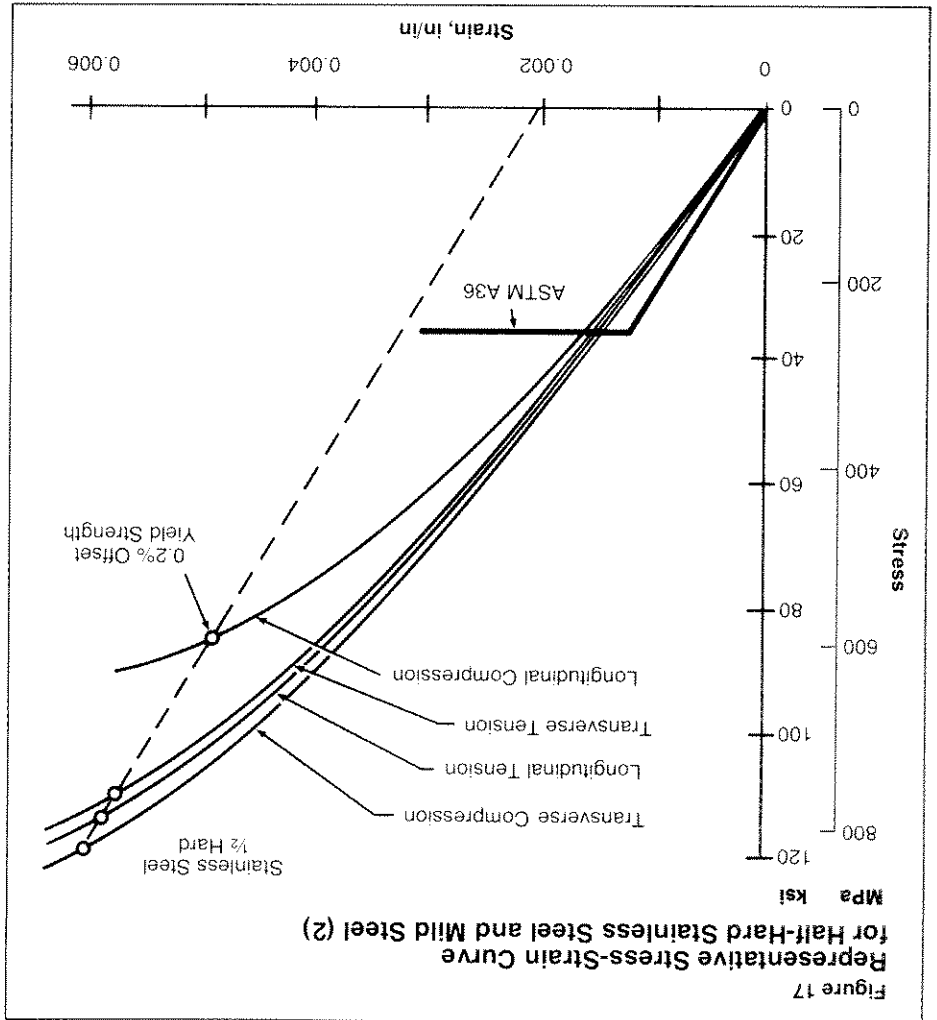


**Figure 17**  
**Representative Stress-Strain Curve**  
**for Half-Hard Stainless Steel and Mild Steel (2)**



On the high-carbon side are Types 440A, B, and C. Types 420, 414, and 431, however, do not fit into either category. Type 420 has a minimum carbon content of 0.15% and is usually produced to a carbon specification of 0.3-0.4%. While it will not harden to such high values as the 440 types, it can be tempered without substantial loss in corrosion resistance. Hence a combination of hardness and adequate ductility (suitable for cutlery) is attained. Types 414 and 431 contain 1.25-2.50% nickel, which is enough to increase hardenability but not enough to make them austenitic at ambient temperature. The addition of nickel serves two purposes: 1) It improves corrosion resistance because it permits a higher chromium content, and 2) it enhances

notch toughness. Martensitic stainless steels are subject to temper brittleness and should not be heat treated or used in the range of 800 to 1050°F (427-566°C) if toughness is important. The effect of tempering in this range is shown by the graph in Figure 18. Tempering is usually performed above this temperature. Impact tests on martensitic grades show that toughness tends to decrease with hardness. Because of this correlation, high-strength (high-carbon) Type 440A exhibits lower toughness than Type 410. Nickel, however, increases toughness, and Type 414 has a higher level of toughness than Type 410 at the same strength level. Martensitic grades have a ductile-brittle transition temperature at which notch ductility drops very suddenly. The transition temperature is near room

temperature, and at low temperature—about -300°F (-184°C)—they become very brittle, as shown by the data in Figure 19. This effect depends on composition, heat treatment, and other variables. Clearly, if notch ductility is critical at room temperature or below, and the steel is to be used in the hardened condition, careful evaluation is required. If the material is to be used much below room temperature, the chances are that quenched-and-tempered Type 410 will not be satisfactory. While its notch ductility is better in the annealed condition down to -100°F (-73°C), another type of stainless steel is probably more appropriate. The fatigue properties of the martensitic stainless steels depend on heat treatment and design. A notch, for example, in a structure or the effect of a corrosive environment can do more to reduce fatigue limit than alloy content or heat treatment. Figure 20 gives fatigue data for Type 403 turbine quality stainless at three test temperatures. The samples were smooth and polished, and the atmosphere was air. Another important property is abrasion or wear resistance. Generally, the harder the material, the more resistance to abrasion it exhibits. In applications where corrosion occurs, however, such as in coal handling operations, this general rule may not hold, because the oxide film is continuously removed, resulting in a high corrosion rate. Other mechanical properties of martensitic stainless steels, such as compressive yield shear strength, are generally similar to those of carbon and alloy steels at the same strength level. Room-temperature physical properties of Type 410 are shown in Table 12. The property of most interest is modulus of elasticity. The modulus of the martensitic stainless steels ( $29 \times 10^6$  psi) (200 GPa) are slightly less than the modulus of carbon steel ( $30 \times 10^6$  psi) (207 GPa) but markedly higher than the modulus of other engineering materials, such as aluminum ( $10 \times 10^6$  psi) (67 GPa). The densities of the martensitic stainless steels (about 0.28 lb. per cu. in.) (7780 Kg/m<sup>3</sup>) are slightly lower than those of the carbon and alloy steels. As a result, they have excellent vibration damping capacity.