SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
485 LEXINGTON AVENUE
NEW YORK 17, N.Y.

AEROSPACE RECOMMENDED PRACTICE

ARP 700

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Revised

HIGH STRENGTH ELEVATED TEMPERATURE BOLTING PRACTICE

1. PURPOSE - This ARP provides general information on the design and installation of threaded fasteners in high strength, high temperature applications. Some of the more common definitions of fastener terminology are also provided.

2. FATIGUE CONSIDERATIONS

2.1 Stress Range - The stress range (i.e., the difference between the minimum and the maximum cyclic stress) shall be as small as practicable. In tension applications the stress range can be made a minimum by preloading the fastener so that the joint cannot separate under load. For optimum fatigue performance the preload should be no greater than that necessary to fully assure that the joint will not separate. In tension applications a preload value of 120% of the load causing joint separation has been used, but in no case should it exceed 90% of the yield strength.

2.2 Upsetting and Cold Work - Where practicable use forged or upset heading and cold work to provide optimum grain flow and surface conditions at points of high stress; e.g., form the fastener by hot or cold upsetting; produce threads by roll forming; cold roll the shank-to-head fillet.

2.3 Stress Raisers - Under cyclic loading, large variations in cross section and sharp internal corners act as stress raisers. They can reduce fatigue performance considerably. Where it is not practicable to avoid such features, minimize their effect by providing generous transition radii. For example, radii should be provided at changes in cross-section, junction of head and shank and by use of the controlled root radius thread form specified in MIL-S-8879. Note that machining flaws, scratches, and similar imperfections are also stress raisers. If the fastener must perform with high reliability, specify maximum limits on depth, number and extent of these imperfections.

3. IMPACT CONSIDERATIONS

3.1 Preload - Keep preload stresses in the fastener as small as practicable (see also paragraph 2.1). In general the smaller the preload stress the greater the impact load the fastener can sustain without failure.

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3.2 Reduced Cross Sections - For fasteners in tensile applications, impact resistance can be improved by making the cross-section area of the shank smaller than the cross-section area at the minor thread diameter. Theoretically, the smaller the shank cross section the greater the impact energy the fastener can dissipate without fracture. However, because of static load requirements and the stress concentration effects associated with large variations in cross section, shank cross-section area is seldom made less than 80% of area at the minor thread diameter.

3.3 Stress Raisers - Large variations in cross section and sharp internal corners also act as stress raisers under impact loading. Consider the recommendations made in paragraph 2.3 when designing for impact loads.

4. MATERIAL COMBINATIONS

4.1 Modulus of Elasticity and Coefficient of Thermal Expansion - In cases where the thermal growth of the fastener is less than that of joint be sure that modulus of elasticity of the fastener is low enough to accommodate the growth without overstressing. On the other hand, where the thermal growth of the fastener is greater than that of the joint, be sure that the growth of the fastener will not reduce the preload below the desired value. Generally, it has been good practice to choose joint materials that have coefficients of thermal expansion within 10% of each other.

4.2 Galvanic Action - Consider the compatibility of materials from the standpoint of galvanic action, not only at room temperature but also at operating temperatures. Galvanic effects can change considerably with temperature.

5. THREAD CONSIDERATIONS - Most thread failures can be attributed to thread seizure and thread galling. The most common methods of preventing or reducing the frequency of such failures are the following:

5.1 Clearance - Provide clearance between the internal and external thread. The unified thread form per MIL-S-8879 has a controlled root radius and clearance is provided by increasing the elements of the internal thread. If threads are plated, clearance values apply after plating. As a general rule, clearance, if used, should be provided for these threads whenever they are intended for use above 700 F.

5.1.1 Caution - On prevailing torque type self-locking nuts, the locking feature must be altered to accommodate modified thread elements. To assure that such nuts will function properly, they must be mated only with the threads for which they were altered. The nuts should be properly identified to avoid their misuse.

5.2 Bolt Threaded Length - For proper engagement of nut and bolt, the bolt should extend beyond the nut a minimum of one and one-half threads plus the maximum chamfer. To minimize oxidation and contamination of the threads which can cause galling and subsequent seizure, it is recommended that the protrusion of the bolt through the nut should be held as close to the minimum as possible.

5.3 Lubrication - Provide some form of thread lubricant. This can be oil or grease or any of a number of "anti-seize compounds", dry film lubricants, or electroplates. The choice depends on the environment and the compatibility of the lubricant with the threaded parts. Plating for coatings tend to be preferred as lubricants because of greater permanence, uniform coverage and convenience of assembly; anti-seize compounds and dry film lubricants are normally used only where plating is impractical or as a supplement to plating. Table I establishes some guide lines on the use of plating for anti-seize and anti-galling purposes.

6. DEFINITIONS OF FASTENER TERMINOLOGY

6.1 Clamping Force - Residual load or preload as effected by relaxation.

6.2 Cold Working - Deforming of metal plastically at a temperature lower than its recrystallization temperature [examples: fillet rolling, thread rolling, shot peening, cold upsetting (below the metal's recrystallation temperature) hot upsetting, hot-cold upsetting, wire drawing, extruding].

6.3 Creep - The time/temperature dependent non-reversible plastic deformation which occurs in metal when subject to stresses below normal yield.

6.3.1 Creep Rate - The creep rate is always measured at a specified temperature and stress and is the rate at which creep deformation occurs. It is classified in four stages and can further be expressed as the slope of the creep/time curve (see Figure 1).

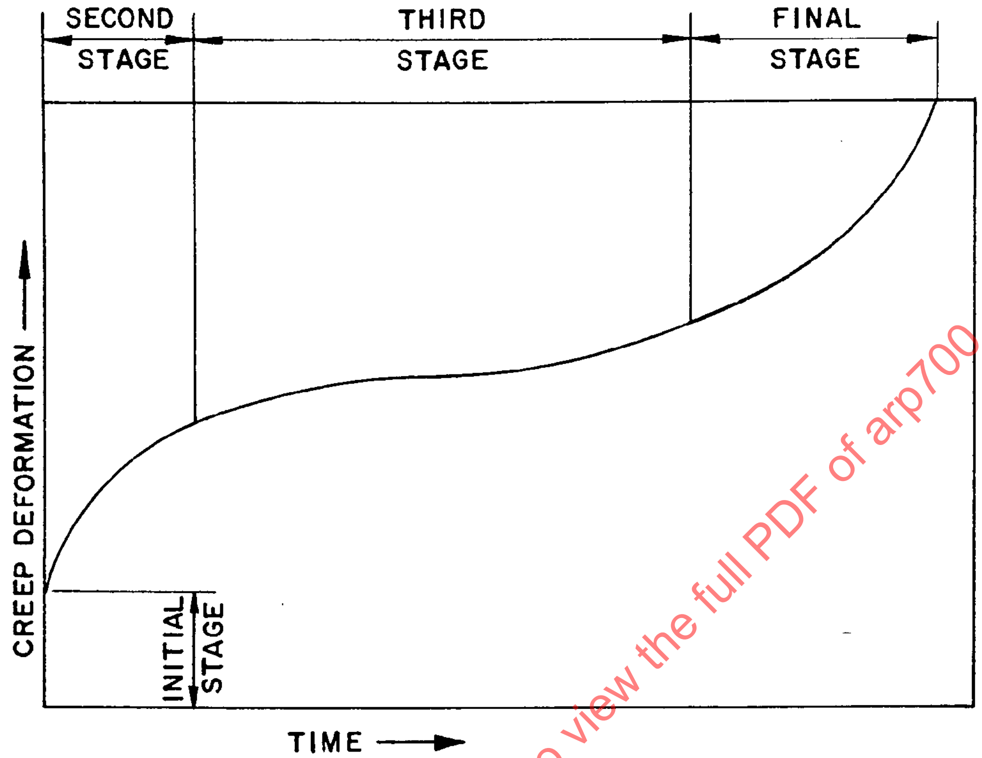

FIGURE 1

Four stages can be distinguished in the creep-time relation. These stages are: (1) an initial stage in which the total deformation is partly plastic and partly elastic; (2) a second stage where the rate of creep deformation decreases with time indicating the influence of strain-hardening; (3) a third stage or the effect of strain-hardening is counteracted by an annealing influence which results in a stage of constant minimum creep rate; and (4) a final stage, or the reduction in the cross section of the specimens, leads to higher stress at greater creep rate and eventual fracture.

6.4 Decarburization - The loss of carbon from the surface of a ferrous alloy as a result of heating in a medium that reacts with the carbon at the alloy surface.

6.5 Elastic Deformation - The changes in dimensions of items, caused by stress, provided a return to original dimensions occurs when stress is removed.

6.6 Elongation - Change in dimensions per unit of dimension and expressed as a percentage.

6.7 Fatigue - The tendency of a metal to break under repeated cyclic stressing under load, the highest of which must be below the metal's ultimate tensile strength.

6.7.1 Fatigue Life - The number of stress cycles that can be sustained under given load conditions.

6.8 Flow Lines - The texture revealed by etching a metal surface or section showing direction of metal flow.

6.9 Heading - The upsetting of wire, rod or bar stock in dies to form parts having some of the cross-sectional area larger than the original.

6.10 Modulus of Elasticity - The ratio of unit stress to unit strain within the elastic limit.

6.11 Notch Sensitivity - A measure of the sensitiveness of a material to the presence of stress concentration caused by notches in the form of threads or grooves, scratches and other stress raisers. Materials with low notch sensitivity are selected for the high fatigue/high stress applications in aircraft primary structure and in aircraft engines.

6.12 Plastic Deformation - The changes in dimensions of items, caused by stress, that are retained after the stress is removed.

6.13 Preload - The final installation load expressed in pounds.

6.14 Relaxation - The relief of stress with regard to time, temperature, and a specific strain.

6.15 Size Effect - The conditions which prevent the direct application of the same strength criteria over a wide range of size considerations.

6.16 Stress

6.16.1 Residual Stress - The stress present in a body that is free of external forces or thermal gradients which is usually the result of fabrication methods. In fastener fabrication, the stresses resulting from heading, forming, machining, grinding and rolling are residual stresses and may be desirable or not depending upon their location and type. In centerless grinding, the residual stress is usually tensile,