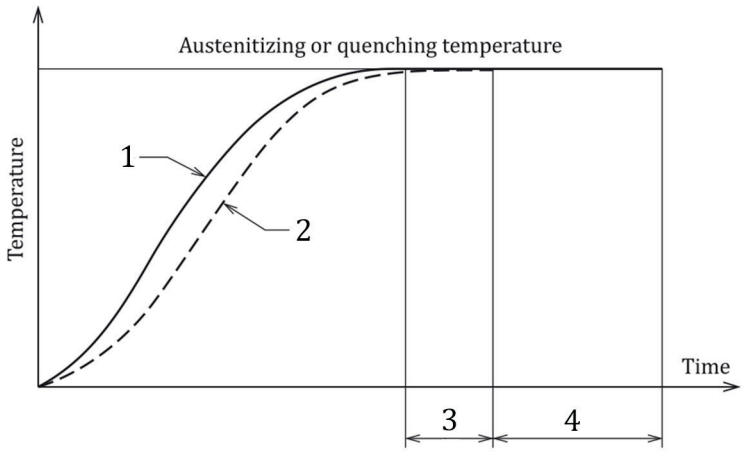
3.78
endothermic atmosphere
furnace atmosphere produced endothermically and with a carbon potential capable of being matched to the carbon content of the ferrous product under *heat treatment* (3.108) in order to reduce, increase or maintain the *carbon level* (3.33) at the surface of the ferrous product

Note 1 to entry: Endothermic means heat energy transfer to the atmosphere.

3.79
epsilon carbide
iron carbide with the approximate formula, $Fe_{2\text{-}4}C$

3.80
equalization
second stage of *heating* (3.109) of a workpiece whereby the required temperature at the surface is attained throughout its section

Note 1 to entry: See Figure 2.



Key

1	surface	3	equalization
2	core	4	soaking

Figure 2 — Schematic representation of heating during an austenitizing treatment

3.81
equilibrium diagram
graphical representation of the temperature and composition limits of phase fields in an alloy system

3.82
equivalent diameter
diameter (d) of a cylinder of the same steel (of length ≥3 d) in which the *cooling rate* (3.48) at its centre is identical to the slowest cooling rate recorded in the workpiece considered, for the same *cooling conditions* (3.46)

Note 1 to entry: The equivalent diameter is also called the ruling section. The determination of the equivalent diameter is described in ISO 683-1 and ISO 683-2.

3.83
eutectoid transformation
reversible transformation of *austenite* (3.12) into *pearlite* (3.155) (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.

3.84
exothermic atmosphere
furnace atmosphere produced exothermically and controlled so that it does not oxidize the ferrous product

Note 1 to entry: Exothermic means heat energy transfer from the atmosphere.

3.85
ferrite
body-centred cubic lattice structure of iron or steel

Note 1 to entry: See Table 1.

3.86
ferritic steel
steel whose structure is ferritic at room temperature

3.87
flame hardening
surface-hardening treatment where the heat source is a flame

3.88
fluidized bed
heat treat medium made by a ceramic powder fluidized by a gas into a furnace that will be heated from the outside

Note 1 to entry: The fluidizing gas could be inert to protect the surface of heat-treated workpieces or a reactive gas for a *thermochemical treatment* (3.207) such as *carburizing* (3.36).

3.89
full annealing
heat treatment (3.108) to achieve a spheroidized structure (see 3.190), which includes full or partial *austenitizing* (3.14) followed with slow *cooling* (3.45)

Note 1 to entry: The austenitization of *hypoeutectoid steel* (3.118) (C < 0,77 %) takes place above A_3 temperature (the structure is then fully austenitic), however *hypereutectoid steels* (3.117) (C > 0,77 %) between A_1 and A_m temperatures (the structure is partially austenitic).

Note 2 to entry: Full annealing is also called critical annealing.

3.90
furnace atmosphere
gaseous filling of a furnace, used for *heat treatment* (3.108)

Note 1 to entry: Gaseous filling could be pure gas or gas mixture. The atmosphere can be inert or reactive, and will operate at or below atmospheric pressure.

Note 2 to entry: The purpose of furnace atmospheres is to prevent *oxidation* (3.150) or *decarburization* (3.54) or to be the carrier or reactive gas in a *thermochemical treatment* (3.207).

3.91
gamma iron
pure iron with face-centred cubic lattice structure

Note 1 to entry: Gamma iron is paramagnetic.

3.92
gamma mixed crystal
iron with face-centred cubic lattice structure with alloying elements in interstitially or substitutively solution

Note 1 to entry: The material science name for gamma mixed crystal is *austenite* (3.12).

Note 2 to entry: Gamma mixed crystal is paramagnetic.

3.93
gas quenching
cooling (3.45) with gas flow, which means quicker than in resting air

Note 1 to entry: The cooling gas could be pure gas or a gas mixture, i.e. air, air with water spray, inert gas or noble gas.

3.94
grain
space lattice formed by atoms with regular interstices

Note 1 to entry: The shape of a ferrite grain can be c-b-c.

3.95
grain boundary
interface separating two grains with different crystallographic orientations

3.96
grain coarsening
annealing (3.8) carried out at a temperature well above A_3 for a soaking period sufficient to bring about *grain growth* (3.97)

3.97
grain growth
increase in the *grain size* (3.99) of the microstructure as a result of *heating* (3.109) to a high temperature and/or to long soaking time

3.98
grain refining
see *core refining* (3.50) and *normalizing* (3.146)

3.99
grain size
characteristic size of a *grain* (3.94) revealed in a metallographic section

Note 1 to entry: The nature of the grain should be specified, e.g. austenitic, ferritic, etc.

Note 2 to entry: See ISO 643.

3.100
graphitic steel
steel in the structure of which a proportion of the carbon is intentionally precipitated in the form of graphite

3.101
graphitization
precipitation of carbon in the form of graphite

3.102
graphitizing
heat treatment (3.108) applied to *cast irons* (3.38) or *hypereutectoid steels* (3.117) to bring about *graphitization* (3.101)

3.103
hardenability
ability of steels to undergo *martensite* (3.137) and/or *bainite* (3.17) transformation

Note 1 to entry: Hardenability is often characterized under defined experimental conditions by the development of hardness as a function of the distance from a quenched surface, e.g. the Jominy curve (see ISO 642). Hardenability can be defined by calculation.

3.104
hardening temperature
start temperature for *quenching* (3.168) austenitized, carburized or carbonitrided workpieces to quench-harden them

Note 1 to entry: The hardening temperature can be identical to the *austenitizing temperature* (3.15).

3.105
heat conduction
spontaneous heat flow from a body at a higher temperature to a body at a lower temperature

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 [12].

3.106
heat convection
convection
transfer of heat from one place to another by the movement of fluids

Note 1 to entry: Convection is usually the dominant form of heat transfer in liquids and gases; see Reference [13].

Note 2 to entry: Heat convection during *quenching* (3.168) can be single phase [as in *gas quenching* (3.93)] or dual phase (as in water quenching with water and vapour film at the same time. Usually, single-phase convection has a lower heat transfer than dual-phase convection.

3.107
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 [12].

3.108
heat treatment
series of operations in the course of which a solid ferrous product is totally or partially exposed to thermal cycles to bring about a change in its properties and/or structure

Note 1 to entry: The chemical composition of a ferrous product can possibly be modified during these operations. See *thermochemical treatment* (3.207).

3.109
heating
increasing the temperature of a workpiece

Note 1 to entry: Heating can be carried out continuously or discontinuously, gradual in one or more steps.

3.110
heating duration
interval of time separating two defined temperatures of the *heating function* (3.111)

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

3.111
heating function
temperature change at a defined point of a workpiece or in a furnace load as a function of time during *heating* (3.109)

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

3.112
heating rate
variation in temperature as a function of time during *heating* (3.109)

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.

3.113
homogenizing
treatment to homogenize a heterogeneous distribution of the chemical composition of ferrous material by a prolonged high-temperature *annealing* (3.8)

3.114
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.

3.115
hydrogen embrittlement
embrittlement (3.76) caused by accumulation of hydrogen atoms and recombination of hydrogen molecules

Note 1 to entry: Hydrogen embrittlement is distinctive at big workpieces and high-strength steels.

Note 2 to entry: It is often the result of unintentional introduction of hydrogen into steel during melting, *hot forming* (3.114), welding or electroplating and increases the risk of cleavage fracture.

3.116
hydrogen removal annealing
annealing (3.8) below A_1 temperature, the holding time depends on the size of the workpiece and the hydrogen content

Note 1 to entry: In quench-hardened or case-hardened steels, the hydrogen will be removed usually at a tempering temperature of 230 °C up to 300 °C, with some hours of soaking time.

3.117
hypereutectoid steel
steel containing more carbon than the eutectoid composition

3.118
hypoeutectoid steel
steel containing less carbon than the eutectoid composition

3.119
impulse hardening
hardening after impulsively *heating* (3.109) by self-cooling of the workpiece

Note 1 to entry: Treatment is used for surface hardening.

3.120
impulse heating
method of *heating* (3.109) by short repeated bursts of energy, giving rise to a local increase in temperature

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

3.121
induction hardening
surface hardening where the *austenitizing* (3.14) of the workpiece is made by induction heating

3.122
inter-critical annealing
inter-critical treatment
annealing (3.8) of a *hypoeutectoid steel* (3.118) involving *heating* (3.109) to and soaking at a temperature between A_1 and A_3, followed by *cooling* (3.45) adapted to the characteristics required

3.123
intermetallic compound
compound of two or more metals possessing physical properties and a crystal structure different from those of the pure metals and their solid solutions

3.124
internal oxidation
occurrence inside heat-treated workpieces by *diffusion* (3.63) of oxygen, caused by precipitation of oxides below the surface

Note 1 to entry: The precipitates could occupy the grain boundaries or are inside of the grains.

3.125
interrupted quenching
quenching (3.168) carried out in a medium giving rapid *cooling* (3.45) and interrupted before the workpiece reaches thermal equilibrium with the *quenching medium* (3.170)

Note 1 to entry: This term should not be used to designate *step quenching* (3.196).

3.126
isoforming
thermomechanical treatment (3.207) of steel consisting of plastic deformation carried out during the transformation of *austenite* (3.12) to *pearlite* (3.155)

3.127
isothermal annealing
heat treatment (3.108) with *austenitizing* (3.14) and interrupted *cooling* (3.45) down to a certain temperature and is held constant until transformation is completed

EXAMPLE Isothermal pearlite transformation or isothermal *bainitizing* (3.18).

Note 1 to entry: This treatment is used for alloyed case-hardening steels in order for pearlitizing to improve the machinability.

3.128
Jominy test
end-quenching test
standardized test for evaluation of *hardenability* (3.103)

Note 1 to entry: For details, see ISO 642.

Note 2 to entry: The Jominy curve can be calculated based on the chemical composition of the steel being tested.

3.129
laser beam hardening
austenitizing (3.14) the surface layer of a workpiece by *heating* (3.109) with a laser beam

Note 1 to entry: See *impulse hardening* (3.119) and *impulse heating* (3.120)

Note 2 to entry: *Quenching* (3.168) for hardening could be done by external *quenching media* (3.170) or it takes place by self-cooling.

3.130
Ledeburite
structure of an iron/carbon alloy which results from a eutectic transformation of a melted iron material and consists of *austenite* (3.12) and *cementite* (3.39)

Note 1 to entry: See Table 1.

3.131
local hardening
quench hardening (3.167) of a local limited area of a workpiece

3.132
low-pressure carburizing
carburizing (3.36) carried out in a vacuum furnace at a pressure below atmospheric pressure

Note 1 to entry: Usually, hydrocarbon gases are used to spend the carbon for *diffusion* (3.63) into the steel. Therefore, *internal oxidation* (3.124) can be avoided.

Note 2 to entry: Low-pressure carbonizing is also often called vacuum carburizing.

3.133
malleablizing
long-time *annealing* (3.8) at high temperatures to change the structure of white *cast iron* (3.38) to produce malleable cast iron

Note 1 to entry: If the annealing would be done in a *decarburizing* (3.55) atmosphere, the malleable cast iron is called "white malleable cast iron". If the annealing atmosphere will not decarburize, elementary carbon is dropped out as graphite, the iron is called black malleable cast iron.

3.134
maraging
heat treatment (3.108) of *maraging steel* (3.135), consisting of *austenitizing* (3.14) and *solution annealing* (3.188), followed by *quenching* (3.168) to produce *martensite* (3.137) and *ageing* (3.3) for precipitation of intermetallic phases to give the required mechanical properties

3.135
maraging steel
steel with specific properties of which can be obtained by *maraging* (3.134)

Note 1 to entry: Typical tensile strength is around 2 000 MPa.

3.136
martempering
heat treatment (3.108) involving *austenitizing* (3.14) followed by *step quenching* (3.196), at a rate fast enough to avoid the formation of *ferrite* (3.85), *pearlite* (3.155) or *bainite* (3.17), to a temperature slightly above M_S, and soaking for long enough to ensure that the temperature is uniform but short enough to avoid the formation of bainite

Note 1 to entry: The final *cooling* (3.45), during which *martensite* (3.137) forms practically simultaneously throughout the cross-section, is generally carried out in air.

3.137
martensite
phase (3.156) formed in carbon containing steels by the *cooling* (3.45) of *austenite* (3.12) at such a high rate that carbon atoms do not have time to diffuse out of the crystal structure in large enough quantities to form *cementite* (3.39) (Fe_3C)

Note 1 to entry: See Table 1.

Note 2 to entry: Plate martensite is formed in steels generally with a carbon content greater than 0,10 %. Plate martensite is typically hard and brittle.

Note 3 to entry: Lath martensite is formed in steels generally with a carbon content below 0,10 %. The toughness of lath martensite is usually good.

Note 4 to entry: Martensite is a metastable solid solution with a body-centred tetragonal distorted structure.

3.138
maximum achievable hardness
maximum value of hardness that can be obtained on a given workpiece by *quench hardening* (3.167), under ideal conditions

3.139
McQuaid-Ehn grain size test
test to evaluate apparent austenitic *grain size* (3.99) of case-hardening steels

Note 1 to entry: Test results are given as an index from 1 upwards; for more details, see ISO 643.

3.140
medium
surrounding in which the ferrous workpiece is placed during *heat treatment* (3.108)

Note 1 to entry: The medium can be solid, liquid or gaseous. The kind and the specific properties of the media are important for the heat treatment results.

3.141
metastable
apparently stable structure outside the conditions defined by the *equilibrium diagram* (3.81)

3.142
nitride
compound of nitrogen with iron and/or nitride-forming alloying elements in ferrous materials

Note 1 to entry: There are several nitrides, depending on the amount of nitrogen. The most important nitrides in nitrided workpieces are ferrous ε- and the γ'-nitrides.

3.143
nitriding
thermochemical treatment (3.207) to produce hard surface layers on workpieces containing nitrides, e.g. *oxynitriding* (3.152), gas nitriding, *plasma nitriding* (3.157)

Note 1 to entry: It would be functional to specify the nitriding media, e.g. gas, plasma, oxygen, etc.

3.144
nitrocarburizing
thermochemical treatment (3.207) to produce a hard surface layer on a workpiece containing nitrides and nitrocarbides to form a compound layer and a diffusion layer below it

Note 1 to entry: It would be functional to specify the treatment media used, e.g. salt bath, gas, plasma, etc.

Note 2 to entry: The term nitrocarburizing should be differentiated from *carbonitriding* (3.35), which is a *carburizing* (3.36) process and takes place above A_3 temperature.

3.145
nitrogen profile
nitrogen content as a function of the distance from the surface

3.146
normalizing
heat treatment (3.108) with the object of refining and eventually making uniform the *grain size* (3.99) of a ferrous product, and comprising *heating* (3.109) it at a temperature slightly above A_3 [A_1 for *hypereutectoid steels* (3.117)], without prolonged soaking at this temperature, followed by *cooling* (3.45) at a suitable rate to a fine ferritic-pearlitic structure

3.147
normalizing forming
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* (3.146), such that the specified mechanical properties would still be met in the event of any subsequent normalizing

3.148
overcarburizing
excess carburizing
carbon enriching of the surface layer could induce carbide precipitations during *carburizing* (3.36) or could lead to a greater content of *retained austenite* (3.175) after *quench hardening* (3.167)

3.149
overheating
oversoaking
heating (3.109) carried out under temperature conditions for a duration such that excessive *grain growth* (3.97) is produced

Note 1 to entry: A distinction can be made between overheating, which is due to the temperature effect, and oversoaking, which is due to the effect of time. An overheated and oversoaked workpiece can be re-treated by appropriate *heat treatment* (3.108) or by deformation, depending on the nature of the product.

Note 2 to entry: If a partial melting occurs during overheating, the process is irreversible.

3.150
oxidation
result of the reaction of oxygen with iron and oxide-forming alloying elements in ferrous materials

Note 1 to entry: Oxide layers grow as temperature and time increase.

Note 2 to entry: Iron has three different oxides, wustite (FeO), magnetite (Fe_3O_4) and hematite (Fe_2O_3).

Note 3 to entry: There should be a distinction between oxidation as a result of an intentional *oxidizing* (3.151), e.g. during *oxynitriding* (3.152), *blueing* (3.26) or after *nitrocarburizing* (3.144) or an unintentional effect by *carburizing* (3.36) in oxygen containing carburizing media; see *internal oxidation* (3.124).

3.151
oxidizing
operation in a medium and at a temperature that the polished surface becomes covered with a thin continuous, adherent film of dark-coloured oxide

Note 1 to entry: After *nitrocarburizing* (3.144), a thin oxide layer will be produced to get higher corrosion resistance.

Note 2 to entry: During *nitriding* (3.143) or nitrocarburizing, oxygen supply could overcome the surface passivation and promote the *diffusion* (3.63) of nitrogen.

3.152
oxynitriding
nitriding (3.143) carried out in a medium to which a certain quantity of oxygen has been added

3.153
parent phase
phase (3.156) from which one or more new phases are formed

3.154
patenting
heat treatment (3.108) consisting of *austenitizing* (3.14) followed by *cooling* (3.45) under conditions suitable for producing the appropriate structures for subsequent wire-drawing or 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 words “continuous”, if the operation would be carried out continuously on the unwound product or “batch” (discontinuously) if the material would be handled as one load and remains in the form of a coil or bundle during the heat treatment.

3.155
pearlite
aggregate of *ferrite* (3.85) and *cementite* (3.39) platelets formed by the eutectoid *decomposition of austenite* (3.56) and the simultaneously transformation into ferrite and cementite

Note 1 to entry: See Table 1.

Note 2 to entry: Pearlite usually appears as light microscopic lamellar and consists of lamellas of cementite and ferrite.

3.156
phase
constituent in the microstructure

Note 1 to entry: In steels, these phases are *ferrite* (3.85), *austenite* (3.12) and *cementite* (3.39).

3.157
plasma nitriding
nitriding (3.143) usually at a pressure below atmospheric pressure and with a plasma support to ionize the nitrogen

3.158
plasma nitrocarburizing
nitrocarburizing (3.144) usually at a pressure below atmospheric pressure and with a plasma support to ionize the nitrogen and the carbon-spending medium

3.159
potential
partial derivative of the Gibbs free energy with respect to the number of moles of that species

Note 1 to entry: For applications concerning *carburizing* (3.36).

3.160
precipitation growth
growth of precipitated particles by *diffusion* (3.63) of elements, dissolve smaller particles into larger particles

Note 1 to entry: This term shall not be considered a synonym for *spheroidizing* (3.191).

3.161
precipitation hardening
hardening of a workpiece caused by the precipitation of one or more compounds from a supersaturated solid solution

Note 1 to entry: See also *secondary hardening* (3.177).

3.162
precipitation hardening treatment
process of increasing the hardness of metallic materials by precipitating of compounds from a supersaturated solid solution, consisting of *solution annealing* (3.188) to solve specific elements, followed by rapid *cooling* (3.45) to hold the solved elements in supersaturated solution and precipitating special compounds by a tempering treatment

3.163
preheating
operation consisting of raising the temperature of a workpiece to one or more temperatures, intermediate between the initial and the maximum temperature, and holding it there for a certain time

3.164
proeutectoid constituent
product formed from *austenite* (3.12) prior to *eutectoid transformation* (3.83)

Note 1 to entry: In the case of *hypoeutectoid steel* (3.118), the proeutectoid constituent is *ferrite* (3.85). In *hypereutectoid steels* (3.117), the proeutectoid constituent is *cementite* (3.39).

3.165
protective gas
gas used to avoid the change of composition of the surface layer of workpieces during *heat treatment* (3.108), usually used to produce a protective furnace atmosphere

Note 1 to entry: Protective gas is usually used to avoid *oxidation* (3.150) or *decarburization* (3.54).

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.

3.166
quench-hardened layer
surface layer of a quench-hardened workpiece, the thickness of which is usually defined by the depth of *quench hardening* (3.167)

3.167
quench hardening
process of hardening a workpiece, obtained after *austenitizing* (3.14), by *cooling* (3.45) under conditions such that the *austenite* (3.12) transforms more or less completely into *martensite* (3.137) and possibly into *bainite* (3.17)

3.168
quenching
operation which consists of *cooling* (3.45) a workpiece more rapidly than in still air

Note 1 to entry: Quenching includes *direct quenching* (3.68).

Note 2 to entry: The use of the term specifying the *cooling conditions* (3.46) is recommended, e.g. water quenching, oil quenching, *step quenching* (3.196), air-blast quenching, etc.

Note 3 to entry: For stainless steels, *solution annealing* (3.188) can be followed by subsequent quenching.

Note 4 to entry: Quenching is also used, instead of slow cooling, to avoid *grain growth* (3.97) of a workpiece with ferritic-pearlitic structure.

3.169
quenching and tempering
quench hardening (3.167) of workpieces followed by tempering at temperature in the range of about 550 °C up to 650 °C to generate a stage characterized by good combination of hardness and toughness

3.170
quenching media
media where *quenching* (3.168) is performed

Note 1 to entry: Quenching media could be a liquid or a gas or a blend gas, e.g. water, oil, nitrogen, hydrogen and salt bath.

3.171
quenching temperature
temperature at which *quenching* (3.168) is initiated

Note 1 to entry: See *hardening temperature* (3.104).

3.172
recarburizing
carbon restoration
thermochemical treatment (3.207) intended to restore the carbon content of the surface layer, decarburized during an earlier treatment

3.173
recovery
annealing (3.8) intended to cause at least partial recovery of the physical or mechanical properties of a cold-worked ferrous product without apparent modification of its structure

Note 1 to entry: This treatment is carried out at a temperature below that of *recrystallizing* (3.174).

3.174
recrystallizing
annealing (3.8) to remove strengthening after a cold forming and developing new grains by nucleation without any change in *phase* (3.156)

3.175
retained austenite
untransformed *austenite* (3.12) remaining, at ambient temperature, after *quench hardening* (3.167)

3.176
scale
layer which is formed on the surface of a workpiece during *heat treatment* (3.108) in a non-protective atmosphere

Note 1 to entry: Usually, the scale is an oxide scale and can be removed by blasting or pickling.

3.177
secondary hardening
increasing of the hardness by the tempering of quench-hardened steel caused by precipitation of carbides and transformation of *retained austenite* (3.175) to *martensite* (3.137) and *bainite* (3.17)

Note 1 to entry: Tempering for initiating secondary hardening is often used for tool steels.

Note 2 to entry: The carbon content of the retained austenite is decreasing and the martensite transformation is continuous.

3.178
secondary martensite
martensite (3.137) formed during *secondary hardening* (3.177)

3.179
segregation
inhomogeneous concentration of elements in steel, e.g. carbon, sulfur and manganese, due to the slow heat transfer during solidification

Note 1 to entry: *Diffusion annealing* (3.64) can decrease the segregation. Modern steelmaking and continuous casting have largely overcome this problem.

3.180
self-quenching
quenching (3.168) of an workpiece

Note 1 to entry: The function presupposes a sufficient relation between the mass of the cold core area and the heated area below the surface.

Note 2 to entry: In case of austenitized hardenable steels the phenomenon can be used to quench-harden a workpiece, see for example 3.129.

3.181
sensitization
increase in the sensitivity of stainless steels to intergranular corrosion due to the precipitation of carbides at the grain boundaries

Note 1 to entry: In order to study the resistance to intergranular corrosion, a sensitizing treatment is used (see ISO 3651-2).

3.182
sherardizing
surface treatment into and on a workpiece (3.201) relating to zinc (zinc diffusion layer)

3.183
siliconizing
surface treatment into and on a workpiece (3.201) relating to silicones

3.184
single-quench hardening treatment
hardening treatment carried out in a single step after *carburizing* (3.36) and slow *cooling* (3.45) to ambient temperature

Note 1 to entry: See Figure 1 b).

Note 2 to entry: It is recommended to refer to the *hardening temperature* (3.104), e.g. single-quench hardening from surface-hardening temperature or single-quench hardening from core-hardening temperature.

3.185
soaking
part of the thermal cycle 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 workpiece, the core or any other particular point on the workpiece or on the furnace load.

3.186
softening
soft annealing
heat treatment (3.108) with the object of reducing the hardness of the ferrous product to a given level

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

3.187
solid solution
homogeneous, solid, crystalline phase formed by two or more elements, at least one metal

Note 1 to entry: A distinction is made between a substitutional solid solution in which the solute atoms are substituted for those of the solvent and an interstitial solid solution in which the solute atoms are inserted between those of the solvent.

3.188
solution annealing
solution treatment
heat treatment (3.108) consisting of *austenitizing* (3.14) to a high temperature followed by *cooling* (3.45) sufficiently rapid to avoid new precipitations on return to ambient temperature, e.g. applied to austenitic stainless steels and maraging steels

3.189
spheroidal graphite iron
grey *cast iron* (3.38) with 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 rare earths that influence the formation of graphite spheres

Note 2 to entry: Usually nodular cast iron will be heat treated, e.g. *austempering* (3.11), *normalizing* (3.146), *quenching and tempering* (3.169).

3.190
spheroidite
characteristic soft microstructure consisting of sphere-like globular *cementite* (3.39) particles within a *ferrite* (3.85) matrix

Note 1 to entry: See *spheroidizing* (3.191) and Table 1.

3.191
spheroidizing
annealing (3.8) just below the A_1 temperature of steels with long soaking time to bring the carbides in the form of spheroids

Note 1 to entry: See also *precipitate growth* (3.160).

3.192
stabilization of retained austenite
phenomenon which reduces or prevents the possibility of the transformation of *retained austenite* (3.175) into *martensite* (3.137) during *cooling* (3.45) to a temperature below ambient temperature

Note 1 to entry: This stabilization occurs during low temperature tempering or holding at ambient temperature after *quenching* (3.168).

3.193
stabilizing
heat treatment (3.108) of a workpiece intended to prevent subsequent dimensional or structural changes with time

Note 1 to entry: Generally, this treatment causes those changes to occur, which at a later date would be undesirable.

3.194
stabilizing annealing
annealing (3.8) at around 850 °C with the aim of obtaining precipitation or spheroidization of compounds, e.g. carbides, in stabilized austenitic stainless steels

3.195
steel
ferrous material the principal element of which is iron and the carbon content of which is not more than 2 % of mass

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* (3.108) and for alloyed steels is defined by ISO 4948-1 and ISO 4948-2.

3.196
step quenching
quenching (3.168) during which *cooling* (3.45) is temporarily interrupted by soaking in a medium at a suitable temperature

Note 1 to entry: This term should not be used to designate *interrupted quenching* (3.125).

3.197
stress relieving
annealing (3.8) at temperatures below A_1 to reduce the internal stresses without substantially modifying the structure of a workpiece or ferrous product down to a level, at which internal stresses would be minimized, followed by slow *cooling* (3.45)

3.198
sub-zero treating
deep freezing
treatment carried out after *quench hardening* (3.167) or *case hardening* (3.37), consisting of cooling down below room temperature to complete the transformation of *austenite* (3.12) to *martensite* (3.137)

Note 1 to entry: *Retained austenite* (3.175) would transform to martensite or martensite and *bainite* (3.17).

3.199
sulfidizing
surface treatment into and on a workpiece (3.201) relating to sulfur

3.200
surface-hardening treatment
quench hardening (3.167) restricted to the surface layer

Note 1 to entry: It is expedient to specify the method of *heating* (3.109), e.g. flame, induction, laser beam, electron beam etc.

Note 2 to entry: The *quenching* (3.168) can occur from outside the workpiece or by *self-quenching* (3.180).

3.201
surface treatment into and on a workpiece
thermochemical treatment (3.207) intended to import a metallic element or a metalloid into and on a workpiece

Note 1 to entry: Specific treatments for modifying the surface layer are, for example, *case hardening* (3.37), *nitrocarburizing* (3.144), *aluminizing* (3.7), *boriding* (3.28), *chromizing* (3.40), *siliconizing* (3.183), *nitriding* (3.143), *sherardizing* (zinc diffusion coating) (3.182), *sulfidizing* (3.199) and *vanadizing* (3.216).

Note 2 to entry: Specific treatments for coating are hot-dip coating, chemical vapour deposition (CVD) and physical vapour deposition (PVD).

3.202
temper embrittlement
embrittlement (3.76) which affects certain quenched and tempered steels during tempering at certain temperatures or during slow *cooling* (3.45) through these temperatures

3.202.1
irreversible temper embrittlement
blue brittleness
temper embrittlement (3.202) that occurs during soaking of certain quenched hardened steels in the temperature range of about 250 °C to 375 °C

Note 1 to entry: It is caused by *segregation* (3.179) and precipitation of carbon and nitrogen on *dislocations* (3.69) and is usually handled by alloying steels with aluminium and titanium.

3.202.2
reversible temper embrittlement
temper embrittlement (3.202) that occurs during tempering of quench-hardened steels in the temperature range of 450 °C up to 550 °C or after tempering at a higher temperature and during slow *cooling* (3.45) through this range

Note 1 to entry: It is caused by *segregation* (3.179) of trace elements such as Sb, P, As and Sn and is usually avoided by alloying with sufficient amounts of tungsten or molybdenum.

Note 2 to entry: The reversible temper embrittlement reveals itself by a displacement of the transition curve for the impact strength of the base metal towards higher temperatures.

Note 3 to entry: The reversible temper embrittlement can be cured by a second tempering at a temperature above 550 °C followed by rapid cooling.

3.203
tempering
heat treatment (3.108) applied to a ferrous product, generally after *quench hardening* (3.167), or another heat treatment to bring the properties to the required level, and consisting of *heating* (3.109) to specific temperatures (<A_1) and soaking one or more times, followed by *cooling* (3.45) at an appropriate rate

Note 1 to entry: The tempering treatment could be done one time or more times, especially tool steels should be tempered at least two times.

Note 2 to entry: Depending of the tempering temperature the hardness will be reduced and the toughness will be increased.

Note 3 to entry: Tempering can also, in certain cases, cause an increase in hardness. See *secondary hardening* (3.177).

3.204
tempering curve
tempering diagram
graphical representation of the relationship between mechanical properties and tempering temperature for specified tempering times

3.205
thermal crack
crack or fissures of heat treated workpieces caused by too big differences of internal stresses between surface and core at *heating* (3.109), *cooling* (3.45) or quench-hardening operation

Note 1 to entry: Generally, the term crack is qualified by an indication of the conditions under which the crack appeared, e.g. heating crack, quenching crack, etc.

3.206
thermal cycle
variation of temperature as a function of time during *heat treatment* (3.108)

3.207
thermochemical treatment
heat treatment (3.108) in a medium suitably chosen to enrich the surface layer of a workpiece with desired elements such as carbon or nitrogen

Note 1 to entry: The process parameters of the thermochemical treatment can be controlled by instruments and data processing.

Note 2 to entry: The targets of thermomechanical treatments are to produce a fine grain, tough and high tensile structure which cannot be achieved or repeated by heat treatment alone and improved weldability and formability of a steel product.

3.208
thermomechanical control process
TMCP
controlled rolling process in which the final deformation is carried out in a certain temperature range followed by air cooling or controlled cooling

Note 1 to entry: Leading to a material condition with certain properties which cannot be achieved or repeated by *heat treatment* (3.108) alone, thermomechanical rolling can include *tempering* (3.203), including *self-tempering* (3.16) but excluding *direct quenching* (3.68) and *quenching and tempering* (3.169).

3.209
through-hardening
quench hardening (3.167) to achieve *martensite* (3.137) forming up to the core of a workpiece

Note 1 to entry: Depending on the geometry of the workpiece, steel used and conditions during the hardening process, it could not always be possible to get a core microstructure only consisting of 100 % martensite.

3.210
transformation diagram
presentation of *austenite* (3.12) transformation of ferrous materials in dependence of time and temperature for a given steel composition

Note 1 to entry: Set of curves drawn in a semi-logarithmic coordinate system with logarithmic time/temperature coordinates which define, for each level of temperature, the transformation of austenite as beginning and ending the transformation to other *phases* (3.156).

Note 2 to entry: At the end of transformation, the amount of constituents of the microstructure and the hardness can be read out.

3.210.1
time-temperature-transformation diagram
TTT diagram
diagram which presents isothermal transformation of *austenite* (3.12)

Note 1 to entry: TTT diagrams can read out after the end of transformation, the volume-% of each *phase* (3.156) and its hardness.

3.210.2
continuous-cooling-transformation diagram
CCT diagram
diagram which presents continuous cooling transformation of *austenite* (3.12)

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 can be read out.

3.211
transformation point
temperature of transformations from one microstructures to another microstructures

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.

3.212
transformation range
interval of temperature within which a product undergoes a change of *phase* (3.156)

3.213
transformation temperature
temperature at which a change of *phase* (3.156) 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 can be distinguished in steels:

— A_1, equilibrium temperature defining the lower limit of existence of *austenite* (3.12);

— A_3, equilibrium temperature defining the upper limit of existence of *ferrite* (3.85);

— A_m, equilibrium temperature defining the upper limit of existence of *cementite* (3.39) in *hypereutectoid steels* (3.117);

— M_s, temperature at which the austenite begins to transform into *martensite* (3.137) during *cooling* (3.45);

— 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.

3.214
two-stage nitriding
nitriding (3.143) with at least one change in the nitriding conditions (temperature and/or gas composition), intended to reduce the thickness of the compound layer

3.215
vapour film
film formed on the piece to be hardened in the first stage of water and oil quenching

3.216
vanadizing
surface treatment into and on a workpiece (3.201) relating to vanadium

3.217
water emulsion
polymer solution
quenching media (3.170) which is a mixture of water and polymers

Note 1 to entry: Water emulsion allows slower *cooling rate* (3.48) than water and helps to avoid cracks and *distortion* (3.70).

3.218
Widmannstaetten structure
structure resulting from the formation of a new *phase* (3.156) along certain crystallographic planes in the parent solid solution

Note 1 to entry: In the case of *hypoeutectoid steel* (3.118), it appears in a metallographic section in the form of ferrite needles in a *pearlite* (3.155) background. In the case of *hypereutectoid steels* (3.117), the needles consist of *cementite* (3.39).

3.219
work hardening
strain hardening
strengthening of a metal by deformation

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

Note 2 to entry: Work-hardened structure can be removed by recrystallization heat treatment.

Annex A
(informative)

Equivalent terms

Table A.1 gives the alphabetical list of terms defined in this document and their equivalents. The following rules have been applied in preparing this table:

— one single equivalent per language has been used for one given term;

— the same equivalents have been used for a term and its synonym.

Table A.1 — Equivalent terms

English	Ref. No.[a]	French	German	Chinese	Japanese
A					
acicular structure	3.1	structure acicu-laire	Nadelförmiges Gefüge/ Nadeliges Gefüge	针状结构	針状組織
activity	3.2	activité	Aktivität	活度	活量
ageing	3.3	vieillissement	Altern	时效	時効
air hardening steel	3.4	auto-trempant (acier)	Lufthärtender Stahl	空冷淬硬钢	空冷硬化鋼
alpha iron	3.5	fer α	α-Eisen	α铁	α鉄
alpha mixed crystal	3.6	avec présence de ferrite	α-Mischkristall	α固溶体	–
aluminizing	3.7	aluminisation	Aluminieren	渗铝	アルミナイジング
annealing	3.8	recuit	Glühen	退火	焼なまし
ausferrite	3.9	austénite-ferrite (structure)	Ausferrit	奥铁体	オースフェライト
ausforming	3.10	austéniformage	Austenitformhärten	奥氏体形变热处理	オースフォーム
austempering	3.11	trempe étagée bainitique	Austempern	等温淬火 贝氏体等温淬火	オーステンパ
austenite	3.12	austénite	Austenit	奥氏体	オーステナイト
austenitic steel	3.13	acier austénitique	Austenitischer Stahl	奥氏体钢	オーステナイト鋼
austenitizing	3.14	austénitisation	Austenitisieren	奥氏体化	オーステナイト化
austenitizing temperature	3.15	température d'austénitisation	Austenitisiertemperatur	奥氏体化温度	オーステナイト化温度
auto-tempering/ self-tempering	3.16	auto-revenu	Selbstanlassen	自回火	オートテンパ
B					
bainite	3.17	bainite	Bainit	贝氏体	ベイナイト
bainitizing	3.18	bainitisation	Bainitisieren	贝氏体化	ベイナイタイジング
bake hardening steel	3.19	acier à bake hardening	Bake-hardening-Stahl	烘烤硬化钢	塗装焼付硬化型鋼

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
baking	3.20	déshydrogénation	Dehydrieren; Wasserst-offentzug Durch Glühen	脱氢处理	ベイキング
banded structure	3.21	bandes (structure de)	Zeilengefüge; Zeilen-struktur	带状组织	しま状組織
blacking	3.22	brunissage	Brünieren	表面氧化处理	黒化
black nitriding	3.23	nitruration noire	(no German equivalent)	渗氮氧化	黒色窒化
blank nitriding	3.24	nitruration à blanc	Blindnitrieren	空白渗氮	ブランク窒化
batch annealing/ box annealing	3.25	recuit base	Haubenglühen	罩式退火/ 装箱退火	箱焼なまし
blueing	3.26	bleuissage	Bläuen	发蓝处理	ブルーイング
boost-diffuse carbur-izing	3.27	cémentation étagée	Mehrstufiges Aufkohlen	加速扩散渗碳	ブースト拡散浸炭
boriding	3.28	boruration	Borieren	渗硼	ボライディング
bright annealing	3.29	recuit blanc	Blankglühen	光亮退火	光輝焼なまし
burning	3.30	brûlure	Verbrennung	过烧	バーニング
C					
carbon activity	3.31	activité du car-bone	Kohlenstoffaktivität; C-Aktivität	碳活度	炭素の活量
carbon mass transfer coefficient	3.32	coefficient de transfert du car-bone	Kohlenstoffüber-gangszahl	碳传递系数	炭素の質量移動係数
carbon level	3.33	teneur en carbone	Kohlenstoffpegel	碳含量	カーボンレベル
carbon profile	3.34	courbe de répart-ition du carbone	Kohlenstoffverlauf	碳含量分布	炭素濃度の変化推移
carbonitriding	3.35	carbonitruration	Carbonitrieren	碳氮共渗	浸炭窒化
carburizing	3.36	cémentation	Aufkohlen	渗碳	浸炭
case hardening	3.37	(no French equiva-lent)	Einsatzhärten	表面硬化	はだ焼き
cast iron	3.38	fonte	Gusseisen	铸铁	鋳鉄
cementite	3.39	cémentite	Zementit	渗碳体	セメンタイト
chromizing	3.40	chromisation	Chromieren	渗铬	クロマイジング
compound layer	3.41	couche de combi-naison	Verbindungsschicht	化合物层	化合物層
continuous annealing	3.42	recuit continu	Kontinuierliches Glühen	连续退火	連続焼なまし、連続焼鈍
continuous-cooling-transformation diagram (CCT diagram)	3.43	diagramme de transformation en refroidisse-ment continu (en conditions aniso-thermes) (diagramme TRC)	Kontinuierliches Zeit-Temperature-Umwandlungsschaubild (Kontinuierliches ZTU-Schaubild)	连续冷却转变图(CCT图)	連続冷却変態曲線 (CCT線図)
controlled rolling	3.44	laminage contrôlé	Kontrolliertes Walzen	控制轧制	制御圧延
cooling	3.45	refroidissement	Abkühlen	冷却	冷却
cooling conditions	3.46	refroidissement (mode de)	Abkühlbedingungen	冷却条件	冷却

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
cooling function	3.47	refroidissement (loi de)	Abkühlfunktion	冷却函数	冷却関数
cooling rate	3.48	refroidissement (vitesse de)	Abkühlgeschwindigkeit	冷却速度	冷却速度
cooling time	3.49	refroidissement (durée de)	Abkühldauer	冷却时间	冷却時間
core refining	3.50	affinage à cœur	(no German equivalent)	心部晶粒细化	芯部調質
critical cooling course	3.51	refroidissement critique (intervalle de)	Kritischer Abkühlverlauf	临界冷却过程	臨界冷却推移
critical cooling rate	3.52	refroidissement critique (vitesse de)	Kritische Abkühlgeschwindigkeit	临界冷却速度	臨界冷却速度
critical diameter	3.53	diamètre critique de trempe	Kritischer Durchmesser	临界直径	臨界直径
D					
decarburization	3.54	décarburation	Entkohlung	脱碳	脱炭
decarburizing	3.55	décarburation (traitement de)	Entkohlen	脱碳处理	脱炭処理
decomposition of austenite	3.56	décomposition de l'austénite	Austenitzerfall	奥氏体分解	オーステナイトの分解
delta iron	3.57	fer δ	δ-Eisen	δ铁	デルタ(δ)鉄
depth of carburizing/ carburizing depth	3.58	profondeur de cémentation	Aufkohlungstiefe	渗碳层深度	浸炭深さ
depth of decarburization/ decarburization depth	3.59	profondeur décarburée	Entkohlungstiefe	脱碳层深度	脱炭層深さ
depth of hardening	3.60	profondeur de durcissement par trempe	Einhärtungstiefe	硬化层深度	焼入硬化層深さ
depth of nitriding/ nitriding depth	3.61	profondeur de nitruration	Nitriertiefe	渗氮层深度	窒化層深さ
destabilization of retained austenite	3.62	déstabilization de l'austénite résiduelle	Destabilizierung des Restaustenits	残留奥氏体的不稳定性	残留オーステナイトの不安定化
diffusion	3.63	diffusion	Diffusion	扩散	拡散
diffusion annealing	3.64	recuit de diffusion	Diffusionsglühen	扩散退火/均匀化退火	拡散焼なまし
diffusion treatment	3.65	diffusion (traitement thermique ou opération de)	Diffusionsbehandlung	扩散处理	拡散処理
diffusion zone	3.66	zone de diffusion	Diffusionszone	扩散层	拡散域
direct-quench hardening	3.67	durcissement par trempe directe (traitement de)	Direkthärten	直接淬火硬化处理	直接焼入処理
direct quenching	3.68	trempe directe	Direktabschrecken	直接淬火	直接焼入れ
dislocation	3.69	dislocation	Versetzung	位错	転位
distortion	3.70	déformation (de traitement thermique)	Verzug (durch Wärmebehandlung)	变形	変形

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
double-quench hardening treatment	3.71	durcissement par double trempe (traitement de)	Doppelhärten	二次淬火硬化	二重焼入硬化処理
E					
effective case depth after carburizing/ case-hardening hardness depth/ carburizing depth	3.72	profondeur conventionnelle de cémentation	Effektive Einsatzhärtetiefe	渗碳有效硬化层深度	浸炭後の有効焼入硬化深さ
effective case depth after nitriding	3.73	profondeur conventionnelle de nitruration	Effektive Nitriertiefe	渗氮有效硬化层深度	窒化後の有効焼入硬化深さ
effective case depth after surface hardening/ surface hardening hardness depth	3.74	profondeur conventionnelle de durcissement par trempe après chauffage superficiel	Effektive Einhärtetiefe nach Randschichthärten	表面淬火有效硬化层深度	表面硬化後の有効焼入硬化深さ
electron beam hardening	3.75	durcissement par faisceau d'électrons	Elektronenstrahlhärten	电子束硬化处理	電子ビーム焼入れ
embrittlement	3.76	fragilisation	Versprödung	脆性	脆化
endogas	3.77	(no French equivalent)	Endogas	吸热式气体	エンドガス
endothermic atmosphere	3.78	atmosphère endothermique	Endotherme Atmosphäre	吸热式气氛	吸熱性雰囲気
epsilon carbide	3.79	carbure ε	ε-Carbid	ε碳化物	イプシロン炭化物
equalization	3.80	(no French equivalent)	Durchwärmen	均温	均等化
equilibrium diagram	3.81	diagramme d'équilibre	Gleichgewichtsdiagramm	平衡相图	当量線図
equivalent diameter	3.82	diamètre équivalent	Äquivalenter durchmesser	当量直径	当量直径
eutectoid transformation	3.83	eutectoïde (transformation)	Eutektoide umwandlung	共析转变	共析変態
exothermic atmosphere	3.84	atmosphère exothermique	Exotherme atmosphäre	放热式气氛	発熱性雰囲気
F					
ferrite	3.85	ferrite	Ferrit	铁素体	フェライト
ferritic steel	3.86	acier ferritique	Ferritischer stahl	铁素体钢	フェライト鋼
flame hardening	3.87	(no French equivalent)	Flammhärten	火焰淬火	炎焼入れ
fluidized bed	3.88	lit fluidisé	Wirbelschicht	流态床	流動床
full annealing	3.89	recuit complet	(no German equivalent)	完全退火	完全焼なまし
furnace atmosphere	3.90	atmosphère de four	Ofenatmosphäre	炉内气氛	炉内雰囲気
G					
gamma iron	3.91	fer γ	γ-Eisen	γ铁	γ鉄

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
gamma mixed crystal	3.92	avec présence d'austénite	γ-Mischkirstall	γ固溶体	–
gas quenching	3.93	trempe par gaz	Gasabschrecken	气冷淬火	ガス焼入れ
grain	3.94	grain	Korn	晶粒	結晶粒
grain boundary	3.95	joint du grain	Korngrenze	晶界	結晶粒界
grain coarsening	3.96	grossissement du grain (recuit de)	Grobkornglühen	晶粒粗化	結晶粒粗大化
grain growth	3.97	grossissement de grain	Kornwachstum	晶粒长大	結晶粒成長
grain refining	3.98	affinement de grain	Kornfeinung	晶粒细化	結晶粒微細化
grain size	3.99	taille de grain	Korngrösse	晶粒度	結晶粒度
graphitic steel	3.100	acier graphitique	Graphitischer Stahl	石墨化钢	黒鉛鋼
graphitization	3.101	graphitisation	Graphitisierung	石墨化	黒鉛化
graphitizing	3.102	graphitisation (traitement de)	Graphitisieren	石墨化处理	黒鉛化焼なまし
H					
hardenability	3.103	trempabilité	Härtbarkeit	淬透性	焼入性
hardening temperature	3.104	température de durcissement	Härtetemperatur	硬化温度	焼入温度
heat conduction	3.105	conduction thermique	Wärmeleitung	热传导	熱伝導
heat convection	3.106	convection thermique	Wärmekonvektion	热对流	熱対流
heat radiation	3.107	radiation thermique	Wärmestrahlung	热辐射	熱放射
heat treatment	3.108	traitement thermique	Wärmebehandlung	热处理	熱処理
heating	3.109	chauffage	Aufheizen	加热	加熱
heating duration	3.110	chauffage (durée de)	Wärmedauer	加热时间	加熱時間
heating function	3.111	chauffage (loi de)	Aufheizfunktion	加热函数	加熱関数
heating rate	3.112	vitesse de chauffage/ vitesse de chauffe	Aufheizgeschwindigkeit	加热速度	加熱速度
homogenizing	3.113	homogénéisation (recuit de)	Diffusionsglühen	均匀化	拡散焼なまし
hot forming	3.114	formage à chaud	Warmumformung	热成形	熱間加工
hydrogen embrittlement	3.115	fragilisation par l'hydrogène	Wasserstoffversprödung	氢脆	水素ぜい(脆)化
hydrogen removal annealing	3.116	recuit de deshydrogènation	Glühen Zum Entfernen des Wasserstoffs	去氢退火	脱水素焼なまし
hypereutectoid steel	3.117	hypereutectoïde (acier)	Übereutektoider Stahl	过共析钢	過共析鋼
hypoeutectoid steel	3.118	hypoeutectoïde (acier)	Untereutektoider Stahl	亚共析钢	亜共析鋼
I					

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
impulse hardening	3.119	durcissement par impulsions	Impulshärten	脉冲淬火	衝撃焼入れ
impulse heating	3.120	impulsions (chauffage par)	Impulswärmen	脉冲加热	衝撃加熱
induction hardening	3.121	durcissement par induction	Induktionshärten	感应淬火	高周波焼入れ
inter-critical annealing/ inter-critical treatment	3.122	recuit intercritique/ traitement intercritique	$\alpha + \gamma$ –Glühen $\alpha + \gamma$ –Behandlung	临界区退火/ 临界区处理	変態域内焼なまし/ 変態域内処理
intermetallic compound	3.123	intermétallique (composé)	Intermetallische verbindung	金属间化合物	金属間化合物
internal oxidation	3.124	oxydation interne	Innere Oxidation	内氧化	内部酸化
interrupted quenching	3.125	trempe interrompue	Unterbrochenes Abschrecken	双介质淬火/双液淬火	中断焼入れ
isoforming	3.126	isoformage	Umformperlitisieren	等温形变珠光体化处理	イソフォーム
isothermal annealing	3.127	recuit isotherme	Isothermes Glühen	等温退火	等温焼なまし
J					
Jominy test/ end-quenching test	3.128	Jominy (essai)	Stirnabschreckversuch	末端淬透性试验	ジョミニー試験 / 一端焼入試験
L					
laser beam hardening	3.129	durcisssement superficiel laser	Oberflächenhärtung mittles Laser	激光表面淬硬处理	レーザー焼入れ
Ledeburite	3.130	Lédéburite	Ledeburit	莱氏体	レーデブライト
local hardening	3.131	durcissement local par trempe	Lokales Härten	局部淬火	部分焼入れ
low pressure carburizing	3.132	cémentation sous pression réduite	Niederdruckaufkohlung	低压渗碳	低圧浸炭
M					
malleablizing	3.133	malléabilisation (recuit de)	Tempern	可锻化退火	マリーブライジング
maraging	3.134	maraging (traitement de)	Martensitaushärten	马氏体时效处理	マルエージ
maraging steel	3.135	acier maraging	Martensitaushärtender stahl	马氏体时效钢	マルエージ鋼
martempering	3.136	trempe étagée martensitique	Warmbadhärten	马氏体分级淬火/分级淬火	マルテンパ
martensite	3.137	martensite	Martensit	马氏体	マルテンサイト
maximum achievable hardness	3.138	capacité de durcissement par trempe	Aufhärtbarkeit	可达到的最大硬度	最高到達硬さ
McQuaid-Ehn grain size test	3.139	détermination de la taille de grain par la méthode de McQuaid-Ehn	Prüfung der Korngröße nach McQuaid-Ehn	麦奎德—埃恩奥氏体晶粒度试验	マッケイドエーン結晶粒度試験
medium	3.140	milieu	Mittel; medium	介质	媒体
metastable	3.141	métastable	Metastabil	亚稳定状态	準安定

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
N					
nitride	3.142	nitrure	Nitrid	氮化物	窒化物
nitriding	3.143	nituration	Nitrieren	渗氮	窒化
nitrocarburizing	3.144	nitrocarburation	Nitrocarburieren	碳氮共渗	炭窒化
nitrogen profile	3.145	profil d'azote	Stickstoffprofil	氮的分布	窒素濃度の変化推移
normalizing	3.146	normalization (traitement de)	Normalglühen	正火	焼ならし
normalizing forming	3.147	formage normalisant	Noramlisierendes Umformen	正火成形	焼ならし加工
O					
overcarburizing/ excess carburizing	3.148	surcarburation	Überkohlung	过渗碳	過浸炭
overheating/ oversoaking	3.149	surchauffe	Überhitzen/ (no German equivalent)	过热/过保温	過熱及び過均熱
oxidation	3.150	oxydation	Oxidation	氧化	酸化
oxidizing	3.151	oxydante	Oxidieren	氧化处理	酸化処理
oxynitriding	3.152	oxynitruration	Oxynitrierung	氧氮共渗	酸窒化
P					
parent phase	3.153	phase-mère	Mutterphase	母相	母相
patenting	3.154	patentage	Patentieren	派登脱处理/索氏体化处理	パテンチング
pearlite	3.155	perlite	Perlit	珠光体	パーライト
phase	3.156	phase	Phase	相	相
plasma nitriding	3.157	nitruration par plasma	Plasmanitrieren	离子渗氮	プラズマ窒化
plasma nitrocarburizing	3.158	carbo-nitruration par plasma	Plasmacarbonitrieren	离子碳氮共渗	プラズマ炭窒化
potential	3.159	potentiel	Potential	化学势	ポテンシャル
precipitation growth	3.160	accroissement/ grossissement de la précipitation	Ausscheidungswachstum	析出长大	析出物成長
precipitation hardening	3.161	durcissement par précipitation	Ausscheidungshärtung	沉淀硬化	析出硬化
precipitation hardening treatment	3.162	durcissement par précipitation (traitement de)	Aushärten	沉淀硬化处理	析出硬化処理
preheating	3.163	préchauffage	Vorwärmen	预热	予熱
proeutectoid constituent	3.164	proeutectoïde (constituant)	Voreutektoide Ausscheidung	先共析体	初析構成成分
protective gas	3.165	gaz protecteur/ atmosphère protectrice	Schutzgas	保护性气体	保護雰囲気ガス
Q					
quench-hardened layer	3.166	couche durcie par trempe	Einhärtungsschicht	淬火硬化层	焼入硬化層
quench hardening	3.167	durcissement par trempe	Abschreckhärten	淬火硬化	焼入硬化

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
quenching	3.168	trempe	Abschrecken	淬火	焼入れ
quenching and tempering	3.169	trempe et revenu	Vergüten	淬回火	焼入焼戻し
quenching media	3.170	milieu de trempe	Abschreckmedium	淬火介质	焼入媒体
quenching temperature	3.171	température de trempe	Abschrecktemperatur	淬火温度	焼入温度
R					
recarburizing/ carbon restauration	3.172	recarburation	Wiederaufkohlen	增碳处理	復炭
recovery	3.173	restauration (traitement de)	Erholung	回复	回復
recrystallizing	3.174	recristallisation (traitement de)	Rekristallisationsglühen	再结晶	再結晶
retained austenite	3.175	austénite résiduelle	Restaustenit	残留奥氏体	残留オーステナイト
S					
scale	3.176	calamine	Skala	氧化铁皮	酸化スケール
secondary hardening	3.177	durcissement secondaire	Sekundärhärtung	二次硬化	二次硬化
secondary martensite	3.178	martensite secondaire	Sekundärmartensit	二次马氏体	二次マルテンサイト
segregation	3.179	ségrégation	Segregation	偏析	偏析
self-quenching	3.180	auto-trempe	Selbstabschrecken	自淬火	自己焼入れ
sensitization	3.181	sensibilisation	Sensibilisierung	敏化	鋭敏化
sherardizing	3.182	shérardisation	Diffusionsverzinken; Sherardisieren	渗锌	シェラダイジング
siliconizing	3.183	siliciuration	Silizieren	渗硅	シリコナイジング
single-quench hardening treatment	3.184	durcissement par simple trempe (traitement de)	Einfachhärten	单淬火硬化处理	単一焼入硬化処理
soaking	3.185	maintien (à température)	Halten	保温	均熱
softening/ soft annealing	3.186	recuit d'adoucissement	Weichglühen	软化/软退火	軟化 / 軟化焼なまし
solid solution	3.187	solution solide	Feste Lösung Mischkristall	固溶体	固溶体
solution annealing/ solution treatment	3.188	mise en solution (traitement de) ou hyper trempe	Lösungsglühen/ Lösungsbehandeln	固溶退火/固溶处理	固溶化焼なまし / 固溶化熱処理
spheroidal graphite iron	3.189	fonte à graphite sphéroidal	Gusseisen mit Kugelgraphit	球墨铸铁	球状黒鉛鋳鉄
spheroidite	3.190	(no French equivalent)	Spheroidit	球状渗碳体	球状組織
spheroidizing	3.191	globularisation (recuit de)	Glühen auf Kugelige Karbide	球化处理	球状化
stabilization of retained austenite	3.192	stabilization de l'austénite résiduelle	Stabilizierung des Restaustenits	残留奥氏体的稳定化	残留オーステナイトの安定化

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
stabilizing	3.193	stabilization (traitement de)	Stabilizieren	稳定化	安定化熱処理
stabilizing annealing	3.194	stabilization de l'austénite (recuit de)	Stabilglühen	稳定化退火	安定化焼なまし
steel	3.195	acier	Stahl	钢	鋼
step quenching	3.196	trempe étagée	Gestuftes Abschrecken	分级淬火	段階焼入れ
stress relieving	3.197	relaxation (traitement de)	Spannungsarmglühen	消除应力	応力除去
sub-zero treating/ deep freezing	3.198	traitement par le froid	Tieftemperaturbehandeln; Tiefkühlen	冷处理, 深度冷冻	サブゼロ処理
sulfidizing	3.199	sulfonitrocarburation	Sulfonitrocarburieren	硫氮碳处理	サルファライジング
surface hardening treatment	3.200	durcissement par trempe après-chauffage superficiel (traitement de)	Randschichthärten	表面淬火	表面硬化処理
surface treatment	3.201	traitement de surface dans et sur une pièce	Oberflächenbehandlung	表面处理	表面処理
T					
temper embrittlement	3.202	fragilité de revenu	Anlassversprödung	回火脆性	焼戻ぜい性
irreversible temper embrittlement/ blue brittlement	3.202.1	fragilisation irréversible par traitement thermique/ fragilisation au bleu	Irreversible Anlassversprödung/ Blausprödigkeit	不可逆回火脆性/ 蓝脆	不可逆的焼戻ぜい性
reversible temper embrittlement	3.202.2	fragilisation réversible par traitement thermique	Anlassversprödung Reversible	可逆回火脆性	可逆的焼戻ぜい性
tempering	3.203	revenu	Anlassen	回火	焼戻し
tempering curve/ tempering diagram	3.204	courbe de résistance au revenu	Anlasschaubild	回火曲线, 回火图	焼戻曲線
thermal crack	3.205	tapure	Wärmebehandlungsriss	热裂	熱亀裂
thermal cycle	3.206	cycle thermique	Zeit-Temperatur-Folge	热循环	熱サイクル
thermochemical treatment	3.207	traitement thermomécanique	Thermochemische Behandlung	化学热处理	熱化学熱処理
thermomechanical control process (TMCP)	3.208	procédé de traitement thermomécanique contrôlé	Thermomechanischer Kontrollierter Prozess	热机械控制工艺/控轧控冷工艺(TMCP)	熱加工制御(TMCP)
through-hardening	3.209	durcissement par trempe à cœur	Durchhärtung	淬透	全断面焼入硬化
transformation diagram	3.210	diagramme de transformation	Umwandlungsschaubild	转变图	変態曲線(TT線図)

[a] Reference number of the term in this document.

Table A.1 *(continued)*

English	Ref. No.[a]	French	German	Chinese	Japanese
time-temperature-transformation diagram/ TTT diagram	3.210.1	diagramme de transformation isotherme	Isothermes Zeit-Temperatur-Umwandlungsschaubild (Isothermes ZTU-Schaubild)	等温转变图/ TTT图	等温変態曲線 (TTT線図)
continuous-cooling-transformation diagram/ CCT diagram	3.210.2	diagramme de transformation en refroidissement continu (en conditions anisothermes)	Kontinuierliches Zeit-Temperatur-Umwandlungsschaubild (Kontinuierliches ZTU-Schaubild)	连续冷却转变图/ CCT图	連続冷却変態曲線(CCT線図)
transformation point	3.211	point de transformation	Umwandlungspunkt	转变点	変態点
transformation range	3.212	intervalle critique	Umwandlungsbereich	转变范围	変態領域
transformation temperature	3.213	température de transformation	Umwandlungstemperatur/ Umwandlungspunkt	相变温度	変態温度
two-stage nitriding	3.214	nitruration séquencée	Zweistufiges nitrieren	两段渗氮	二段窒化
V					
vapour film	3.215	film de vapeur	Dampffilm	蒸汽膜	蒸気膜
vanadizing	3.216	vanadisation	Vanadieren	渗钒	バナダイジング
W					
water emulsion/ polymer solution	3.217	emulsion acqueuse	Wässrige Emulsion/ Polymerlösung	聚合物水溶液 淬火介质	水溶性焼入液 / ポリマー焼入液
Widmannstaetten structure	3.218	structure de Widmannstätten	Widmannstätten Struktur	魏氏组织	ウイドマンステッテン組織
work hardening/ strain hardening	3.219	durcissement par écrouissage	Kaltverfestigung	加工硬化/ 应变硬化	加工硬化 / ひずみ硬化

[a] Reference number of the term in this document.

Bibliography

[1] ISO 642, *Steel – Hardenability test by end quenching (Jominy test)*

[2] ISO 643, *Steels — Micrographic determination of the apparent grain size*

[3] ISO 683-1, *Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering*

[4] ISO 683-2, *Heat-treatable steels, alloy steels and free-cutting steels — Part 2: Alloy steels for quenching and tempering*

[5] ISO 2639, *Steels — Determination and verification of the depth of carburized and hardened cases*

[6] ISO 3754, *Steel — Determination of effective depth of hardening after flame or induction hardening*

[7] ISO 3887, *Steels — Determination of depth of decarburization*

[8] ISO 4948-1, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*

[9] ISO 4948-2, *Steels — Classification — Part 2: Classification of unalloyed and alloy steels according to main quality classes and main property or application characteristics*

[10] ISO 15787, *Technical product documentation — Heat-treated ferrous parts — Presentation and indications*

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

[12] Metals Handbook, Volume 4, 1999

[13] Neumann F. Der Potentialbegriff und seine Aussage im Rahmen thermochemischer Prozesse — Kohlenstoffpotential — Stickstoffpotential — Sauerstoffpotential, Härterei-Techn. Mitt. 33 (1978) 4, p. 192–200.

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