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Keeping your Contacts Stressed Out! – A continued discussion on stress relaxation and its effects on connector design

- **Stress Relaxation**
- **Creep**
- **Rate Dependence**

The next issue of Technical Tidbits will discuss what happens to materials when they experience yielding.

Factors Affecting Stress Relaxation and Creep

Last months edition of Technical Tidbits was an introduction to the concepts of creep and stress relaxation. This month's edition will discuss what factors influence the performance of materials under elevated temperatures where creep and stress relaxation may occur.

Stress relaxation can be plotted as the percent stress remaining versus time (see Figure 1). The initial stress would be 100% when the time equals zero. However, because the curves shown are plotted on a logarithmic scale, there is no zero point. As the time increases, the amount of stress remaining will fall. At higher temperatures, the rate of decrease will be more rapid. Additionally, a higher initial stress level will induce faster relaxation. Generally, if the initial stress level in the material is less than 10% of its yield strength, stress relaxation is not a concern. Between 30% and 80% of the yield strength, there is only a small increase in the rate of stress relation. Beyond 80%, the stress relaxation rate can be significantly higher, depending on the base metal.

Creep curves display similar tendencies, although they are more complex than stress relaxation curves. Creep curves can best be plotted as strain versus time. Creep is divided into three stages (see Figure 2). In the primary stage, the initial rate of creep is rapid, although it steadily decreases to a constant rate that is found in the secondary stage. In the tertiary stage, the creep rate accelerates, and the strain rapidly increases until the material fractures. At every stage, however, the rate is dependent on the initial stress level and the temperature **(rate dependence)**. High initial stress levels and high temperatures will accelerate the creep process. On the other hand, low temperatures and initial stress levels will tend to slow the process. For example, a plastic coat hanger holding a heavy coat in a hot attic will tend to creep more than one holding a tee shirt in a cool basement.

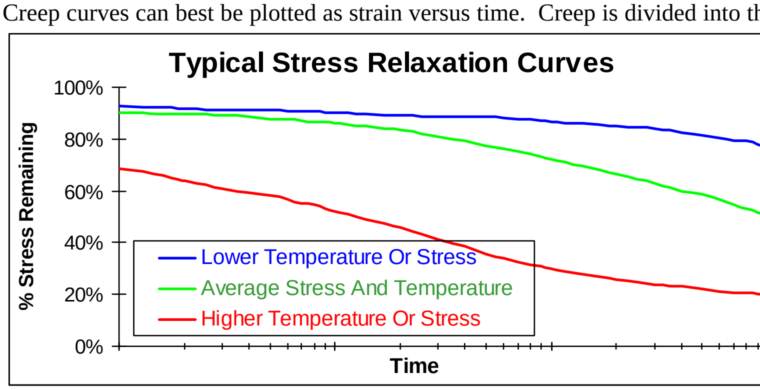

Figure 1. Typical Stress Relaxation Curve

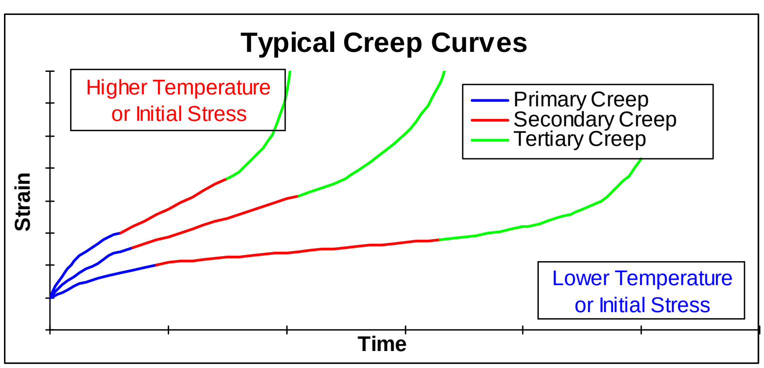

Figure 2. Typical Creep Curves

Factors Affecting Stress Relaxation and Creep (continued)

These curves will also highlight another important distinction between creep and stress relaxation: the failure mode. In creep, the failure is obvious to the naked eye. The part will continuously deform until fracture, leaving behind several very distorted pieces. In stress relaxation, the failure mode is a loss of contact force, and an inability for a deflected contact to return to its original position. A part with virtually no stress left in it will look no different than it did when the load was first applied. However, the normal force necessary to maintain electrical contact will no longer be present. Therefore, stress relaxation can be manifested as a constant increase in contact resistance across the contact interface, eventually leading to an open circuit.

In order to understand what causes these phenomena, it is necessary to look briefly at the process of plastic deformation (this topic will be discussed in detail in next month's edition on Technical Tidbits). Metals are made up of tiny, ordered crystals called grains. When a metal is stressed, each individual grain slightly elongates as the atoms spread apart. If the stress is less than the elastic limit of the material, the crystals will return to their original shape when the load is removed. At higher stress levels, the atoms in the crystals will rearrange themselves in a way to reduce the stress within the grains. This is yielding. These atoms are now "more comfortable" in their new positions than they were in their old positions. Therefore, when the load is removed, only the crystals that had not yielded will return to their original shapes, and some permanent deformation will be evident.

It takes some amount of energy for the crystals to permanently distort. This energy comes from load placed on the metal. At stress levels below the elastic limit, there is not enough energy available for the atoms to rearrange themselves. (More precisely, it is dislocations in the crystals that move, which will be covered in the next issue of Technical Tidbits.) At higher stress levels, there is more energy available for the atoms to move. Therefore, deformation is more severe at higher stress levels. Additionally, elevated temperatures add thermal energy to the system, making the crystalline reorganization more likely. This is why there is more creep and stress relaxation at higher temperatures. At high enough temperatures, there is enough thermal energy available to induce creep and stress relaxation, even if the initial stress level is well below the yield strength of the material.

The same mechanisms that add strength to a material also impart good resistance to creep and stress relaxation. Higher strength provides two advantages. First, a high strength material has more resistance to deformation regardless of temperature than a low strength material. Secondly, a high strength material will have an initial stress level at a much lower percentage of the yield strength than a low strength material at the same stress level. Stress relaxation data is usually published for an initial stress level of 75% of the yield strength. However, it is important to realize that a higher strength material will have more stress than a low strength material at the same percentage of the yield strength. This means that higher strength materials will create a higher force than low strength materials at the same stress level. When choosing a material for a contact, it is therefore important to look at both the strength and stress relaxation resistance before coming to a decision.

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