

**PRINCIPLES  
OF MECHANICAL DESIGN**

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**PRINCIPLES OF MECHANICAL DESIGN**

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product operating normally, and shelf life is the life of the product when it is not operating but is deteriorating in storage. Various combinations of operating life and shelf life are required, depending on the product.

Generally, the longer the life that is required, the greater the cost; thus, it is uneconomical to provide a longer life than is necessary.

Factors such as fatigue, wear, and corrosion have a great effect on the life of a product. Some parts of a product will have a shorter life than others, because of these factors. It is uneconomical to have a greater life in some parts than in others. There are two ways of providing for the life of parts that are subject to conditions such as wear, fatigue, and corrosion. The part can be designed to last the total life of the product, which may require expensive materials and processes. The other way is to design the part using inexpensive materials and processes, but in a manner that it is easily replaced.

Designing a product that must have a long life using new materials or processes is complicated by the fact that tests under conditions approaching those that will be encountered in service cannot be made. Great care must be exercised in using data pertaining to life that have been derived from short tests.

### 5-7 RELIABILITY

A product possessing reliability performs correctly each time it is operated. There are different degrees of reliability, and the higher degrees are generally achieved at a higher cost. Thus, a degree of reliability in excess of that required may not be appropriate. Reliability should be thought of as a property of the product that behaves in accordance with physical laws, the same as the kinematic arrangement, and that is produced in the same manner as the desired motions, that is, by designing it into the product.

A design with a small number of simple parts is inherently more reliable than one with complex parts or with a large number of parts. This is because, with the simple design, there is less chance for something to go wrong. Also, in the interest of reliability, any nonessential functions should be eliminated. The concept of "fewer and simpler" contributing to reliability also applies to the functions to be performed by the operator. It is especially desirable to avoid the necessity of following a precise sequence.

One design may be less sensitive to its environment and to the manufacturing tolerances than another. The less sensitive a design is, the greater is its inherent reliability. A greater life than is required often results from providing the required degree of reliability. This must be kept in mind when

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One way of gaining increased reliability is to use a component that  
has a capacity several times as great as is required. However, it must be  
remembered that this method is valid only if the component with the  
larger capacity has a life and reliability equal to that of the component with  
the smaller capacity. Sometimes a slight sacrifice can be made in a feature  
such as accuracy to gain greater reliability. This is referred to as a trade-off.

The following situation is overlooked too often, to the detriment of  
reliability. A linkage is required to actuate a nonessential item, such as  
an indicator. There is practically no load involved. The linkage is given  
little attention, which is thought to be consistent with its importance.  
However, such a linkage can become disassembled or can fail and jam the  
major control with which it is associated. Thus, its reliability in not causing  
trouble rather than its reliability in performing its function dictates the  
thoroughness to be exercised in its design.

Some of the items discussed in other sections, such as assembly and  
maintenance, also affect reliability.

### **5-8 SAFETY**

There are several instances in which a product can endanger the person  
using it:

1. The product does not perform correctly. This is considered under  
function and reliability. If failure of the product is likely to cause serious  
injury to the person using it, reliability in this instance becomes more  
important.

2. The product is not used correctly. The designer cannot do much  
to ensure the correct use of a product. But he should put forth an effort  
to minimize the possibility of incorrect use creating a hazard and also to  
minimize the skill required of the person using the product. This is es-  
pecially important for products to be used by the general public. The  
relation between the operator and the machine will be discussed later in  
this chapter.

3. The product performs perfectly. This is the instance where the  
designer has the greatest responsibility, and where his efforts will produce  
the greatest effect. Housings and guards must be provided that will protect  
the operator and that will not unduly interfere with the efficient use of the  
product. It should not be possible to bypass the safety device accidentally.  
Thought should be given to the advisability of incorporating an overload  
release mechanism and emergency controls. There are instances where an  
emergency control that will override an overload prevention device is