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Chart for recommended temperature for various steels and non-ferrous metals.

1. Transformation Range. In this range steels undergo internal atomic changes which radically affect the properties of the material.

2. Lower Transformation Temperature (A3). Termed A3 on heating, A3 on cooling. Below A3, structure ordinarily consists of ferrite and pearlite (see below). On heating through A3, these constituents begin to dissolve in each other to form austenite (see below) which is non-magnetic. This dissolution action continues on heating through the transformation range until the solid solution is complete at the upper transformation temperature.

3. Upper Transformation Temperature (A1). Termed A1 on heating, A1 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 is iron carbide is a compound of iron and carbon, 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 A3, 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 A3, 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. Stress Relieving extends to several hundred degrees above the upper transformation temperature.

7. Burning Range is above the forging range. Burned steel is raised and cannot be cured except by remelting.

8. Stress Relieving consists of heating to a point below the lower transformation temperature, A1, holding for a sufficiently long period to relieve locked-up stresses, then slowly cooling. This process is sometimes called Process Annealing.

9. Blue Brittle Range occurs approximately from 300°F to 700°F. Premachining or working of steels should not be done between these temperatures, since they are more brittle in this range than above or below it.

10. Preheating for Welding is carried out to prevent crack formation. See TEMPILO PREHEATING CHART for recommended temperature for various steels and non-ferrous metals.

11. Carburizing consists of dissolving carbon into surface of steel by heating to above transformation range in presence of carburizing compounds.

12. Nitriding consists of heating certain special steels to about 1000°F for long periods in the presence of ammonia gas. Nitrogen is absorbed into the surface to produce extremely hard "skins".

13. Spheroidizing consists of heating to just below the lower transformation temperature, A1, for a sufficient length of time to put the cementite constituent of pearlite into globular form. This produces softness and in many cases good machinability.

14. Martensite is the hardest of the transformation products of austenite and is formed only on cooling below a certain temperature known as the Ms temperature (about 400°F 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.

- Spheroidoid Steel contains approximately 0.85% carbon.
- Pellizing occurs in many alloy steels and is a defect characterized by localized micro-cracking and "baule-like" fracturing. It is usually attributed to hydrogen bursts. Cure consists of cycle cooling to at least 600°F before air-cooling.

- Open or Burning Steel has not been completely deoxidized and the ingot solidifies with a sound surface ("rim") and a core position containing blowholes which are welded in subsequent heat rolling.

- Killed Steel has been deoxidized at least sufficiently to solidify without appreciable gas evolution.

- Semi-Killed Steel has been partially deoxidized to reduce solidification shrinkage in the ingot.

- A Simple Rule: Brinnell Hardness divided by two, times 1000, equals approximate Tensile Strength in pounds per square inch. (200 Brinnell — 2 × 1000 = approx. 100,000 Tensile Strength, p.s.i.)
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