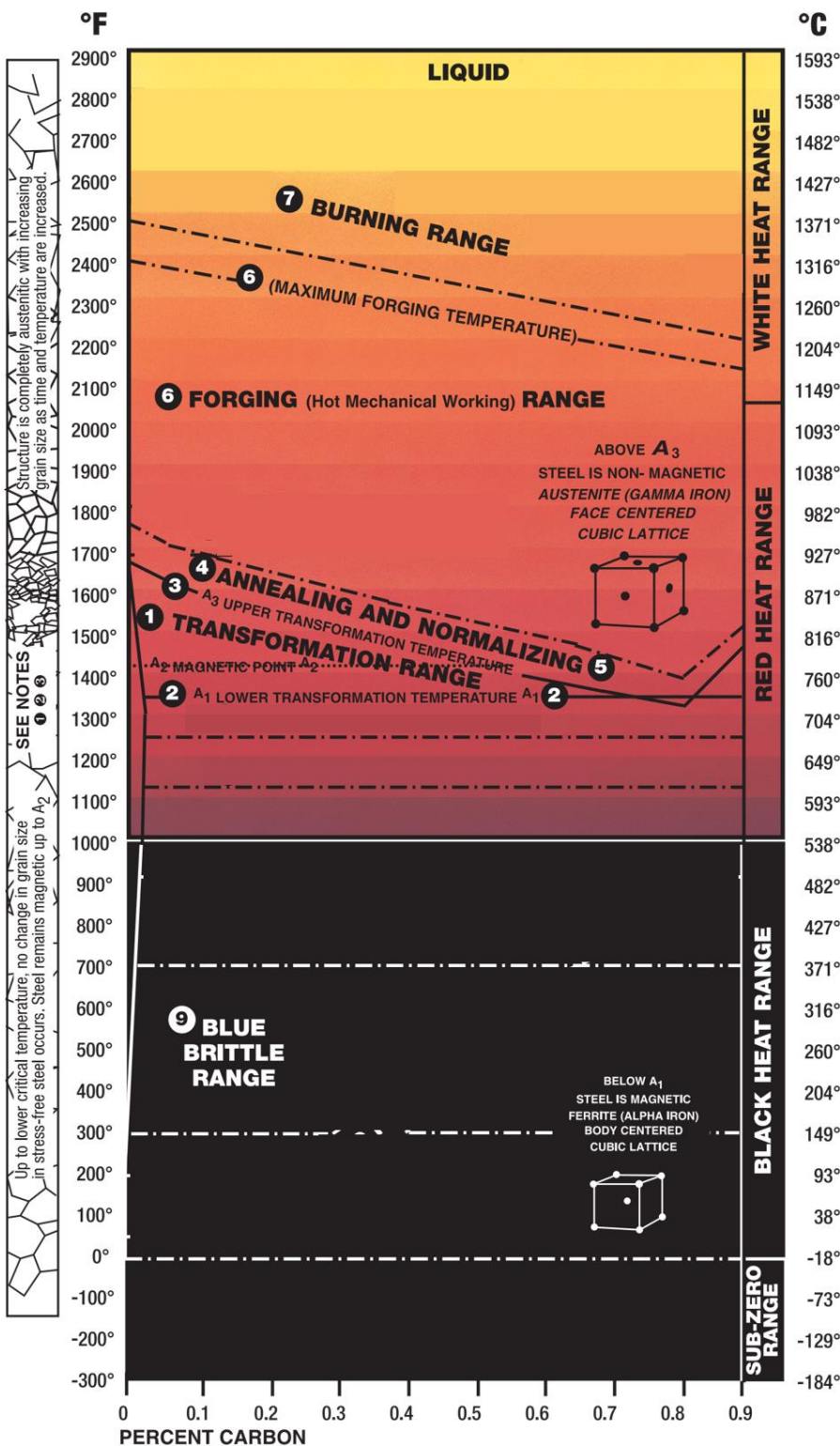




Basic Guide to Ferrous Metallurgy



- ① **TRANSFORMATION RANGE** In this range steels undergo internal atomic changes which radically affect the properties of the material.
- ② **LOWER TRANSFORMATION TEMPERATURE (A₁)**. Termed Ac₁ on heating, Ar₁ on cooling. Below Ac₁ structure ordinarily consists of FERRITE and PEARLITE (see below). On heating through Ac₁ these constituents begin to dissolve in each other to form AUSTENITE (see below) which is non-magnetic. This dissolving action continues on heating through the TRANSFORMATION RANGE until the solid solution is complete at the upper transformation temperature.
- ③ **UPPER TRANSFORMATION TEMPERATURE (A₃)**. Termed Ac₃ on heating, Ar₃ on cooling. Above this temperature the structure consists wholly of AUSTENITE which coarsens with increasing time and temperature. Upper transformation temperature is lowered as carbon increases to 0.85% (eutectoid point).
- **FERRITE** is practically pure iron (in plain carbon steels) existing below the lower transformation temperature. It is magnetic and has very slight solid solubility for carbon.
- **PEARLITE** is a mechanical mixture of FERRITE and CEMENTITE.
- **CEMENTITE** or IRON CARBIDE is a compound of iron and carbide, Fe₃C.
- **AUSTENITE** is the non-magnetic form of iron and has the power to dissolve carbon and alloying elements.
- ④ **ANNEALING**, frequently referred to as FULL ANNEALING, consists of heating steels to slightly above Ac₃, holding for AUSTENITE to form, then slowly cooling in order to produce small grain size, softness, good ductility and other desirable properties. On cooling slowly the AUSTENITE transforms to FERRITE and PEARLITE.
- ⑤ **NORMALIZING** consists of heating steels to slightly above Ac₃, holding for AUSTENITE to form, then followed by cooling (in still air). On cooling, AUSTENITE transforms giving somewhat higher strength and hardness and slightly less ductility than in annealing.
- ⑥ **FORGING RANGE** extends to several hundred degrees above the UPPER TRANSFORMATION TEMPERATURE.
- ⑦ **BURNING RANGE** is above the FORGING RANGE. Burned steel is ruined and cannot be cured except by remelting.
- ⑨ **BLUE BRITTLE RANGE** occurs approximately from 300° to 700°F. Peening or working of steels should not be done between these temperatures, since they are more brittle in this range than above or below it.
- **MARTENSITE** is the hardest of the transformation products of AUSTENITE and is formed only on cooling below a certain temperature known as the M_s temperature (about 400° to 600°F for carbon steels). Cooling to this temperature must be sufficiently rapid to prevent AUSTENITE from transforming to softer constituents at higher temperatures.

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