

Magnesium Alloys—

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1. *Purpose*—This report on magnesium alloys covers those alloys which have been more commonly used in the United States for automotive, aircraft, and missile applications. Basic information on nomenclature and temper designation is given. Design data and many characteristics covered by a purchase specification are not included.

2. *Sources of Magnesium*—Magnesium is the third most abundant structural element in the earth's crust, and considered inexhaustible. Common sources are sea water, natural brines, magnesite, and dolomite. Three methods of extraction are used in the United States. One method involves treating sea water with a source of alkalinity (lime or caustic soda) to precipitate the magnesium as hydroxide, which is then mixed with hydrochloric acid to produce magnesium chloride. The magnesium chloride is reduced electrolytically to produce magnesium metal and a mixture of chlorine and hydrochloric acid. A second method produces coproduct magnesium metal and pure chlorine in the electrolytic cell by the reduction of anhydrous magnesium chloride. The anhydrous cell feed results from the dehydration of natural brines. Another method of extraction which is also used in the United States and in other countries is a thermal reduction method, generally referred to as the ferro-silicon process, employing an alloy of iron and silicon to reduce magnesium oxide. Most of the magnesium ingot sold is of 99.80% purity. Grades of magnesium of 99.90, 99.95, and 99.98% purity are also available. The higher purity grades are used mostly in nuclear applications and for reduction purposes.

3. *Properties*—Magnesium is extremely light with the common alloys having a specific gravity of about 1.8 compared to 2.7 for aluminum. The heavier structural metals like iron, copper, and zinc are approximately four times as heavy as magnesium. Magnesium melts at 1202°F (650°C). The coefficient of thermal expansion between 68–212°F (20–100°C) is approximately 0.000145/°F (0.000261/°C) and is slightly higher than for aluminum, 0.00013/°F (0.00023/°C), and over twice that of steel. The thermal and electrical conductivities of magnesium are relatively high and some alloys approach values comparable to aluminum alloys. The modulus of elasticity is approximately 6 500 000 psi (45 GPa). The pure metal is not used for structural applications. A number of alloys have been developed with good strength-to-weight ratios.

4. *Alloying Elements*—Common alloying elements used in magnesium alloys are aluminum, manganese, rare earths, silver, thorium, zinc, and zirconium. Alloys are stronger than the pure metal but have lower electri-

cal and thermal conductivities. Certain of the alloys respond to heat treatment with an increase in strength and hardness. Another means used to increase the strength of magnesium is by cold work. Most commercial alloys are stable at room temperature. Certain alloying elements such as the rare earths and thorium give better high temperature strength than can be obtained with the more common alloying elements aluminum and zinc.

5. *Alloy Nomenclature*—A designation system for magnesium alloys used commercially and described in ASTM B275, Recommended Practice for Codification of Light Metals and Alloys, Cast and Wrought, was adopted by SAE in 1971. The initial letter(s) represent the major alloying element(s) with the following numeral(s) representing the nominal percent by weight of each element. The final letter is assigned arbitrarily.

6. *Temper Designation*—The same temper designation system is used for both aluminum base and magnesium base alloys. It is described in detail under the aluminum alloy section of this book and in ASTM B 296, Recommended Practice for Temper Designation of Magnesium Alloys, Cast and Wrought.

7. *Working*—Magnesium alloys are available in most commercial forms such as die castings, investment, sand and permanent mold castings, extrusion, forgings, sheet, and plate. It can be formed by drawing, spinning, and pressing. The working is done best at elevated temperatures because of improved workability and freedom from springback. Magnesium can be joined by adhesive bonding, bolting, riveting, and welding. Arc welding, using an inert gas shield, is the most commonly used method of fusion welding. Spot welding is used extensively. Magnesium, in all its forms, can be readily machined with exceptional speed and tool life.

8. *Finishing and Coating*—Bare magnesium is suitable for many applications. Protective finishes may be required to prevent tarnishing or for protection from corrosion in humid industrial or marine atmospheres. It is subject to galvanic attack when coupled to most other metals, and such connections should be adequately protected if moisture will be present. Magnesium can be finished by plating and painting for either protection or decoration.

9. *Testing*—Magnesium alloys are tested like other metals using standard ASTM methods. The tensile and compressive yield strengths are defined as the stress at which the stress-strain curve deviates 0.2% from the initial modulus line.

The ϕ symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.