data to obtain ASME code approval of Ti-3Al-2.5V.

Physical Properties

Titanium and its alloys possess many unique physical properties which make them ideal for equipment design, even when strength or corrosion resistance may not be critical. These unique properties include:

- ☐ Low Density
- ☐ Low Modulus of Elasticity
- ☐ Low Coefficient of Expansion
- ☐ High Melting Point
- ☐ Non-Magnetic
- ☐ Extremely Short Radioactive Half-Life

Titanium's low density, roughly 56% that of steel, means twice as much metal volume per pound. Particularly when combined with alloy strength, this often means smaller and/or lighter components. Although obviously the basis for aerospace applications, positive implications are also apparent for many types of rotating or reciprocating components such as centrifuges and pumps.

Reduced component weight is also of interest in certain aggressive environments. For example, downhole oil and geothermal well production tubulars and logging tools are being produced from titanium alloys based on these property combinations. In marine service, pleasure boat components, Naval surface ships and submarine cooling water systems are growing markets for titanium driven by its immunity to seawater corrosion and light weight.

Titanium alloys exhibit modulus of elasticity values which are approximately 50% of steel. This low modulus means excellent flexibility which has been the basis for its use in dental fixtures (braces, etc.) and human prosthetic devices (hip joints, bone implants, etc.). Titanium's excellent compatability provides an additional incentive for titanium's rapidly expanding use in body prosthetics. Other applications include springs, bellows, golf club shafts and tennis racquets.

Titanium possesses a coefficient of expansion which is significantly less than ferrous alloys. This property also allows titanium to be much more compatible with ceramic or glass materials than most metals, particularly when metal-ceramic/glass seals are involved.

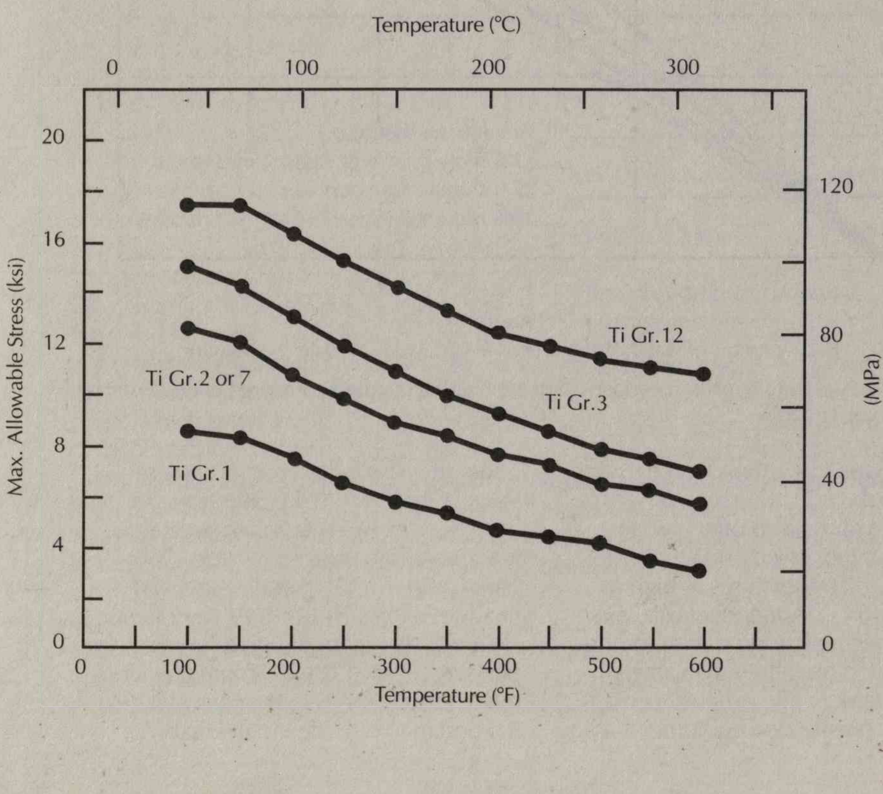
The relatively high melting point of titanium has led to consideration of titanium for ballistic armor. The higher melting point tends to reduce susceptibility to armor melting and ignition (burning) during ballistic impact. Good toughness and light weight are additional factors for considering titanium alloys in this application.

Titanium is virtually non-magnetic, making it ideal for applications where electro-magnetic interference must be minimized. Desirable applications include electronic equipment housing and downhole well logging tools.

Titanium has an extremely short half-life, thereby permitting its use in nuclear systems. In contrast to many ferrous alloys, many titanium alloys do not contain a significant amount of alloying elements which may become radioactive.

Typical physical properties for the family of titanium alloys are presented in Appendix I.

Figure 5: Maximum design allowable in tension for ASME Code-qualified titanium alloys.



Fabrications

The technology of fabricating titanium has evolved from simple conventional processes to highly sophisticated techniques. A wide range of capabilities are now available. End application specifications and economics should determine the process selected. In order to optimize fabrication, considerations must be given to the grade or alloy, heat treatment and crystal structure.

Although titanium is readily fabricable, some general differences from other structural metals should be recognized: lower modulus of elasticity, higher melting point, lower ductility, propensity to gall and sensitivity to contamination in air at welding temperatures.

Titanium can usually be cold worked on equipment designed for stainless steel. Press brakes used for forming sheet, shears, cold rolls, hydro press forming, drawing and pilgering can all be used. The majority of aircraft and some industrial components require hot working to overcome springback, minimize stresses and to reduce the high forming forces needed for titanium alloys.

Casting, forging, hot forming and other elevated temperature processes, play an important roll in providing shapes with desired properties and maximum metal utilization. Forgings are the workhorse of