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Definitions of Heat Treating Terms

RATIONALE

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1. **Scope**—(These definitions were prepared by the Joint Committee on Definitions of Terms Relating to Heat Treatment appointed by the American Society for Testing and Materials, The American Society for Metals, the American Foundrymen's Association, and the SAE.) This SAE revision emphasizes the terms used in heat treating ferrous alloys, but also includes for reference some non-ferrous definitions at the end of the document.

This glossary is not intended to be a specification, and it should not be interpreted as such. Since this is intended to be strictly a set of definitions, temperatures have been omitted purposely.

2. **References**

- 2.1 **Applicable Publications**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J418—Grain Size Determination

SAE J763—Aging of Carbon Steel Sheet and Strip

SAE J940—Glossary of Carbon Steel Sheet and Strip Terms

3. **Definitions**

- 3.1 **Ac_{cm}, Ac₁, Ac₃, Ac₄**—Defined under Transformation Temperature.
- 3.2 **Ae_{cm}, Ae₁, Ae₃, Ae₄**—Defined under Transformation Temperature.
- 3.3 **Age Hardening**—Hardening by aging, usually after rapid cooling or cold working. See Aging.

- 3.4 Aging**—A generic term denoting a time-temperature-dependent change in the properties of certain alloys. Except for strain aging and age softening, it is the result of precipitation from a solid solution of one or more compounds whose solubility decreases with decreasing temperature. For each alloy system susceptible to aging, there is a unique range of time-temperature combinations to which the system will respond. See also Age Hardening, Artificial Aging, Age Softening, Natural Aging, Overaging, Peak Aging, Precipitation Hardening, Precipitation Heat Treatment, Quench Aging, Strain Aging, and Underaging.
- 3.5 Annealing**—A generic term denoting a treatment, consisting of heating at an appropriate rate to a suitable temperature, holding for an appropriate time, and cooling at a suitable rate. Used primarily to soften metallic materials, but also to simultaneously produce desired changes in other properties or in microstructure. The purpose of such changes may be, but is not confined to, one or more of: (a) improvement of machinability; (b) facilitation of cold work; (c) improvement of mechanical or electrical properties or increase in stability of dimensions.
- The time-temperature cycles used vary widely in heating rate, maximum temperature attained, and in cooling rate employed, depending on the composition of the material, its condition, and the results desired. When applicable, the following more specific commercial process names should be used: Black Annealing, Blue Annealing, Box Annealing, Bright Annealing, Cycle Annealing, Flame Annealing, Full Annealing, Graphitizing, In-Process Annealing, Isothermal Annealing, Malleabilizing, Orientation Annealing, Process Annealing, Quench Annealing, and Spheroidizing. When the term is used without qualification full annealing is implied. Any process of annealing will usually reduce stresses, but when applied only for the relief of stress, the process is properly called stress relief annealing.
- 3.6 Artificial Aging**—Aging above room temperature. See Aging and Precipitation Heat Treatment. Compare with Natural Aging.
- 3.7 Ausforming**—Mechanically working an appropriate high hardenability steel after quenching from above the upper critical temperature to a temperature between the lower critical and the M_s temperature, and isothermally transforming or quenching to produce the desired properties.
- 3.8 Austempering**—Quenching a ferrous alloy from a temperature above the transformation range, in a medium having a rate of heat extraction sufficient to prevent the formation of ferrite or pearlite, and then holding the alloy just above M_s until transformation to bainite is complete.
- 3.9 Austenitizing**—Forming austenite by heating a ferrous alloy into the transformation range (partial austenitizing) or above the transformation range (complete austenitizing). When used without qualification, the term implies complete austenitizing.
- 3.10 Austentic Nitrocarburizing**—A lower-temperature variant of carbonitriding, austenitic nitrocarburizing is applied to ferrous materials at typical processing temperatures of 676 °C to 774 °C (1250 °F to 1425 °F). The process involves the diffusion of nitrogen and carbon into the surface of the work piece and the formation of a thin white layer of epsilon carbonitrides. Subsurface microstructure includes martensite and bainite which improve the load carrying capability when compared to ferritic nitrocarburizing.
- 3.11 Baking**—Heating to a low temperature usually to remove gases such as hydrogen. Aging may result from baking treatments.
- 3.12 Black Annealing**—Box annealing or pot annealing ferrous alloy sheet, strip, or wire. See Box Annealing.
- 3.13 Blank Carburizing**—Simulating the carburizing operation without introducing carbon. This is usually accomplished by using an inert material in place of the carburizing agent, or by applying a suitable protective coating to the ferrous alloy.

3.14 Blank Nitriding—Simulating the nitriding operation without introducing nitrogen. This is usually accomplished by using an inert material in place of the nitriding agent, or by applying a suitable protective coating to the ferrous alloy.

3.15 Blue Annealing—Heating hot-rolled ferrous sheet in an open furnace to a temperature within the transformation range and then cooling in air, in order to soften the metal, normally with the formation of a bluish oxide on the surface.

3.16 Bluing—Subjecting the scale free surface of a ferrous alloy to the action of air, steam, or other agents at a suitable temperature, thus forming a thin blue film of oxide and improving the appearance and resistance to corrosion and adhesive wear.

NOTE—This term is ordinarily applied to sheet, strip, or finished parts. It is used also to denote the heating of springs after fabrication, in order to improve their properties.

3.17 Box Annealing—Annealing a metal or alloy in a sealed container under conditions that minimize oxidation. In box annealing a ferrous alloy, the charge is usually heated slowly to a temperature below the transformation range, but sometimes above or within it, and is then cooled slowly; this process is also called "close annealing" or "pot annealing." See Black Annealing and SAE J940.

3.18 Bright Annealing—Annealing in a protective medium to prevent discoloration of the bright surface or to produce a bright surface.

3.19 Burning—Permanently damaging a metal or alloy by heating to cause either incipient melting or intergranular oxidation. See Overheating.

3.20 Carbon Potential—A measure of the ability of an environment containing active carbon to alter or maintain, under prescribed conditions, the carbon content of the steel exposed to it.

NOTE—In any particular environment, the carbon level attained will depend on such factors as temperature, time, and steel composition.

3.21 Carbon Restoration—Replacing the carbon lost in the surface layer from previous processing by adding carbon to this layer to substantially the original carbon level.

3.22 Carbonitriding—A case hardening process in which a suitable ferrous material is heated above the lower transformation temperature in a gaseous atmosphere of such composition as to cause simultaneous absorption of carbon and nitrogen by the surface and, by diffusion, create a concentration gradient. The process is completed by cooling at a rate which produces the desired properties in the workpiece.

3.23 Carburizing—A process in which an austenitized ferrous material is brought into contact with a carbonaceous atmosphere of sufficient carbon potential to cause absorption of carbon at the surface and, by diffusion, create a concentration gradient.

3.24 Case—In a ferrous alloy workpiece, the outer discrete layer whose composition has been altered by one of the processes of case hardening.

3.25 Case Hardening—A generic term covering several processes applicable to steel that change the chemical composition of the surface layer by absorption of carbon, nitrogen, or a mixture of the two and, by diffusion, create a concentration gradient. The processes commonly used are: carburizing and quench hardening, cyaniding, nitriding, and carbonitriding. The surface is characteristically harder than the subsurface material. The use of the applicable specific process name is preferred.