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Elevated Temperature Properties of Cast Irons

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1. Scope—The purpose of this SAE Information Report is to provide automotive engineers and designers with a concise statement of the basic characteristics of cast iron under elevated temperature conditions. As such, the report concentrates on general statements regarding these properties with limited illustrative data, anticipating that those who may be interested in more detail will want to use the bibliography provided at the conclusion of the report.

2. References

2.1 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

2.1.1 OTHER PUBLICATIONS

1. "Mechanical Properties of Metals and Alloys." U.S. Dept. of Commerce Circular C-447, National Bureau of Standards, 1943.
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6. Colin J. Smithell, "Metals Reference Book." Washington Butterworths, 1962.
7. Metals Handbook, 8th Edition. American Society for Metals, 1961.
8. "Engineering Properties of Ductile Ni-Resist Austenitic Irons." International Nickel Co., 1955.
9. Schelleng and Eash, "Effect of Composition on the Elevated-Temperature Properties of Ductile Iron." Proceedings of ASTM, Vol. 57, 1957.
10. Greene and Sefing, "Cast Irons in High Temperature Service." Corrosion, Vol. 11, No. 7, July 1955.
11. Turnbull and Wallace, "Molybdenum Effect on Gray Iron Elevated Temperature Properties." Transactions AFS, Vol. 67, 1959.
12. F. B. Foley, "Mechanical Properties at Temperature of Ductile Cast Iron." Preprint No. 55-A-204, ASME, 1955.
13. Engineering Properties of Ni-Resist Ductile Irons." International Nickel Co., 1958.

14. Elevated Temperature Properties of Ductile Cast Irons." ASM Transactions, Vol. 47, 1955.
15. Scholz, Doane, and Timmons, "Effects of Molybdenum on Stability and High Temperature Properties of Pearlitic Malleable Iron." AFS Transactions, Vol. 63, 1955.
16. D. A. Pearson, "Stress-Rupture and Elongation of Malleable Iron at Elevated Temperatures." AFS Transactions, Vol. 74, 1966.
17. W. L. Collins, "Fatigue and Static Load Tests of an Austenitic Cast Iron at Elevated Temperatures." ASTM Proceedings, Vol. 48, 1948.

3. **Introduction**—Cast irons, like steels and other metals, lose strength as operating temperatures increase. Composition is of importance not only because of its effect on the basic properties of materials at elevated temperatures, but also because in cast irons it influences growth resulting from oxidation and microstructural changes. Irons may be used in most atmospheres at temperatures up to 750 °F without growth being a serious factor. Beyond 900 °F graphitization can cause growth and above 1200 °F internal oxidation can cause growth unless sufficient alloy is present to prevent it.

Deterioration of properties at high temperatures is in general time-dependent as well as temperature-dependent. Even at temperatures where strength has been greatly reduced, many useful hours of life can be obtained from a structure if proper allowances are made in the initial design. Where applications involve sustained stress at high temperature, the most valuable information for the designer is the creep rate at the temperature and stress involved. However, creep rate data generally involve long time tests and as a consequence complete information has not been generated for all materials under all conditions. Instead, it has been the practice for many years to compare materials in shorter duration tests. Such tests are called stress-to-rupture tests or more simply stress-rupture tests. These are conducted in the temperature ranges of interest but usually at much greater loads than any realistic design. In general, materials showing superior stress-rupture life have the lowest creep rates. This type of information has been used primarily for material development work. It can be used by the designer, however, to select better material on a comparison basis.

Several types of iron are included in this section to show trends; they are representative of broad classes of irons used commercially, and for which thermal data are available in the literature.

4. **Effect of Elevated Temperature on Mechanical Properties**

- 4.1 **Tensile Strength**—The tensile strength of ferrous materials generally shows small changes from room temperature up to 600–800 °F, at higher temperature the strengths usually fall rather rapidly. The presence of alloying elements which affect the stability of the higher strength microstructures tends to delay this effect or raise the temperature at which rapid loss of strength occurs. In some ferrous alloys, changes in microstructure occur at temperatures between room temperature and 800 °F which may cause small changes in strength and, in fact, may cause reversals in the strength versus temperature curve. In Figure 1, examples of tensile strength versus temperature for some typical cast irons are illustrated in comparison with the behavior of low carbon steel. Generally, the changes in structure which occur over this temperature range are associated with tempering after hardening. These changes are irreversible.