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# STRESS ANALYSIS ON SCREW THREAD

A. R. YAO and J. A. DORAN

AUGUST 1984

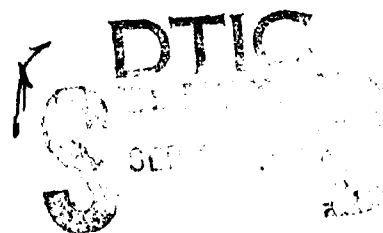


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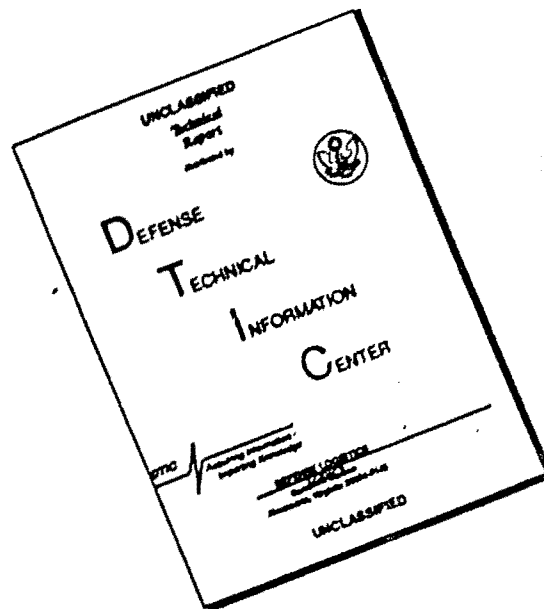
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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>This report documents a thread joint analysis method which has been applied to an interactive computer program for evaluation of thread form deviations encountered in production. Thread forms covered include FED-STD-H28 standards and special forms generated by user supplied input. The analysis method, which includes static and dynamic analysis using elastic theory, provides thread joint performance indicators in the form of static load capacity and fatigue safety factor for various life cycle ranges. The analysis method and subsequent program is a useful for developing thread joint design criteria and |                                     |                                                                |

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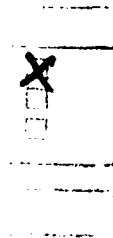
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Block 20. Abstract

verification of existing designs.



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## FOREWORD

This report was prepared by A. R. Yao and J. A. Doran, Rock Island Arsenal, Engineering Directorate, Rock Island, Illinois. The purpose of this screw thread stress analysis program was to provide a tool for estimating load capacities and fatigue life cycles of threaded connection.

The program material contained herein is supplied without warranty or representation of any kind. Rock Island Arsenal assumes no responsibility and shall have no liability, consensual or otherwise, of any kind arising from the use of this program material or any part thereof.

## STRESS ANALYSIS ON SCREW THREAD

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## 1. Introduction

During the past several years of production at Rock Island Arsenal, approximately 10% of all submitted material nonconformances have directly involved thread forms. Variations in minor, pitch, and major diameters along with other geometry considerations in V, Acme, Buttress, and special thread forms; may adversely affect the assembly, life, and strength of a given thread joint. Nonconforming parts have ranged from common fasteners under static loading to recoil yokes and piston adapters subjected to enormous weapon firing loads. The cost/scheduling impact and critical function requirements have established a crucial need for a rapid and reliable thread joint evaluation method.

Thread analysis procedures to date include (1) Precedent Method, (2) Thread Class Substitution, (3) Routine Stress Analysis, and (4) Testing.

The Precedent Method, as the name implies, bases a thread nonconformance evaluation on previous evaluations of similar types under similar loading and environmental conditions, where these results may be derived from calculations, experiments, or experience. This method is practical and effective, being employed whenever a reasonable and verifiable precedent case can be found. The quantitative "how much" or "how bad" answers, however, must be obtained by other means.

The Class Substitution Method, somewhat similar in philosophy to

the Precedent Method, uses the tolerance variations within thread class specifications as a criterion for acceptance. The method is primarily a "rule-of-thumb" approach and also lacks quantitative assessment of thread joint performance. The Class Substitution Method, used only occasionally for critical fit applications, does have the distinct advantage of providing distinct documented limits, but is generally so conservative as to disqualify thread conditions that still possess adequate strength.

Routine Stress Analysis, using the more readily available textbook references, serve to provide quantitative analysis of limited accuracy, being based on several simplifying and gross assumptions. Highly detailed stress results, leading to more accurate analysis, is not a simple exercise and must generally be conducted by persons having that specialized discipline. Usually, evaluation response time for a given occurrence precludes this type of in-depth analysis.

The testing approach, used sparingly due to cost and time constraints, offers perhaps the most accurate and verifiable means of analyzing thread nonconformances. Testing as a sole means of evaluation, however, would require experimental recreation of exact geometry and loading conditions per given nonconformance. More general experiments designed to evaluate "trends" due to certain geometry and load conditions can provide useful and interesting results, but seldom provide the required degree of accuracy.

An alternative evaluative method, which is being documented in this report, involves development of three-dimensional state-of-stress equations using specific thread geometry relationships and Heywood's formula. Thorough literature research on thread analysis, both domestic and foreign, have confirmed and further refined this analytical approach to solve joint strength of nonconforming threads. However, as with any analytical solution, several key assumptions were required to simplify complicated geometries and loading conditions. Some experimental data adopted from literatures and mathematical model were integrated into an interactive computer program for solution of user supplied thread geometry, applied loads and material property parameters. In this report, both static analysis and fatigue analysis were provided under assumption of elasticity.

## 2. Thread Geometry

A screw thread is a complex configuration comprised of several elements and characteristics. According to definition of FED-STD-H28 (1) and ANSI B1 (2) handbooks, a screw thread is a ridge, usually of uniform section and produced by forming a groove in the form of a cylinder. (Taper thread is not included in this report.) A thread is a portion of a screw thread encompassed by one pitch. On a single-start thread it is equal to one turn.

There are several basic thread forms such as V thread, Acme thread, Buttress thread, square thread and special thread such as Watervliet 20/45 modified Buttress thread. Due to loading conditions and applications, threads are identified with thread type, thread series, size, fit or class, and some special specifications. Figure 2.1 shows a typical thread geometry. For detail definition, geometry, allowance, tolerance and limit of size of thread forms, FED-STD-H28 and ANSI B1 handbooks are recommended. Typical thread forms, thread series and classes are listed as follow:

UNC: Unified coarse thread, Classes-1A,2A,3A,1B,2B and 3B.

UNF: Unified fine thread, Classes-1A,2A,3A,1B,2B and 3B.

UNEF: Unified extra fine thread, Classes-1A,2A,3A,1B,2B and 3B.

UNM: Unified miniature thread

UNJ: Unified controlled root radius thread, ANSI B1.15.

UNR: Unified controlled root radius thread, ANSI B1.14.

4UN,6UN,8UN,12UN,16UN,20UN,28UN and 32UN: Unified thread,

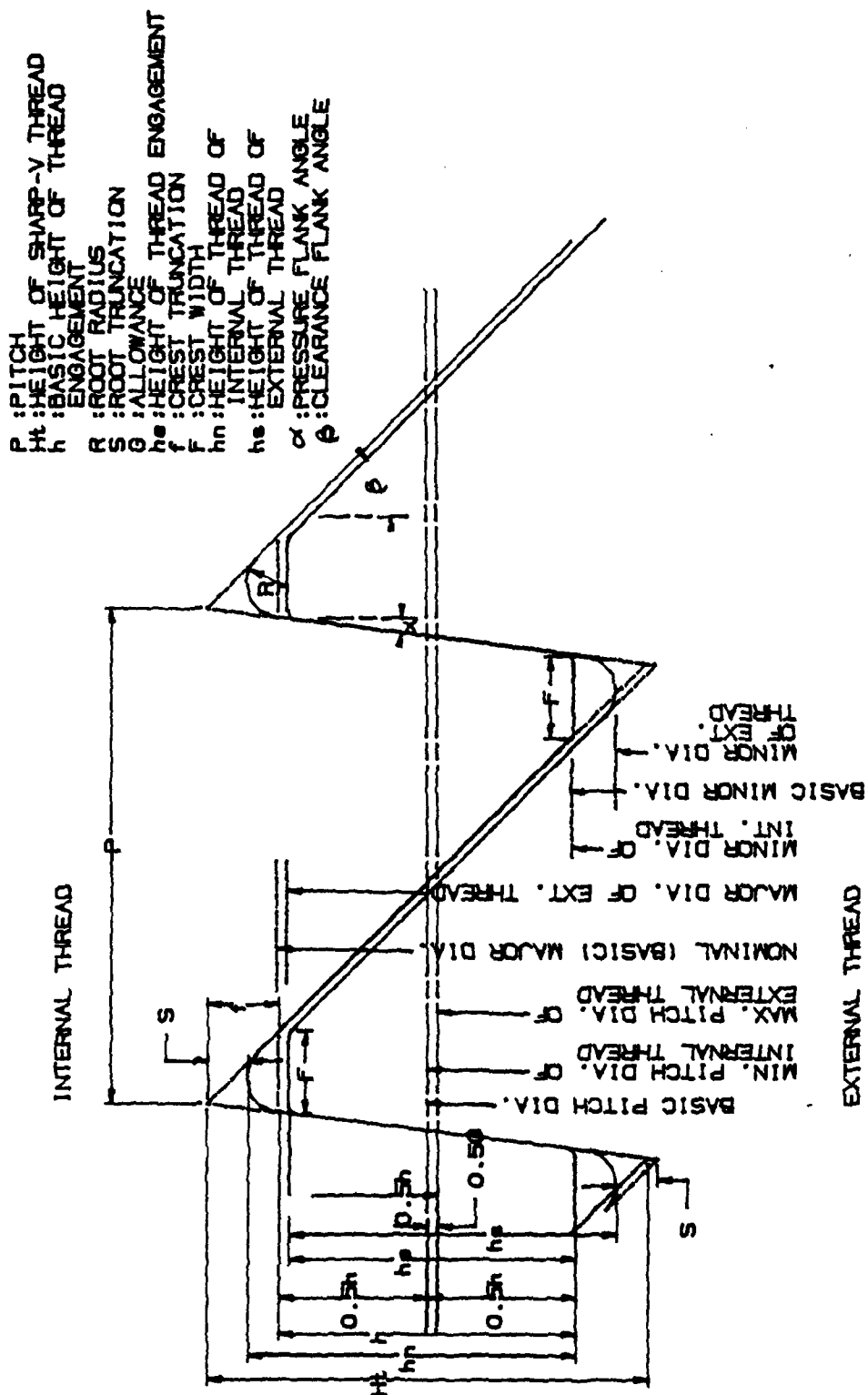


FIGURE 2.1 TYPICAL THREAD GEOMETRY.

Classes-1A,2A,3A,1B,2B and 3B.

ACME: Acme thread, two general applications for Acme thread used chiefly for purpose of producing traversing motions on machines and tools. Acme thread is divided into three general classes, 2G,3G and 4G, and five centralizing classes, 2C,3C,4C,5C and 6C.

STUB ACME: Used for unusual applications pertinent to Acme thread but where a coarse pitch or shallow depth is required. While no class callout, the Stub Acme corresponds to class 2G of the Acme thread.

BUTT and PUSH-BUTT: Buttruss thread for pull or push type, used where high stresses are along the thread axis in one direction only.

Classes-1A,2A,3A,1B,2B and 3B.

Thread design is to a large extent empirical and is partially based on previous experience with similar designs and the judgment of the designer. The interrelation of length of engagement, minimum major diameter of the external thread, maximum minor diameter of the internal thread, and the strength of the assembled thread needs to be understood and carefully considered in order to produce the optimum design of a special thread. It is not economical to use either a length of thread engagement which is longer than required or shorter than that which will develop the full strength of the externally threaded member. Other factors such as loading conditions and geometry restrictions required careful analysis and adjustment of the design with respect to selection of the diameter-pitch combination, the class of thread, length of engagement, and minor and major diameter tolerances.

### 3. Theoretical Background

#### 3.1 Failure Modes

The screw thread is one of the machine elements, in the form of a nut and bolt or stud, which have widespread application for virtually every machine and structure. A screw thread differs from a conventional cylindrical notched specimen in that, firstly, a screw thread consists of a series of adjacent notches and, secondly, the load is transmitted through the stress concentration, that is, the nut transmits the load to the bolt through the flank and root radius of the thread. The threaded connections are, in general, subjected to tension, compression, shear, bending and torsion, statically and dynamically. Torsional stress is presented in the threaded connection during tightening, however, the threaded connection will unwind slightly during the initial period of operation under dynamic loading, and relieve the torsional stress. In addition to the stress due to axial loading (tension and compression), the thread contact surface transmits bending stress at the thread roots.

Thread failure modes are mainly: (1) shear failure, and (2) failure due to maximum fillet stress at thread roots subjected to uniaxial static or fatigue loadings. Other detrimental factors for threaded connections are fretting on thread contact surface and eccentric loading conditions.

Under simple tension test of a threaded connection with thread form manufactured per designed specification, the failure is due to bending (or maximum fillet stress). However, according to Smith (3), the

truncated or deviated threads fail in bending and shear where the degree of failure due to shear increasing with the amount of truncation. The effect of deviation or truncation on thread failure strength is not too great. Tests on both ground and rolled threads showed that a reduction in the depth of engagement, even to 25% of normal, caused no significant loss in fatigue strength, provided that the truncation was either divided equally between the external and internal thread or nearly all in the internal thread.

Thread surface finish, degree of lubrication, accuracy of thread form machining and material of thread members are factors which relate to fretting and galling. When a threaded connection is subjected to cyclic loading, fretting may occur along the thread contact surface. As the fretting area is remote from the region of maximum fillet stress, according to Field (4), fretting plays no part in crack initiation, fatigue cracks grew from the thread roots not from an area of fretting. Eccentric loading condition on threaded connection may be produced by inclination of the contact face of the nut and the adjacent structural member or by deformation of the structure under the working loads. The eccentric loads will introduce additional bending stress to the thread pressure flank and increase the maximum fillet stress in the thread root area, and therefore increase the chance of failure at the thread root area. In this report, fretting, galling, and eccentric loading conditions will not be considered.

### 3.2 Load Distribution Along Threaded Connection

The distribution of thread loads along a threaded connection has been studied theoretically by Sopwith (5). A thread load concentration factor  $H$  was introduced to account for nonuniform thread load distribution along the thread helix. This factor is defined as the ratio of the maximum thread load per inch of thread helix to the average thread load per inch over the entire length of engagement of external and internal threads.

The experimental study on this topic was carried out by Goodier (6), Hetenyi (7) and Chalupni (8), etc.. The highest thread load was found at the external thread at about one turn in from the loaded face of the internal thread. This occurred because the load carried by a external thread was not distributed uniformly between the mating threads, the first engaged thread carrying a higher percentage of the total thread load than succeeding threads. The thread load concentration factor were estimated varying from 1 to 4. This factor depends on coefficient of friction between internal and external threads and thread geometries, such as thread form, equivalent outside diameter and height of internal thread member, hollow diameter in external thread member, pitch and included angle. From a photoelastic model of threaded connection having six engaged threads, Cazaud (9) found that the percentages of the external thread load carried by the first and subsequent engaged threads were 34, 23, 16, 11, 9 and 7, respectively. The thread load concentration factor for this threaded connection is 2.04. Both theoretical

and experimental studies were performed under elastic condition. If the external loads applied to the thread joint causes the thread root regions to deform plastically, the resulting thread load distribution along the contact surface will become more uniform. This indicates that strength of a thread connection can be improve by prestressing the thread connection such that the material at thread roots region must to be equal to or become close to yield point.

Threaded connections of the cannon breech mechanism, consisting of breech ring, breech block and gun tube, were studied by using both two and three dimensional photoelasticity methods by Marino and Riley (10). Their attempt was to optimize thread root contours for designing cannon breech mechanism. In the breech mechanism the breech block and gun tube have external threads, whereas the breech ring threads are internal. The threads on all components are sectored to permit quick and convenient assembly of the parts.

Experimental data from 3-dimensional photoelastic test for breech block with standard Buttress thread, the mean maximum fillet stress at the center of the sector is 6.16 times  $p$  (internal pressure applied in the breech mechanism). The mean maximum fillet stress at the edge of thread sector of the breech block is 7.45 times  $p$ , and  $H$  is 1.114. For breech ring with Buttress thread, the mean maximum fillet stress at the center of thread sector is 4.36 times  $p$ , and  $H$  is 1.69. Whereas, the mean maximum fillet stress at the edge of thread sector is 4.52 times  $p$ , and  $H$  is 1.66. In the similar test,  $3/8$ " pitch V threads were tried in the breech mechanism.

For breech ring the mean maximum fillet stress at the center of thread sector is 3.3 times  $p$ , and  $H$  is 1.9, while the mean maximum fillet stress at the edge of thread sector is 3.6 times  $p$  and  $H$  is 1.7. In the same report, the same thread forms were tried and load distribution along the threaded connection were compared. The thread load concentration factor for Buttress thread  $H$  is averaging 1.5 for 3-D model, while for 2-D model the thread load concentration factor  $H$  is 2.48. Obviously, the thread load concentration factor in 3-D model is smaller than that in 2-D model.

Dynamic tests on full scale cannon breech mechanism were performed by Weigle and Lasselle (11). In the test a peak pressure of 48,000 psi and a rise time of 3.45 msec with operation at a rate of 68-70 cpm were applied. Thread forms of Buttress thread, V thread and modified 20/45 Buttress thread were used in the full scale dynamic tests. The thread load concentration factor  $H$  was estimated to be 1.4. In the interactive computer thread stress analysis program, the default value of thread load concentration factor  $H$  is 1.5. However, users have options to define  $H$  value ranged from 1 to 4.

### 3.3 Axial Load

The threaded connections are usually subjected to uniaxial loading. The axial loading conditions applied to external thread (bolt) and internal thread (nut) can be tension, and/or compression. The most frequent case of threaded connection, however, is external thread under tension and internal thread under compression. In this case, on the external thread, the axial tensile stress tends to increase the tensile fillet stress caused by thread load, while on the internal thread, the axial compressive stress tends to decrease the tensile fillet stress caused by thread load, which increases the load capacity of internal thread. This is why, on most occasions external threads (bolts) fail instead of the internal threads (nuts). In the case of cannon breech mechanism, both external thread (breech block and gun tube) and internal thread (breech ring) are subjected to tensile stresses.

For axial loading, according to Neuber (12) and Heywood (13), the maximum elastic stress concentration factor occurring in the vicinity of a row of grooves is not so great as that created by a single groove of the same geometry. The difference depending on the specimen and groove geometries and the distance between adjacent grooves. With multiple grooves, Neuber considered that the reduced stress concentration factor may be attributed to a small effective depth of groove. In addition, the stress concentration factor for thread forms depend on included

angle  $(\alpha+\beta)$ , equivalent outside diameter  $(D_o)$ , minimum major diameter  $(D_{imin})$  of the internal thread, inside (hollow) diameter  $(d)$ , and minimum minor diameter  $(K_{emin})$  of the external thread. The stress concentration factor for a row of thread forms at the boundary of the thread root, in general, can be expressed as

$$K_a(\theta) = 1 + f(\alpha+\beta, rh/R, (K_{emin}-d)/(2rh) \text{ or } (D_o-D_{imin})/(2rh), \cos 2\theta) \quad (3.3.1)$$

where  $r = 0.3(P/h)^{0.7}$ ,  $r$  is a factor less than unit,  $h$  is the thread height,  $R$  is the thread root radius and  $\theta$  is an angle in degree measured from the bottom of the thread root. It is observed that for standard thread  $(K_{emin}-d)/(2rh)$  and  $(D_o-D_{imin})/(2rh)$  are always greater than 1.0. From Neuber's nomographs (12), the stress concentration factor  $(K_{ae}(\theta))$  of external thread due to axial load can be calculated by the equation

$$K_{ae}(\theta) = 1 + \frac{1.25(K_1-1)((K_{emin}/2R)^{\frac{1}{2}}-1)(1-((\alpha+\beta)/180)^{1+2.4(R/rh)^{\frac{1}{2}}})\cos 2\theta}{((K_1-1)^2 + 1.5625((K_{emin}/2R)^{\frac{1}{2}}-1)^2)^{\frac{1}{2}}} \quad (3.3.2)$$

$$\text{where } K_1 = \frac{0.6(rh/R)^{\frac{1}{2}}(6((K_{emin}-d)/2R)^{\frac{1}{2}}-1)}{(4rh/R + 0.09(6((K_{emin}-d)/2R)^{\frac{1}{2}}-1)^2)^{\frac{1}{2}}} \quad (3.3.3).$$

Similarly, the stress concentration factor ( $K_{ai}(\theta)$ ) of internal thread due to axial load can be calculated by the equation

$$K_{ai}(\theta) = 1 + \frac{(K_2 - 1) \left( 1.667 \left( \frac{D_{imin}}{2R} \right)^{\frac{1}{2}} - 0.5 \right) \left( 1 - \frac{(\alpha + \beta)}{180} \right)^{1 + 2.4(R/rh)^{\frac{1}{2}}} \cos 2\theta}{\left( (K_2 - 1) + \left( 1.667 \left( \frac{D_{imin}}{2R} \right)^{\frac{1}{2}} - 0.5 \right)^2 \right)^{\frac{1}{2}}} \quad (3.3.4)$$

$$\text{where } K_2 = \frac{0.6(rh/R)^{\frac{1}{2}} \left( 6 \left( \frac{D_o - D_{imin}}{2R} \right)^{\frac{1}{2}} - 1 \right)}{\left( 4rh/R + 0.09 \left( 6 \left( \frac{D_o - D_{imin}}{2R} \right)^{\frac{1}{2}} - 1 \right)^2 \right)^{\frac{1}{2}}} \quad (3.3.5).$$

The fillet stress at the thread root area due to axial load ( $W$ ) will be the product of the stress concentration factors ( $K_{ae}$  or  $K_{ai}$ ) and nominal axial stress. The stresses of external and internal threads at fillet contours due to axial (tensile or compressive) loading can be calculated, respectively, by

$$St(\theta) = K_{ae}(\theta) W (4/\pi) / (K_{emin}^2 - d^2) \quad (3.3.6)$$

and

$$St(\theta) = K_{ai}(\theta) W (4/\pi) / (D_o^2 - D_{imin}^2) \quad (3.3.7).$$

The maximum stresses take place at bottom of the thread root ( $\theta=0$ ), such that  $K_{ae}(0)=K_{ae}$  and  $K_{ai}(0)=K_{ai}$ .

### 3.4. Shear Failure

Thread shear failure is caused by excessive loading on the thread contact surface. Shear stress and effective shear area are dependent upon the relative tensile strength of the material of the external and internal threads. The formula for shear stress is

$$S_s = W/A_s \quad (3.4.1)$$

where  $W$  = Total axial load, and  $A_s$  = Shear area. Total length of thread engagement helix at a projection diameter  $x$  can be expressed as

$$L(x) = n \cdot L_e \cdot ((\pi x)^2 + P^2)^{\frac{1}{2}} \quad (3.4.2)$$

where  $L_e$  = Length of thread connection axial engagement

$n$  = Number of threads per inch

$P = 1/n$ , Pitch.

When the external and internal threads are manufactured from materials of equal unit tensile strength and shear failure occurs, the failure will usually take place simultaneously in both threads at or close to the basic pitch diameter. The shear area will be

$$A_s = L(E)/(2n)$$

(3.4.3) .

When the tensile strength of the external thread material greatly exceeds that of the internal thread material, shear failure will usually take place in the internal thread at or close to minimum major diameter of the external thread. The shear area will be

$$A_s = 0.5 L(D_{\min}) (P + (\tan \alpha + \tan \beta)(D_{\min} - E_{\max})) \quad (3.4.4)$$

where  $D_{\min}$  = Minimum major diameter of external thread

$E_{\max}$  = Maximum pitch diameter of internal thread.

When tensile strength of the internal thread material greatly exceeds that of external thread material, shear failure will usually take place in the external thread at or close to maximum minor diameter of internal thread. The shear area will be

$$A_s = 0.5 L(K_{\max}) (P + (\tan \alpha + \tan \beta)(E_{\min} - K_{\max})) \quad (3.4.5)$$

where  $K_{\max}$  = Maximum minor diameter of internal thread

$E_{\min}$  = Minimum pitch diameter of external thread.

### 3.5 Preload

Tightening and preload are recommended on some threaded connections due to mechanical or structural design criteria, such as functional and strength requirements. Statically, preloads improve locking effect of the thread joint. For example, sufficient tensile preload is required in pipe flange bolts to overcome the longitudinal forces caused by the pressure in the piping, so that the flanged connection does not leak. A similar problem is faced in tightening the nut on the cylinder head of an engine block, so that the studs are all stressed equally and to a tension that precludes leakage. If the threaded connection subjected to cyclic loading, preload reduces the ratio of alternating stress ( $S_a$ ) to mean stress ( $S_m$ ) and that improves the fatigue resistance of the threaded connection, according to the fatigue fracture criteria in  $S_a$ - $S_m$  diagram.

Preload is recommended only for the material of threaded connections with a stress-strain curve in which there is no clearly defined yield point and progresses smoothly upward until fracture. For the described material, proof load is defined as the maximum load applied to the material without creating permanent deformation. For static loading conditions, the torsional stress due to preload disappears after tightening, if the strain of the material pass plastic yielding. Therefore, the minimum preload is recommended as 90% of the proof load,

and takes the form

$$F_p = 0.9 S_y A_t \quad (3.5.1)$$

where  $S_y$  is the yield stress and  $A_t$  is the stress area of the threaded connection. According to Federal Standard H-28 handbook, for steel parts with tensile strength up to 180 ksi, the stress area is computed from the following formula:

$$A_t = (\pi/4) (E - 3h/4)^2 \quad (3.5.2)$$

where  $E$  is basic pitch diameter and  $h$  is the thread height. A threaded connection subjected to slight movements will cause flattening of high spots, paint or dirt and will relieve the torsional friction. Thus, if the threaded connection does not fail during tightening, there is a very good chance that it will never fail under static loading condition. For cyclic loading condition, care must be taking for deciding direction of preload. According to Juvinall (14), an overload causing yielding produces residual stresses which are favorable to future overloads in the same direction and unfavorable to future overloads in the opposite direction. Apply preload only in the direction of anticipated service loads.

Torque required to provide the specified preload for thread joint

is

$$T = K_p F_p D \quad (3.5.3)$$

where  $K_p$  is torque coefficient, and  $D$  is major diameter of the threaded connection. According to Shigley (15), Blake and Kurtz (16), no matter what size and condition of lubrication of the threaded connection, the torque coefficient  $K_p$  can be estimated as a constant 0.2, and equation (3.5.3) becomes

$$T = 0.2 F_p D \quad (3.5.4)$$

The torque applied to the nut is used up in three ways. About 50% of it is used to overcome the friction between the bearing face of the nut and the member. About 40% of the applied torque is used to overcome thread friction, and the balance produces the bolt tension. Only the last two items contribute the torsion in the screw thread. During tightening the torsional stresses of external and internal threads due to torque become, respectively,

$$T_{pe} = (0.16/\pi) F_p D_{max} K_{emin} / (K_{emin} - d) \quad (3.5.5)$$

and

$$T_{pi} = (0.16/\pi) F_p D_o D_{imin} / (D_o^4 - D_{imin}^4) \quad (3.5.6)$$

where  $D_{max}$  = Maximum major diameter of external thread

$K_{emin}$  = Minimum minor diameter of external thread

$D_{imin}$  = Minimum minor diameter of internal thread

$D_o$  = Equivalent outside diameter of internal thread

$d$  = Inside (Hollow) diameter of external thread.

### 3.6 Thread Load and Heywood's Formula

The screw thread on each thread form can be considered as a short, very wide cantilever, the width being the total length of the thread along the helix. If the thread load is applied at a relatively great distance from the thread root, the fillet stress at the thread root is caused by bending moment. However, if the thread load is applied close to the thread root, the nominal fillet stress can not be determined by merely considering the effect of bending moment. The well-known Lewis formula (17) calculating the maximum fillet stress for loaded projection, such as screw and gear tooth, is based on a pure bending effect. The modified Lewis formula proposed combined bending and compression effects to assess the maximum fillet stress. But with introduction of stress concentration factor both Lewis formula and modified Lewis formula can only correctly correlate well with experimental results for a comparatively narrow range of shapes of loaded projection.

From photoelastic data, Heywood (18), Kelly and Pedersen (19) introduced load proximity and shear effects and proposed an empirical formula for estimating fillet stress for various type of loaded projections. Heywood's empirical formula correlates rather well, over a wide range of shapes of loaded projection, with the experimental results from different researchers. Heywood observed that, in case of screw thread, the maximum fillet stress occurred at approximately  $30^\circ$  to the flank. The Heywood's empirical formula take the form:

$$S_b = K_b(W/t \cos \alpha) \left( \frac{1.5a}{e^2} + \frac{0.45}{(be)^{\frac{1}{2}}} + \frac{\sin \phi}{2e} \right) \quad (3.6.1)$$

where  $S_b$  = Maximum fillet stress due to a thread load  $W/\cos \alpha$  applied

to the thread projection

$K_b = (1 + 0.26(e/R)^{0.7})$  Fillet stress concentration factor

$W$  = Axial load applied to the threaded connection

= Pressure flank

$e$  = Dimension of resisting material

$b$  = Straight line distance between point of the maximum tensile fillet stress and point of applied load

$R$  = Thread root radius at point of maximum stress

$a$  = Arm of bending moment

$t$  = Projection thickness

$\phi$  = Angle defining direction of load with respect to the tangent to the fillet.

The first term in parentheses is Lewis bending moment term, the second is a load proximity term, increasing the stress as the point of loading

approaches the fillet, and the third is a shear effect term. The proximity term arises partly from the local distortion and complex load distribution occurring in the region where the load is applied, and partly from the effect of high rigidity near the base of the projection. A typical thread form with parameters in Heywood's empirical formula are defined in Figure 3.6.1. The maximum tensile fillet stress is estimated taking place at point A, and the maximum compressive fillet stress is estimated taking place at point B. The arm of the bending moment  $a$  is determined by the perpendicular distance from the mid-point C of AB on to the line of action of the load. The weakest semi-section of the projection is defined by the line AD of length  $e$ , this being the perpendicular from point A on the center line of the projection. The angle  $\phi$  is related to wedge effect or friction force of the pressure flank of the threaded connection. By using finite element analysis, shear transfer rate was introduced and explored by O'Hara (20) by changing angle of applied load to the pressure flank.

If the thread loads are normal to pressure flank, then angle  $\phi$  is 30 degrees. If height of sharp v-thread of thread form is  $H_t$ , root truncation is  $s$  as defined in FED-STD-H28 handbook, the parameters shown in Heywood's formula can be calculated as follow:

$$e = \frac{H_t - s - R(1 - \cos(60 - \alpha))}{\cos \alpha} \sin\left(\frac{\alpha + \beta}{2}\right) \quad (3.6.2)$$

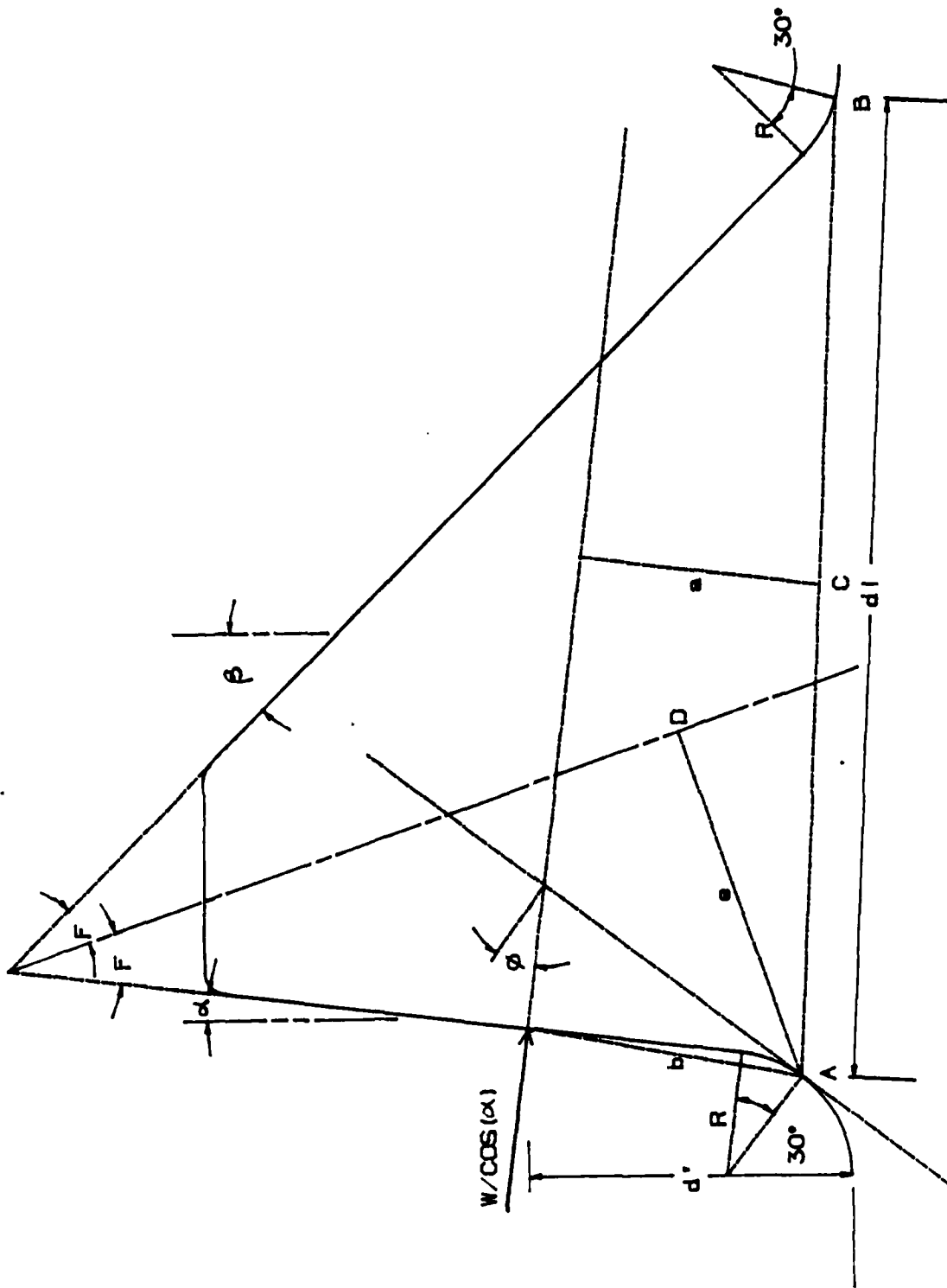


FIGURE 3.6.1 TYPICAL THREAD FORM WITH HEYWOOD'S PARAMETERS.

$$a = \frac{d' - R(1 - \cos(60 - \alpha))}{\cos \alpha} - \sin(\alpha + \theta) (d_1/2 - R \tan(45 - \alpha/2) + R \sin(60 - \alpha)) \quad (3.6.3)$$

$$b = \frac{d' - R(1 - \cos(60 - \alpha))}{\cos \left( \tan^{-1} \left( \frac{d' \tan \alpha + R \tan(45 - \alpha/2) - R \sin(60 - \alpha)}{d' - R(1 - \cos(60 - \alpha))} \right) \right)} \quad (3.6.4)$$

where

$$d_1 = m_1 / \cos(\theta) \quad (3.6.5)$$

$$\theta = \tan^{-1} (R \cdot (\cos(60 - \beta) - \cos(60 - \alpha)) / m_1) \quad (3.6.6)$$

$$m_1 = R(\tan(45 - \alpha/2) + \tan(45 - \beta/2) - \sin(60 - \alpha) - \sin(60 - \beta))$$

$$+ P/2 + (\tan \alpha + \tan \beta)(E_{\min} - K_{\min})/2 \quad (\text{for external thread}) \quad (3.6.7)$$

or

$$m_1 = R(\tan(45 - \alpha/2) + \tan(45 - \beta/2) - \sin(60 - \alpha) - \sin(60 - \beta))$$

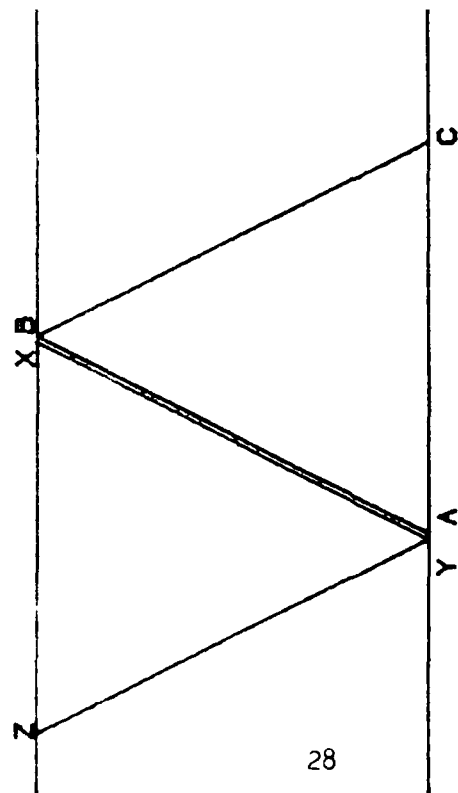
$$+ P/2 + (\tan \alpha + \tan \beta)(D_{\min} - E_{\min})/2 \quad (\text{for internal thread}) \quad (3.6.8)$$

and  $d'$  is the distance from point of applied load to minimum minor diameter of the external thread ( $K_{\min}$ ) or minimum major diameter of the internal thread ( $D_{\min}$ ). The parameter  $d_1$  is the distance in between point A and point B as shown in Figure 3.6.1.

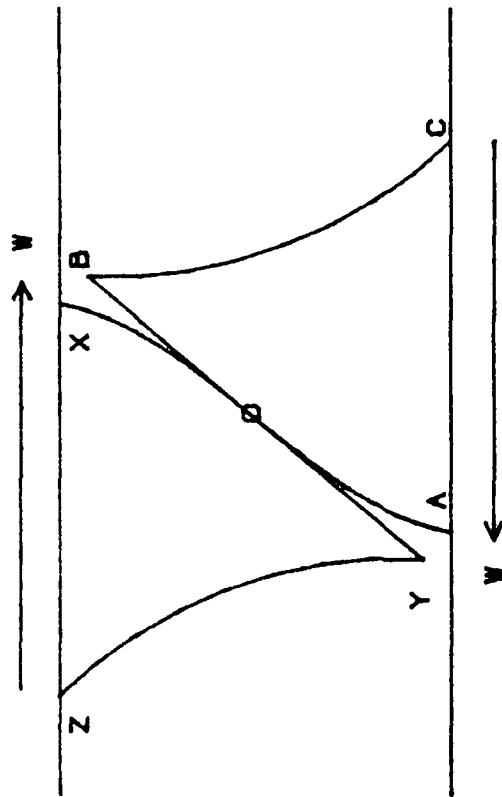
### 3.7 Pressure Flank Load Distribution

A pressure flank load distribution and application method was needed for the mathematical thread joint model that would reflect real world behavior and conform in principle to the leading accepted load distribution theories of Sopwith and Heywood. In addition, this method was required to handle loading of a variety of non-conforming thread conditions. The resulting method represents an approximation to actual thread loading phenomena and does not attempt to quantify the effects of surface hardness and finish, friction, non-axial loading, non-parallel pressure flank surfaces, residual stress, and other factors involved in the overall thread loading mechanism.

According to Sopwith (5), the screw thread on each component can be considered as a short, very wide cantilever, the width being the total length of the thread measured along the helix. The method of load application is shown in Figure 3.7.1. The cantilevers ABC and XYZ in Figure 3.7.1a are initially in contact over their entire length, but when load W is applied, the cantilevers deform as shown in Figure 3.7.1b. Sopwith contends that by symmetry, the load will be concentrated at the center O of the two cantilevers; the inner parts AO and OX will bend as shown, the unloaded outer parts remaining straight and in line (BOY). Sopwith further asserts that, "In practice the load will be distributed over a narrow band, such that the pressure is of the order of the Brinnell hardness of the material, and even at failure the width of this band will not exceed about 1/10th the length AB



(a)



(b)

FIGURE 3.7.1 APPLICATION OF LOAD TO SCREW THREAD (SOPWITH).

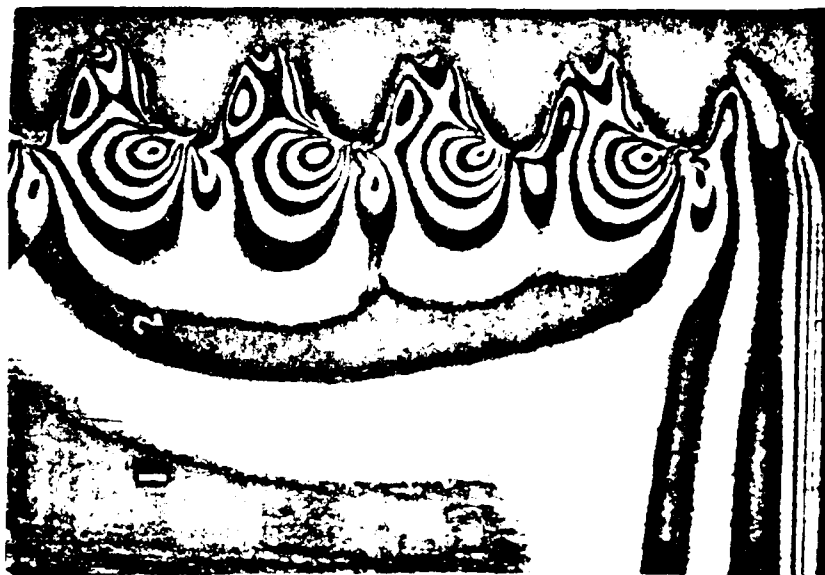
or XY (depth of engagement of thread) and may be taken as concentrated. In the screw thread case, the mean width of the two 'cantilevers' is slightly different, and the load will be concentrated not at mid-depth, but very slightly nearer the root of the male thread." To condense Sopwith's analysis, the thread loading is a point load (possibly a small distribution) acting very near the center of the thread depth.

Heywood (18), presents two-dimensional photoelastic analysis of thread joints under single point loads having different orientations and simulated thread-to-thread contact loads. In comparing the two photographs of Figure 3.7.2, they both exhibit some similar tendencies in the relative locations and magnitude of stresses, except at the contact surfaces where some obvious differences are noted. The interference bands indicating the stress contours in Figure 3.7.2a show a concentrated high stress from which circular bands emulate. However, in Figure 3.7.2b the simulated thread-to-thread contact shows an elongated stress contour roughly parallel to the pressure flank surface, a marked departure from the point load photograph. The contour appears to be a slightly lop-sided parabolic shape with the axis located approximately at the center of the thread depth.

Before proceeding with developing a non-uniform load distribution, the uniform load distribution using seven point loads proposed by O'Hara (20) was studied for possible application to this effort. In our opinion, the



(a) STRESS PATTERN ON THREAD PROJECTION  
HAVING CONCENTRATED LOAD



(b) STRESS PATTERN ON PLANE MODEL  
THREADED JOINT

FIGURE 3.7.2 PHOTOELASTIC STRESS PATTERNS OF THREAD PROJECTION.

uniform represents a significant step towards a more realistic modelling of thread loading phenomena. In view of results of Sopwith and Heywood, discussed above, however, the authors of this effort have elected to augment the loading proposed by O'Hara in two ways: (1) Use non-uniform distribution and (2) limit the distribution to only the central portion of the pressure flank contact area. Figure 3.7.3 provides a comparison of the different load distributions being considered.

The thread load distribution system adopted for our model is shown in Figure 3.7.4. The distribution is assumed to be parabolic (using seven point loads) and is centered about the center of the thread depth (load diameter) defined by equation 3.7.1. The parabolic distribution is assumed to act

$$\text{Load Dia} = (\text{Min Major Dia Ext Thrd} - \text{Max Minor Dia Int Thrd})/2 \quad (3.7.1)$$

over 40% of the total thread surface contact area to roughly approximate the distribution shown in Figure 3.7.2b and to allow a 30% thread contact area on either sides to accommodate contact variations caused by non-conforming thread dimensions for the external thread major and internal thread minor diameters.

The form of the parabolic distribution shown in Figure 3.7.4 is defined by equation 3.7.2, where the seven point loads along the distribution are calculated by the ratio of the area of a given section divided by the total

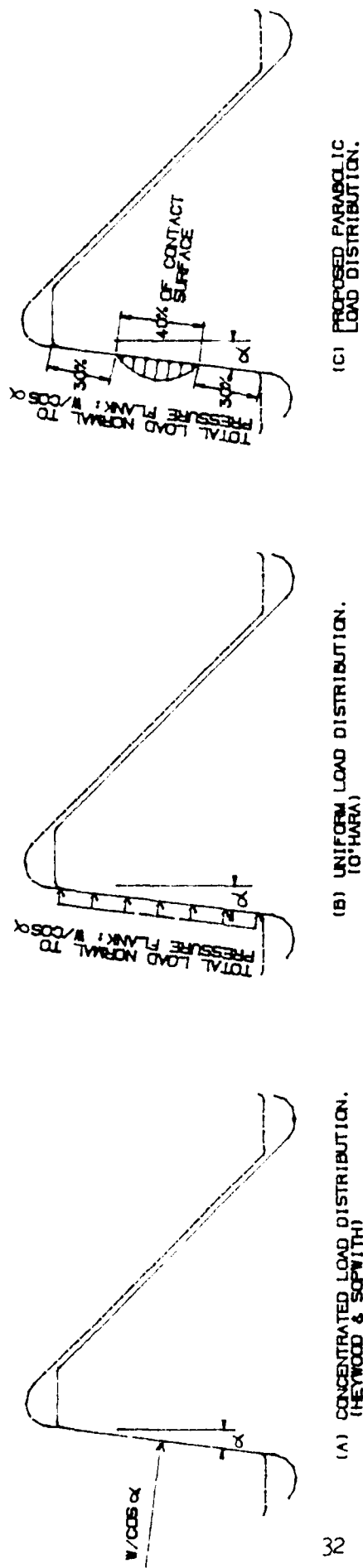


FIGURE 3.7.3 LOAD DISTRIBUTIONS ON PRESSURE FLANK.

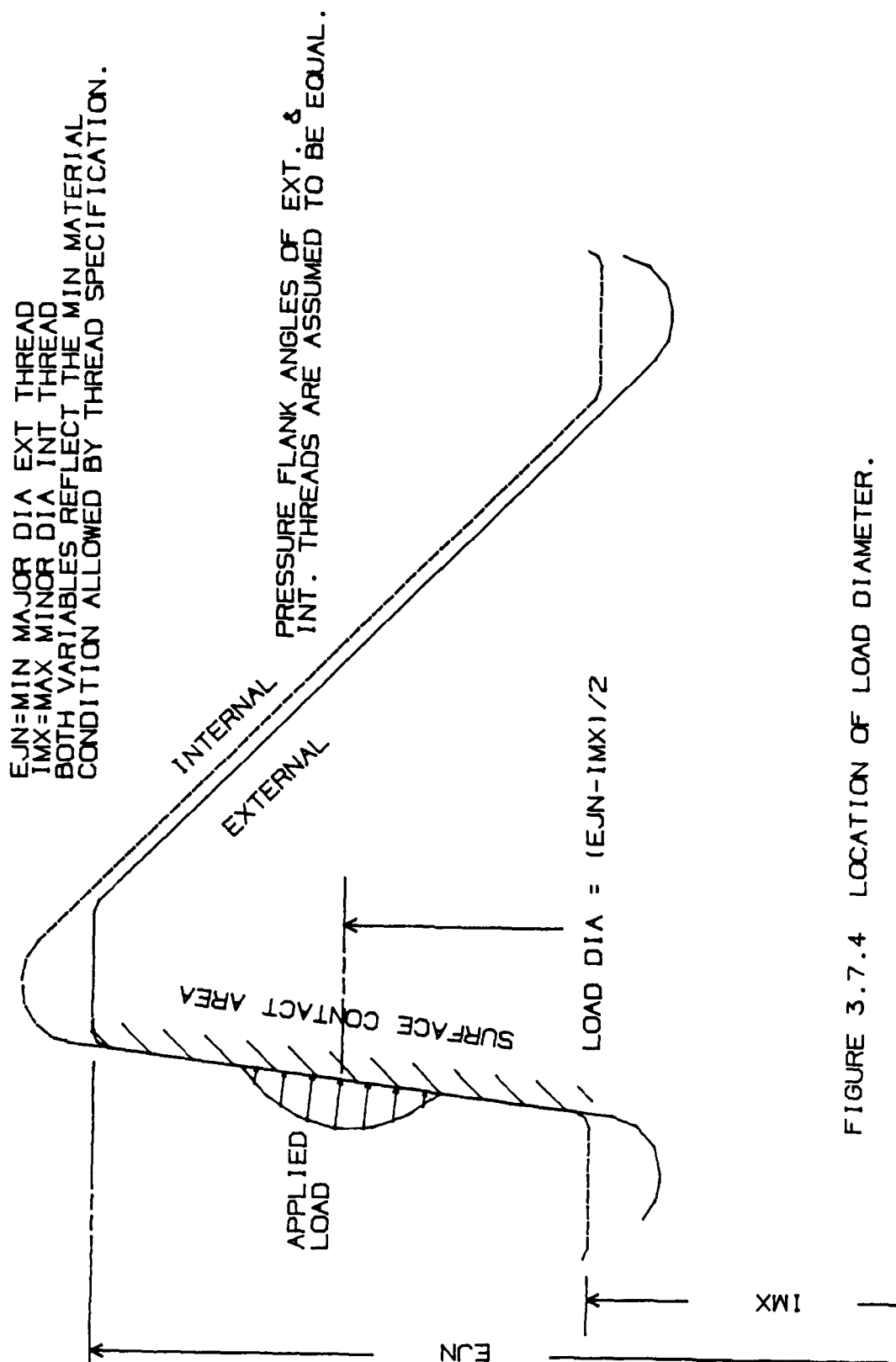


FIGURE 3.7.4 LOCATION OF LOAD DIAMETER.

area under the parabola. Equation 3.7.3 provides the expression for the load magnitudes of each section. Equation 3.7.4 expresses the location of the centroid of each section where the equivalent load is assumed to act.

$$y = \frac{(4u - x)^2}{4u} \quad (3.7.2)$$

where:  $u = .1 \frac{\text{Min Major Dia (external)} - \text{Max Minor Dia (internal)}}{2 \cos(\text{Pressure Flank Angle})}$

$$W_n = W_n \frac{\text{Area of Section } n}{\text{Total Area}} = W \frac{\int_{b_n}^{a_n} y \, dx}{\int_{-2u}^{2u} y \, dx} \quad (3.7.3)$$

$$W_n = W \frac{\int_{b_n}^{a_n} (u - x/4u)^2 \, dx}{\int_{-2u}^{2u} (u - x/4u)^2 \, dx}$$

$$\bar{x}_n = \frac{\int xy \, dx}{\int y \, dx} = \frac{\int_b^a (ux - x^3/4u) \, dx}{\int_b^a (u - x^2/4u) \, dx} \quad (3.7.4)$$

where: W = Total applied load to thread joint

W<sub>n</sub> = Portion of load applied to section n

a<sub>n</sub> & b<sub>n</sub> = X-axis boundaries of section n

Calculated results obtained from the above equations are given in the following table:

Table 3.7.1 Calculated Load Distribution Parameters

| Section No | Section Area         | Load Value | Location from center |
|------------|----------------------|------------|----------------------|
| 1          | .1477 u <sup>2</sup> | .0554 W    | - 1.6241 u           |
| 2          | .3809 u <sup>2</sup> | .0554 W    | - 1.1197 u           |
| 3          | .5209 u <sup>2</sup> | .1953 W    | - .5629 u            |
| 4          | .5675 u <sup>2</sup> | .2128 W    | 0                    |
| 5          | .5209 u <sup>2</sup> | .1953 W    | .5629 u              |
| 6          | .3809 u <sup>2</sup> | .1428 W    | 1.1197 u             |
| 7          | .1477 u <sup>2</sup> | .0554 W    | 1.6241 u             |

### 3.8 Combined Loading

Both axial loads and thread loads produce fillet stresses in the thread root area. As indicated in Figure 3.8.1, the axial loads cause concentration of stress at the bottom of thread roots (points c and c'); while thread loads cause stress concentration at approximately 30 degrees to pressure flank (point A), and compressive stress at approximately 30 degrees to clearance flank (point B). The magnitude of tensile fillet stress is usually much larger than that of compressive fillet stress. The angle between fillet stress due to axial load and tensile fillet stress is  $(60 - \alpha)$ , where  $\alpha$  is the pressure flank angle in degrees. Combined loading will produce a maximum fillet stress which is considered a major factor of thread failure.

Notched parts subjected to bending or axial loads often experience a biaxial stress at the surface of the notch. A threaded connection in tension sees a tangential or a circumferential tensile stress in the notch, in addition to the primary axial stress. Peterson (21) has considered the influence of this biaxial stress factor, as assessed by the distortion energy theory of failure. Addition of the primary and secondary principal stresses, which have the same sign, reduces the energy of distortion. The biaxial effect is a favorable one which lowers the effective stress concentration factor to an estimated maximum of 15% lower than the regular stress concentration factor.

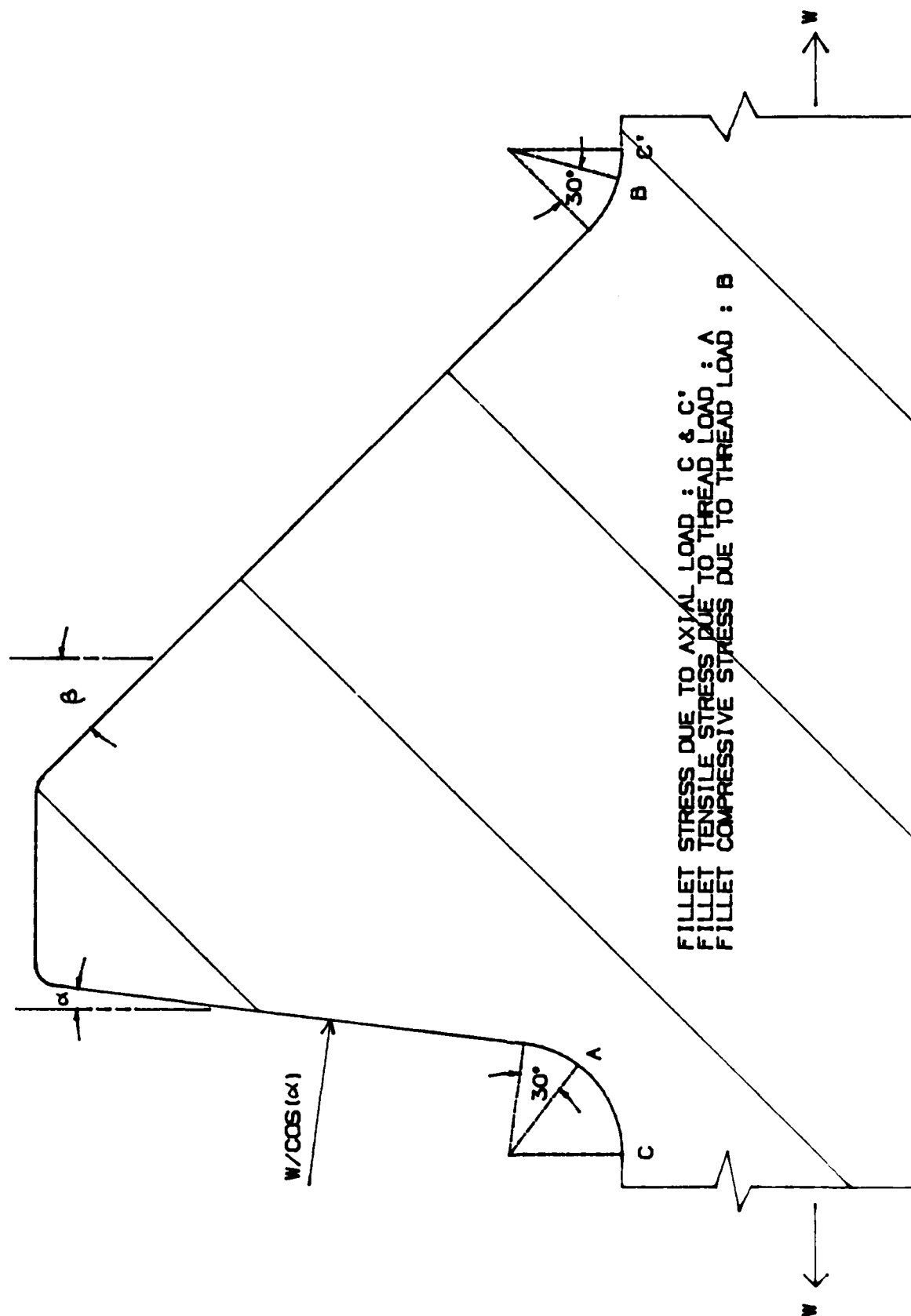


FIG. 3.8.1 LOCATIONS OF MAXIMUM FILLET STRESSES DUE TO AXIAL LOAD & THREAD LOAD.

Tangential (hoop) stress at the thread root area should be included in the thread stress analysis, as in the case of the cannon breech mechanism where the threaded connections are subjected to internal pressure. Consider a thick wall cylinder with inside radius ( $r_i$ ) and outside radius ( $r_o$ ), which is subjected to an internal pressure ( $p_i$ ). The radial stress ( $S_r$ ) and tangential stress ( $S_h$ ) can be expressed as

$$S_r(r) = K_h \left( 1 - \left( \frac{r_o}{r_i} \right)^2 \right) \quad (3.8.1)$$

and

$$S_h(r) = K_h \left( 1 + \left( \frac{r_o}{r_i} \right)^2 \right) \quad (3.8.2)$$

where  $K_h = \frac{p_i (r_i)^2}{((r_o)^2 - (r_i)^2)}$ ,  $r$  is the radius varying from  $r_i$  to  $r_o$ .

At outside surface of the thick wall cylinder  $r=r_o$ , the radial stress and tangential stress become

$$S_r(r_o) = 0 \quad (3.8.3)$$

and

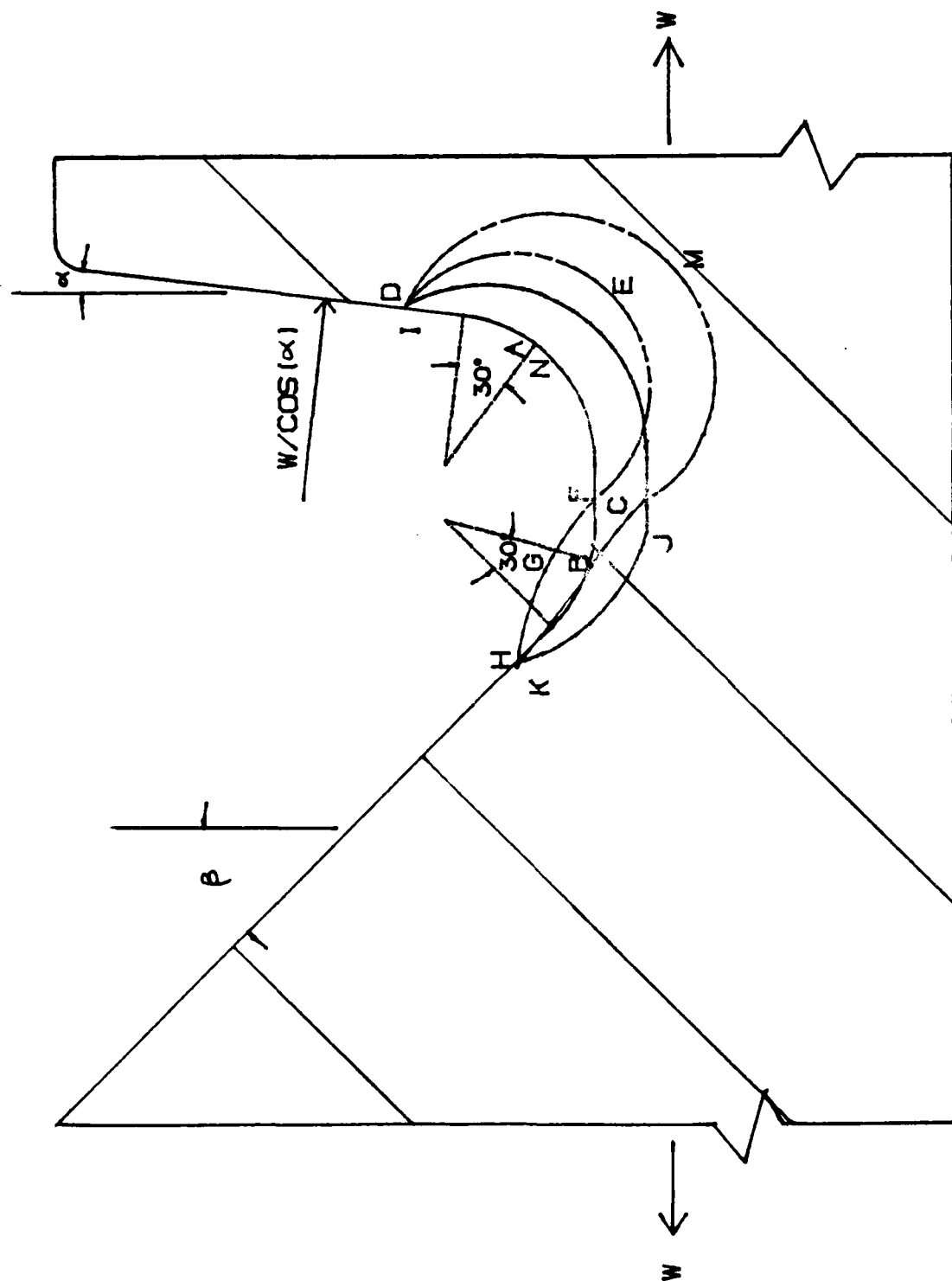
$$S_h(r_o) = \frac{2 p_i (r_i)^2}{((r_o)^2 - (r_i)^2)} \quad (3.8.4).$$

The tangential stress at external thread root area can be estimated by the equation

$$S_h = \frac{2 p_i (d)^2}{((K_{emin})^2 - d^2)} \quad (3.8.5)$$

where  $d$  is hollow diameter and  $K_{min}$  is minimum minor diameter of the external thread. If preload is applied on the threaded connection, the tangential stress for internal thread at the thread root area can be estimated by simulating the threaded connection as concentric cylinders with an interference fit. Since the loading condition of internal pressure is two-dimensional, only plane stresses will be involved. The tangential stress can be superimposed with fillet stresses due to axial load and thread load.

The actual magnitudes of combined stresses due to axial load, thread load and internal pressure at any point along the thread root boundary are extremely difficult to assess for they depend on the complicated distortions and strains occurring in the two threaded members. However, photoelastic data show that the tensile fillet stress is the dominating component in the combined loading effects. The maximum fillet stress is observed in between bottom of the thread root and point A, 30 degrees to pressure flank, and very close to point A. Figure 3.8.2 shows the combined effect of fillet stresses. The dotted line DEF represents the distribution of tensile fillet stress due to thread load (along the boundary of thread root) and has its maximum value at point A. The dotted line FGH represents the distribution of compressive fillet stress due to thread load and has its maximum value in magnitude at point B. Similarly, dotted line IJK represents distribution of tensile fillet



stress due to axial load having its maximum value at point C. By adding the three stresses at points along the thread root boundary, an estimate is obtained for the stress distribution due to the combined effect, which is represented by chain dotted line HMD having a maximum value at point N and very close to point A. For simplicity, it is assumed that the maximum value of the combined effect takes place at point A. The maximum combined stress, obviously, is not equal to the algebraic sum of maximum values due to separately applied loads.

On the boundary of the thread root, stresses normal to fillet contours are zero, and there are no shear stresses on free contour surface. Therefore, the combined fillet stress at point A is a principal stress which is tangent to the fillet contour, and takes the form

$$S_c = S_b + S_t(60 - \alpha) \quad (3.8.6)$$

where  $S_b$  is the maximum fillet stress due to thread load and  $S_t(60 - \alpha)$  is the fillet stress due to axial load at point A. Including tangential (hoop) stress  $S_h$ , the state stress at point A is shown in Figure 3.8.3. The hydrostatic tension and pure shear on octahedral plane can be written, respectively, as

$$S_{oct} = (1/3)(S_b + S_t(60 - \alpha) + S_h) \quad (3.8.7)$$

and

$$T_{oct} = (1/3)(S_b + S_t(60 - \alpha) - S_h) \quad (3.8.8) .$$

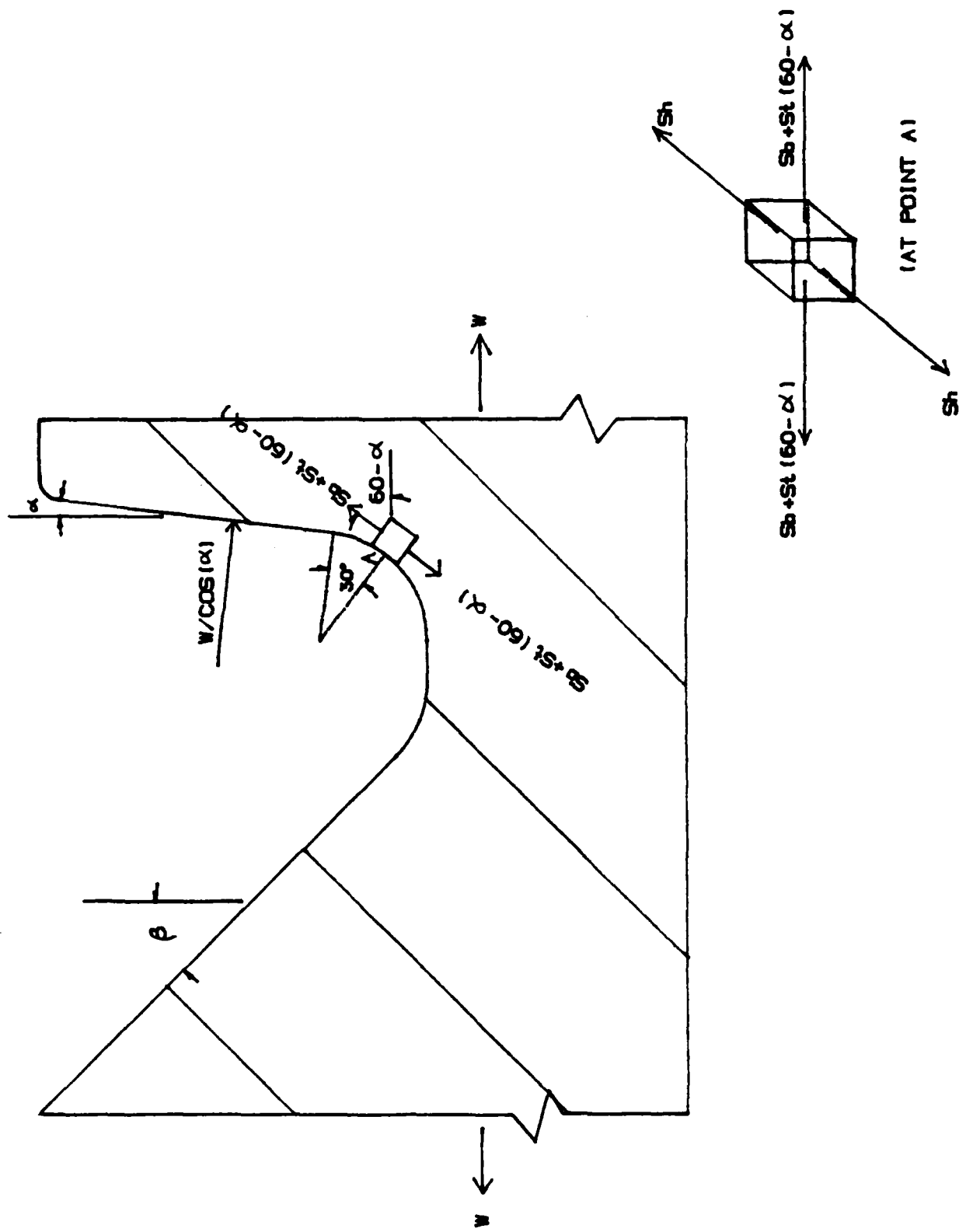


FIGURE 3.8.3 THE STATE OF STRESS AT LOCATION OF MAXIMUM FILLET STRESS DUE TO COMBINED LOADING.

Under the static loading condition, the safety factors of the threaded connection due to triaxial tensile fillet stress are defined as

$$N_y = S_y / S_{oct} \quad (3.8.9)$$

and

$$N_u = S_u / S_{oct} \quad (3.8.10)$$

where  $N_y$  and  $N_u$  are safety factors referring to yield stress and ultimate strength, respectively. Similarly, if the maximum distortion energy theory is applied, safety factors of the threaded connection due to triaxial shear fillet stress are defined as

$$N_y = 0.577 S_y / T_{oct} \quad (3.8.11)$$

and

$$N_u = 0.577 S_u / T_{oct} \quad (3.8.12) .$$

### 3.9 Fatigue

The most frequent failure mode of the threaded connections is fatigue failure due to maximum fillet stresses at the thread root area. Fatigue strength is, therefore, a main concern of design criterion for the thread connection.

To establish the fatigue strength of a material, several tests are necessary because of the statistical nature of fatigue. Through a series of fatigue tests, a S-N (fatigue strength vs. fatigue life cycle) diagram is obtained. Figure 3.9.1 shows an example S-N curve generated on log-log paper for a steel part. The graph shows a knee beyond which no failure will occur regardless of how great the number of cycles. The strength corresponding to the knee is called endurance limit  $S_e$ , or fatigue limit. The graph never becomes horizontal for nonferrous metals and alloys and hence these materials do not have an endurance limit. Experimental data show that the endurance limit ranges from 40% to 60% of tensile strength ( $S_u$ ) for steel up to  $S_u=200$  ksi with mean endurance limit  $S_e'=0.5S_u$ . For tensile strength of 200 kpsi and over, the mean endurance limit is 100 kpsi.

The endurance limit ( $S_e$ ) of a machine element such as threaded connection may be affected by geometric and environmental factors. The major factors are size effect ( $C_d$ ), surface finish effect ( $C_s$ ), effect of load type ( $C_l$ ),

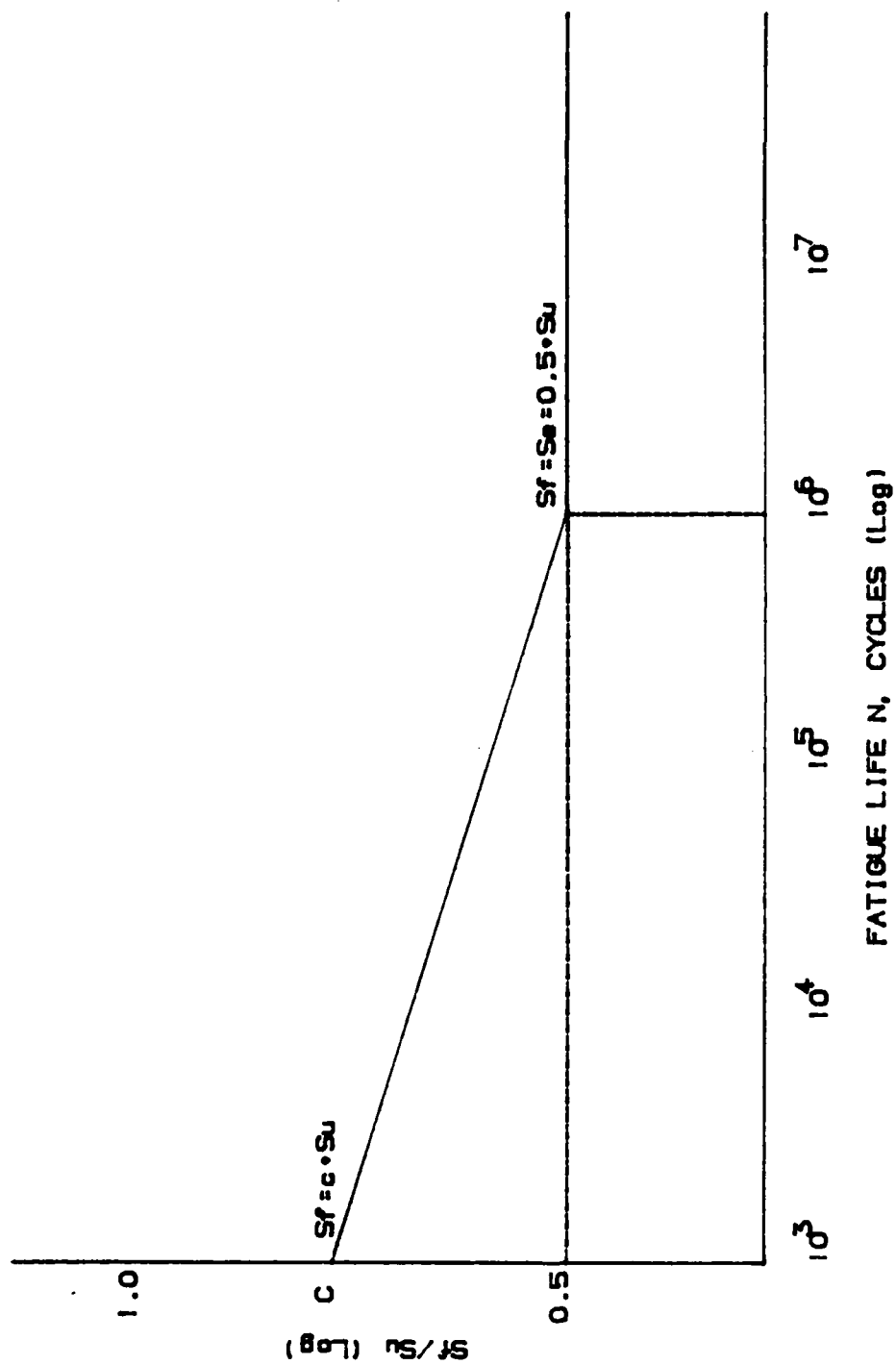


FIGURE 3.9.1 GENERALIZED S-N DIAGRAM.

modifying factor due to fatigue stress concentration ( $C_k$ ), temperature effect ( $C_t$ ) and reliability factor ( $C_r$ ). The modified endurance limit may be written as

$$S_e = C_d C_s C_1 C_k C_t C_r S_e' \quad (3.9.1).$$

The size effect is generally believed to be related to the stress gradient. For bending and torsion  $C_d$  is selected as follow:

$$\begin{aligned} C_d &= 1 & D &\leq 0.4'' \\ C_d &= 0.85 & 0.4'' &< D \leq 2'' \\ C_d &= 0.75 & D &> 2'' \end{aligned} \quad (3.9.2)$$

where  $D$  is major diameter of the threaded connection. And for axial load  $C_d = 1$ .

Surface finish of a part may affect its endurance limit in three ways:

- (1) by introducing stress concentration resulting from surface roughness,
- (2) by altering the physical properties of the surface layer of the material, e.g., an as-forged surface is not only rough but also decarburized, and the decarburization decreases the strength of the surface layer, and (3)
- by introducing residual stresses, e.g., grinding operations often leave the surface layer in residual tension and thereby reduce its ability to withstand reversed loading. The surface finish effect  $C_s$  is defined as the ratio between the endurance limit obtained with arbitrary surface finish and that obtained with the standard Moore mirror-polished finish as shown in Figure 3.9.2.

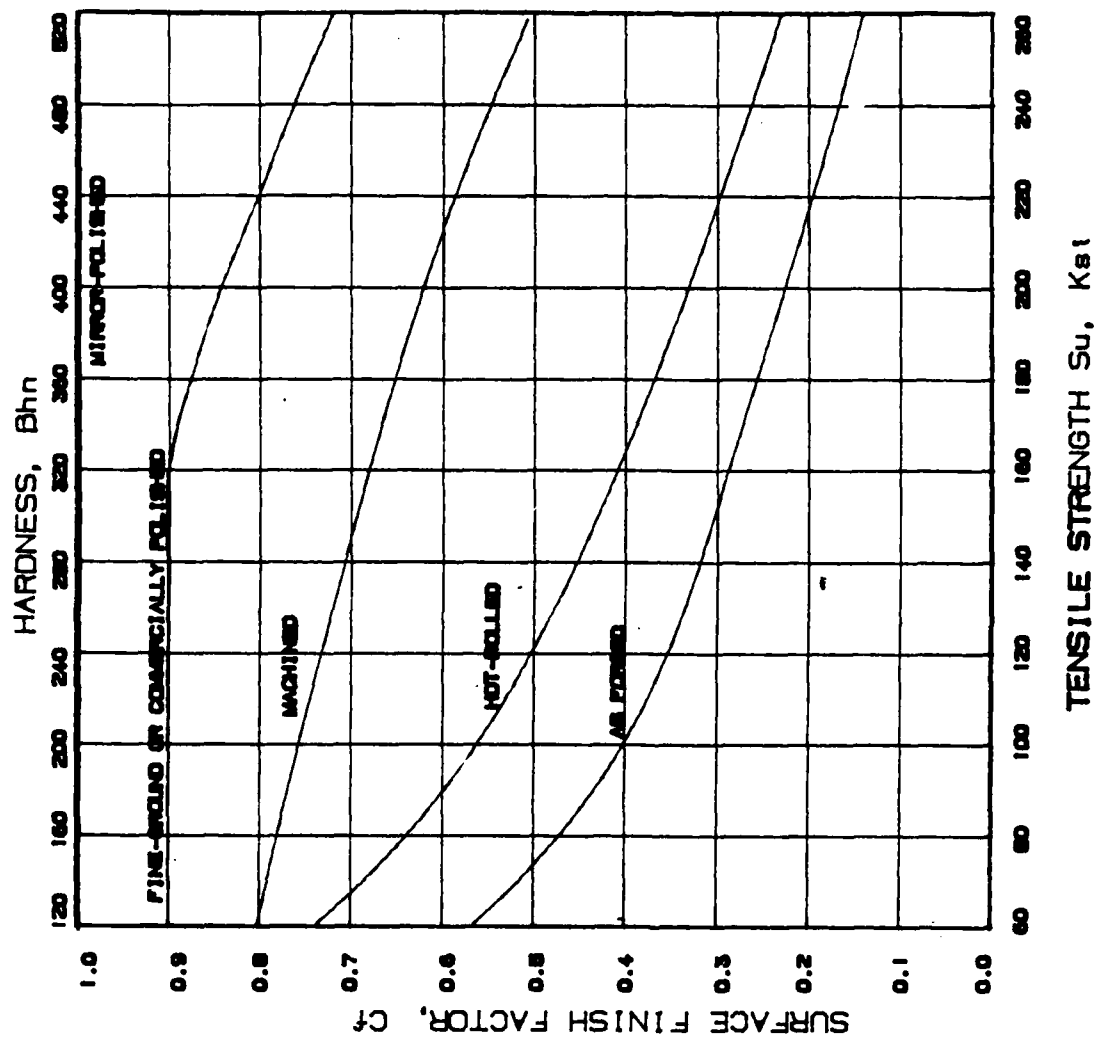


FIGURE 3.9.2 REDUCTION OF ENDURANCE STRENGTH DUE TO SURFACE FINISH FOR STEEL PARTS.

According to Juvinall (14), the endurance limit at  $10^6$ -cycle strength for various load types may, in absence of specific test data, be approximated by multiplying the standard mean endurance limit  $S_e'$  by the following load constants ( $C_l$ ):

Reversed or rotating bending:  $C_l=1.0$

Reversed axial loads:  $C_l=0.9$  without bending,

$C_l=0.6$  to  $0.85$  with indeterminate bending

Reversed torsion:  $C_l=0.58$  ductile metals,

$C_l=0.8$  cast iron (and most brittle materials).

Stress concentration is a highly localized effect. The high stresses actually exist in only very small region in the vicinity of the discontinuity such as fillet, notch and crack. In the case of ductile materials the first load applied to the member will cause yielding at the discontinuity which relieves the stress concentration. Thus when the parts are made of ductile materials and the loads are static, it isn't necessary to use a stress concentration factor. However, when parts are made of brittle materials or when they are subject to fatigue loading, then the stress concentration to be considered. Fatigue stress concentration factor  $K_f$  is defined as a ratio between endurance limit of notch free specimen and endurance limit of notched specimen. This factor can be expressed in terms of notch sensitivity  $q$  and stress concentration factor  $K_t$ , such that

$$K_f = 1 + q(K_t - 1)$$

$$(3.9.3)$$

where  $0 \leq q \leq 1$ . If  $q=0$ ,  $K_f=1$ , the material has no sensitivity to notches at all. If  $q=1$ ,  $K_f=K_t$ , the material has full sensitivity to notches.

Figure 3.9.3, provided by R. E. Peterson (21), shows a family of curves of notch sensitivity  $q$  with respect to notch radius  $r$  for various steel tensile strengths. For a typical unified and American standard thread steel bolt subjected to bending or axial loading, the fatigue stress concentration factor  $K_f$  is estimated as follow:

Annealed (less than 200 Bhn):  $K_f=2.2$  (rolled),  $K_f=2.8$  (machined)

Quenched and drawn (over 200 Bhn):  $K_f=3.0$  (rolled),  $K_f=3.8$  (machined).

The modifying factor for stress concentration is defined as  $C_k=1/K_f$ . According to Heywood (13), fatigue stress concentration factor for finite life ( $K_f'$ ) ranges from 1 to  $K_f$ , where  $(K_f'-1)/(K_f-1)$  is fairly linearly proportional to ultimate tensile strength ( $S_u$ ) as shown in Figure 3.9.4. In this report, the estimated safety factor for simple cyclic loading at various finite life cycles ( $N$ ),  $K_f'$  is assumed to be linearly proportional to  $\log(N)$ .

The temperature effect is considered when the machine elements are operated under high temperature environment. For ferrous metals the temperature effect ( $C_t$ ) is estimated to be:

$$\begin{aligned} C_t &= 620 / (460 + T) && \text{When } T > 160^\circ \text{ F} \\ C_t &= 1 && \text{When } T \leq 160^\circ \text{ F} \end{aligned} \quad (3.9.4).$$

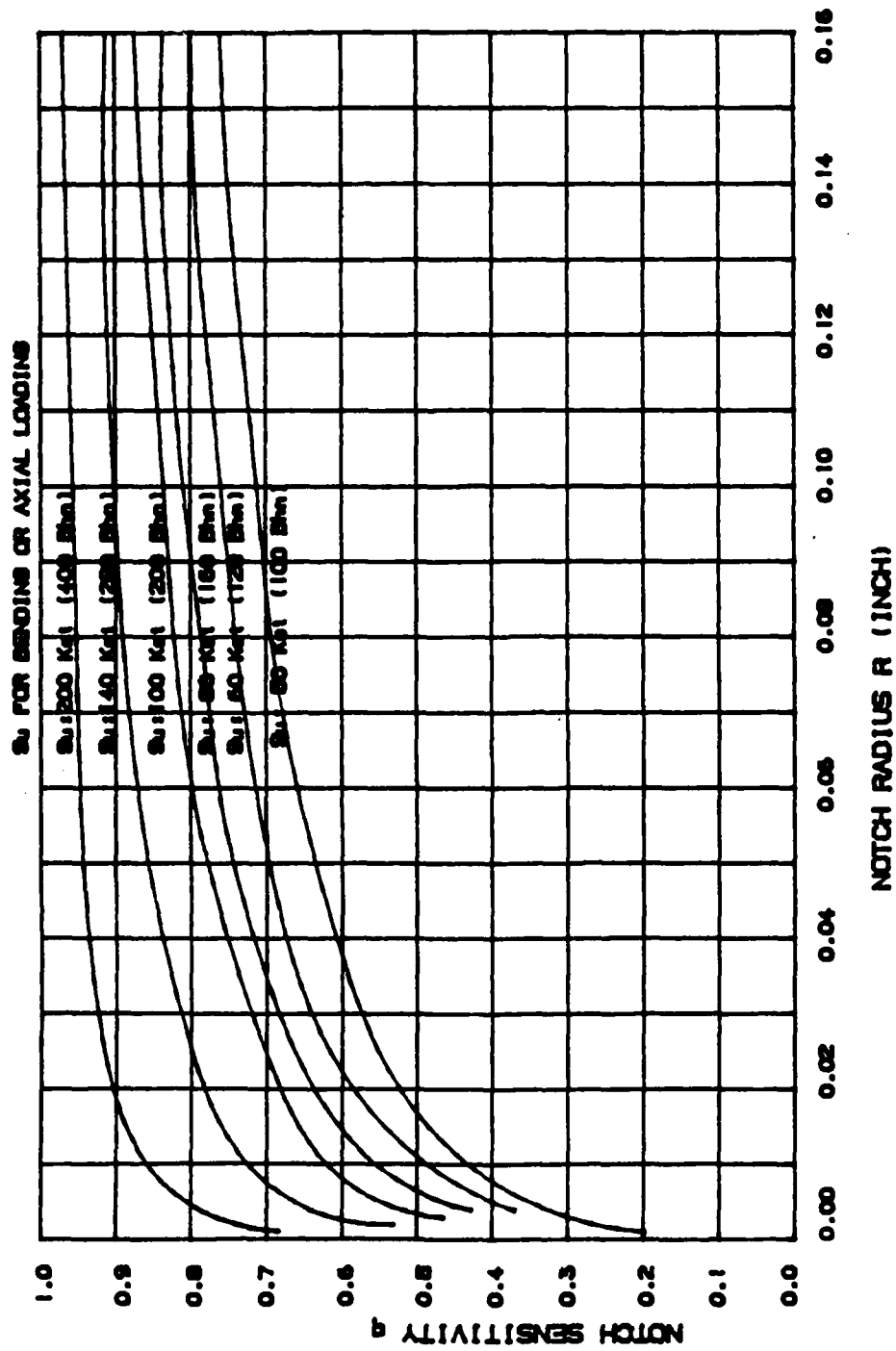


**FIGURE 3.9.3 NOTCH SENSITIVITY CURVES FOR STEEL PARTS.**

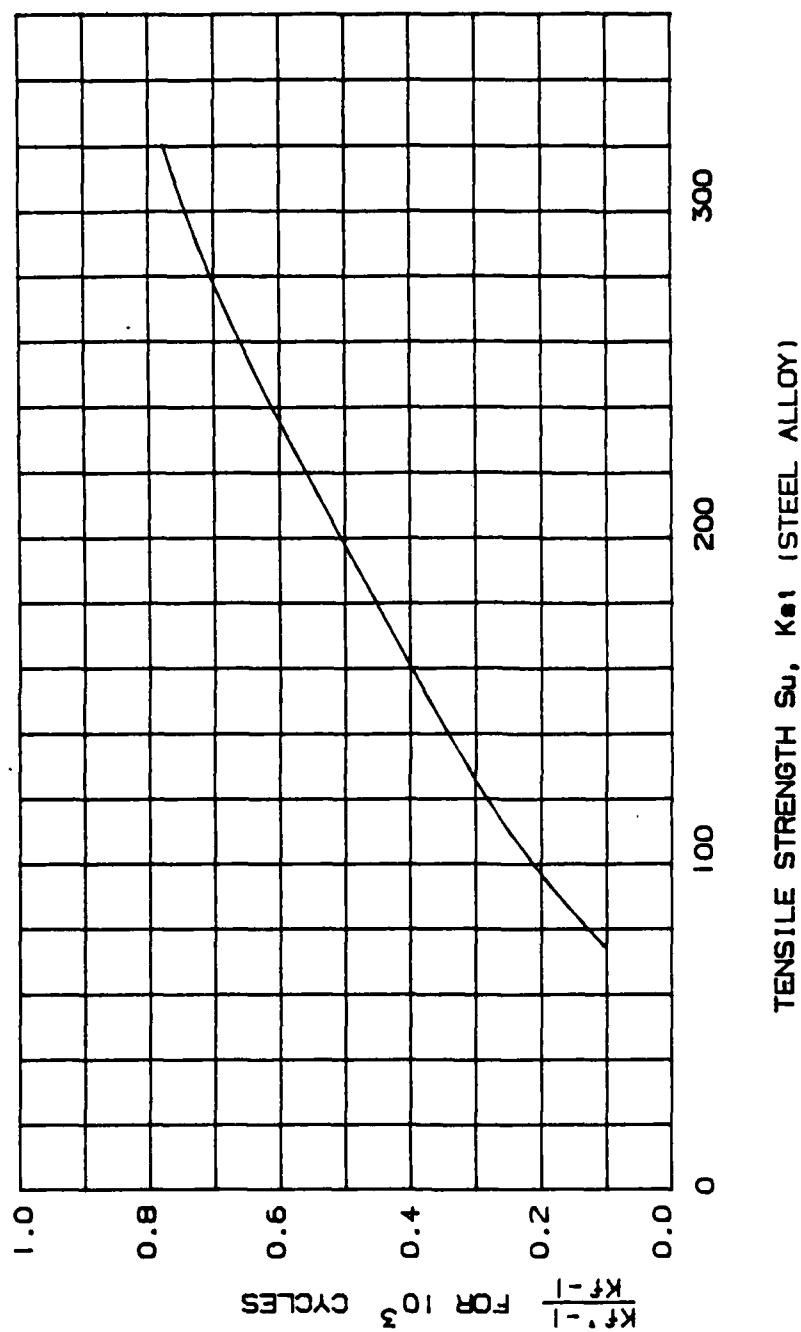


FIGURE 3.9.4 FATIGUE STRESS CONCENTRATION FACTOR FOR FINITE LIFE  $K_f$  AT  $10^3$  CYCLES (HEYWOOD (13)).

Table 3.9.1 Reliability factor Cr

| Reliability R | Standardized variable Zr | Reliability factor Cr |
|---------------|--------------------------|-----------------------|
| 0.50          | 0.                       | 1.000                 |
| 0.90          | 1.288                    | 0.897                 |
| 0.95          | 1.645                    | 0.868                 |
| 0.99          | 2.326                    | 0.814                 |
| 0.999         | 3.091                    | 0.753                 |

In estimating the S-N diagram for ferrous metals, the endurance limit  $S_e$ , plotted at  $10^6$  cycles on log-log coordinates, is connected by a straight line with the estimated fatigue strength ( $S_f = cS_u$ ) at  $10^3$  cycles. For bending and torsional load, the constant  $c$  is estimated to be 0.9, and for axial loads,  $c$  ranges from 0.75 to 0.9. The straight line can be used to define the mean fatigue strength  $S_f$  corresponding to any fatigue life  $N$ , where  $10^3 \leq N \leq 10^6$ , The line equation can be written as

$$\log S_f = -m \log N + b \quad (3.9.6)$$

where

$$m = (1/3) \log(cS_u/S_e) \quad (3.9.7)$$

and

$$b = \log((cS_u)^2 / S_e) \quad (3.9.8).$$

This line intersects  $10^6$  cycles at  $S_e$  and  $10^3$  cycles at  $cS_u$  in logS-logN

curve. When  $S_u$  and  $S_e$  are given, parameters  $m$  and  $b$  can be solved. Then if fatigue life  $N$  is given, the corresponding fatigue strength  $S_f$  can be calculated through the following relation:

$$S_f = 10^{\frac{b}{m}} / N^{\frac{1}{m}}, \quad 10^3 \leq N \leq 10^6 \quad (3.9.9).$$

Alternatively, if the fatigue strength  $S_f$  is given, the fatigue life  $N$  can be found as

$$N = 10^{\frac{b/m}{S_f^{1/m}}}, \quad 10^3 \leq N \leq 10^6 \quad (3.9.10).$$

For the loading history, fluctuating stresses are presented in terms of maximum stress  $S_{max}$  (or  $T_{max}$  for torsion), minimum stress  $S_{min}$  (or  $T_{min}$ ), mean stress  $S_m$  (or  $T_m$ ), alternating stress  $S_a$  (or  $T_a$ ) and prestress  $S_p$  (or  $T_p$ ). The mean stress and alternating stress can be expressed as

$$S_m = S_p + (S_{max} + S_{min})/2 \quad (3.9.11)$$

and

$$S_a = (S_{max} - S_{min})/2 \quad (3.9.12).$$

A few criteria for fatigue fracture are presented in the literatures such as Soderberg line, Goodman line, Gerber parabola, Sine octahedral approach and Kececioglu curve. Figure 3.9.5 shows a typical  $S_a$ - $S_m$  diagram with test data and various fatigue fracture criteria with respect to the endurance limit. The Sine octahedral approach cannot be illustrated except for special cases. These proposals, each having their particular degree

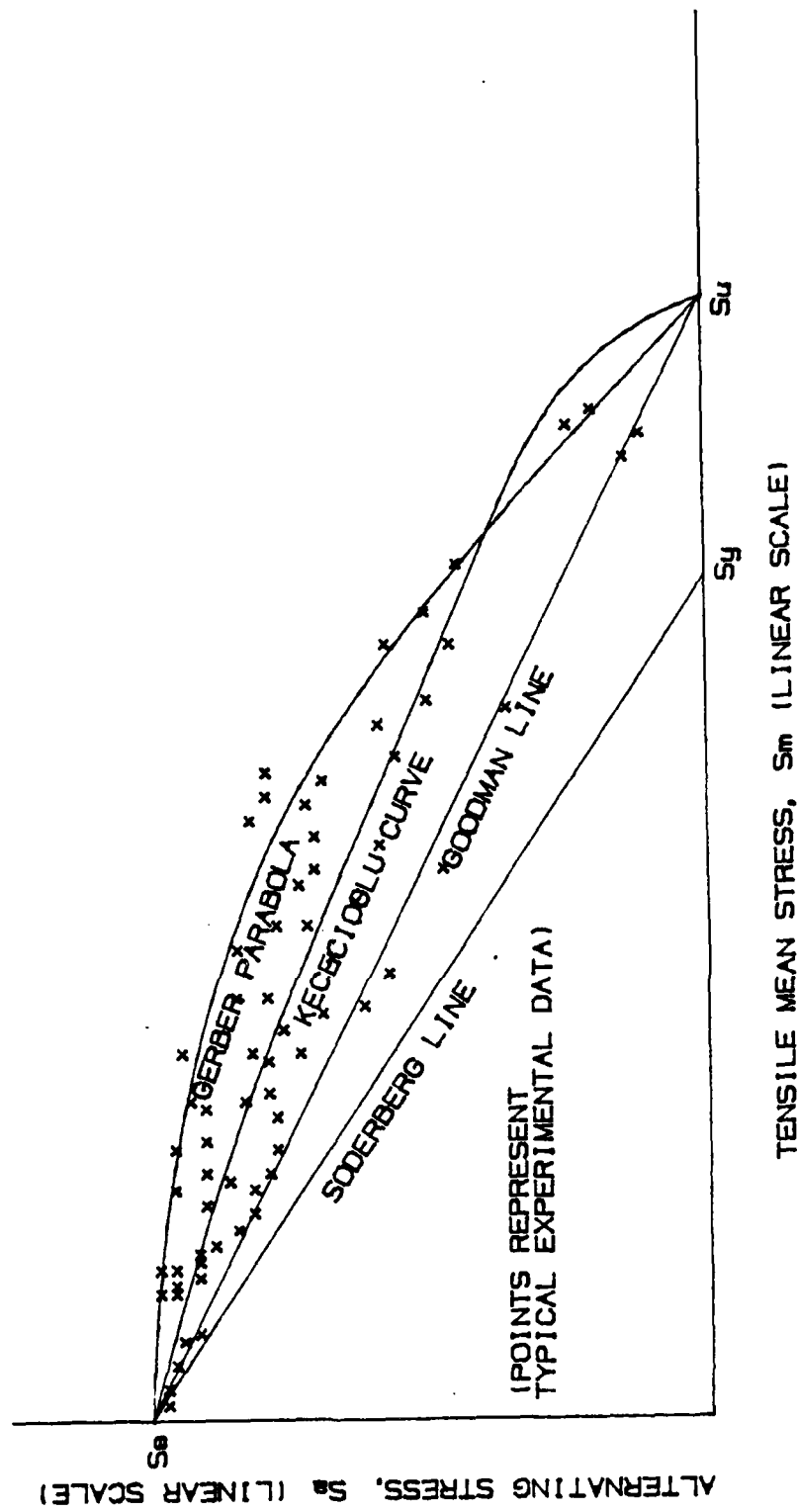


FIGURE 3.9.5 PROPOSED FATIGUE FRACTURE CRITERIA ON  $S_m$ - $S_a$  DIAGRAM.

of conservatism, are verified by many experiments. Modified Goodman, a conservative criterion of fatigue fracture, is applied in this threaded connection stress analysis. For notched specimens of ductile metals, a typical  $S_m$ - $S_a$  (or  $T_m$ - $T_a$ ) diagram for tensile, bending or torsional loads is shown in Figure 3.9.6. The fatigue strength can be the endurance limit, corresponding to  $10^6$  cycles of infinite fatigue life, or any fatigue strength corresponding to fatigue life in between  $10^3$  cycles and  $10^6$  cycles. The line AB, Goodman line, is the criterion of fatigue fracture. The lines CD and CE are the criteria of static yielding. The line AF is the criterion of fatigue fracture in compression. The equation of lines AB, CD, CE and AF can be written as:

$$S_a + (S_f/S_u)S_m = S_f \quad (3.9.13)$$

$$S_m + S_a = S_y \quad (3.9.14)$$

$$S_a - S_m = S_y \quad (3.9.15)$$

and

$$S_a = S_f \quad (3.9.16)$$

where  $S_f$ ,  $S_u$  and  $S_y$  are known positive values. All points below EFAGD correspond to fluctuating stresses which should cause neither fatigue fracture nor plastic deformation. If a machine element such as the threaded connection subjected to cyclic tensile loads and ratio  $S_a/S_m$  can be calculated, without fatigue test one can estimate fatigue strength corresponding to desired fatigue life or estimate fatigue life for a given loading condition by using

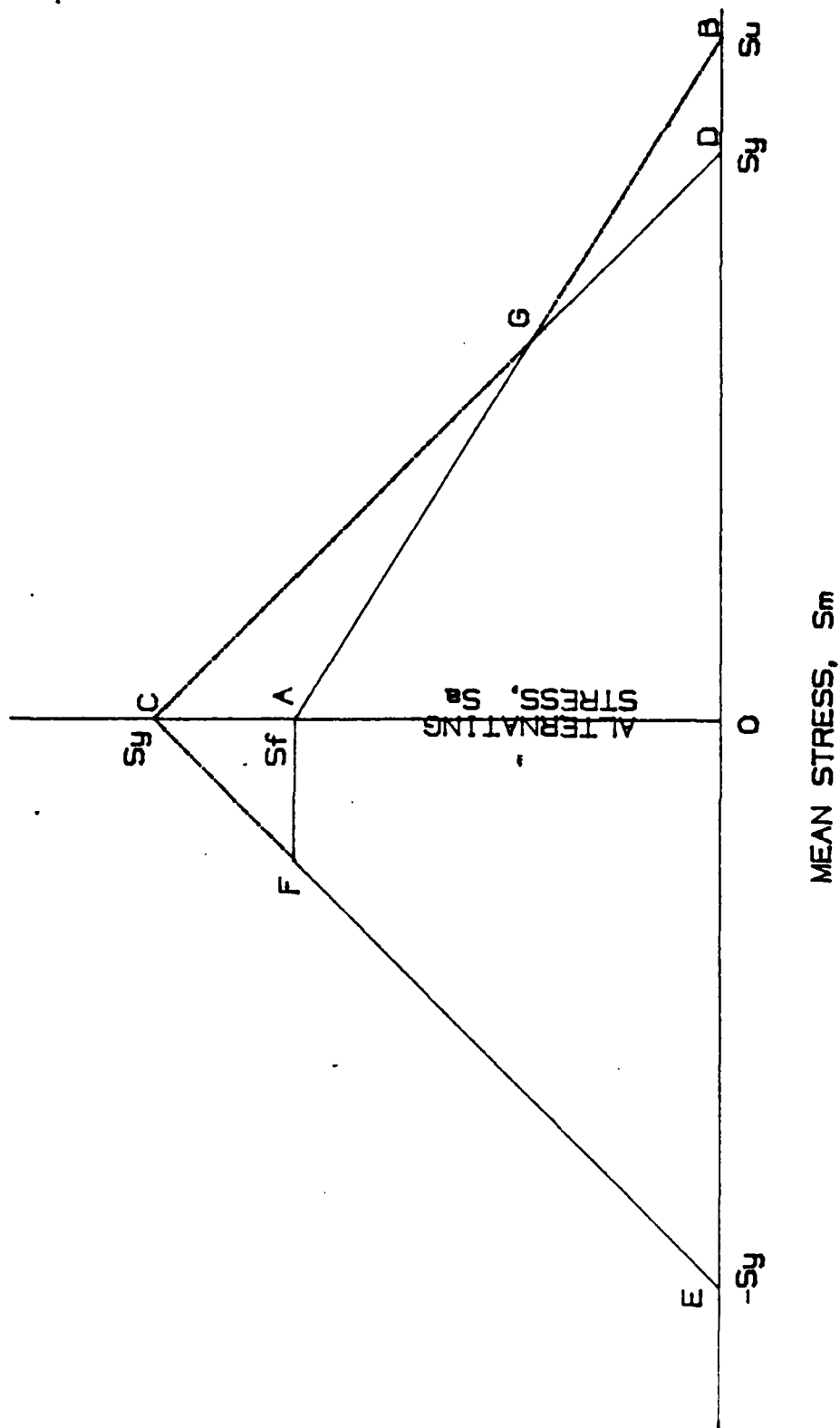


FIGURE 3.9.6  $S_m$ - $S_a$  DIAGRAM FOR DUCTILE METALS.

Figures 3.9.1 or 3.9.6. Figure 3.9.7 shows a experimental fatigue strength diagram for alloy steel with  $S_u=125$  to 180 kpsi under axial loading using  $S_m-S_a$  as well as  $S_{max}-S_{min}$  coordinates. The curves are generated by Grumman Aircraft Engineering Corp., and applicable to alloy steel as AISI 4340, 4130, 2330 and 8630 etc. The diagram shows that the fatigue strength at  $10^3$  cycles is about 84% of the ultimate strength. This diagram and fatigue factor of size effect ( $C_d$ ), surface finish effect ( $C_f$ ), load type effect ( $C_l$ ), modifying factor due to fatigue stress concentration ( $C_k$ ), temperature effect ( $C_t$ ) and reliability factor ( $C_r$ ) will be used in the program to estimate the safety factor of the threaded joint under a simple cyclic loading condition at various fatigue life cycles.

From Section 3.8, combined loading, the elements on the fillet contour have two stress components which are the hoop stress ( $S_h$ ) and the combined fillet stress due to axial load and thread load ( $S_c$ ). Both stresses  $S_h$  and  $S_c$  may have both mean and alternating components ( $S_{hm}$ ,  $S_{ha}$ ,  $S_{cm}$  and  $S_{ca}$ ). By using distortion energy theory, the mean and alternating von Mises stresses are defined as:

$$S'_m = \left( S_{hm}^2 - S_{hm}S_{cm} + S_{cm}^2 \right)^{\frac{1}{2}} \quad (3.9.17)$$

and

$$S'_a = \left( S_{ha}^2 - S_{ha}S_{ca} + S_{ca}^2 \right)^{\frac{1}{2}} \quad (3.9.18)$$

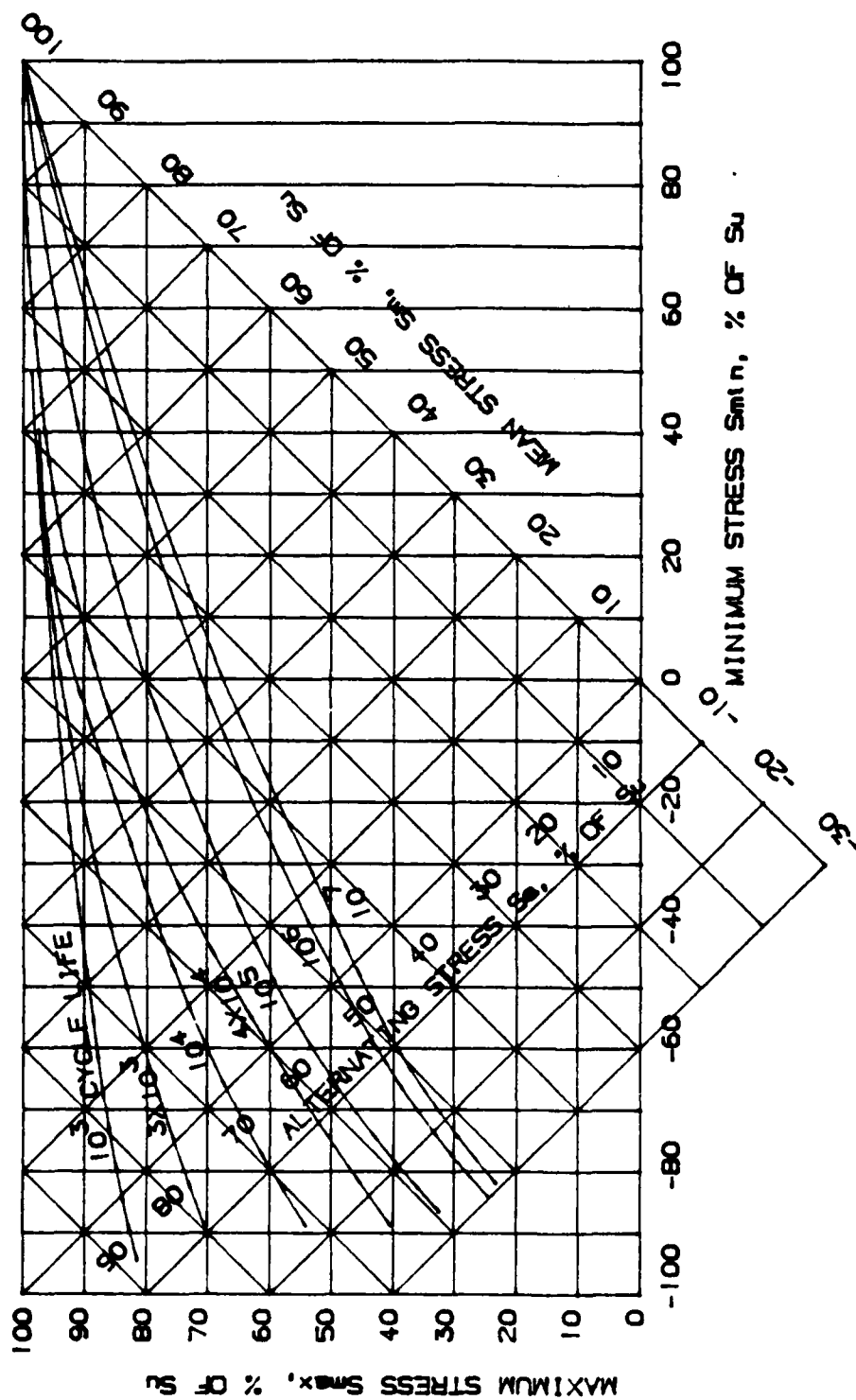


FIGURE 3.9.7 FATIGUE STRENGTH DIAGRAM FOR ALLOY STEEL,  $S_u = 125$  TO  $180 \text{ Ksi}$  AXIAL LOADING.  
 (AVERAGE OF TEST DATA FOR POLISHED SPECIMENS OF AISI 4340, 4130, 2330 & 8630)  
 (GRUMMAN AIRCRAFT ENGINEERING CORP.)

These two stress components may then be applied to S'm-S'a diagram and fatigue criterion such as modified Goodman criterion to estimate fatigue strength or fatigue life.

The safety factor due to combination of mean and alternating stresses can be determined by Sm-Sa diagram with fatigue fracture criterion. If a threaded connection is under cyclic loads, a load line OP and nominal load point N can be established in Sm-Sa diagram as shown in Figure 3.9.8. The nominal load point corresponds to the combination of mean and alternating stresses. It is observed that there are three possible design overload points on the fatigue fracture criterion curve (modified Goodman line is applied in this study) of specified fatigue strength which may correspond to any fatigue lifes from  $10^3$  cycles to  $10^6$  cycles. The three interpretations, according to Juvinall (14), represented on the figure are discussed as follow:

(1) If the nature of the machine involved was such that only the alternating stress could be increased due to overload, point Q would be the design overload point, and the safety factor would be

$$N_f = OQ/OD \quad (3.9.19)$$

(2) If the mean stress, by itself, could be increased during overloading, point R would be the design overload point, and the safety factor would be

$$N_f = OR/OA \quad (3.9.20)$$

(3) If the mean and alternating stresses increased by the same percentage during overload, point P would be the design overload point, and the

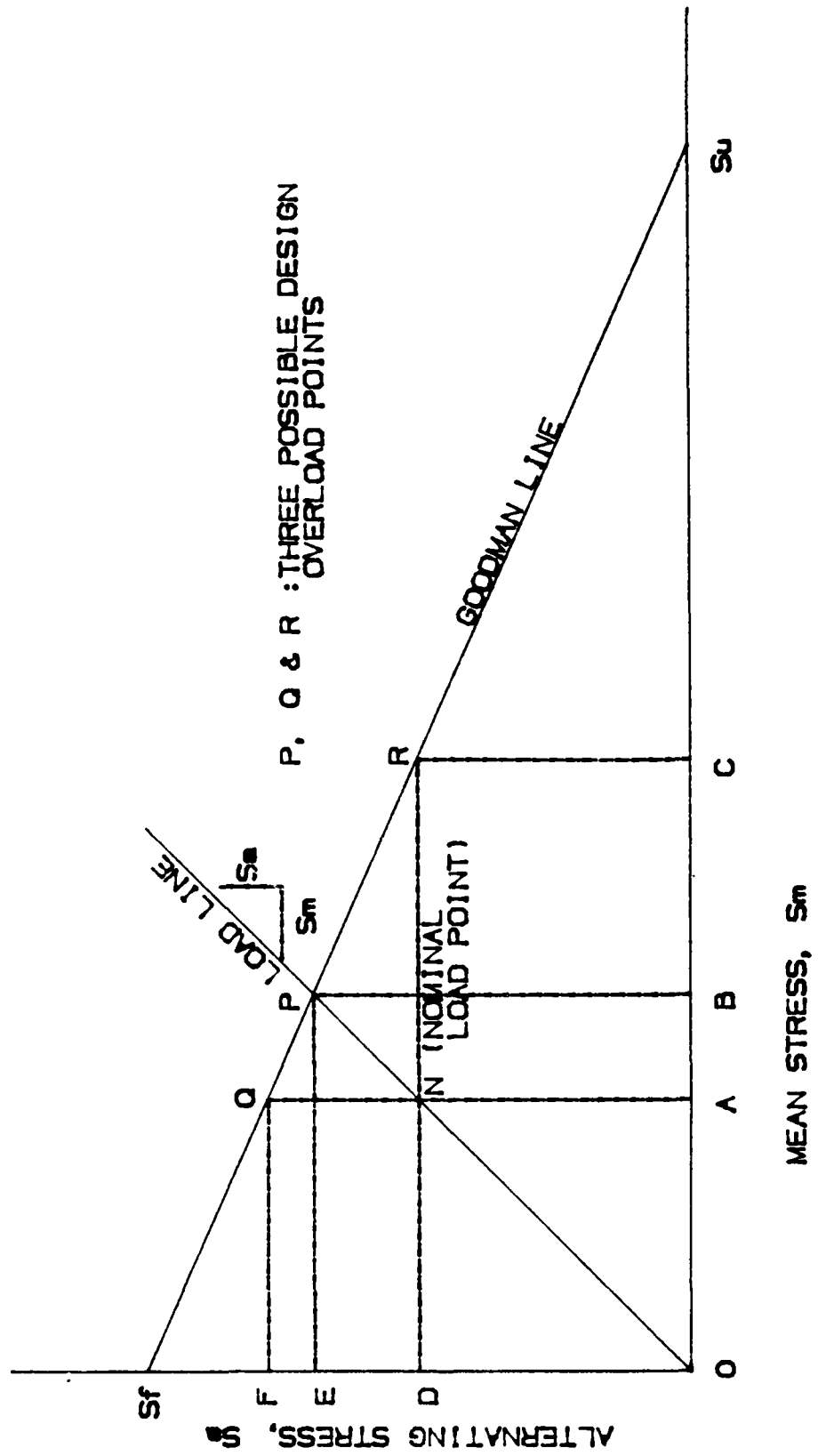


FIGURE 3.9.8 THREE POSSIBLE DESIGN OVERLOAD POINTS FOR SAFETY FACTOR CALCULATION.

safety factor would be

$$N_f = O_P / O_N = O_E / O_D = O_B / O_A \quad (3.9.21) .$$

Without knowing nature of the machine element responding to overloading, interpretation (3) will be adopted. Figure 3.9.9 illustrates that safety factors of the nominal load point N can be calculated corresponding to fatigue lifes ranged from  $10^3$  cycles to  $10^6$  cycles, such that

$$\begin{aligned} N_f(10^6) &= \frac{O_B}{O_A} = \frac{O_C}{O_A} = \frac{O_D}{O_A} \\ N_f(10^5) &= \frac{O_B}{O_A} = \frac{O_C}{O_A} = \frac{O_D}{O_A} \\ N_f(10^4) &= \frac{O_B}{O_A} = \frac{O_C}{O_A} = \frac{O_D}{O_A} \\ N_f(10^3) &= \frac{O_B}{O_A} = \frac{O_C}{O_A} = \frac{O_D}{O_A} \end{aligned} \quad (3.9.22).$$

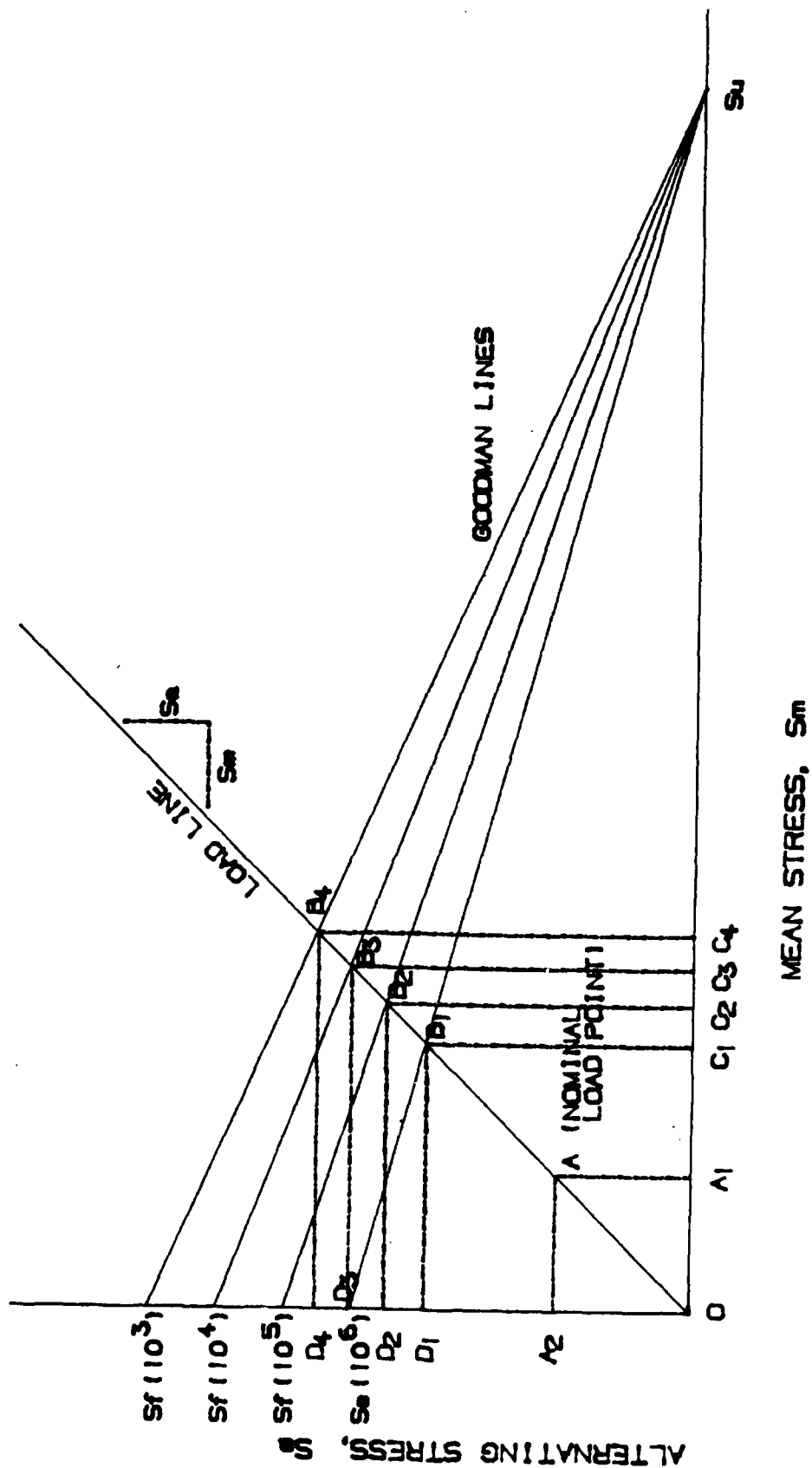


FIGURE 3.9.9 SAFETY FACTORS CORRESPONDING TO VARIOUS FATIGUE LIFE.

#### 4. Interactive Computer Program on Thread Stress Analysis

The easy-to-use menu driven program is initiated with the command  
SEG THREAD which then prints the following menu on the screen:

\*\*\* THREAD PROGRAM CONTROL MENU \*\*\*

|                                   |   |
|-----------------------------------|---|
| INTRODUCTION .....                | 1 |
| RECALL THREAD FILE .....          | 2 |
| INPUT THREAD DATA .....           | 3 |
| EDIT THREAD DATA .....            | 4 |
| LIST THREAD DATA .....            | 5 |
| SAVE THREAD DATA .....            | 6 |
| STATIC AND FATIGUE ANALYSIS ..... | 7 |
| EXIT TO PRIMOS .....              | 8 |

ENTER:.

Selection of menu will guide user to prepare thread data or conduct static and fatigue analysis.

Selection of (1) INTRODUCTION will provide a brief description of the type of static and fatigue analysis that the program will perform and the types of thread forms that can be analyzed. A brief explanation of the output format and the required user provided variables is also listed.

Selection (2) RECALL THREAD FILE will prompt the user to provide a file name of a previously saved file (thread data saved by menu selection of (6)). Following user entry of a valid file name, the program reads thread data into program memory, where the data can then be listed, edited, saved, and have static and fatigue analysis applied to it.

Selection (3) INPUT THREAD DATA permits user input of thread parameters for a particular thread analysis problem. The entered data goes directly into program memory where editing, listing, saving, and analysis may be performed. Table 4.1 gives the thread stress analysis information input form which itemizes required information for thread analysis. Table 4.2 shows this information input form which has been filled in with an example.

Selection (4) EDIT THREAD DATA gives user the opportunity of changing any of the thread analysis problem parameters contained in program memory (either from input data or recalled data file). After 4 is selected, the program lists all thread parameters which are each identified with a menu number. To change any parameter, user selects appropriate thread parameter identity number and makes the change. When the editing session is over, user keys in 0 followed by a carriage return to return to the menu.

Selection (5) LIST THREAD DATA gives a listing of the parameters currently in the program memory.

Selection (6) SAVE THREAD DATA will write thread analysis parameters currently in program memory to a separate file external to the program. User is prompted for a file name, which must be used to recall the saved data when using selection (2).

Selection (7) STATIC AND FATIGUE ANALYSIS solves static and fatigue

TABLE 4.1 THREAD STRESS ANALYSIS INFORMATION INPUT FORM

|                                                                           |           |              |
|---------------------------------------------------------------------------|-----------|--------------|
| 1. WAIVER NO.: RIW                                                        | 2. SON #: | 3. PART NO.: |
| 4. ANALYSIS: (1) STATIC OR (2) STAIIC & FATIGUE                           |           |              |
| 5. DATE MACH. (DDMMYY):                                                   |           |              |
| 6. SUBCODE:                                                               |           |              |
| 7. BASIC MAJOR DIA. (OR DATUM DIA. FOR PF20) (IN):                        |           |              |
| 8. PITCH (PF20):                                                          |           |              |
| 9. THREAD CLASS:                                                          |           |              |
| 10. THREAD FORM: (1) V-THREAD (UN, UNC, UNF OR UNEF) (2) EQUIV O.D. (IN): |           |              |
| 11. HOLLOW DIA. (IN):                                                     |           |              |
| 12. ENGAGEMENT LENGTH (IN):                                               |           |              |
| 13. INTERRUPTED THRD FACTOR:                                              |           |              |
| 14. LOAD FACTOR (1-4, 1.5 NOM.):                                          |           |              |
| 15. T.S. EXT. MEMBER (KSI):                                               |           |              |
| 16. T.S. INT. MEMBER (KSI):                                               |           |              |
| 17. Y.S. EXT. MEMBER (KSI):                                               |           |              |
| 18. Y.S. INT. MEMBER (KSI):                                               |           |              |
| 19. T.S. EXT. MEMBER (KSI):                                               |           |              |
| 20. T.S. INT. MEMBER (KSI):                                               |           |              |
| 21. THRD SURFACE FINISH EXT.:                                             |           |              |
| 22. THRD SURFACE FINISH INT.:                                             |           |              |
| 23. EXT. P.D. (DATUM DIA. FOR PF20) (IN):                                 |           |              |
| 24. INT. P.D. (DATUM DIA. FOR PF20) (IN):                                 |           |              |
| 25. EXT. MIN. DIA. (IN):                                                  |           |              |
| 26. INT. MIN. DIA. (IN):                                                  |           |              |
| 27. EXT. MAX. DIA. (IN):                                                  |           |              |
| 28. INT. MAX. DIA. (IN):                                                  |           |              |
| 29. PRELOAD: (1) NONE (2) FULL (3) PARTIAL: (4) BY AXIAL PRELOAD (KIP):   |           |              |
| FRICITION FACTOR:                                                         |           |              |
| MIN.                                                                      |           |              |
| MAX.                                                                      |           |              |
| 30. AXIAL LOAD (KIP):                                                     |           |              |
| 31. INTERNAL PRESSURE (KSI):                                              |           |              |
| 32. TEMPERATURE (F DEG) (O IF UNDER 160):                                 |           |              |
| 33. RELIABILITY (R=.5 MEAN): 0.5, 0.9, 0.95, 0.99, 0.999                  |           |              |
| REMARK:                                                                   |           |              |

TABLE 4.2 EXAMPLE FOR THREAD STRESS ANALYSIS INFORMATION INPUT FORM

|                                                                         |                                                           |                                                |
|-------------------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------|
| 1. WAIVER NO.: RIW 7592                                                 | 2. SCN #: 3538                                            | 3. PART NO.: 12007723 (REAR YOKE, INT. THREAD) |
| 4. ANALYSIS: (1) STATIC OR (2) STATIC & FATIGUE                         | X                                                         | 5. DATE MACH. (DDMMYY): 14JUN84                |
| 6. SUBCODE:                                                             | 7. BASIC MAJOR DIA. (OR DATUM DIA. FOR PF20) (IN): 7.0625 |                                                |
| PITCH (PF20):                                                           | 8. THREAD CLASS: 2                                        | 11. HOLLOW DIA. (IN): 0                        |
| 8. THREADS/IN: 6                                                        | 9. THREAD (UN, UNC, UNF OR UNEF)                          | 12. EQUIV O.D. (IN): 8.3                       |
| 10. THREAD FORM: (1) V-THREAD (2) ACME THREAD                           |                                                           | 13. ENGAGEMENT LENGTH (IN): 3.185              |
| (3) STUB ACME THREAD                                                    |                                                           | 14. INTERRUPTED THRD FACTOR: 0.483             |
| X (4) BUTTRESS THREAD                                                   |                                                           | 15. LOAD FACTOR (1-4, 1.5 NOM.): 1.5           |
| (5) PF20 THREAD (20/45 BUTT.)                                           |                                                           | 16. T.S. EXT. MEMBER (KSI): 154                |
| FOR NON-STD DESIGN: PF ANGLE (DEG):                                     |                                                           | 17. T.S. INT. MEMBER (KSI): 130                |
| OF ANGLE (DEG):                                                         |                                                           | 18. Y.S. EXT. MEMBER (KSI): 120                |
| EXT. ROOT RADIUS (IN):                                                  |                                                           | 19. Y.S. INT. MEMBER (KSI): 95                 |
| INT. ROOT RADIUS (IN):                                                  |                                                           | 20. THRD SURFACE FINISH EXT. MACH. & GROUND    |
| ENTER DEVIATED DIM. IN 22-27: (0 IF PER SPEC)                           |                                                           | 21. THRD SURFACE FINISH INT. MACH. & GROUND    |
| 22. EXT. MAJ. DIA. (IN): 0                                              | 23. EXT. P.D. (DATUM DIA. FOR PF20) (IN): 0               |                                                |
| 24. EXT. MIN. DIA. (IN): 0                                              | 26. INT. P.D. (DATUM DIA. FOR PF20) (IN): 6.7894          |                                                |
| 25. INT. MAJ. DIA. (IN): 0                                              | 27. INT. MIN. DIA. (IN): 6.9185                           |                                                |
| 28. PRELOAD: (1) NONE (2) FULL (3) PARTIAL: (4) BY AXIAL PRELOAD (KIP): |                                                           |                                                |
| (5) BY TORQUE (FT-LB):                                                  |                                                           | FRICTION FACTOR:                               |
| 29. AXIAL LOAD (KIP): MAX. 12.20                                        |                                                           | MIN. 0                                         |
| 30. INTERNAL PRESSURE (KSI): 0                                          |                                                           | 31. TEMPERATURE (IF DEG) (0 IF UNDER 160): 200 |
| 32. RELIABILITY (R=.5 MEAN): 0.5, 0.9, 0.95, 0.99, 0.999                |                                                           | X                                              |
| REMARK:                                                                 |                                                           |                                                |

(simple load history) problems under assumption of elasticity for thread parameters currently in program memory. In static analysis, load capacity of the threaded joint and safety factors are calculated under maximum, minimum and actual material conditions corresponding to yield stress and tensile strength. In fatigue analysis, safety factors corresponding to various fatigue life cycle ranges are estimated based on user supplied parameters.

Selection (8) EXIT TO PRIMOS returns user to the PRIME operating system at the conclusion of the thread analysis session.

Specific example sessions for V, Acme, Stub Acme, Buttress, and PF20 Watervliet Special Threads are given in appendices A.5 through A.9, respectively.

The interactive thread analysis program documented in this report is written in PRIME F77, an extended version of FORTRAN 77 which conforms fully to ANSIx3.9-1978. A complete software reference including program variable list, common block definitions, source code listing, and compile load instructions is provided in appendices A.1 through A.4.

## 5. Discussion

The object of this report is to establish a program for estimating load capacities and fatigue life cycles of designed threaded connection subjected to a simple cyclic loading. Elastic material property is assumed in this report. For a more realistic material model and numerical method of analysis, finite element analysis with assumption of elastic-plastic material model is recommended for this project in the future. This approach has been explored by many researches such as O'Hara (22), and Chen and O'Hara (23).

A parabolic load distribution on pressure flank is proposed in this report to reflect stress response in the threaded connection. Flank angle deviation is assumed to be negligible in the program. If flank angle deviation is significant for a non-conforming thread, bias load distribution may occur and a complicated load distribution program will be needed to describe the mismatched flank angles of non-conforming threaded connection. Hoop stress of internal thread member is considered far less than fillet stresses due to bending and axial loading and is not included in the program. However for external thread member, hoop stress is calculated if internal pressure applied. It is noticed that stress due to shear is far less than triaxial root stresses so that thread failure usually due to fillet stress. Shear failure takes place when threads have significant truncation and reduce thread contact surface.

In fatigue analysis, load history is calculated by using user supplied

axial maximum applied and minimum applied load to calculated alternating and mean stresses. Internal pressure applied to threaded joint is assumed to be in phase with load history. The threaded connection is assumed to be subjected to axial loading, hence, size effect is  $C_d=1$  and load type effect is  $C_l=0.9$ . In the program, an experimental fatigue strength diagram for alloy steel with tensile strength  $S_u=125$  to  $180$  ksi under axial loading is adopted. To estimate safety factors at various fatigue life cycles, factors of size effect ( $C_d$ ), surface finish effect ( $C_s$ ), load type effect ( $C_l$ ), modifying factor due to fatigue stress concentration ( $C_k$ ), temperature effect ( $C_t$ ) and reliability factor ( $C_r$ ) are applied. Those factors are adopted from various sources, although precision is not claimed, but the results can serve as a reference or indicator. For material with tensile strength  $S_u$  less than  $125$  ksi or larger than  $180$  ksi, S-N curves with equation (3.9.10) and Goodman lines with equation (3.9.22) can be applied to find fatigue life cycle and safety factor at various fatigue life cycles.

Currently, this program only cover thread forms of UN, UNC, UNF, UNEF, ACME, Stub ACME, Buttress and PF20 Watervliet special thread. It is planned to add additional thread forms used on the components manufactured at Rock Island Arsenal.

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## APPENDICES

## A.1 Program Variable List

PI = 3.14159 (PHI)  
 BMJDIA = BASIC MAJOR DIAMETER (OR DATUM DIAMETER FOR PF20 THREAD)  
 EJX = MAX MAJOR DIAMETER (EXTERNAL THREAD)  
 EJN = MIN MAJOR DIAMETER (EXTERNAL THREAD)  
 EJA = ACT MAJOR DIAMETER (EXTERNAL THREAD)  
 EPX = MAX PITCH DIAMETER (EXTERNAL THREAD)  
 EPN = MIN PITCH DIAMETER (EXTERNAL THREAD)  
 EPA = ACT PITCH DIAMETER (EXTERNAL THREAD)  
 EMX = MAX MINOR DIAMETER (EXTERNAL THREAD)  
 EMN = MIN MINOR DIAMETER (EXTERNAL THREAD)  
 EMA = ACT MINOR DIAMETER (EXTERNAL THREAD)  
 IJX = MAX MAJOR DIAMETER (INTERNAL THREAD)  
 IJN = MIN MAJOR DIAMETER (INTERNAL THREAD)  
 IJA = ACT MAJOR DIAMETER (INTERNAL THREAD)  
 IPX = MAX PITCH DIAMETER (INTERNAL THREAD)  
 IPN = MIN PITCH DIAMETER (INTERNAL THREAD)  
 IPA = ACT PITCH DIAMETER (INTERNAL THREAD)  
 IMX = MAX MINOR DIAMETER (INTERNAL THREAD)  
 IMN = MIN MINOR DIAMETER (INTERNAL THREAD)  
 IMA = ACT MINOR DIAMETER (INTERNAL THREAD)  
 A(1) = PITCH DIAMETER TOLERANCE (EXT THREAD)  
 A(2) = PITCH DIAMETER TOLERANCE (INT THREAD)  
 G = PITCH ALLOWANCE  
 T(1) = MINIMUM DIAMETER TOLERANCE  
 T(2) = MAXIMUM DIAMETER TOLERANCE  
 ETS = EXTERNAL MEMBER TENSILE STRENGTH  
 ITS = INTERNAL MEMBER TENSILE STRENGTH  
 EYS = EXTERNAL MEMBER YIELD STRENGTH  
 IYS = INTERNAL MEMBER YIELD STRENGTH  
 TS = MINIMUM ULT STRESS BETWEEN EXT & INT ULT STRENGTHS  
 YS = MINIMUM YIELD STRESS BETWEEN EXTERNAL & INTERNAL YIELDS STRENGTHS  
 ASHEAR = SHEAR AREA  
 SSTRESS = SHEAR STRESS DUE TO MAX LOAD  
 KAEX = AXIAL STRESS CONCENTRATION FACTOR EXT THRD (MAX MATL COND)  
 KAEN = AXIAL STRESS CONCENTRATION FACTOR EXT THRD (MIN MATL COND)  
 KAEA = AXIAL STRESS CONCENTRATION FACTOR EXT THRD (ACT MATL COND)  
 KAIX = AXIAL STRESS CONCENTRATION FACTOR INT THRD (MAX MATL COND)  
 KAIN = AXIAL STRESS CONCENTRATION FACTOR INT THRD (MIN MATL COND)  
 KAIA = AXIAL STRESS CONCENTRATION FACTOR INT THRD (ACT MATL COND)  
 KQEX = FATIGUE STRESS CONCENTRATION FACTOR EXT THRD (MAX MATL COND)  
 KQEN = FATIGUE STRESS CONCENTRATION FACTOR EXT THRD (MIN MATL COND)  
 KQEA = FATIGUE STRESS CONCENTRATION FACTOR EXT THRD (ACT MATL COND)  
 KQIX = FATIGUE STRESS CONCENTRATION FACTOR INT THRD (MAX MATL COND)

KQIN = FATIGUE STRESS CONCENTRATION FACTOR INT THRD (MIN MATL COND)  
 KQIA = FATIGUE STRESS CONCENTRATION FACTOR INT THRD (ACT MATL COND)  
 KPEX = FINITE LIFE S.C. FACTOR EXT THRD (MAX MATL COND)  
 KPEN = FINITE LIFE S.C. FACTOR EXT THRD (MIN MATL COND)  
 KPEA = FINITE LIFE S.C. FACTOR EXT THRD (ACT MATL COND)  
 KPIX = FINITE LIFE S.C. FACTOR INT THRD (MAX MATL COND)  
 KPIN = FINITE LIFE S.C. FACTOR INT THRD (MIN MATL COND)  
 KPIA = FINITE LIFE S.C. FACTOR INT THRD (ACT MATL COND)  
 STEX = AXIAL STRESS EXT THRD (MAX MATL COND)  
 STEN = AXIAL STRESS EXT THRD (MIN MATL COND)  
 STEA = AXIAL STRESS EXT THRD (ACT MATL COND)  
 STIX = AXIAL STRESS INT THRD (MAX MATL COND)  
 STIN = AXIAL STRESS INT THRD (MIN MATL COND)  
 STIA = AXIAL STRESS INT THRD (ACT MATL COND)  
 HDIA = HOLLOW DIAMETER IN EXTERNAL MEMBER  
 ODIA = EQUIVALENT O.D. OF INTERNAL MEMBER  
 HV = HEIGHT OF SHARP V-THREAD  
 N = NUMBER OF THREADS PER INCH  
 PITCH = PITCH (INVERSE OF THREADS PER INCH)  
 PFANG = PRESSURE FLANK ANGLE (DEGREES)  
 STD(1) = STANDARD OR NON-STANDARD STRING FOR PFANG  
 CLANG = CLEARANCE FLANK ANGLE (DEGREES)  
 STD(2) = STANDARD OR NON-STANDARD STRING FOR CLANG  
 PFRAD = PRESSURE FLANK ANGLE (RADIAN)  
 CLRAD = CLEARANCE FLANK ANGLE (RADIAN)  
 ERR = MIN ROOT RADIUS (EXT THRD)  
 STD(3) = STANDARD OR NON-STANDARD STRING FOR ERR  
 IRR = MIN ROOT RADIUS (INT THRD)  
 STD(4) = STANDARD OR NON-STANDARD STRING FOR IRR  
 CLASS = THREAD CLASS DESIGNATION  
 HE1 = HEIGHT OF THRD IN EXT THRD  
 HI1 = HEIGHT OF THRD IN INT THRD  
 HE2 = BASIC THREAD HEIGHT EXT THRD  
 HI2 = BASIC THREAD HEIGHT INT THRD  
 LE = MINIMUM LENGTH OF ENGAGEMENT (IN)  
 SERIES = THREAD SERIES DESIGNATION  
 SECTOR = DECIMAL FRACTION OF THREAD PORTION LEFT AFTER SEGMENTING  
 INTFLG = FLAG - INDICATES INTERFERENCE CONDITION IF = 1  
 PRES(1) = INTERNAL PRESSURE (PSI)  
 SHEX = HOOP STRESS EXT THRD (MAX MATL COND)  
 SHEN = HOOP STRESS EXT THRD (MIN MATL COND)  
 SHEA = HOOP STRESS EXT THRD (ACT MATL COND)  
 BLPFS = BACKLASH ON PRESSURE FLANK SIDE (TO SPEC COND)  
 BLCFS = BACKLASH ON CLEARANCE FLANK SIDE (TO SPEC COND)  
 BLPFD = BACKLASH ON PRESSURE FLANK SIDE (ACTUAL COND)

BLCFD = BACKLASH ON CLEARANCE FLANK SIDE (ACTUAL COND)  
 BLS = BACKLASH TOTAL (TO SPEC COND)  
 BLD = BACKLASH TOTAL (ACTUAL COND)  
 HELIXS = LENGTH OF HELIX  
 SARA = SURFACE CONTACT AREA (TO SPEC COND)  
 SARAX = SURFACE CONTACT AREA (MAX MATL COND)  
 SARAN = SURFACE CONTACT AREA (MIN MATL COND)  
 SARV = % VARIANCE OF SURFACE CONTACT AREA  
 EJV = VARIANCE IN MAJOR DIAMETERS (EXT THRD)  
 EPV = VARIANCE IN PITCH DIAMETERS (EXT THRD)  
 EMV = VARIANCE IN MINOR DIAMETERS (EXT THRD)  
 IJV = VARIANCE IN MAJOR DIAMETERS (INT THRD)  
 IPV = VARIANCE IN PITCH DIAMETERS (INT THRD)  
 IMV = VARIANCE IN MINOR DIAMETERS (INT THRD)  
 AT = STRESS AREA  
 PREMAX = MAXIMUM RECOMMENDED PRELOAD (W/O PLASTIC DEFORMATION)  
 TORQMAX = MAXIMUM RECOMMENDED TORQUE (W/O PLASTIC DEFORMATION)  
 FPFRAC = DECIMAL FRACTION OF MAX ALLOWABLE PRELOAD  
 LOAD(1) = PRELOAD APPLIED TO THREAD JOINT, INPUT AS A DIRECT CLAMPING  
 LOAD, AS A RESULT FROM TIGHTENING TORQUE, OR AS A FRACTION  
 OF MAX ALLOWABLE PRELOAD FORCE AS LIMITED BY THE PLASTIC  
 DEFORMATION OF THE MEMBERS.  
 LOAD(2) = MAX APPLIED FORCE (KIP)  
 LOAD(3) = MIN APPLIED FORCE (KIP)  
 TORQ = APPLIED TORQUE TO THREAD JOINT (FT-LBS)  
 FF = FRICTION FACTOR FOR TIGHTENING TORQUE  
 TPE = TORSIONAL STRESS DUE TO TIGHTENING & PRELOAD (EXT THRD)  
 TPI = TORSIONAL STRESS DUE TO TIGHTENING & PRELOAD (INT THRD)  
 SEMAX = MAX ROOT TRUNCATION FOR EXT THREADS  
 SEMIN = MIN ROOT TRUNCATION FOR EXT THREADS  
 SIMAX = MAX ROOT TRUNCATION FOR INT THREADS  
 SIMIN = MIN ROOT TRUNCATION FOR INT THREADS  
 EEX = HEYWOOD E PARAMETER FOR EXT THREAD (MAX MATL COND)  
 EEN = HEYWOOD E PARAMETER FOR EXT THREAD (MIN MATL COND)  
 EEA = HEYWOOD E PARAMETER FOR EXT THREAD (ACT MATL COND)  
 EIX = HEYWOOD E PARAMETER FOR INT THREAD (MAX MATL COND)  
 EIN = HEYWOOD E PARAMETER FOR INT THREAD (MIN MATL COND)  
 EIA = HEYWOOD E PARAMETER FOR INT THREAD (ACT MATL COND)  
 M1EX = M1 PARAMETER EXT THREAD (MAX MATL COND)  
 M1EN = M1 PARAMETER EXT THREAD (MIN MATL COND)  
 M1EA = M1 PARAMETER EXT THREAD (ACT MATL COND)  
 M1IX = M1 PARAMETER INT THREAD (MAX MATL COND)  
 M1IN = M1 PARAMETER INT THREAD (MIN MATL COND)  
 M1IA = M1 PARAMETER INT THREAD (ACT MATL COND)  
 ETHETAX = ANGLE THETA EXT THREAD (MAX MATL COND)

ETHETAN = ANGLE THETA EXT THREAD (MIN MATL COND)  
 ETHETAA = ANGLE THETA EXT THREAD (ACT MATL COND)  
 ITHETAX = ANGLE THETA INT THREAD (MAX MATL COND)  
 ITHETAN = ANGLE THETA INT THREAD (MIN MATL COND)  
 ITHETAA = ANGLE THETA INT THREAD (ACT MATL COND)  
 DPEX(I) = DISTANCE FROM ROOT TO CENTER LOAD LINE EXT THRD (MAX MATL COND)  
 DPEN(I) = DISTANCE FROM ROOT TO CENTER LOAD LINE EXT THRD (MIN MATL COND)  
 DPEA(I) = DISTANCE FROM ROOT TO CENTER LOAD LINE EXT THRD (ACT MATL COND)  
 DPIX(I) = DISTANCE FROM ROOT TO CENTER LOAD LINE INT THRD (MAX MATL COND)  
 DPIN(I) = DISTANCE FROM ROOT TO CENTER LOAD LINE INT THRD (MIN MATL COND)  
 DPIA(I) = DISTANCE FROM ROOT TO CENTER LOAD LINE INT THRD (ACT MATL COND)  
 (I) DENOTES INCREMENTALIZED PARABOLIC LOAD DISTRIBUTION (1-7)  
 BEX(I) = HEYWOOD B PARAMETER EXT THRD (MAX MATL COND)  
 BEN(I) = HEYWOOD B PARAMETER EXT THRD (MIN MATL COND)  
 BEA(I) = HEYWOOD B PARAMETER EXT THRD (ACT MATL COND)  
 BIX(I) = HEYWOOD B PARAMETER INT THRD (MAX MATL COND)  
 BIN(I) = HEYWOOD B PARAMETER INT THRD (MIN MATL COND)  
 BIA(I) = HEYWOOD B PARAMETER INT THRD (ACT MATL COND)  
 AEX(I) = HEYWOOD A PARAMETER EXT THRD (MAX MATL COND)  
 AEN(I) = HEYWOOD A PARAMETER EXT THRD (MIN MATL COND)  
 AEA(I) = HEYWOOD A PARAMETER EXT THRD (ACT MATL COND)  
 AIX(I) = HEYWOOD A PARAMETER INT THRD (MAX MATL COND)  
 AIN(I) = HEYWOOD A PARAMETER INT THRD (MIN MATL COND)  
 AIA(I) = HEYWOOD A PARAMETER INT THRD (ACT MATL COND)  
 KBEX = FILLET STRESS CONCENTRATION FACTOR EXT THRD (MAX MATL COND)  
 KBEN = FILLET STRESS CONCENTRATION FACTOR EXT THRD (MIN MATL COND)  
 KBEA = FILLET STRESS CONCENTRATION FACTOR EXT THRD (ACT MATL COND)  
 KBIX = FILLET STRESS CONCENTRATION FACTOR INT THRD (MAX MATL COND)  
 KBIN = FILLET STRESS CONCENTRATION FACTOR INT THRD (MIN MATL COND)  
 KBIA = FILLET STRESS CONCENTRATION FACTOR INT THRD (ACT MATL COND)  
 PTX(I) = THREAD PROJECTION THICKNESS (MAX MATL COND)  
 PTN(I) = THREAD PROJECTION THICKNESS (MIN MATL COND)  
 PTA(I) = THREAD PROJECTION THICKNESS (ACT MATL COND)  
 T1X(I) = SECOND COEFFICIENT TERM IN HEYWOOD EQ (UNIT LOAD)(MAX MATL COND)  
 T1N(I) = SECOND COEFFICIENT TERM IN HEYWOOD EQ (UNIT LOAD)(MIN MATL COND)  
 T1A(I) = SECOND COEFFICIENT TERM IN HEYWOOD EQ (UNIT LOAD)(ACT MATL COND)  
 T2EX(I) = 1ST TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MAX MATL COND)  
 T2EN(I) = 1ST TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MIN MATL COND)  
 T2EA(I) = 1ST TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (ACT MATL COND)  
 T2IX(I) = 1ST TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MAX MATL COND)  
 T2IN(I) = 1ST TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MIN MATL COND)  
 T2IA(I) = 1ST TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (ACT MATL COND)  
 T3EX(I) = 2ND TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MAX MATL COND)  
 T3EN(I) = 2ND TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MIN MATL COND)  
 T3EA(I) = 2ND TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (ACT MATL COND)

T3IX(I) = 2ND TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MAX MATL COND)  
 T3IN(I) = 2ND TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MIN MATL COND)  
 T3IA(I) = 2ND TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (ACT MATL COND)  
 T4EX(I) = 3RD TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MAX MATL COND)  
 T4EN(I) = 3RD TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MIN MATL COND)  
 T4EA(I) = 3RD TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (ACT MATL COND)  
 T4IX(I) = 3RD TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MAX MATL COND)  
 T4IN(I) = 3RD TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MIN MATL COND)  
 T4IA(I) = 3RD TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (ACT MATL COND)  
 SBEXT = SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST EXT THRD (MAX MATL COND)  
 SBENT = SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST EXT THRD (MIN MATL COND)  
 SBEAT = SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST EXT THRD (ACT MATL COND)  
 SBIXT = SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST INT THRD (MAX MATL COND)  
 SBINT = SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST INT THRD (MIN MATL COND)  
 SBIAT = SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST INT THRD (ACT MATL COND)  
 GAMMA = AXIAL LOAD FACTOR  
 SOCTEX = HYDROSTATIC TENSION ON OCTAHEDRAL PLANE EXT THRD (MAX MATL COND)  
 SOCTEN = HYDROSTATIC TENSION ON OCTAHEDRAL PLANE EXT THRD (MIN MATL COND)  
 SOCTEA = HYDROSTATIC TENSION ON OCTAHEDRAL PLANE EXT THRD (ACT MATL COND)  
 SOCTIX = HYDROSTATIC TENSION ON OCTAHEDRAL PLANE INT THRD (MAX MATL COND)  
 SOCTIN = HYDROSTATIC TENSION ON OCTAHEDRAL PLANE INT THRD (MIN MATL COND)  
 SOCTIA = HYDROSTATIC TENSION ON OCTAHEDRAL PLANE INT THRD (ACT MATL COND)  
 TOCTEX = SIMPLE SHEAR ON OCTAHEDRAL PLANE EXT THRD (MAX MATL COND)  
 TOCTEN = SIMPLE SHEAR ON OCTAHEDRAL PLANE EXT THRD (MIN MATL COND)  
 TOCTEA = SIMPLE SHEAR ON OCTAHEDRAL PLANE EXT THRD (ACT MATL COND)  
 TOCTIX = SIMPLE SHEAR ON OCTAHEDRAL PLANE INT THRD (MAX MATL COND)  
 TOCTIN = SIMPLE SHEAR ON OCTAHEDRAL PLANE INT THRD (MIN MATL COND)  
 TOCTIA = SIMPLE SHEAR ON OCTAHEDRAL PLANE INT THRD (ACT MATL COND)  
 SF1YEX = Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (MAX MATL COND)  
 SF1YEN = Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (MIN MATL COND)  
 SF1YEA = Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (ACT MATL COND)  
 SF1YIX = Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (MAX MATL COND)  
 SF1YIN = Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (MIN MATL COND)  
 SF1YIA = Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (ACT MATL COND)  
 SF2YEX = Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (MAX MATL COND)  
 (MAX DISTORTION ENERGY THEORY)  
 SF2YEN = Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (MIN MATL COND)  
 (MAX DISTORTION ENERGY THEORY)  
 SF2YEA = Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (ACT MATL COND)  
 (MAX DISTORTION ENERGY THEORY)  
 SF2YIX = Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (MAX MATL COND)  
 (MAX DISTORTION ENERGY THEORY)  
 SF2YIN = Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (MIN MATL COND)  
 (MAX DISTORTION ENERGY THEORY)  
 SF2YIA = Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (ACT MATL COND)

(MAX DISTORTION ENERGY THEORY)

SF1TEX = T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (MAX MATL COND)

SF1TEN = T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (MIN MATL COND)

SF1TEA = T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (ACT MATL COND)

SF1TIX = T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (MAX MATL COND)

SF1TIN = T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (MIN MATL COND)

SF1TIA = T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (ACT MATL COND)

SF2TEX = T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (MAX MATL COND)  
(MAX DISTORTION ENERGY THEORY)

SF2TEN = T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (MIN MATL COND)  
(MAX DISTORTION ENERGY THEORY)

SF2TEA = T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (ACT MATL COND)  
(MAX DISTORTION ENERGY THEORY)

SF2TIX = T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (MAX MATL COND)  
(MAX DISTORTION ENERGY THEORY)

SF2TIN = T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (MIN MATL COND)  
(MAX DISTORTION ENERGY THEORY)

SF2TIA = T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (ACT MATL COND)  
(MAX DISTORTION ENERGY THEORY)

SFYEX = OVERALL STATIC S.F. EXT THRD (MAX MATL COND) BASED ON YS

SFYEN = OVERALL STATIC S.F. EXT THRD (MIN MATL COND) BASED ON YS

SFYEA = OVERALL STATIC S.F. EXT THRD (ACT MATL COND) BASED ON YS

SFYIX = OVERALL STATIC S.F. INT THRD (MAX MATL COND) BASED ON YS

SFYIN = OVERALL STATIC S.F. INT THRD (MIN MATL COND) BASED ON YS

SFYIA = OVERALL STATIC S.F. INT THRD (ACT MATL COND) BASED ON YS

SFTEX = OVERALL STATIC S.F. EXT THRD (MAX MATL COND) BASED ON TS

SFTEN = OVERALL STATIC S.F. EXT THRD (MIN MATL COND) BASED ON TS

SFTEA = OVERALL STATIC S.F. EXT THRD (ACT MATL COND) BASED ON TS

SFTIX = OVERALL STATIC S.F. INT THRD (MAX MATL COND) BASED ON TS

SFTIN = OVERALL STATIC S.F. INT THRD (MIN MATL COND) BASED ON TS

SFTIA = OVERALL STATIC S.F. INT THRD (ACT MATL COND) BASED ON TS

CL = LOAD CONSTANT

CD = SIZE EFFECT

FCYCLE = LOADING CONDITION FOR FATIGUE EVALUATION

ECF = SURFACE FINISH FACTOR (EXT THRD)

ICF = SURFACE FINISH FACTOR (INT THRD)

ESURF = SURFACE FINISH TEXTURE (EXT THRD)

ESURFS = SURFACE FINISH TEXT STRING (EXT THRD)

ISURF = SURFACE FINISH TEXTURE (INT THRD)

ISURFS = SURFACE FINISH TEXT STRING (INT THRD)

TEMP = TEMPERATURE (DEGREE F)

CT = TEMPERATURE EFFECT FACTOR

REL = RELIABILITY OF STANDARD MATERIAL PROPERTIES

CR = RELIABILITY FACTOR

EKF = FATIGUE STRESS CONCENTRATION FACTOR (EXTERNAL THRD)

IKF = FATIGUE STRESS CONCENTRATION FACTOR (INTERNAL THRD)  
 EQ = NOTCH SENSITIVITY (EXTERNAL THRD)  
 IQ = NOTCH SENSITIVITY (INTERNAL THRD)  
 ECK = FATIGUE STRESS CONCENTRATION MOD FACTOR (EXTERNAL THRD)  
 ICK = FATIGUE STRESS CONCENTRATION MOD FACTOR (INTERNAL THRD)  
 ARR(I,J) = ARRAY HOLDING NOTCH SENSITIVITY CURVE DATA  
 EC = CURVE NUMBER - NOTCH DATA ARRAY (EXTERNAL THRD)  
 IC = CURVE NUMBER - NOTCH DATA ARRAY (INTERNAL THRD)  
 ESE = MODIFIED ENDURANCE LIMIT (EXTERNAL THRD)  
 ISE = MODIFIED ENDURANCE LIMIT (INTERNAL THRD)  
 EKT = THEORETICAL STRESS CONCENTRATION FACTOR (EXTERNAL THRD)  
 IKT = THEORETICAL STRESS CONCENTRATION FACTOR (INTERNAL THRD)  
 KTC(N,J) = THEORETICAL STRESS CONCENTRATION CURVE DATA  
 APPLD = APPLIED LOAD IN KIP TO THREAD JOINT  
 CAPPLD(14) = MAX STATIC APPLIED LOAD FOR SAFETY FACTOR OF 1  
                   1,3,5,7,9,11 RELATIVE TO YIELD STRENGTH  
                   13 OVERALL BASED ON YS  
                   14 OVERALL BASED ON TS  
                   2,4,6,8,10,12 RELATIVE TO TENSILE STRENGTH  
 TLCF = THREAD LOAD CONCENTRATION FACTOR, APPLIED ONLY TO  
           HEYWOOD'S FORMULA, TLCF=1.5 Normal RANGE 1 - 4  
 EMXOCT = MAX OCTAHEDRAL TENSILE STRESS (EXTERNAL THRD)  
 IMXOCT = MAX OCTAHEDRAL TENSILE STRESS (INTERNAL THRD)  
 ESPX = STRESS CAUSED BY PRELOAD, MAX MATL COND (EXT THRD)  
 ESPN = STRESS CAUSED BY PRELOAD, MIN MATL COND (EXT THRD)  
 ESPA = STRESS CAUSED BY PRELOAD, ACT MATL COND (EXT THRD)  
 ISPX = STRESS CAUSED BY PRELOAD, MAX MATL COND (INT THRD)  
 ISPN = STRESS CAUSED BY PRELOAD, MIN MATL COND (INT THRD)  
 ISPA = STRESS CAUSED BY PRELOAD, ACT MATL COND (INT THRD)  
 S(I,J) = STRESS CAUSED BY MAX & MIN APPLIED LOADS  
           I=1 MAX MATL COND (EXT THRD)      J=1 MAX LOAD  
           I=2 MIN MATL COND (EXT THRD)      J=2 MIN LOAD  
           I=3 ACT MATL COND (EXT THRD)  
           I=4 MAX MATL COND (INT THRD)  
           I=5 MIN MATL COND (INT THRD)  
           I=6 ACT MATL COND (INT THRD)  
 MEAN(I) = MEAN STRESS (SAME I MEANING AS FOR S(I,J) ABOVE)  
 ALT(I) = ALTERNATING STRESS (I - SAME AS ABOVE)  
 FSF(I,J) = FATIGUE LIFE SAFETY FACTOR FOR I CYCLE,  
           WHERE I=1: 10\*\*3 CYCLES  
                   I=2: 3\*10\*\*4 "  
                   I=3: 10\*\*4 "  
                   I=4: 4\*10\*\*4 "  
                   I=5: 10\*\*5 "  
                   I=6: 10\*\*6 "

I=7: 10\*\*7 "  
 J=MATL CONDITION  
   1 - MAX MATL COND EXT THRD  
   2 - MIN MATL COND EXT THRD  
   3 - ACT MATL COND EXT THRD  
   4 - MAX MATL COND INT THRD  
   5 - MIN MATL COND INT THRD  
   6 - ACT MATL COND INT THRD  
   J= 7 - MIN SAFETY FACTOR OF OVER ALL MATL COND  
 DATE     = DATE PART MACHINED (ddmmmyy) INTEGER  
 WVN     = WAIVER NUMBER - STRING  
 SCN     = SHOP CONTROL NUMBER - STRING  
 PN     = PART NUMBER - STRING  
 SDFLAG   = FLAG FOR TYPE OF ANALYSIS, STATIC OR STATIC + FATIGUE  
 SUBCODE   = 10 CHARACTER SECONDARY IDENTIFIER  
 SERIES   = SERIES IDENTIFIER - INTEGER  
       1 - V-THREAD  
       2 - ACME  
       3 - STUB ACME  
       4 - BUTTRESS  
       5 - PF20 BUTTRESS  
 SERSTR   = SERIES TYPE (UNC, BUTT, UNF, ETC.)  
 METHD   = STRING DEFINING ANALYSIS MODE (Static, or Static+Fatigue)  
 SFY     = OVERALL SF BASED ON YS  
 SFT     = OVERALL SF BASED ON TS

## A.2 Common Blocks

\*\*\* COMMON BLOCK      CB1.THRD \*\*\*

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CHARACTER*10 WVN,SCN,PN,SUBCODE,SERSTR,STD(4),CLASS,DATE
CHARACTER*20 METHD,ESURFS,ISURFS
CHARACTER*32 FNAME
INTEGER*4 SDFLAG,SERIES,ESURF,ISURF,TEMP,FLAGO
REAL*4 PI,EJX,EJN,EJA,EPX,EPN,EPA,EMX,EMN,EMA,IJX,IJN,IJA,IPX,IPN,
*IPA,IMX,IMN,IMA,A(2),G,T(2),ETS,ITS,EYS,IYS,YS,TS,EJV,EPV,
*EMV,IJV,IPV,IMV,LOAD(3),PRES(2),HV,SEMAX,SEMIN,SEACT,SIMAX,SIMIN,
*SIACT,PITCH,LE,AT,VAR(6),HDIA,ODIA,N,ERR,IRR,PFANG,CLANG,PFRAD,
*CLRAD,SECTOR,REL,FF,TORQ,FPFRAC,TLCF,BMJ DIA
COMMON /ONE/ SDFLAG,SERIES,ESURF,ISURF,TEMP,FLAGO,PI,EJX,EJN,
*EJA,EPX,EPN,EPA,EMX,EMN,EMA,IJX,IJN,IJA,IPX,IPN,IPA,IMX,IMN,IMA,A,
*G,T,ETS,ITS,EYS,IYS,YS,TS,EJV,EPV,EMV,IJV,IPV,IMV,LOAD,
*PRES,HV,SEMAX,SEMIN,SEACT,SIMAX,SIMIN,SIACT,PITCH,LE,AT,VAR,HDIA,
*ODIA,N,ERR,IRR,PFANG,CLANG,PFRAD,CLRAD,SECTOR,REL,FF,TORQ,FPFRAC,
*TLCF,BMJ DIA,WVN,SCN,PN,SUBCODE,SERSTR,STD,CLASS,DATE,METHD,ESURFS,
*ISURFS,FNAME

```

\*\*\* COMMON BLOCK      CB2.THRD \*\*\*

```

INTEGER*4 INTFLG,LIFE(6)
REAL*4 BLS,BLD,SARX,SARN,SARA,SARV,BLV,HELIXS,ASHEAR,SSTRESS,
*SHEX,SHEN,SHEA,KAEX,KAEN,KAEA,KAIX,KAIN,KAIA,STEX,STEN,STEA,STIX,
*STIN,STIA,SOCTEX,SOCTEN,SOCTEA,SOCTIX,SOCTIN,SOCTIA,TOCTEX,TOCTEN,
*TOCTEA,TOCTIX,TOCTIN,TOCTIA,EQ,IQ,YSA(7),FSF(7,7),MEAN(6),ALT(6),
*APPLD,CAPPLD(14),PREMAX,TORQMAX,HE1,HE2,HI1,HI2
COMMON /TWO/ INTFLG,LIFE,BLS,BLD,SARX,SARN,SARA,SARV,BLV,HELIXS,
*ASHEAR,SSTRESS,SHEX,SHEN,SHEA,KAEX,KAEN,KAEA,KAIX,KAIN,KAIA,STEX,
*STEN,STEA,STIX,STIN,STIA,SOCTEX,SOCTEN,SOCTEA,SOCTIX,SOCTIN,SOCTIA,
*,TOCTEX,TOCTEN,TOCTEA,TOCTIX,TOCTIN,TOCTIA,EQ,IQ,YSA,FSF,MEAN,ALT,
*APPLD,CAPPLD,PREMAX,TORQMAX,HE1,HE2,HI1,HI2

```

\*\*\* COMMON BLOCK      CB3.THRD \*\*\*

```

REAL*4 BLPFS,BLCFS,BLPFD,BLCFD,TPE,TPI,EEX,EEN,EEA,EIX,EIN,EIA,
*M1EX,M1EN,M1EA,M1IX,M1IN,M1IA,ETHETAX,ETHETAN,ETHETAA,ITHETAX,
*ITHETAN,ITHETAA,DPEX(7),DPEN(7),DPEA(7),DPIX(7),DPIN(7),DPIA(7),
*BEX(7),BEN(7),BEA(7),BIX(7),BIN(7),BIA(7),AEX(7),AEN(7),AEA(7),
*AIX(7),AIN(7),AIA(7),KBEX,KBEN,KBEA,KBIX,KBIN,KBIA,PTX(7),PTN(7),

```

\*PTA(7),T1X(7),T1N(7),T1A(7),T2EX(7),T2EN(7),T2EA(7),T2IX(7),T2IN(7  
 \*),T2IA(7),T3EX(7),T3EN(7),T3EA(7),T3IX(7),T3IN(7),T3IA(7),T4EX(7),  
 \*T4EN(7),T4EA(7),T4IX(7),T4IN(7),T4IA(7),SBEXT,SBENT,SBEAT,SBIXT,  
 \*SBINT,SBIAT,GAMMA,SF1YEX,SF1YEN,SF1YEA,SF1YIX,SF1YIN,SF1YIA,SF2YEX  
 \*,SF2YEN,SF2YEA,SF2YIX,SF2YIN,SF2YIA,SF1TEX,SF1TEN,SF1TEA,SF1TIX,  
 \*SF1TIN,SF1TIA,SF2TEX,SF2TEN,SF2TEA,SF2TIX,SF2TIN,SF2TIA,SFYEX,SFYE  
 \*N,SFYEA,SFYIX,SFYIN,SFYIA,SFTEX,SFTEN,SFTEA,SFTIX,SFTIN,SFTIA,  
 \*ESPX,ESPN,ESPA,ISPX,ISPN,ISPA,S(12,2),SFY,SFT,LDYE,LDYI,  
 \*LDTE,LDTI,CR,KFEX,KFEN,KFEA,KFIX,KFIN,KFIA(7),KPEX,  
 \*KPEN,KPEA,KPIX,KPIN,KPIA,KQEX,KQEN,KQEA,KQIX,KQIN,KQIA,KNEX,KNEN,  
 \*KNEA,KNIX,KNIN,KNIA,CL,CD,ECF,ICF,CT,ESE,ISE,EMXOCT,IMXOCT  
 COMMON /THREE/ BLPFS,BLCFS,BLPFD,BLCLD,TPE,TPI,EEX,EEN,EEA,EIX,  
 \*EIN,EIA,M1EX,M1EN,M1EA,M1IX,M1IN,M1IA,ETHETAX,ETHETAN,ETHETAA,  
 \*ITHETAX,ITHETAN,ITHETAA,DPEX,DPEN,DPEA,DPIX,DPIN,DPIA,BEX,BEN,  
 \*BEA,BIX,BIN,BIA,AEX,AEN,AEA,AIX,AIN,AIA,KBEX,KBEN,KBEA,KBIX,  
 \*KBIN,KBIA,PTX,PTN,PTA,T1X,T1N,T1A,T2EX,T2EN,T2EA,T2IX,T2IN,T2IA,  
 \*T3EX,T3EN,T3EA,T3IX,T3IN,T3IA,T4EX,T4EN,T4EA,T4IX,T4IN,T4IA,SBEXT,  
 \*SBENT,SBEAT,SBIXT,SBINT,SBIAT,GAMMA,SF1YEX,SF1YEN,SF1YEA,SF1YIX,  
 \*SF1YIN,SF1YIA,SF2YEX,SF2YEN,SF2YEA,SF2YIX,SF2YIN,SF2YIA,SFYEX,  
 \*SFYEN,SFYEA,SFYIX,SFYIN,SFYIA,SFTEX,SFTEN,SFTEA,SFTIX,SFTIN,SFTIA,  
 \*ESPX,ESPN,ESPA,ISPX,ISPN,ISPA,S,SFY,SFT,LDYE,LDYI,  
 \*LDTE,LDTI,CR,KFEX,KFEN,KFEA,KFIX,KFIN,KFIA,KPEX,KPEN,KPEA,KPIX,  
 \*KPIN,KPIA,KQEX,KQEN,KQEA,KQIX,KQIN,KQIA,KNEX,KNEN,KNEA,KNIX,KNIN,  
 \*KNIA,CL,CD,ECF,ICF,CT,ESE,ISE,EMXOCT,IMXOCT

### A.3 Compile and Load Instructions

#### COMPILE INSTRUCTIONS

F77 THREAD  
F77 H28VEE  
F77 H28ACM  
F77 H28STB  
F77 H28BUT  
F77 PF20  
F77 INTRO  
F77 SAVE  
F77 RECALL  
F77 INPUT  
F77 EDIT  
F77 OUTPT  
F77 INTCHK  
F77 BKLASH  
F77 PCVAR  
F77 TCLASS  
F77 CALCU  
F77 RECALC  
F77 SURFAR  
F77 SAREA  
F77 PRELOAD  
F77 TORSION  
F77 LDHIST  
F77 HOOP  
F77 SSHEAR  
F77 AXSCF  
F77 HEYWD  
F77 OCT  
F77 STATSF  
F77 NOTCH  
F77 TSCF  
F77 FATIGUE  
F77 FOUTPT

#### LOAD INSTRUCTIONS

SEG -LOAD  
SEG rev 19.2  
\$ LO THREAD  
\$ LO H28VEE  
\$ LO H28ACM  
\$ LO H28STB  
\$ LO H28BUT  
\$ LO PF20  
\$ LO INTRO  
\$ LO SAVE  
\$ LO RECALL  
\$ LO INPUT  
\$ LO EDIT  
\$ LO OUTPT  
\$ LO INTCHK  
\$ LO BKLASH  
\$ LO PCVAR  
\$ LO TCLASS  
\$ LO CALCU  
\$ LO RECALC  
\$ LO SURFAR  
\$ LO SAREA  
\$ LO PRELOD  
\$ LO TORSION  
\$ LO LDHIST  
\$ LO HOOP  
\$ LO SSHEAR  
\$ LO AXSCF  
\$ LO HEYWD  
\$ LO OCT  
\$ LO STATSF  
\$ LO NOTCH  
\$ LO TSCF  
\$ LO FATIGUE  
\$ LO FOUTPT  
\$ LI VAPPLB  
\$ LI  
LOAD COMPLETE  
\$ MA 3  
  
\$ Q

#### A.4 Main Program and Subroutines

```

C
C *****
C ***          THREAD PROGRAM CONTROL MODULE          ***
C *****
C
C      PROGRAM THREAD
C
C      CHARACTER*3 RETN
C      INTEGER*4 PICK
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
      PI=3.14159265359
C
      CALL TNOUA(:115614,INTS(4))
10 WRITE(1,*) ' '
      WRITE(1,*) '*** THREAD PROGRAM CONTROL MENU ***'
      WRITE(1,*) ' '
      WRITE(1,*) 'INTRODUCTION ..... 1'
      WRITE(1,*) 'RECALL THREAD FILE ..... 2'
      WRITE(1,*) 'INPUT THREAD DATA ..... 3'
      WRITE(1,*) 'EDIT THREAD DATA ..... 4'
      WRITE(1,*) 'LIST THREAD DATA ..... 5'
      WRITE(1,*) 'SAVE THREAD DATA ..... 6'
      WRITE(1,*) 'STATIC AND FATIGUE ANALYSIS ..... 7'
      WRITE(1,*) 'EXIT TO PRIMOS ..... 8'
      WRITE(1,*) ' '
20 CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=20) PICK
      IF(PICK.LT.1.OR.PICK.GT.8) GOTO 20
      IF(PICK.EQ.1) THEN
          CALL INTRO
          GOTO 10
      ENDIF
      IF(PICK.EQ.2) THEN
          CALL RECALL
          CALL SURFAR
          GOTO 10
      ENDIF

```

```

IF(PICK.EQ.3) THEN
  CALL INPUT
  GOTO 10
ENDIF
IF(PICK.EQ.4) THEN
  CALL EDIT
  GOTO 10
ENDIF
IF(PICK.EQ.5) THEN
  CALL OUTPT
  CALL TNOUA('      PRESS RETURN FOR PROGRAM CONTROL MENU',INTS(42))
  READ(1,30) RETN
  IF(RETN.NE.' ') GOTO 40
30  FORMAT(A1)
40  CALL TNOUA(:115514,INTS(4))
  GOTO 10
ENDIF
IF(PICK.EQ.6) THEN
  CALL SAVE
  GOTO 10
ENDIF
IF(PICK.EQ.7) THEN
  CALL CALCU
  GOTO 10
ENDIF
IF(PICK.EQ.8) THEN
  CALL EXIT
ENDIF
RETURN
END

```

```

C
C *****
C *** SUBROUTINE TO GENERATE H28 HANDBOOK DATA FOR VEE THREAD FORM ***
C *****
C
C This subroutine generates Unified National thread form geometry for
C v-threads as specified in FED-STD-H28/2 dated 31 March 1978
C
      SUBROUTINE H28VEE
      REAL*4 U0,U1,U2,L1
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      HV=.8660254/N                      /* HEIGHT OF SHARP V-THREAD
      HE1=.708333*HV
      HI1=.66766*HV
      HE2=.625*HV
      HI2=.625*HV
      PITCH=1./N
      L1=BMJDIA                          /* MIN LENGTH OF ENGAGEMENT
      PFANG=30.
      CLANG=30.
      PFRAD=PFANG*PI/180.
      CLRAD=CLANG*PI/180.
      ERR=PITCH/8.
      IRR=PITCH/8.
      IF(SERSTR(1:3).EQ.'UN '.AND.N.GE.12.) L1=9.*PITCH
      IF(SERSTR(1:4).EQ.'UNEF') L1=9.*PITCH
      U0=(.0015*BMJDIA**(1./3.))+.0015*L1**.5+.015*((PITCH)**(2./3.))
      IF(CLASS(1:2).NE.'3 ') THEN
      U1=.3*U0
      ELSE
      U1=0.
      ENDIF
      IF(CLASS(1:2).EQ.'1 ') THEN
      A(1)=1.5*U0
      T(1)=.09*(PITCH**(2./3.))
      A(2)=1.95*U0
      T(2)=HV/6.+A(2)
      ENDIF
      IF(CLASS(1:2).EQ.'2 ') THEN
      A(1)=1.0*U0
      T(1)=.06*(PITCH**(2./3.))
      A(2)=1.3*U0
      T(2)=HV/6.+A(2)
      ENDIF
      IF(CLASS(1:2).EQ.'3 ') THEN
      A(1)=.75*U0
      T(1)=.06*(PITCH**(2./3.))

```

```

A(2)=.975*U0
T(2)=HV/6.+A(2)
ENDIF
IF(BMJDIA.LT..25.AND.CLASS(1:2).NE.'3 ') THEN
  U2=.05*(PITCH**(2./3.))+.03*PITCH/BMJDIA-.002
  IF(U2.LT..25*PITCH-.4*PITCH**2.) U2=.25*PITCH-.4*PITCH**2.
  IF(U2.GT..394*PITCH) U2=.394*PITCH
  GOTO 10
ENDIF
IF(BMJDIA.GE..25.AND.CLASS(1:2).NE.'3 ') THEN
  U2=.25*PITCH-.4*PITCH**2.
  IF(N.LT.4.) U2=.15*PITCH
  GOTO 10
ENDIF
U2=.05*(PITCH**(2./3.))+.03*PITCH/BMJDIA-.002
IF(N.LE.80.AND.N.GE.13.) THEN
  IF(U2.LT..23*PITCH-1.5*PITCH**2.) U2=.23*PITCH-1.5*PITCH**2.
ENDIF
IF(N.LE.12.AND.U2.LT..120*PITCH) U2=.120*PITCH
IF(U2.GT..394*PITCH) U2=.394*PITCH
10 EJJX=BMJDIA-U1
EJJN=EJJX-T(1)
EPX=BMJDIA-2.*(.375*HV)-U1
EPN=EPX-A(1)
EMX=BMJDIA-2.*(.7083333*HV)-U1
EMN=EMX
IJJN=EJJX+U1
IJJX=IJJN+T(2)
IPN=BMJDIA-2.*(.375*HV)
IPX=IPN+A(2)
IMN=BMJDIA-2.*(.625*HV)
IMX=IMN+U2
SEMAX=.144338*PITCH
SEMIN=.0721688*PITCH
SIMAX=.108253*PITCH
SIMIN=.0360844*PITCH
EJJX=AINTEJJX*10000.+5)/10000.
EJJN=AINTEJJN*10000.+5)/10000.
EPX=AINTEPX*10000.+5)/10000.
EPN=AINTEPN*10000.+5)/10000.
EMX=AINTEMX*10000.+5)/10000.
EMN=AINTEMN*10000.+5)/10000.
IJJX=AINTEIJJX*10000.+5)/10000.
IJJN=AINTEIJJN*10000.+5)/10000.
IPX=AINTEIPX*10000.+5)/10000.
IPN=AINTEIPN*10000.+5)/10000.
IMX=AINTEIMX*10000.+5)/10000.
IMN=AINTEIMN*10000.+5)/10000.
RETURN
END

```

```

C
C *****
C *** SUBROUTINE TO GENERATE H28 HANDBOOK DATA FOR ACME THREADS ***
C *****
C
      SUBROUTINE H28ACM
      REAL*4 STO
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      PITCH=1./N
      PFANG=29./2.
      CLANG=29./2.
      PFRAD=PFANG*PI/180.
      CLRAD=CLANG*PI/180.
      HV=.5*PITCH/TAN(PFRAD)
      IF(CLASS(1:2).EQ.'2G') THEN
        EJX=BMJDIA
        EJN=BMJDIA-.05*PITCH
        IPN=BMJDIA-.5*PITCH
        EPX=IPN-.008*BMJDIA**.5
        EPN=EPX-(.030*PITCH**.5+.006*BMJDIA**.5)
        IF(N.GT.10.) G=.010
        IF(N.LE.10.) G=.020
        EMX=BMJDIA-PITCH-G
        EMN=EMX-1.5*(.030*PITCH**.5+.006*BMJDIA**.5)
        IJN=BMJDIA+G
        IJX=IJN+G
        IPX=IPN+(.030*PITCH**.5+.006*BMJDIA**.5)
        IMB=BMJDIA-PITCH
        IMN=BMJDIA-PITCH
        IMX=IMN+.05*PITCH
        ERR=.06*PITCH
        IRR=.06*PITCH
        SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
        SEMIN=SEMAX-.5*(.03*PITCH**.5+.006*BMJDIA**.5)
        STO=G-(.03*PITCH**.5+.006*BMJDIA**.5)
        IF(STO.GE.0.) THEN
          SIMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
          SIMIN=SIMAX-STO
        ELSE
          SIMIN=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
          SIMAX=SIMIN-STO
        ENDIF
      GOTO 50

```

```

ENDIF
IF(CLASS(1:2).EQ.'3G') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.05*PITCH
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.006*BMJDIA**.5
  EPN=EPX-(.014*PITCH**.5+.0028*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
  IJN=BMJDIA+G
  IJX=IJN+G
  IPX=IPN+(.014*PITCH**.5+.0028*BMJDIA**.5)
  IMB=BMJDIA-PITCH
  IMN=BMJDIA-PITCH
  IMX=IMN+.05*PITCH
  ERR=.06*PITCH
  IRR=.06*PITCH
  SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
  SEMIN=SEMAX-.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
  STO=G-(.0028*BMJDIA**.5+.014*PITCH**.5)
  IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
  ELSE
    SIMIN=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
  ENDIF
  GOTO 50
ENDIF
IF(CLASS(1:2).EQ.'4G') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.05*PITCH
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.004*BMJDIA**.5
  EPN=EPX-(.010*PITCH**.5+.002*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.010*PITCH**.5+.002*BMJDIA**.5)
  IJN=BMJDIA+G
  IJX=IJN+G
  IPX=IPN+(.010*PITCH**.5+.002*BMJDIA**.5)
  IMB=BMJDIA-PITCH

```

```

IMN=BMJDIA-PITCH
IMX=IMN+.05*PITCH
ERR=.06*PITCH
IRR=.06*PITCH
SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
SEMIN=SEMAX-.5*(.010*PITCH**.5+.0020*BMJDIA**.5)
STO=G-(.0020*BMJDIA**.5+.010*PITCH**.5)
IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
ELSE
    SIMIN=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
ENDIF
GOTO 50
ENDIF
IF(CLASS(1:2).EQ.'2C') THEN
    EJX=BMJDIA
    EJN=BMJDIA-.0035*BMJDIA**.5
    IPN=BMJDIA-.5*PITCH
    EPX=IPN-.008*BMJDIA**.5
    EPN=EPX-(.030*PITCH**.5+.006*BMJDIA**.5)
    IF(N.GT.10.) G=.010
    IF(N.LE.10.) G=.020
    EMX=BMJDIA-PITCH-G
    EMN=EMX-1.5*(.030*PITCH**.5+.006*BMJDIA**.5)
    IJN=BMJDIA+.001*BMJDIA**.5
    IJX=IJN+.0035*BMJDIA**.5
    IPX=IPN+(.030*PITCH**.5+.006*BMJDIA**.5)
    IMB=BMJDIA-PITCH
    IMN=BMJDIA-PITCH+.1*PITCH
    IMX=IMN+.05*PITCH
    ERR=.07*PITCH
    IRR=.07*PITCH
    SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SEMIN=SEMAX-.5*(.030*PITCH**.5+.006*BMJDIA**.5)
    STO=.0035*BMJDIA**.5-(.006*BMJDIA**.5+.03*PITCH**.5)
    IF(STO.GE.0.) THEN
        SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMIN=SIMAX-STO
    ELSE
        SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMAX=SIMIN-STO
    ENDIF
GOTO 90

```

```

ENDIF
IF(CLASS(1:2).EQ.'3C') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.0015*BMJDIA**.5
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.006*BMJDIA**.5
  EPN=EPX-(.014*PITCH**.5+.0028*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
  IJN=BMJDIA+.001*BMJDIA**.5
  IJX=IJN+.0035*BMJDIA**.5
  IPX=IPN+(.014*PITCH**.5+.0028*BMJDIA**.5)
  IMB=BMJDIA-PITCH
  IMN=BMJDIA-PITCH+.1*PITCH
  IMX=IMN+.05*PITCH
  ERR=.07*PITCH
  IRR=.07*PITCH
  SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
  SEMIN=SEMAX-.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
  STO=.0035*BMJDIA**.5-(.0028*BMJDIA**.5+.014*PITCH**.5)
  IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
  ELSE
    SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
  ENDIF
  GOTO 90
ENDIF
IF(CLASS(1:2).EQ.'4C') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.001*BMJDIA**.5
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.004*BMJDIA**.5
  EPN=EPX-(.010*PITCH**.5+.002*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.010*PITCH**.5+.002*BMJDIA**.5)
  IJN=BMJDIA-.001*BMJDIA**.5
  IJX=IJN+.002*BMJDIA**.5
  IPX=IPN+(.010*PITCH**.5+.002*BMJDIA**.5)
  IMB=BMJDIA-PITCH

```

```

IMN=BMJDIA-PITCH+.1*PITCH
IMX=IMN+.05*PITCH
ERR=.07*PITCH
IRR=.07*PITCH
SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
SEMIN=SEMAX-.5*(.010*PITCH**.5+.002*BMJDIA**.5)
STO=.002*BMJDIA**.5-(.002*BMJDIA**.5+.01*PITCH**.5)
IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
ELSE
    SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
ENDIF
GOTO 90
ENDIF
IF(CLASS(1:2).EQ.'5C') THEN
    EJX=BMJDIA-.025*BMJDIA**.5
    EJN=EJX-.0015*BMJDIA**.5
    IPN=EJX-.5*PITCH
    EPX=IPN-.008*BMJDIA**.5
    EPN=EJX-(.014*PITCH**.5+.0028*BMJDIA**.5)
    IF(N.GT.10.) G=.010
    IF(N.LE.10.) G=.020
    EMX=EJX-PITCH-G
    EMN=EMX-1.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
    IJN=EJX+.001*BMJDIA**.5
    IJX=IJN+.0035*BMJDIA**.5
    IPX=IPN+(.014*PITCH**.5+.0028*BMJDIA**.5)
    IMB=EJX-PITCH
    IMN=EJX-PITCH+.1*PITCH
    IMX=IMN+.05*PITCH
    ERR=.07*PITCH
    IRR=.07*PITCH
    SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SEMIN=SEMAX-.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
    STO=.0035*BMJDIA**.5-(.0028*BMJDIA**.5+.014*PITCH**.5)
    IF(STO.GE.0.) THEN
        SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMIN=SIMAX-STO
    ELSE
        SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMAX=SIMIN-STO
    ENDIF
GOTO 90

```

```

ENDIF
IF(CLASS(1:2).EQ.'6C') THEN
  EJX=BMJDIA-.025*BMJDIA**.5
  EJN=EJX-.0010*BMJDIA**.5
  IPN=EJX-.5*PITCH
  EPX=IPN-.006*BMJDIA**.5
  EPN=EJX-(.010*PITCH**.5+.002*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=EJX-PITCH-G
  EMN=EMX-1.5*(.010*PITCH**.5+.002*BMJDIA**.5)
  IJN=EJX+.001*BMJDIA**.5
  IJX=IJN+.002*BMJDIA**.5
  IPX=IPN+(.010*PITCH**.5+.002*BMJDIA**.5)
  IMB=EJX-PITCH
  IMN=EJX-PITCH+.1*PITCH
  IMX=IMN+.05*PITCH
  ERR=.07*PITCH
  IRR=.07*PITCH
  SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
  SEMIN=SEMAX-.5*(.01*PITCH**.5+.002*BMJDIA**.5)
  STO=.002*BMJDIA**.5-(.002*BMJDIA**.5+.010*PITCH**.5)
  IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
  ELSE
    SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
  ENDIF
  GOTO 90
ENDIF
50 HE2=.5*PITCH
  HI2=HE2
  HE1=HE2+.5*G
  HI1=HE1
  GOTO 100
90 HE2=.5*PITCH
  HI2=.45*PITCH
  HE1=HE2+.5*G
  HI1=HI2+.05*PITCH
100 EJX=AINTE(EJX*10000.+.5)/10000.
  EJN=AINTE(EJN*10000.+.5)/10000.
  EPX=AINTE(EPX*10000.+.5)/10000.
  EPN=AINTE(EPN*10000.+.5)/10000.
  EMX=AINTE(EMX*10000.+.5)/10000.

```

```
EMN=AINTE(MN*10000.+5)/10000.  
IJX=AINTE(IJX*10000.+5)/10000.  
IJN=AINTE(IJN*10000.+5)/10000.  
IPX=AINTE(IPX*10000.+5)/10000.  
IPN=AINTE(IPN*10000.+5)/10000.  
IMX=AINTE(IMX*10000.+5)/10000.  
IMN=AINTE(IMN*10000.+5)/10000.  
RETURN  
END
```

```

C
C *****
C *** SUBROUTINE TO GENERATE H28 HANDBOOK DATA FOR STUB ACME THREADS ***
C *****
C
      SUBROUTINE H28STB
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      PITCH=1./N
      IF(CLASS(1:2).EQ.'1 ') HE2=.3*PITCH          /* STD STUB ACME FORM
      IF(CLASS(1:2).EQ.'2 ') HE2=.375*PITCH        /* MODIFIED FORM 1 STUB
      IF(CLASS(1:2).EQ.'3 ') HE2=.25*PITCH        /* MODIFIED FORM 2 STUB
      HI2=HE2
      PFANG=29./2.
      CLANG=29./2.
      PFRAD=PFANG*PI/180.
      CLRAD=CLANG*PI/180.
      ERR=.005*PITCH                                /* ASSUME SMALL RADIUS
      IRR=.005*PITCH                                /* ASSUME SMALL RADIUS
      HV=.5*PITCH/TAN(PFRAD)
      EJX=BMJDIA                                    /* (BASIC)
      EJN=EJX-.05*PITCH
      IPN=EJX-HE2
      EPX=IPN-.008*BMJDIA**.5
      EPN=EPX-(.030*PITCH+.006*BMJDIA**.5)
      IMN=EJX-2.*HE2
      IF(N.GT.10.) G=.010
      IF(N.LE.10.) G=.020
      HE1=HE2+.5*G
      HI1=HE1
      EMX=IMN-G
      EMN=EMX-(.030*PITCH+.006*BMJDIA**.5)
      IJN=EJX+G
      IJX=IJN-(.030*PITCH+.006*BMJDIA**.5)
      IPN=EJX-HE2
      IPX=IPN-(.030*PITCH+.006*BMJDIA**.5)
      IMN=EJX-2.*HE2
      IMX=IMN+.05*PITCH
      SEMAX=(.4224*PITCH-.259*G)/TAN(PFRAD)*.5
      SEMIN=SEMAX
      SIMAX=SEMAX
      SIMIN=SEMAX
      EJX=AINT(EJX*10000.+5)/10000.
      EJN=AINT(EJN*10000.+5)/10000.

```

```
EPX=AINI(EPX*10000.+.5)/10000.  
EPN=AINI(EPN*10000.+.5)/10000.  
EMX=AINI(EMX*10000.+.5)/10000.  
EMN=AINI(EMN*10000.+.5)/10000.  
IJX=AINI(IJX*10000.+.5)/10000.  
IJN=AINI(IJN*10000.+.5)/10000.  
IPX=AINI(IPX*10000.+.5)/10000.  
IPN=AINI(IPN*10000.+.5)/10000.  
IMX=AINI(IMX*10000.+.5)/10000.  
IMN=AINI(IMN*10000.+.5)/10000.  
RETURN  
END
```

```

C
C *****
C *** SUBROUTINE TO GENERATE H28 HANDBOOK DATA FOR BUTTRESS FORM ***
C *****
C
C This subroutine generates National Buttress Thread form geometry
C as specified in FED-STD-H28/14 dated 31 Aug 1978.
C
  SUBROUTINE H28BUT
    REAL*4 AO,C,U(2)
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
    HE1=.66271/N          /* HEIGHT OF THRD IN INT & EXT THRD
    HI1=HE1
    HE2=.6/N              /* BASIC THREAD HEIGHT
    HI2=HE2
    HV=.89064/N          /* HEIGHT OF SHARP V-THREAD
    PITCH=1./N           /* INVERSE OF THRD PER IN
    PFANG=7.
    CLANG=45.
    PFRAD=PFANG*PI/180.   /* PRESSURE FACE ANGLE(RAD)
    CLRAD=CLANG*PI/180.   /* CLEARANCE FACE ANGLE(RAD)
    IRR=.0357/N           /* MIN ROOT RADIUS INT
    ERR=.0357/N           /* MIN ROOT RADIUS EXT
    IF(CLASS(1:2).EQ.'1 ') C=1.5
    IF(CLASS(1:2).EQ.'2 ') C=1.0
    IF(CLASS(1:2).EQ.'3 ') C=2./3.
    AO=.002*BMJDIA**(1./3.)+.0173*PITCH**.5
    A(1)=C*AO              /* PITCH DIA TOL (EXT)
    A(2) =A(1)             /* PITCH DIA TOL (INT)
    G=2. *AO/3.            /* PITCH ALLOWANCE
    IF(CLASS(1:2).EQ.'1 ') THEN /* T(1)=T(2) MIN & MAJ DIA TOL
      IF(BMJDIA.LE.1.) T(1)=.005
      IF(BMJDIA.LE.4..AND.BMJDIA.GT.1.) T(1)=.006
      IF(BMJDIA.LE.6..AND.BMJDIA.GT.4.) T(1)=.008
      IF(BMJDIA.LE.10..AND.BMJDIA.GT.6.) T(1)=.01
      IF(BMJDIA.LE.16..AND.BMJDIA.GT.10.) T(1)=.011
      IF(BMJDIA.GT.16.) T(1)=.013
    ENDIF
    IF(CLASS(1:2).EQ.'2 ') THEN
      IF(BMJDIA.LE.1.) T(1)=.004
      IF(BMJDIA.LE.4..AND.BMJDIA.GT.1.) T(1)=.005
      IF(BMJDIA.LE.6..AND.BMJDIA.GT.4.) T(1)=.007
      IF(BMJDIA.LE.10..AND.BMJDIA.GT.6.) T(1)=.008

```

```

      IF(BMJDIA.LE.16..AND.BMJDIA.GT.10.) T(1)=.009
      IF(BMJDIA.GT.16.) T(1)=.010
      ENDIF
      IF(CLASS(1:2).EQ.'3 ') THEN
        IF(BMJDIA.LE.1.) T(1)=.003
        IF(BMJDIA.LE.1.5..AND.BMJDIA.GT.1.) T(1)=.004
        IF(BMJDIA.LE.4..AND.BMJDIA.GT.1.5) T(1)=.005
        IF(BMJDIA.LE.10..AND.BMJDIA.GT.4.) T(1)=.006
        IF(BMJDIA.LE.16..AND.BMJDIA.GT.10.) T(1)=.007
        IF(BMJDIA.GT.16.) T(1)=.008
      ENDIF
      T(2)=T(1)
      U(2)=T(1)
C     EXTERNAL THREAD DIMENSIONS
      EJX=BMJDIA-G          /* MAX MAJOR DIA
      EJN=EJX-T(1)          /* MIN MAJOR DIA
      EPX=EJX-HE2           /* MAX PITCH DIA
      EPN=EPX-A(1)          /* MIN PITCH DIA
      EMX=EJX-2.*HE1        /* MAX MINOR DIA
      EMN=EPX-A(1)-.80803/N /* MIN MINOR DIA
C     INTERNAL THREAD DIMENSIONS
      BMJDIA=BMJDIA        /* BASIC MAJOR DIA
      IMN=BMJDIA-2.*HE2     /* MIN MINOR DIA
      IMX=IMN+U(2)          /* MAX MINOR DIA
      IPN=BMJDIA-HE2        /* MIN PITCH DIA
      IPX=IPN+A(2)          /* MAX PITCH DIA
      IJX=IPX+.80803*PITCH  /* MAX MAJOR DIA
      IJN=BMJDIA-2.*HE2+2.*HE1 /* MIN MAJOR DIA
      SEMAX=.0826*PITCH
      SEMIN=.0413*PITCH
      SIMAX=.0826*PITCH
      SIMIN=.0413*PITCH
      EJX=AIN(T(EJX*10000.+5)/10000.
      EJN=AIN(T(EJN*10000.+5)/10000.
      EPX=AIN(T(EPX*10000.+5)/10000.
      EPN=AIN(T(EPN*10000.+5)/10000.
      EMX=AIN(T(EMX*10000.+5)/10000.
      EMN=AIN(T(EMN*10000.+5)/10000.
      IJX=AIN(T(IJX*10000.+5)/10000.
      IJN=AIN(T(IJN*10000.+5)/10000.
      IPX=AIN(T(IPX*10000.+5)/10000.
      IPN=AIN(T(IPN*10000.+5)/10000.
      IMX=AIN(T(IMX*10000.+5)/10000.
      IMN=AIN(T(IMN*10000.+5)/10000.
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO GENERATE PF20 WTV BUTTRESS THREAD FORM ***
C *****
C
C This subroutine generates special 20 deg. pressure flank Buttress
C thread form designed by Watervliet Arsenal.
C In this subroutine Datum Dia.=Pitch Dia.=BMJDIA
C
      SUBROUTINE PF20
        INTEGER*4 PICK
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
        PFANG=20.
        CLANG=45.
        PFRAD=PFANG*PI/180.
        CLRAD=CLANG*PI/180.
        WRITE(1,*) 'PITCH=0.250 ..... 1'
        WRITE(1,*) 'PITCH=0.375 ..... 2'
        WRITE(1,*) 'PITCH=0.500 ..... 3'
        WRITE(1,*) 'PITCH=0.750 ..... 4'
2      CALL TNOUA('SELECT PITCH: ',INTS(14))
        READ(1,'(I2)',ERR=2) PICK
        IF(PICK.LT.1.OR.PICK.GT.4) GOTO 2
        IF(PICK.EQ.1) THEN
          PITCH=0.250
          N=1./PITCH
          HV=0.1833
          SEMAX=.042/(1.+TAN(PFRAD))
          SEMIN=.037/(1.+TAN(PFRAD))
          SIMAX=SEMAX
          SIMIN=SEMIN
          ERR=0.0327
          IRR=0.0327
          EPX=BMJDIA
          EPN=EPX
          EJX=EPX+0.101
          EJN=EJX-0.005
          EMX=EPX-0.139
          EMN=EMX-0.010
          IPX=EPX
          IPN=IPX
          IJN=IPX+0.139
          IJX=IJN+0.010

```

```

IMN=IPX-0.101
IMX=IMN+0.005
GOTO 100
ENDIF
IF(PICK.EQ.2) THEN
PITCH=0.375
N=1./PITCH
HV=0.2749
SEMAX=.061/(1.+TAN(PFRAD))
SEMIN=.056/(1.+TAN(PFRAD))
SIMAX=SEMAX
SIMIN=SEMIN
ERR=0.045
IRR=0.045
EPX=BMJDIA
EPN=EPX
EJX=EPX+0.151
EJN=EJX-0.005
EMX=EPX-0.208
EMN=EMX-0.010
IPX=EPX
IPN=IPX
IJN=IPX+0.208
IJX=IJN+0.010
IMN=IPX-0.151
IMX=IMN+0.005
GOTO 100
ENDIF
IF(PICK.EQ.3) THEN
PITCH=0.500
N=1./PITCH
HV=0.3666
SEMAX=.079/(1.+TAN(PFRAD))
SEMIN=.074/(1.+TAN(PFRAD))
SIMAX=SEMAX
SIMIN=SEMIN
ERR=0.061
IRR=0.061
EPX=BMJDIA
EPN=EPX
EJX=EPX+0.202
EJN=EJX-0.005
EMX=EPX-0.278
EMN=EMX-0.010
IPX=EPX

```

```

      IPN=IPX
      IJN=IPX+0.278
      IJX=IJN+0.010
      IMN=IPX-0.202
      IMX=IMN+0.005
      GOTO 100
    ENDIF
  IF(PICK.EQ.4) THEN
    PITCH=0.75
    N=1./PITCH
    HV=0.5499
    SEMAX=.117/(1.+TAN(PFRAD))
    SEMIN=.112/(1.+TAN(PFRAD))
    SIMAX=SEMAX
    SIMIN=SEMIN
    ERR=0.095
    IRR=0.095
    EPX=BMJDIA
    EPN=EPX
    EJX=EPX+0.302
    EJN=EJX-0.005
    EMX=EPX-0.416
    EMN=EMX-0.010
    IPX=EPX
    IPN=IPX
    IJN=IPX+0.416
    IJX=IJN+0.010
    IMN=IPX-0.302
    IMX=IMN+0.005
    GOTO 100
  ENDIF
100 HE1=EJX-EMN
    HI1=HE1
    HE2=EJX-IMN
    HI2=HE2
    RETURN
  END

```

```

C
C *****
C ***   INTRODUCTION   ***
C *****
C
C   SUBROUTINE INTRO
C
C   CHARACTER CONT1,CONT2
C   EXTERNAL TNOUA
C
C   CALL TNOUA(:115614,INTS(4))
C   WRITE(1,*) ' '
C   WRITE(1,*) ' '
C   WRITE(1,*) '   This is a thread stress analysis program which solv
*es static and fatigue'
C   WRITE(1,*) '(simple load history) problems under assumption of ela
*sticity.'
C   WRITE(1,*) ' '
C   WRITE(1,*) '   Standard thread form data of V thread (UN, UNC,UNF
*and UNEF), Acme thread,'
C   WRITE(1,*) 'stub Acme thread and Buttress thread are generated acc
*ording to FED-STD-H28 '
C   WRITE(1,*) 'screw thread handbook. Special thread form data of PF
*20 thread are generated '
C   WRITE(1,*) 'per design specification provided by Watervliet Arsen
*al.'
C   WRITE(1,*) ' '
C   WRITE(1,*) '   In static analysis, load capacity of threaded joint
* and safety factors are '
C   WRITE(1,*) 'calculated under maximum, minimum and actual material
*conditions corresponding '
C   WRITE(1,*) 'to yield stress and tensile strength. In fatigue anal
*ysis, safety factors '
C   WRITE(1,*) 'corresponding to various fatigue life cycle ranges are
* estimated base on user '
C   WRITE(1,*) 'supplied input information.'
C   WRITE(1,*) ' '
C   WRITE(1,*) ' '
C   WRITE(1,*) ' '
C   WRITE(1,*) ' '
C   CALL TNOUA('   PRESS RETURN TO CONTINUE',INTS(29))
C   READ(1,10) CONT1
C   IF(CONT1.NE.' ') GOTO 50
10  FORMAT(A1)
50  CALL TNOUA(:115614,INTS(4))
C   WRITE(1,*) ' '
C   WRITE(1,*) ' '
C   WRITE(1,*) '   Required input information and examples are listed
*as follow:'
C   WRITE(1,*) '1. Waiver no.: e.g. RIW1234'

```

```

WRITE(1,*) '2. SCN no.: e.g. 1234'
WRITE(1,*) '3. Part no.: e.g. 12007723'
WRITE(1,*) '4. Analysis methods:(1)static or (2)static & fatigue
*analysis'
WRITE(1,*) '5. Date machined (DDMMYY): e.g. 05JUL84'
WRITE(1,*) '6. Subcode: e.g. 12345 (press return if not applied)'
WRITE(1,*) '7. Basic major diameter (or dtaum diameter for PF20 t
*hread)(in.): e.g. 3.75'
WRITE(1,*) '8. Thread/in.: e.g. 6,(or pitch for PF20: e.g. .375)'
WRITE(1,*) '9. Thread class: e.g. 2'
WRITE(1,*) '10. Select thread form from menu & specify non-std de
*sign data (if any)'
WRITE(1,*) '11. Hollow diameter of exterior thread member (in.): e
*.g. 1.5'
WRITE(1,*) '12. Equiv. outside diameter of internal thread member
*(in.): e.g. 10.'
WRITE(1,*) '13. Thread engagement length (in.): e.g.3.85'
WRITE(1,*) '14. Interrupted thread factor: e.g. .483, if not secto
*red enter 1.0'
WRITE(1,*) '15. Thread load concentration factor (1- 4): e.g. 1.5'
WRITE(1,*) '16. Tensile strength of external member (ksi): e.g. 16
*0'
WRITE(1,*) '17. Tensile strength of internal member (ksi): e.g. 12
*0'
WRITE(1,*) '18. Yield stress of external member (ksi): e.g. 130'
WRITE(1,*) '19. Yield stress of internal member (ksi): e.g. 95'
WRITE(1,*) '20. Select thread surface finish method for exterior m
*ember: e.g. machined'
WRITE(1,*) '21. Select thread surface finish method for internal m
*ember: e.g. machined'
WRITE(1,*) '22.-27. Enter deviated dimensions (in.),if no deviatio
*n enter 0 or press return'
WRITE(1,*) '28. Select preload condition: none, full, partial,'
WRITE(1,*) '    by loading (kip) or by torque (ft-lb)'
WRITE(1,*) '29. Applied load (kip): e.g. max. 200, min. 0'
WRITE(1,*) '30. Internal pressure (ksi): e.g.    2'
WRITE(1,*) '31. Temperature (deg F): e.g. 180, enter 0 if less tha
*n 160'
WRITE(1,*) '32. Fatigue strength reliability(R): .5, .9, .99, or
*.999,'
WRITE(1,*) '    (R=.5 mean fatigue strength, Cr=1)'
WRITE(1,*) ' '
WRITE(1,*) ' '
WRITE(1,*) ' '
CALL TNOUA('    PRESS RETURN TO CONTINUE',INTS(29))
READ(1,10) CONT2
IF(CONT2.NE.' ') GOTO 100
100 CALL TNOUA(:115614,INTS(4))
RETURN
END

```

```

C
C *****
C ***          SUBROUTINE TO SAVE DATA          ***
C *****
C
C          SUBROUTINE SAVE
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
$INSERT SYSCOM>A$KEYS
$INSERT SYSCOM>KEYS.F
      CHARACTER*3 YESNO
      INTEGER*2 LEN
      EXTERNAL TNOUA
10 CALL TNOUA('ENTER FILENAME: ',INTS(16))
      READ(1,'(A32)') FNAME
      LEN=NLEN$(FNAME,INTS(32))
      IF(FNAME(1:4).EQ.'QUIT'.OR.FNAME(1:4).EQ.'STOP') RETURN
      OPEN(20,FILE=FNAME(1:INTL(LEN)),STATUS='NEW',ERR=20)
      GOTO 30
20 CALL TNOUA('FILE ALREADY EXISTS. DO YOU WANT TO OVERWRITE?: ',IN
      *TS(48))
      READ(1,'(A3)') YESNO
      IF(YESNO(1:1).EQ.'N') GOTO 10
      OPEN(20,FILE=FNAME(1:INTL(LEN)),STATUS='OLD',ERR=10)
      REWIND(20)
30 WRITE(20,40) WVN,SCN,PN,SUBCODE,SERSTR,STD(1),STD(2),STD(3),STD(4)
      *,CLASS,DATE,METHD,ESURFS,ISURFS
40 FORMAT(11(A10),3(A20))
      WRITE(20,50) SDFLAG,SERIES,ESURF,ISURF,TEMP
50 FORMAT(4(I1),I4)
      WRITE(20,60) BMJDIA,N,HDIA,ODIA,PFANG,CLANG,LE,ERR,IRR,SECTOR,TLCF
      *,ETS,ITS,EYS,IYS,YS,TS,LOAD(1),LOAD(2),LOAD(3),FPFRAC,TORQ,FF,
      *PRES(1),PRES(2),REL,EJA,EPA,EMA,IJA,IPA,IMA,PITCH
60 FORMAT(F7.4,F5.2,2(F6.3),3(F5.2),2(F4.3),2(F4.2),6(F6.2),3(F8.2),
      *F4.2,F8.2,F4.2,2(F8.2),F5.4,7(F7.4))
      CLOSE (20)
      RETURN
      END

```

```

C
C *****
C ***          SUBROUTINE TO RECALL DATA          ***
C *****
C
      SUBROUTINE RECALL
      CHARACTER*3 YESNO,RET
      INTEGER*2 LEN
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
$INSERT SYSCOM>A$KEYS
$INSERT SYSCOM>KEYS.F
      EXTERNAL TNOUA
      10 CALL TNOUA('ENTER FILENAME: ',INTS(16))
      READ(1,'(A32)') FNAME
      LEN=NLEN$(FNAME,INTS(32))
      IF(FNAME(1:4).EQ.'QUIT'.OR.FNAME(1:4).EQ.'STOP') RETURN
      OPEN(20,FILE=FNAME(1:INTL(LEN)),STATUS='OLD',ERR=20)
      GOTO 30
      20 WRITE(1,*) 'FILE DOES NOT EXIST.'
      GOTO 10
      30 READ(20,40) WVN,SCN,PN,SUBCODE,SERSTR,STD(1),STD(2),STD(3),STD(4),
      *CLASS,DATE,METHD,ESURFS,ISURFS
      40 FORMAT(11(A10),3(A20))
      READ(20,50) SDFLAG,SERIES,ESURF,ISURF,TEMP
      50 FORMAT(4(I1),I4)
      READ(20,60) BMJDIA,N,HDIA,ODIA,PFANG,CLANG,LE,ERR,IRR,SECTOR,TLCF,
      *ETS,ITS,EYS,IYS,YS,TS,LOAD(1),LOAD(2),LOAD(3),FPFRAC,TORQ,FF,
      *PRES(1),PRES(2),REL,EJA,EPA,EMA,IJA,IPA,IMA,PITCH
      60 FORMAT(F7.4,F5.2,2(F6.3),3(F5.2),2(F4.3),2(F4.2),6(F6.2),3(F8.2),
      *F4.2,F8.2,F4.2,2(F8.2),F5.4,7(F7.4))
      CLOSE (20)
      CALL RECALC
      CALL INTCHK
      CALL SURFAR
      CALL BKLASH
      CALL PCVAR
      CALL OUTPT
      WRITE(1,*) ' '
      CALL TNOUA('      PRESS RETURN FOR PROGRAM CONTROL MENU',INTS(42))
      READ(1,70) RET
      IF(RET.NE.' ') GOTO 100
      70 FORMAT(A1)
      100 CALL TNOUA(:115614,INTS(4))
      RETURN
      END

```

```

C
C *****
C ***          SUBROUTINE FOR THE INPUT MODULE          ***
C *****
C
      SUBROUTINE INPUT
      CHARACTER*3 YESNO
      INTEGER*4 PICK
      REAL*4 PFANGT,CLANGT,ERRMINT,IRRMINT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
      HDIA=0.
      LOAD(1)=0.
      LOAD(2)=100.
      LOAD(3)=0.
      TLCF=1.5
      REL=0.5
      EJA=0.
      EPA=0.
      EMA=0.
      IJA=0.
      IPA=0.
      IMA=0.
      CALL TNOUA(115614,INTS(4))
      WRITE(1,*) 'THREAD ANALYSIS PROGRAM - DATA INPUT'
      WRITE(1,*) ' '
3    CALL TNOUA('ENTER WAIVER NO (e.g. RIW1234): ',INTS(32))
      READ(1,'(A7)',ERR=3) WVN
4    CALL TNOUA('ENTER SHOP CONTROL NUMBER (e.g.123456): ',INTS(40))
      READ(1,'(A6)',ERR=4) SCN
6    CALL TNOUA('ENTER PART NUMBER (e.g.12007766): ',INTS(34))
      READ(1,'(A10)',ERR=6) PN
8    CALL TNOUA('ANALYSIS TYPE: (1) STATIC OR (2) STATIC+FATIGUE: ',INT
      *S(49))
      READ(1,'(I1)',ERR=8) SDFLAG
      IF(SDFLAG.GT.2.OR.SDFLAG.LT.1) GOTO 8
      IF(SDFLAG.EQ.1) METHD='Static'
      IF(SDFLAG.EQ.2) METHD='Static+Fatigue'
9    CALL TNOUA('ENTER DATE MACHINED (e.g.ddmmmyy): ',INTS(35))
      READ(1,'(A7)',ERR=9) DATE
10   CALL TNOUA('ENTER SUBCODE: ',INTS(15))
      READ(1,'(A10)',ERR=10) SUBCODE
12   CALL TNOUA('BASIC MAJOR DIA (OR DATUM DIA FOR PF20): ',INTS(41))
      READ(1,*,ERR=12) BMJDIA
      WRITE(1,*) ' '
      WRITE(1,*) 'THREAD FORM TYPE'
      WRITE(1,*) ' '

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```

WRITE(1,*) 'V-THREAD ..... 1'
WRITE(1,*) 'ACME ..... 2'
WRITE(1,*) 'STUB ACME ..... 3'
WRITE(1,*) 'BUTTRESS ..... 4'
WRITE(1,*) 'PF20 ..... 5'
20 CALL TNOUA('ENTER TYPE: ',INTS(12))
   READ(1,'(I1)',ERR=20) SERIES
   IF(SERIES.LT.1.OR.SERIES.GT.5) GOTO 20
   IF(SERIES.NE.5) THEN
14   CALL TNOUA('THREADS PER INCH: ',INTS(18))
      READ(1,*,ERR=14) N
      ENDIF
   IF(SERIES.EQ.1) THEN
      WRITE(1,*) ' '
      WRITE(1,*) 'UN ..... 1'
      WRITE(1,*) 'UNC ..... 2'
      WRITE(1,*) 'UNF ..... 3'
      WRITE(1,*) 'UNEF ..... 4'
22   CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=22) PICK
      IF(PICK.LT.1.OR.PICK.GT.4) GOTO 22
      IF(PICK.EQ.1) SERSTR='UN '
      IF(PICK.EQ.2) SERSTR='UNC'
      IF(PICK.EQ.3) SERSTR='UNF'
      IF(PICK.EQ.4) SERSTR='UNEF'
      CALL TCLASS
      CALL H28VEE
      ENDIF
   IF(SERIES.EQ.2) THEN
      SERSTR='ACME'
      CALL TCLASS
      CALL H28ACM
      ENDIF
   IF(SERIES.EQ.3) THEN
      SERSTR='STUB ACME'
      CALL TCLASS
      CALL H28STB
      ENDIF
   IF(SERIES.EQ.4) THEN
      SERSTR='BUTT'
      CALL TCLASS
      CALL H28BUT
      ENDIF
   IF(SERIES.EQ.5) THEN
      SERSTR='PF20'
      CLASS='- '
      CALL PF20
      ENDIF
   WRITE(1,*) ' '
   WRITE(1,'(A26,F5.2)') 'PRESSURE FACE (PF ANGLE): ',PFANG

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```

WRITE(1, '(A22,F5.2)') 'CLEARANCE (CL ANGLE): ', CLANG
25 CALL TNOUA('STANDARD PF & CL ANGLES?: ', INTS(26))
   STD(1)=' '
   STD(2)=' '
   READ(1, '(A3)', ERR=25) YESNO
   IF(YESNO(1:1).EQ.'N') THEN
26   CALL TNOUA('ENTER PF ANGLE: ', INTS(16))
   READ(1, *, ERR=26) PFANGT
   IF(PFANGT.NE.PFANG) THEN
     STD(1)='non-std'
     PFANG=PFANGT
   ENDIF
28   CALL TNOUA('ENTER CL ANGLE: ', INTS(16))
   READ(1, *, ERR=28) CLANGT
   IF(CLANGT.NE.CLANG) THEN
     STD(2)='non-std'
     CLANG=CLANGT
   ENDIF
   CALL RECALC
   ENDIF
   WRITE(1, *) ' '
   WRITE(1, '(A22,F5.4)') 'EXT THRD ROOT RADIUS: ', ERR
   WRITE(1, '(A22,F5.4)') 'INT THRD ROOT RADIUS: ', IRR
30 CALL TNOUA('STANDARD THREAD ROOT RADII?: ', INTS(29))
   STD(3)=' '
   STD(4)=' '
   READ(1, '(A3)', ERR=30) YESNO
   IF(YESNO(1:1).EQ.'N') THEN
32   CALL TNOUA('ENTER EXT THRD ROOT RADIUS: ', INTS(28))
   READ(1, '(F5.4)', ERR=32) ERRMINT
   IF(ERRMINT.NE.ERR) THEN
     STD(3)='non-std'
     ERR=ERRMINT
   ENDIF
34   CALL TNOUA('ENTER INT THRD ROOT RADIUS: ', INTS(28))
   READ(1, '(F5.4)', ERR=34) IRRMINT
   IF(IRRMINT.NE.IRR) THEN
     STD(4)='non-std'
     IRR=IRRMINT
   ENDIF
   CALL RECALC
   ENDIF
40 CALL TNOUA('HOLLOW DIA(in): ', INTS(16))
   READ(1, *, ERR=40) HDIA
   IF(HDIA.GE.BMJDIA) THEN
     WRITE(1, *) 'HOLLOW DIA MUST BE LESS THAN EXT MEMBER DIA.'
     GOTO 40
   ENDIF
42 CALL TNOUA('EQUIV O.D.(in): ', INTS(16))
   READ(1, *, ERR=42) ODIA

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IF(ODIA.LE.BMDIA) THEN
  WRITE(1,*) 'EQUIV OD MUST BE GREATER THEN INT THRD DIA.'
  GOTO 42
ENDIF
44 CALL TNOUA('THRD ENGAGEMENT LENGTH: ',INTS(24))
  READ(1,*,ERR=44) LE
46 CALL TNOUA('THRD SEGMENT (FRACTION OF FULL): ',INTS(33))
  READ(1,*,ERR=46) SECTOR
  IF(SECTOR.LT..249) THEN
    WRITE(1,*) 'CURRENT LOWER SEGMENT LIMIT IS .25'
    GOTO 46
  ENDIF
48 CALL TNOUA('LOAD FACTOR(1.5 normal): ',INTS(25))
  READ(1,*,ERR=48) TLCF
50 CALL TNOUA('ULTIMATE STRENGTH (EXT MEMBER) KSI: ',INTS(36))
  READ(1,*,ERR=50) ETS
52 CALL TNOUA('YIELD STRENGTH (EXT MEMBER) KSI: ',INTS(34))
  READ(1,*,ERR=52) EYS
54 CALL TNOUA('ULTIMATE STRENGTH (INT MEMBER) KSI: ',INTS(36))
  READ(1,*,ERR=54) ITS
56 CALL TNOUA('YIELD STRENGTH (INT MEMBER) KSI: ',INTS(34))
  READ(1,*,ERR=56) IYS
  YS=AMIN1(EYS,IYS)
  WRITE(1,*) YS
  IS=AMIN1(ETS,ITS)
  WRITE(1,*) ' '
  WRITE(1,*) '*** SURFACE FINISH FOR EXTERNAL MEMBER ***'
  WRITE(1,*) ' '
  WRITE(1,*) 'MIRROR POLISHED ..... 1'
  WRITE(1,*) 'FINE GROUND ..... 2'
  WRITE(1,*) 'MACHINED ..... 3'
  WRITE(1,*) 'HOT ROLLED ..... 4'
  WRITE(1,*) 'AS FORGED ..... 5'
  CALL TNOUA('ENTER: ',INTS(7))
  READ(1,'(1)',ERR=58) ESURF
  IF(ESURF.LT.1.OR.ESURF.GT.5) GOTO 58
  IF(ESURF.EQ.1) ESURFS='MIRROR POLISHED'
  IF(ESURF.EQ.2) ESURFS='FINE GROUND'
  IF(ESURF.EQ.3) ESURFS='MACHINED'
  IF(ESURF.EQ.4) ESURFS='HOT ROLLED'
  IF(ESURF.EQ.5) ESURFS='AS FORGED'
  WRITE(1,*) ' '
  WRITE(1,*) '*** SURFACE FINISH FOR INTERNAL MEMBER ***'
  WRITE(1,*) ' '
  WRITE(1,*) 'MIRROR POLISHED ..... 1'
  WRITE(1,*) 'FINE GROUND ..... 2'
  WRITE(1,*) 'MACHINED ..... 3'
  WRITE(1,*) 'HOT ROLLED ..... 4'
  WRITE(1,*) 'AS FORGED ..... 5'
  CALL TNOUA('ENTER: ',INTS(7))

```

```

READ(1,'(I1)',ERR=60) ISURF
IF(ISURF.LT.1.OR.ISURF.GT.5) GOTO 60
IF(ISURF.EQ.1) ISURFS='MIRROR POLISHED'
IF(ISURF.EQ.2) ISURFS='FINE GROUND'
IF(ISURF.EQ.3) ISURFS='MACHINED'
IF(ISURF.EQ.4) ISURFS='HOT ROLLED'
IF(ISURF.EQ.5) ISURFS='AS FORGED'
WRITE(1,*) '*** EXTERNAL THREAD ***'
62 CALL TNOUA('MAJOR DIA DEVIATION(in): ',INTS(25))
READ(1,'(F7.4)',ERR=62) EJA
WRITE(1,*) '*** EXTERNAL THREAD ***'
64 CALL TNOUA('PITCH DIA DEVIATION(in): ',INTS(25))
READ(1,'(F7.4)',ERR=64) EPA
WRITE(1,*) '*** EXTERNAL THREAD ***'
66 CALL TNOUA('MINOR DIA DEVIATION(in): ',INTS(25))
READ(1,'(F7.4)',ERR=66) EMA
WRITE(1,*) '*** INTERNAL THREAD ***'
68 CALL TNOUA('MAJOR DIA DEVIATION(in): ',INTS(25))
READ(1,'(F7.4)',ERR=68) IJA
WRITE(1,*) '*** INTERNAL THREAD ***'
70 CALL TNOUA('PITCH DIA DEVIATION(in): ',INTS(25))
READ(1,'(F7.4)',ERR=70) IPA
WRITE(1,*) '*** INTERNAL THREAD ***'
72 CALL TNOUA('MINOR DIA DEVIATION(in): ',INTS(25))
READ(1,'(F7.4)',ERR=72) IMA
CALL INTCHK
CALL SURFAR
CALL BKLASH
CALL PCVAR
CALL PRELOD
74 CALL TNOUA('ENTER MAX APPLIED AXIAL LOAD(kip): ',INTS(35))
READ(1,*,ERR=74) LOAD(2)
76 CALL TNOUA('ENTER MIN APPLIED AXIAL LOAD(kip): ',INTS(35))
READ(1,*,ERR=76) LOAD(3)
IF(HDIA.EQ.0.) GOTO 82
78 CALL TNOUA('ENTER INTERNAL PRESSURE(Psi): ',INTS(30))
READ(1,*,ERR=78) PRES(1)
82 CALL TNOUA('ENTER TEMPERATURE(deg F): ',INTS(26))
READ(1,'(I4)',ERR=82) TEMP
WRITE(1,*) ' '
WRITE(1,*) '** FATIGUE DATA RELIABILITY FACTOR **'
WRITE(1,*) ' '
WRITE(1,*) '.5 (mean) ..... 1'
WRITE(1,*) '.9 ..... 2'
WRITE(1,*) '.95 ..... 3'
WRITE(1,*) '.99 ..... 4'
84 CALL TNOUA(' ENTER: ',INTS(8))
READ(1,'(I1)',ERR=84) IPICK
IF(IPICK.LT.1.OR.IPICK.GT.4) GOTO 84
IF(IPICK.EQ.1) REL=.5

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IF(IPICK.EQ.2) REL=.9  
IF(IPICK.EQ.3) REL=.95  
IF(IPICK.EQ.4) REL=.99  
CALL TNOUA(:115614,INTS(4))  
100 RETURN  
END
```

```

C
C *****
C ***      SUBROUTINE TO EDIT THREAD DATA      ***
C *****
C
      SUBROUTINE EDIT
      CHARACTER*3 YESNO
      INTEGER*4 PICK
      REAL*4 PFANGT,CLANGT,ERRMINT,IRRMINT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
5    CALL OUTPT
10   CALL TNOUA('ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE): ',INTS(44))
      READ(1,'(I2)',ERR=10) PICK
      IF(PICK.EQ.1) THEN
12    CALL TNOUA('NEW WAIVER NO: ',INTS(15))
      READ(1,'(A7)',ERR=12) WVN
      GOTO 5
      ENDIF
      IF(PICK.EQ.2) THEN
14    CALL TNOUA('NEW SHOP CONTROL NO: ',INTS(21))
      READ(1,'(A10)',ERR=14) SCN
      GOTO 5
      ENDIF
      IF(PICK.EQ.3) THEN
16    CALL TNOUA('NEW PART NO: ',INTS(13))
      READ(1,'(A10)',ERR=16) PN
      GOTO 5
      ENDIF
      IF(PICK.EQ.4) THEN
18    CALL TNOUA('ANALYSIS TYPE: (1) STATIC OR (2) STATIC+FATIGUE: ',I
      *NTS(49))
      READ(1,'(I2)',ERR=18) SDFLAG
      IF(SDFLAG.LT.1.OR.SDFLAG.GT.2) GOTO 18
      IF(SDFLAG.EQ.1) METHD='Static'
      IF(SDFLAG.EQ.2) METHD='Static+Fatigue'
      GOTO 5
      ENDIF
      IF(PICK.EQ.5) THEN
20    CALL TNOUA('NEW DATE MACHINED(ddmmmyy): ',INTS(28))
      READ(1,'(A7)',ERR=20) DATE
      GOTO 5
      ENDIF

```

```

IF(PICK.EQ.6) THEN
22  CALL TNOUA('NEW SUBCODE: ',INTS(13))
    READ(1,'(A10)',ERR=22) SUBCODE
    GOTO 5
ENDIF
IF(PICK.EQ.7) THEN
24  CALL TNOUA('NEW BASIC DIA (or DATUM DIA for PF20)(in): ',INTS(14))
    *)
    READ(1,*,ERR=24) BMJDIA
    CALL RECALC
    CALL INTCHK
    CALL SURFAR
    CALL BKLASH
    CALL PCVAR
    CALL PRELOD
    GOTO 5
ENDIF
IF(PICK.EQ.8) THEN
    IF(SERSTR.EQ.'PF20') THEN
26  CALL TNOUA('NEW PITCH: ',INTS(11))
        READ(1,*,ERR=26) PITCH
        N=1./PITCH
    ELSE
27  CALL TNOUA('NEW THREADS/IN: ',INTS(16))
        READ(1,*,ERR=27) N
        PITCH=1./N
    ENDIF
    CALL RECALC
    CALL INTCHK
    CALL SURFAR
    CALL BKLASH
    CALL PCVAR
    CALL PRELOD
    GOTO 5
ENDIF
IF(PICK.EQ.9) THEN
28  CALL TCLASS
    CALL RECALC
    CALL INTCHK
    CALL SURFAR
    CALL BKLASH
    CALL PCVAR
    CALL PRELOD
    GOTO 5
ENDIF

```

```

IF(PICK.EQ.10) THEN
  WRITE(1,*) ' '
  WRITE(1,*) 'THREAD FORM TYPE(SERIES)'
  WRITE(1,*) ' '
  WRITE(1,*) 'V-THREAD ..... 1'
  WRITE(1,*) 'ACME ..... 2'
  WRITE(1,*) 'STUB ACME ..... 3'
  WRITE(1,*) 'BUTTRESS ..... 4'
  WRITE(1,*) 'PF20 ..... 5'
30 CALL TNOUA('ENTER TYPE: ',INTS(12))
  READ(1,'(I1)',ERR=30) SERIES
  IF(SERIES.LT.1.OR.SERIES.GT.5) GOTO 30
  IF(SERIES.EQ.1) THEN
    WRITE(1,*) ' '
    WRITE(1,*) 'UN ..... 1'
    WRITE(1,*) 'UNC ..... 2'
    WRITE(1,*) 'UNF ..... 3'
    WRITE(1,*) 'UNEF ..... 4'
    WRITE(1,*) ' '
32 CALL TNOUA('ENTER: ',INTS(7))
    READ(1,'(I1)',ERR=32) PICK
    IF(PICK.LT.1.OR.PICK.GT.4) GOTO 32
    IF(PICK.EQ.1) SERSTR='UN '
    IF(PICK.EQ.2) SERSTR='UNC'
    IF(PICK.EQ.3) SERSTR='UNF'
    IF(PICK.EQ.4) SERSTR='UNEF'
    CALL TCLASS
    CALL H28VEE
    ENDIF
  IF(SERIES.EQ.2) THEN
    SERSTR='ACME'
    CALL TCLASS
    CALL H28ACM
    ENDIF
  IF(SERIES.EQ.3) THEN
    SERSTR='STUB ACME'
    CALL TCLASS
    CALL H28STB
    ENDIF
  IF(SERIES.EQ.4) THEN
    SERSTR='BUTT'
    CALL TCLASS
    CALL H28BUT
    ENDIF
  IF(SERIES.EQ.5) THEN

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```

SERSTR='PF20 '
CLASS=' -'
CALL TCLASS
CALL PF20
ENDIF
WRITE(1,*) ' '
34 CALL TNOUA('STANDARD PF & CL ANGLES?: ',INTS(26))
   STD(1)=' '
   STD(2)=' '
   READ(1,'(A3)',ERR=34) YESNO
   IF(YESNC(1:1).EQ.'N') THEN
36   CALL TNOUA('ENTER PF ANGLE: ',INTS(16))
      READ(1,*,ERR=36) PFANGT
      IF(PFANGT.NE.PFANG) THEN
         STD(1)='non-std'
         PFANG=PFANGT
      ENDIF
38   CALL TNOUA('ENTER CL ANGLE: ',INTS(16))
      READ(1,*,ERR=38) CLANGT
      IF(CLANGT.NE.CLANG) THEN
         STD(2)='non-std'
         CLANG=CLANGT
      ENDIF
   ENDIF
   WRITE(1,*) ' '
40   CALL TNOUA('STANDARD THREAD ROOT RADII?: ',INTS(29))
      STD(3)=' '
      STD(4)=' '
      READ(1,'(A3)',ERR=30) YESNO
      IF(YESNO(1:1).EQ.'N') THEN
42   CALL TNOUA('ENTER EXT THRD ROOT RADIUS: ',INTS(28))
         READ(1,'(F5.4)',ERR=42) ERRMINT
         IF(ERRMINT.NE.ERR) THEN
            STD(3)='non-std'
            ERR=ERRMINT
         ENDIF
44   CALL TNOUA('ENTER INT THRD ROOT RADIUS: ',INTS(28))
         READ(1,'(F5.4)',ERR=44) IRRMINT
         IF(IRRMINT.NE.IRR) THEN
            STD(4)='non-std'
            IRR=IRRMINT
         ENDIF
      ENDIF
   CALL RECALC
   CALL INTCHK

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```

CALL SURFAR
CALL BKLASH
CALL PCVAR
CALL PRELOD
GOTO 5
ENDIF
IF(PICK.EQ.11) THEN
46 CALL TNOUA('NEW HOLLOW DIA(in): ',INTS(20))
   READ(1,*,ERR=46) HDIA
   IF(HDIA.GE.BMJDIA) THEN
       WRITE(1,*) 'HOLLOW DIA MUST BE LESS THAN EXT MEMBER DIA.'
       GOTO 46
   ENDIF
   GOTO 5
ENDIF
IF(PICK.EQ.12) THEN
48 CALL TNOUA('NEW EQUIV O.D.(in): ',INTS(20))
   READ(1,*,ERR=48) ODIA
   IF(ODIA.LE.BMJDIA) THEN
       WRITE(1,*) 'EQUIV OD MUST BE GREATER THAN INT THRD DIA.'
       GOTO 48
   ENDIF
   GOTO 5
ENDIF
IF(PICK.EQ.13) THEN
50 CALL TNOUA('NEW ENGAGEMENT LENGTH(in): ',INTS(27))
   READ(1,*,ERR=50) LE
   GOTO 5
ENDIF
IF(PICK.EQ.14) THEN
52 CALL TNOUA('NEW THRD SEGMENT (FRACTION OF FULL): ',INTS(36))
   READ(1,*,ERR=52) SECTOR
   IF(SECTOR.LT..249) THEN
       WRITE(1,*) 'CURRENT LOWER LIMIT IS .25'
       GOTO 52
   ENDIF
   IF(SECTOR.GT.1.) GOTO 52
   GOTO 5
ENDIF
IF(PICK.EQ.15) THEN
54 CALL TNOUA('NEW LOAD FACTOR(1.5 normal): ',INTS(29))
   READ(1,*,ERR=54) TLCF
   GOTO 5
ENDIF
IF(PICK.EQ.16) THEN

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56  CALL TNOUA('NEW T.S. EXT MEMBER(ksi): ',INTS(26))
    READ(1,*,ERR=56) ETS
    TS=AMIN1(ETS,ITS)
    GOTO 5
    ENDIF
    IF(PICK.EQ.17) THEN
58  CALL TNOUA('NEW T.S. INT MEMBER(ksi): ',INTS(26))
    READ(1,*,ERR=58) ITS
    TS=AMIN1(ETS,ITS)
    GOTO 5
    ENDIF
    IF(PICK.EQ.18) THEN
60  CALL TNOUA('NEW Y.S. EXT MEMBER(ksi): ',INTS(26))
    READ(1,*,ERR=60) EYS
    YS=AMIN1(EYS,IYS)
    GOTO 5
    ENDIF
    IF(PICK.EQ.19) THEN
62  CALL TNOUA('NEW Y.S. INT MEMBER(ksi): ',INTS(26))
    READ(1,*,ERR=62) IYS
    YS=AMIN1(EYS,IYS)
    GOTO 5
    ENDIF
    IF(PICK.EQ.20) THEN
        WRITE(1,*) ' '
        WRITE(1,*) '*** SURFACE FINISH FOR EXTERNAL MEMBER ***'
        WRITE(1,*) ' '
        WRITE(1,*) 'MIRROR POLISHED ..... 1'
        WRITE(1,*) 'FINE GROUND ..... 2'
        WRITE(1,*) 'MACHINED ..... 3'
        WRITE(1,*) 'HOT ROLLED ..... 4'
        WRITE(1,*) 'AS FORGED ..... 5'
04  CALL TNOUA('ENTER: ',INTS(7))
    READ(1,'(I1)',ERR=64) ESURF
    IF(ESURF.LT.1.OR.ESURF.GT.5) GOTO 64
    IF(ESURF.EQ.1) ESURFS='MIRROR POLISHED'
    IF(ESURF.EQ.2) ESURFS='FINE GROUND'
    IF(ESURF.EQ.3) ESURFS='MACHINED'
    IF(ESURF.EQ.4) ESURFS='HOT ROLLED'
    IF(ESURF.EQ.5) ESURFS='AS FORGED'
    GOTO 5
    ENDIF
    IF(PICK.EQ.21) THEN
        WRITE(1,*) ' '
        WRITE(1,*) '*** SURFACE FINISH FOR INTERNAL MEMBER ***'

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```

WRITE(1,*) ' '
WRITE(1,*) 'MIRROR POLISHED ..... 1'
WRITE(1,*) 'FINE GROUND ..... 2'
WRITE(1,*) 'MACHINED ..... 3'
WRITE(1,*) 'HOT ROLLED ..... 4'
WRITE(1,*) 'AS FORGED ..... 5'
66 CALL TNOUA('ENTER: ',INTS(7))
   READ(1,'(I1)',ERR=66) ISURF
   IF(ISURF.LT.1.OR.ISURF.GT.5) GOTO 66
   IF(ISURF.EQ.1) ISURFS='MIRROR POLISHED'
   IF(ISURF.EQ.2) ISURFS='FINE GROUND'
   IF(ISURF.EQ.3) ISURFS='MACHINED'
   IF(ISURF.EQ.4) ISURFS='HOT ROLLED'
   IF(ISURF.EQ.5) ISURFS='AS FORGED'
   GOTO 5
   ENDIF
IF(PICK.EQ.22) THEN
   WRITE(1,*) '*** EXTERNAL THREAD ***'
68   CALL TNOUA('NEW MAJOR DIA(in) DEVIATION: ',INTS(29))
   READ(1,'(F7.4)',ERR=68) EJA
   CALL INTCHK
   CALL SURFAR
   CALL PCVAR
   GOTO 5
   ENDIF
IF(PICK.EQ.23) THEN
   WRITE(1,*) '*** EXTERNAL THREAD ***'
70   CALL TNOUA('NEW PITCH DIA(in) DEVIATION: ',INTS(29))
   READ(1,'(F7.4)',ERR=70) EPA
   CALL INTCHK
   CALL SURFAR
   CALL PCVAR
   GOTO 5
   ENDIF
IF(PICK.EQ.24) THEN
   WRITE(1,*) '*** EXTERNAL THREAD ***'
72   CALL TNOUA('NEW MINOR DIA(in) DEVIATION: ',INTS(29))
   READ(1,'(F7.4)',ERR=72) EMA
   CALL INTCHK
   CALL SURFAR
   CALL PCVAR
   GOTO 5
   ENDIF
IF(PICK.EQ.25) THEN
   WRITE(1,*) '*** INTERNAL THREAD ***'

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74  CALL TNOUA('NEW MAJOR DIA(in) DEVIATION: ',INTS(29))
    READ(1,'(F7.4)',ERR=74) IJA
    IF(IJA.LE.IJX.AND.IJA.GE.IJN) IJA=0.
    CALL INTCHK
    CALL SURFAR
    CALL PCVAR
    GOTO 5
    ENDIF
IF(PICK.EQ.26) THEN
    WRITE(1,*) '*** INTERNAL THREAD ***'
76  CALL TNOUA('NEW PITCH DIA(in) DEVIATION: ',INTS(29))
    READ(1,'(F7.4)',ERR=76) IPA
    IF(IPA.LE.IPX.AND.IPA.GE.IPN) IPA=0.
    CALL INTCHK
    CALL SURFAR
    CALL PCVAR
    GOTO 5
    ENDIF
IF(PICK.EQ.27) THEN
    WRITE(1,*) '*** INTERNAL THREAD ***'
78  CALL TNOUA('NEW MINOR DIA(in) DEVIATION: ',INTS(29))
    READ(1,'(F7.4)',ERR=78) IMA
    IF(IMA.LE.IMX.AND.IMA.GE.IMN) IMA=0.
    CALL INTCHK
    CALL SURFAR
    CALL PCVAR
    GOTO 5
    ENDIF
IF(PICK.EQ.28) THEN
    CALL PRELOD
    GOTO 5
    ENDIF
IF(PICK.EQ.29) THEN
80  CALL TNOUA('ENTER MAX APPLIED AXIAL LOAD(kip): ',INTS(35))
    READ(1,*,ERR=80) LOAD(2)
82  CALL TNOUA('ENTER MIN APPLIED AXIAL LOAD(kip): ',INTS(35))
    READ(1,*,ERR=82) LOAD(3)
    GOTO 5
    ENDIF
IF(PICK.EQ.30) THEN
    IF(HDIA.EQ.0.) THEN
        WRITE(1,*) 'EXT THRD MEMBER IS NOT HOLLOW'
        GOTO 100
    ENDIF
84  CALL TNOUA('ENTER INTERNAL PRESSURE(KSI): ',INTS(30))
    READ(1,*,ERR=84) PRES(1)
    GOTO 5
    ENDIF

```

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      IF(PICK.EQ.31) THEN
88    CALL TNOUA('ENTER TEMPERATURE(deg F): ',INTS(26))
      READ(1,'(I4)',ERR=88) TEMP
      GOTO 5
      ENDIF
      IF(PICK.EQ.32) THEN
        WRITE(1,*) ' '
        WRITE(1,*) '* FATIGUE DATA RELIABILITY FACTOR *'
        WRITE(1,*) ' '
        WRITE(1,*) '.5 (mean) ..... 1'
        WRITE(1,*) '.9 ..... 2'
        WRITE(1,*) '.95 ..... 3'
        WRITE(1,*) '.99 ..... 4'
92    CALL TNOUA(' ENTER: ',INTS(8))
      READ(1,'(I1)',ERR=92) IPICK
      IF(IPICK.LT.1.OR.IPICK.GT.4) GOTO 84
      IF(IPICK.EQ.1) REL=.5
      IF(IPICK.EQ.2) REL=.9
      IF(IPICK.EQ.3) REL=.95
      IF(IPICK.EQ.4) REL=.99
      GOTO 5
      ENDIF
100   CALL TNOUA(:115614,INTS(4))
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO GENERATE INTERMEDIATE OUTPUT FOR REVIEW & EDIT ***
C *****
C
      SUBROUTINE OUTPT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      REAL*4  EJTOL,EPTOL,EMTOL,IJTOL,IPTOL,IMTOL
      EXTERNAL TNOUA
      CALL TNOUA(:115614,INTS(4))
      WRITE(1,*) '          *** THREAD DATA ***'
      WRITE(1,*) ' '
      WRITE(1,10) ' 1. WAIVER NO:',WVN,'2. SCN#:',SCN,'3. PART NO:',PN
10  FORMAT(A14,1X,A7,8X,A8,1X,A7,8X,A11,1X,A8)
      WRITE(1,11) ' 4. METHOD:',METHD,'5. DATE MACH:',DATE,'6. SUBCODE:'
      *,SUBCODE
11  FORMAT(A11,1X,A14,4X,A13,1X,A7,3X,A11,1X,A10)
      IF(SERIES.EQ.5) THEN
      WRITE(1,12) ' 7. DATUM DIA(in):',BMJDIA,'8. PITCH: ',PITCH
12  FORMAT(A18,1X,F7.4,4X,A10,1X,F7.4)
      ENDIF
      IF(SERIES.NE.5) THEN
      WRITE(1,13) ' 7. BASIC DIA(in):',BMJDIA,'8. THREADS/IN:',N,'9. CLA
      *SS:',CLASS
13  FORMAT(A18,1X,F7.4,4X,A14,1X,F5.2,4X,A9,1X,A2)
      ENDIF
      WRITE(1,*) ' '
      WRITE(1,14) '10. THREAD FORM:',SERSTR,'11. HOLLOW DIA(in):',HDIA
14  FORMAT(A16,1X,A10,17X,A19,1X,F6.3)
      WRITE(1,16) 'PF ANGLE(deg):',PFANG,STD(1),'12. EQUIV O.D.(in):',OD
      *IA
16  FORMAT(4X,A14,1X,F5.2,1X,A8,11X,A19,1X,F6.3)
      WRITE(1,18) 'CL ANGLE(deg):',CLANG,STD(2),'13. ENGAGEMENT LENGTH(1
      *n):',LE
18  FORMAT(4X,A14,1X,F5.2,1X,A8,11X,A26,1X,F5.2)
      WRITE(1,20) 'EXT ROOT RADIUS(in):',ERR,STD(3),'14. INTERRUPTED THR
      *D FACTOR:',SECTOR
20  FORMAT(4X,A20,1X,F5.4,1X,A9,4X,A28,1X,F5.3)
      WRITE(1,22) 'INT ROOT RADIUS(in):',IRR,STD(4),'15. LOAD FACTOR(1-4
      *,1.5nom):',TLCF
22  FORMAT(4X,A20,1X,F5.4,1X,A9,4X,A28,1X,F4.2)
      WRITE(1,*) ' '
      WRITE(1,24) '16. T.S. EXT MEMBER(ksi):',ETS,'17. T.S. INT MEMBER(
      *ksi):',ITS
24  FORMAT(A25,1X,F6.2,5X,A25,1X,F6.2)
      WRITE(1,24) '18. Y.S. EXT MEMBER(ksi):',EYS,'19. Y.S. INT MEMBER(
      *ksi):',IYS
      WRITE(1,26) '20. SURF EXT MEMBER:',ESURFS,'21. SURF INT MEMBER:',I

```

```

*SURFS
26 FORMAT(A20,1X,A15,1X,A20,1X,A15)
   WRITE(1,*) ' '
   WRITE(1,28) 'EXTERNAL THREAD','SPEC(in)','DEV(in)','VAR(%)'
28 FORMAT(3X,A15,11X,A4,15X,A3,13X,A3)
   EJTOL=EJX-EJN
   EPTOL=EPX-EPN
   EMTOL=EMX-EMN
   IJTOL=IJX-IJN
   IPTOL=IPX-IPN
   IMTOL=IMX-IMN
   WRITE(1,30) '22. MAJOR DIA(in):',EJX,'-',EJTOL,EJA,EJV
30 FORMAT(A17,9X,F7.4,A1,F5.4,7X,F7.4,9X,F7.5)
   WRITE(1,30) '23. PITCH DIA(in):',EPX,'-',EPTOL,EPA,EPV
   WRITE(1,30) '24. MINOR DIA(in):',EMX,'-',EMTOL,EMA,EMV
   WRITE(1,28) 'INTERNAL THREAD','SPEC','DEV','VAR'
   WRITE(1,30) '25. MAJOR DIA(in):',IJN,'+',IJTOL,IJA,IJV
   WRITE(1,30) '26. PITCH DIA(in):',IPN,'+',IPTOL,IPA,IPV
   WRITE(1,30) '27. MINOR DIA(in):',IMN,'+',IMTOL,IMA,IMV
   WRITE(1,*) ' '
   WRITE(1,32) '28. APPLIED PRELOAD(kip):',LOAD(1),'DECIMAL OF MAX AL
*LOWABLE:',FPFRAC
32 FORMAT(A25,1X,F8.2,7X,A25,1X,F4.2)
   WRITE(1,34) 'APPROX TIGHTENING TORQUE(ft-lb):',TORQ,'FRICTION FACT
*OR:',FF
34 FORMAT(4X,A32,1X,F8.2,9X,A16,1X,F4.2)
   WRITE(1,36) '29. AXIAL LOAD(kip):',LOAD(2),'(max)',LOAD(3),'(min)'
36 FORMAT(A20,1X,F8.2,1X,A5,2X,F8.2,1X,A5)
   WRITE(1,38) '30. INTERNAL PRESSURE(ksi):',PRES(1)
38 FORMAT(A27,1X,F8.2)
   WRITE(1,40) '31. TEMPERATURE(deg F):',TEMP,'32. FATIGUE DATA REL:'
*,REL
40 FORMAT(A23,1X,I4,14X,A21,1X,F5.4)
   WRITE(1,*) ' '
   IF(SARV.GT.30.) THEN
      WRITE(1,*) 'NOTE:  THREAD SURFACE CONTACT AREA HAS BEEN REDUCED
*MORE THAN '
      WRITE(1,*) '30% OF MIN SPEC CONDITION.  SPECIAL CONSIDERATION MA
*Y BE REQUIRED.'
   ENDIF
   IF(SERIES.EQ.2.OR.SERIES.EQ.3) THEN
      WRITE(1,*) 'NOTE:  THREAD BACKLASH CONDITIONS ARE AS FOLLOWS.'
      WRITE(1,50) 'BL TO SPEC: ',BLS,' BL TO DEV: ',BLD
50  FORMAT(A12,F5.4,10X,A12,F5.4)
   ENDIF
   WRITE(1,*)
   RETURN
   END

```

```

C
C *****
C *** SUBROUTINE TO CHECK FOR INTERFERENCES ***
C *****
C
SUBROUTINE INTCHK
REAL*4 G1,G2
CHARACTER*3 RETN
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
INTFLG=0
IF(EJA.EQ.0.) G1=EJX
IF(EJA.NE.0.) G1=EJA
IF(IJA.EQ.0.) G2=IJN
IF(IJA.NE.0.) G2=IJA
IF(G1.GT.G2) THEN
WRITE(1,*) ' '
WRITE(1,*) ' *** INTERFERENCE CONDITION ***'
WRITE(1,5) INT(1000*(G1-G2)+.5)/1000,'IN INTERFERENCE AT THREAD
* MAJOR DIAMETERS'
WRITE(1,*) ' '
INTFLG=1
ENDIF
IF(EPA.EQ.0.) G1=EPX
IF(EPA.NE.0.) G1=EPA
IF(IPA.EQ.0.) G2=IPN
IF(IPA.NE.0.) G2=IPA
IF(G1.GT.G2) THEN
WRITE(1,*) ' '
WRITE(1,*) ' *** INTERFERENCE CONDITION ***'
WRITE(1,5) INT(1000*(G1-G2)+.5)/1000,'IN INTERFERENCE AT THREAD
* PITCH DIAMETERS'
WRITE(1,*) ' '
INTFLG=1
ENDIF
IF(EMA.EQ.0.) G1=EMX
IF(EMA.NE.0.) G1=EMA
IF(IMA.EQ.0.) G2=IMN
IF(IMA.NE.0.) G2=IMA
IF(G1.GT.G2) THEN
WRITE(1,*) ' '
WRITE(1,*) ' *** INTERFERENCE CONDITION ***'
WRITE(1,5) INT(1000*(G1-G2)+.5)/1000,'IN INTERFERENCE AT THREAD
* MINOR DIAMETERS'
WRITE(1,*) ' '
INTFLG=1
ENDIF
5 FORMAT(F7.4,2X,A42)
IF(INTFLG.EQ.1) THEN
CALL TWOQA(' PRESS RETURN FOR PROGRAM CONTROL MENU',INTS(42))
READ(1,30) RETN
IF(RETN.NE.' ') RETURN
30 FORMAT(A1)
ENDIF
RETURN
END

```

```

C
C *****
C ***      SUBROUTINE TO CALCULATE BACKLASH CONDITIONS      ***
C *****
C
C This calculation assumes perfect thread formulation as per the
C H28 specifications.
C
      SUBROUTINE BKLASH
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      BLPFS=(IPX-EPN)*TAN(PFRAD) /*BACKLASH PRESSURE FACE SIDE: TO SPEC
      BLCFS=(IPX-EPN)*TAN(CLRAD) /*BACKLASH CLEARANC FACE SIDE: TO SPEC
      IF(IPA.EQ.0) THEN
        Q1=IPX
      ELSE
        Q1=IPA
      ENDIF
      IF(EPA.EQ.0) THEN
        Q2=EPN
      ELSE
        Q2=EPN
      ENDIF
      BLPFD=(Q1-Q2)*TAN(PFRAD) /*BACKLASH PRESSURE FACE SIDE: ACTUAL
      BLCFD=(Q1-Q2)*TAN(CLRAD) /*BACKLASH CLEARANC FACE SIDE: ACTUAL
      BLS=BLPFS+BLCFS          /*BACKLASH TOTAL: TO SPEC
      BLD=BLPFD+BLCFD          /*BACKLASH TOTAL: ACTUAL
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO CALCULATE VARIANCES FROM TO SPEC GEO ***
C *****
C
      SUBROUTINE PCVAR
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      CHARACTER*2 RET
C *** VARIANCE OF MAJOR DIA ON EXTERNAL THREAD ***
      IF(EJA.LT.EJN.AND.EJA.NE.O.) EJV=EJA-EJN
      IF(EJA.EQ.O.) EJV=0.
      IF(EJA.LE.EJX.AND.EJA.GE.EJN) EJV=0.
      IF(EJA.GT.EJX) EJV=EJA-EJX
C *** VARIANCE OF PITCH DIA ON EXTERNAL THREAD ***
      IF(EPA.LT.EPN.AND.EPA.NE.O.) EPV=EPA-EPN
      IF(EPA.EQ.O.) EPV=0.
      IF(EPA.LE.EPX.AND.EPA.GE.EPN) EPV=0.
      IF(EPA.GT.EPX) EPV=EPA-EPX
C *** VARIANCE OF MINOR DIA ON EXTERNAL THREAD ***
      IF(EMA.LT.EMN.AND.EMA.NE.O.) EMV=EMA-EMN
      IF(EMA.EQ.O.) EMV=0.
      IF(EMA.LE.EMX.AND.EMA.GE.EMN) EPV=0.
      IF(EMA.GT.EMX) EMV=EMA-EMX
C *** VARIANCE OF MAJOR DIA ON INTERNAL THREAD ***
      IF(IJA.LT.IJN.AND.IJA.NE.O.) IJV=IJA-IJN
      IF(IJA.EQ.O.) IJV=0.
      IF(IJA.LE.IJX.AND.IJA.GE.IJN) IJV=0.
      IF(IJA.GT.IJX) IJV=IJA-IJX
C *** VARIANCE OF PITCH DIA ON INTERNAL THREAD ***
      IF(IPA.LE.IPN.AND.IPA.NE.O.) IPV=IPA-IPX
      IF(IPA.EQ.O.) IPV=0.
      IF(IPA.LE.IPX.AND.IPA.GE.IPN) IPV=0.
      IF(IPA.GT.IPX) IPV=IPA-IPX
C *** VARIANCE OF MINOR DIA ON INTERNAL THREAD ***
      IF(IMA.LE.IMN.AND.IMA.NE.O.) IMV=IMA-IMN
      IF(IMA.EQ.O.) IMV=0.
      IF(IMA.LE.IMX.AND.IMA.GE.IMN) IMV=0.
      IF(IMA.GT.IMX) IMV=IMA-IMX
      IF(SARA.GT.SARX) THEN
        SARV=100.*(INTL((10000.*(SARA-SARX)/SARX)+.5)/10000.)
      ENDIF
      IF(SARA.LT.SARN) THEN
        SARV=100.*(INTL((10000.*(SARA-SARN)/SARN)+.5)/10000.)
      ENDIF
      IF(SARA.GE.SARN.AND.SARA.LE.SARX) SARV=0.
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO PRESENT CLASS MENU AND SELECTION ***
C *****
C
      SUBROUTINE TCLASS
      INTEGER*4 PICK
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
      IF(SERIES.EQ.1) THEN          /* V-THREAD SERIES
      WRITE(1,*) ' '
      WRITE(1,*) '*** UNIFIED NATIONAL THREAD CLASSES ***'
      WRITE(1,*) ' '
      WRITE(1,*) '          CLASS 1 ..... 1'
      WRITE(1,*) '          CLASS 2 ..... 2'
      WRITE(1,*) '          CLASS 3 ..... 3'
      WRITE(1,*) ' '
      CALL TNOUA('ENTER: ',INTS(7))
10    READ(1,'(I1)',ERR=10) PICK
      IF(PICK.EQ.1) CLASS='1 '
      IF(PICK.EQ.2) CLASS='2 '
      IF(PICK.EQ.3) CLASS='3 '
      ENDIF
      IF(SERIES.EQ.2) THEN          /* ACME SERIES
      WRITE(1,*) ' '
      WRITE(1,*) '*** ACME THREAD CLASSES ***'
      WRITE(1,*) ' '
      WRITE(1,*) '(1) CLASS 2G          (4) CLASS 2C'
      WRITE(1,*) '(2) CLASS 3G          (5) CLASS 3C'
      WRITE(1,*) '(3) CLASS 4G          (6) CLASS 4C'
      WRITE(1,*) '          (7) CLASS 5C'
      WRITE(1,*) '          (8) CLASS 6C'
      WRITE(1,*) ' '
20    CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=20) PICK
      IF(PICK.EQ.1) CLASS='2G'
      IF(PICK.EQ.2) CLASS='3G'
      IF(PICK.EQ.3) CLASS='4G'
      IF(PICK.EQ.4) CLASS='2C'
      IF(PICK.EQ.5) CLASS='3C'
      IF(PICK.EQ.6) CLASS='4C'
      IF(PICK.EQ.7) CLASS='5C'
      IF(PICK.EQ.8) CLASS='6C'
      ENDIF
      IF(SERIES.EQ.3) THEN          /* STUB ACME SERIES
      WRITE(1,*) ' '
      WRITE(1,*) '*** STUB ACME CLASSES ***'
      WRITE(1,*) ' '

```

```

WRITE(1,*) 'CLASS 1 (Std Stub Acme Form) ..... 1'
WRITE(1,*) 'CLASS 2 (Modified Form 1 Stub) ... 2'
WRITE(1,*) 'CLASS 3 (Modified Form 2 Stub) ... 3'
WRITE(1,*)
30 CALL TNOUA('ENTER: ',INTS(7))
   READ(1,'(I1)',ERR=30) PICK
   IF(PICK.EQ.1) CLASS='1 '
   IF(PICK.EQ.2) CLASS='2 '
   IF(PICK.EQ.3) CLASS='3 '
   ENDIF
   IF(SERIES.EQ.4) THEN /* BUTTRESS SERIES
     WRITE(1,*) ' '
     WRITE(1,*) '*** STANDARD BUTTRESS CLASSES ***'
     WRITE(1,*) ' '
     WRITE(1,*) ' CLASS 1 ..... 1'
     WRITE(1,*) ' CLASS 2 ..... 2'
     WRITE(1,*) ' CLASS 3 ..... 3'
     WRITE(1,*) ' '
40 CALL TNOUA('ENTER: ',INTS(7))
     READ(1,'(I1)',ERR=40) PICK
     IF(PICK.EQ.1) CLASS='1 '
     IF(PICK.EQ.2) CLASS='2 '
     IF(PICK.EQ.3) CLASS='3 '
     IF(PICK.LT.1.OR.PICK.GT.4) GOTO 40
     ENDIF
     IF(SERIES.EQ.5) THEN /* PF20 SPECIAL THREAD
       CLASS='- '
     ENDIF
     RETURN
   END

```

```

C
C *****
C ***  STAITC AND FATIGUE ANALYSIS  ***
C *****
C
C      SUBROUTINE CALCU
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
C
      WRITE(1,*) 'CALL SURFAR'
      CALL SURFAR
      WRITE(1,*) 'CALL SAREA'
      CALL SAREA
      WRITE(1,*) 'CALL TORSION'
      CALL TORSION
      WRITE(1,*) 'CALL LDHIST'
      CALL LDHIST
      WRITE(1,*) 'CALL STATSF'
      CALL STATSF
      IF(SDFLAG.EQ.1) THEN
      DO 20 I=1,7
      DO 10 J=1,7
      FSF(I,J)=0.
10 CONTINUE
20 CONTINUE
      ENDIF
      IF(SDFLAG.EQ.2) THEN
      WRITE(1,*) 'CALL NOTCH'
      CALL NOTCH
      WRITE(1,*) 'CALL TSCF'
      CALL TSCF
      WRITE(1,*) 'CALL FATIGUE'
      CALL FATIGUE
      ENDIF
      WRITE(1,*) 'CALL FOUTPT'
      CALL FOUTPT
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO RECALCULATE THREAD GEOMETRY & ANALYSIS RESULTS ***
C *****
C
      SUBROUTINE RECALC
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      IF(SERIES.EQ.1) CALL H28VEE
      IF(SERIES.EQ.2) CALL H28ACM
      IF(SERIES.EQ.3) CALL H28STB
      IF(SERIES.EQ.4) CALL H28BUT
      IF(SERIES.EQ.5) CALL PF20
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO CALCULATE THREAD SURFACE CONTACT AREAS ***
C *****
C
      SUBROUTINE SURFAR
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      HELIXS=((PI*IPN)**2.+PITCH**2.)**.5/PITCH*LE
      SARX=HELIXS*((EJX-IMN)/COS(PFRAD))*0.5
      SARN=HELIXS*((EJN-IMX)/COS(PFRAD))*0.5
      IF(EJA.GT.EJX.OR.(EJA.LT.EJN.AND.EJA.NE.0)) G1=EJA
      IF((EJA.LE.EJX.AND.EJA.GE.EJN).OR.EJA.EQ.0) G1=EJN
      IF(IMA.GT.IMX.OR.(IMA.LT.IMN.AND.IMA.NE.0)) G2=IMA
      IF((IMA.LE.IMX.AND.IMA.GE.IMN).OR.IMA.EQ.0) G2=IMN
      SARA=HELIXS*((G1-G2)/COS(PFRAD))*0.5
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO CALCULATE STRESS AREA AT ***
C *****
C
      SUBROUTINE SAREA
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      REAL*4 HO
      IF(SERIES.EQ.1) HO=.48*PITCH
      IF(SERIES.EQ.2) HO=.5*PITCH
      IF(SERIES.EQ.3) HO=.3*PITCH
      IF(SERIES.EQ.4) HO=.6*PITCH
      IF(SERIES.EQ.5) THEN
        IF(PITCH.EQ..5) HO=.24
        IF(PITCH.EQ..75) HO=.359
        IF(PITCH.EQ..375) HO=.1795
        IF(PITCH.EQ..25) HO=.12
      ENDIF
      AT=(PI/4.)*(IPN-3.*HO/4.)**2.
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO INPUT/EDIT THREAD JOINT PRELOAD ***
C *****
C
      SUBROUTINE PRELOD
      INTEGER*4 CHOICE
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
      WRITE(1,*) ' '
      WRITE(1,*) '*** SELECT APPROPRIATE PRELOAD ***'
      WRITE(1,*) ' '
      WRITE(1,*) 'PRELOAD AMOUNT'
      WRITE(1,*) 'NONE ..... 1'
      WRITE(1,*) 'FULL ..... 2'
      WRITE(1,*) 'PARTIAL ..... 3'
      WRITE(1,*) 'BY LOAD . . . . . 4'
      WRITE(1,*) 'BY TORQUE ..... 5'
120 CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=120) CHOICE
      CALL SAREA
      PREMAX=.9*YS*AT          /* MAX RECOMMENDED PRELOAD (W/O PLASTIC)
      IF(CHOICE.EQ.1) THEN
        LOAD(1)=0.
        FF=.2
        TORQ=0.
        FPFRAC=0.
        ENDIF
      IF(CHOICE.EQ.2) THEN
        LOAD(1)=PREMAX
121 CALL TNOUA('ENTER FRICTION FACTOR(.2-DRY,.15-LUB): ',INTS(39))
        READ(1,'(F4.3)',ERR=121) FF
        FPFRAC=1.
        TORQ=LOAD(1)*1000.*EJN*FF/12.
        ENDIF
      IF(CHOICE.EQ.3) THEN
        WRITE(1,*) ' '
122 CALL TNOUA('ENTER DECIMAL FRACTION: ',INTS(24))
        READ(1,'(F4.3)',ERR=122) FPFRAC
        LOAD(1)=PREMAX*FPFRAC
123 CALL TNOUA('ENTER FRICTION FACTOR(.2-DRY,.15-LUB): ',INTS(39))
        READ(1,'(F4.3)',ERR=123) FF
        TORQ=LOAD(1)*1000.*EJN*FF/12.

```

```

ENDIF
IF(CHOICE.EQ.4) THEN
  WRITE(1,*) ' '
124  CALL TNOUA('ENTER PRELOAD OR CLAMPING LOAD (kip): ',INTS(38))
  READ(1,*,ERR=124) LOAD(1)
  IF(LOAD(1).GT.PREMAX) THEN
    WRITE(1,*) 'Preload given is beyond the approximate elastic'
    WRITE(1,125) 'limit of the specified material:',PREMAX,'(kip)'
125  FORMAT(A32,1X,F5.1,A5)
    GOTO 124
  ENDIF
126  CALL TNOUA('ENTER FRICTION FACTOR(.2-DRY,.15-LUB): ',INTS(39))
  READ(1,'(F4.3)',ERR=126) FF
  FPFRAC=LOAD(1)/PREMAX
  TORQ=LOAD(1)*1000.*FF*EJN/12.
  ENDIF
IF(CHOICE.EQ.5) THEN
  WRITE(1,*) ' '
  WRITE(1,*) 'CAUTION: Determining preload by tightening torque'
  WRITE(1,*) 'can only be considered as a rough approximation.'
  WRITE(1,*) 'Experimental verification of actual conditions '
  WRITE(1,*) 'should be applied for critical applications.'
  WRITE(1,*) ' '
130  CALL TNOUA('ENTER FRICTION FACTOR(.2-DRY,.15-LUB): ',INTS(39))
  READ(1,'(F4.3)',ERR=130) FF
140  CALL TNOUA('ENTER APPLIED TORQUE(FT-LBS): ',INTS(30))
  READ(1,*,ERR=140) TORQ
  LOAD(1)=TORQ/(EJN*FF)*12./1000.
  IF(LOAD(1).GT.PREMAX) THEN
    TORQMAX=PREMAX*1000.*EJN*FF/12.
    WRITE(1,*) 'Preload induced by given torque exceeds linear '
    WRITE(1,*) 'elastic range of specified material. '
    WRITE(1,142) 'Maximum Recommended Torque:',TORQMAX,'(ft-lb)'
142  FORMAT(A27,1X,F8.2,A7)
    GOTO 140
  ENDIF
  FPFRAC=LOAD(1)/PREMAX
  ENDIF
RETURN
END

```

```

C
C *****
C *** SUBROUTINE TO CALC TORSIONAL STRESS DUE TO TIGHTENING & PRELOAD **
C *****
C
      SUBROUTINE TORSION
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      YS=AMIN1(EYS,IYS)  /* FIND MINIMUM YIELD STRESS
      PREMAX=.9*YS*AT
      TPE=(.16/PI)*PREMAX*EJX*EMN/(EMN**4.-HDIA**4.)
      TPI=(.16/PI)*PREMAX*ODIA*IMN/(ODIA**4.-IMN**4.)
      RETURN
      END

```

```

C
C *****
C ***          SUBROUTINE TO EVALUATE LOAD HISTORY PARAMETERS          ***
C *****
C
C          SUBROUTINE LDHIST
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
C
C CALCULATE STRESS DUE TO PRELOAD CONDITION
C
      DO 2 I=1,12
      DO 1 J=1,2
      S(I,J)=0.
1 CONTINUE
2 CONTINUE
      IF(LOAD(1).EQ.0.) THEN
        ESPX=0.
        ESPN=0.
        ESPA=0.
        ISPX=0.
        ISPN=0.
        ISPA=0.
        GOTO 10
      ENDIF
      APPLD=LOAD(1)
      WRITE(1,*) 'CALL HOOP'
      CALL HOOP
      WRITE(1,*) 'CALL SSHEAR'
      CALL SSHEAR
      WRITE(1,*) 'CALL AXSCF'
      CALL AXSCF
      WRITE(1,*) 'CALL HEYWD'
      CALL HEYWD
      WRITE(1,*) 'CALL OCT'
      CALL OCT
      ESPX=SOCTEX
      ESPN=SOCTEN
      ESPA=SOCTEA
      ISPX=SOCTIX
      ISPN=SOCTIN
      ISPA=SOCTIA
C
C CALCULATE STRESSES DUE TO GIVEN MAX & MIN LOADS
C AND GIVEN MAX & MIN INTERNAL PRESSURES (IF ANY)
C
10 DO 20 I=1,2
      APPLD=LOAD(I+1)
      IPRES=PRES(1)

```

```

WRITE(1,*) 'CALL HOOP'
CALL HOOP
WRITE(1,*) 'CALL SSHEAR'
CALL SSHEAR
WRITE(1,*) 'CALL AXSCF'
CALL AXSCF
WRITE(1,*) 'CALL HEYWD'
CALL HEYWD
WRITE(1,*) 'CALL OCT'
CALL OCT
S(1,I)=SOCTEX
S(2,I)=SOCTEN
S(3,I)=SOCTEA
S(4,I)=SOCTIX
S(5,I)=SOCTIN
S(6,I)=SOCTIA
S(7,I)=TOCTEX
S(8,I)=TOCTEN
S(9,I)=TOCTEA
S(10,I)=TOCTIX
S(11,I)=TOCTIN
S(12,I)=TOCTIA
IF(LOAD(3).EQ.0.) GOTO 30
20 CONTINUE
30 MEAN(1)=(ESPX+(S(1,1)+S(1,2))/2.)*100./ETS
   MEAN(2)=(ESPN+(S(2,1)+S(2,2))/2.)*100./ETS
   MEAN(3)=(ESPA+(S(3,1)+S(3,2))/2.)*100./ETS
   MEAN(4)=(ISPX+(S(4,1)+S(4,2))/2.)*100./ITS
   MEAN(5)=(ISPN+(S(5,1)+S(5,2))/2.)*100./ITS
   MEAN(6)=(ISPA+(S(6,1)+S(6,2))/2.)*100./ITS
   ALT(1)=((S(1,1)-S(1,2))/2.)*100./ETS
   ALT(2)=((S(2,1)-S(2,2))/2.)*100./ETS
   ALT(3)=((S(3,1)-S(3,2))/2.)*100./ETS
   ALT(4)=((S(4,1)-S(4,2))/2.)*100./ITS
   ALT(5)=((S(5,1)-S(5,2))/2.)*100./ITS
   ALT(6)=((S(6,1)-S(6,2))/2.)*100./ITS
RETURN
END

```

```

C
C *****
C ***      SUBROUTINE TO CALCULATE HOOP STRESS ON EXTERNAL MEMBER      ***
C *****
C
      SUBROUTINE HOOP
      REAL*4 G1
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      SHEX=(2.*PRES(1)*(HDIA)**2.)/(EMX**2.-HDIA**2.)
      SHEN=(2.*PRES(1)*(HDIA)**2.)/(EMN**2.-HDIA**2.)
      IF((EMA.GE.EMN.AND.EMA.LE.EMX).OR.EMA.EQ.0.) G1=EMN
      IF((EMA.LT.EMN.AND.EMA.NE.0.).OR.EMA.GT.EMX) G1=EMA
      SHEA=(2.*PRES(1)*(HDIA)**2.)/(G1**2.-HDIA**2.)
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO CALCULATE SHEAR AREAS AND STRENGTHS ***
C *****
C
      SUBROUTINE SSHEAR
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
C      ETS - EXTERNAL MEMBER TENSILE STRENGTH
C      ITS - INTERNAL MEMBER TENSILE STRENGTH
      IF(ETS.EQ.ITS) THEN                                /* EQUAL INT & EXT STRENGTH
          HELIXS=N*LE*((PI*IPN)**2.+PITCH**2.）**5
          ASHEAR=HELIXS/(2.*N)
          ENDIF
      IF(ETS.GT.ITS) THEN                                /* EXT STRENGTH GREATER
          HELIXS=N*LE*((PI*EJN)**2.+PITCH**2.）**5
          ASHEAR=.5*HELIXS*(PITCH+(TAN(PFRAD)+TAN(CLRAD))*(EJN-IPX))
          ENDIF
      IF(ITS.GT.ETS) THEN                                /* INT STRENGTH GREATER
          HELIXS=N*LE*((PI*IMX)**2.+PITCH**2.）**5
          ASHEAR=.5*HELIXS*(PITCH+(TAN(PFRAD)+TAN(CLRAD))*(EPN-IMX))
          ENDIF
      SSTRESS=LOAD(2)/ASHEAR
      RETURN
      END

```

```

C
C *****
C *** SUBROUTINE TO CALCULATE AXIAL STRESS CONCENTRATION FACTOR ***
C *** AND FILLET STRESS AT THREAD ROOT AREA DUE TO AXIAL LOAD ***
C *****
C
      SUBROUTINE AXSCF
      REAL*4 GAMMA,WVAR1,WVAR2,WVAR3,K1,W0,W1,W2,K2
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      GAMMA=.3*(PITCH/HE1)**.7
      WVAR1=((GAMMA*HE1/ERR)**.5)*.6
      WVAR2=(((EMN-HDIA)/(2.*ERR))**.5)*6.)-1.
      WVAR3=4*GAMMA*HE1/ERR
      K1=WVAR1*WVAR2/((WVAR3+.09*(WVAR2)**2.))**.5)
      W0=1.-((PFANG+CLANG)/180.))**(1.+2.4*(ERR/(GAMMA*HE1))**.5)
      W1=((EMX/2./ERR)**.5)-1.
      W2=((EMN/2./ERR)**.5)-1.
      IF(EMA.GT.EMX.OR.(EMA.LT.EMN.AND.EMA.NE.0.)) G1=EMA
      IF((EMA.LE.EMX.AND.EMA.GE.EMN).OR.EMA.EQ.0.) G1=EMN
      W3=((G1/2./ERR)**.5)-1.
      KAEX=1.+((1.25*(K1-1.)*W1*W0)/((K1-1.))**2.+1.5625*W1**2.))**.5)*COS
      *(2.*PI/3.-2.*PFRAD)
      KAEN=1.+((1.25*(K1-1.)*W2*W0)/((K1-1.))**2.+1.5625*W2**2.))**.5)*COS
      *(2.*PI/3.-2.*PFRAD)
      KAEA=1.+((1.25*(K1-1.)*W3*W0)/((K1-1.))**2.+1.5625*W3**2.))**.5)*COS
      *(2.*PI/3.-2.*PFRAD)
      KNEX=1.+((1.25*(K1-1.)*W1*W0)/((K1-1.))**2.+1.5625*W1**2.))**.5)
      IF(KAEX.LT.1.) KAEX=1.
      IF(KAEN.LT.1.) KAEN=1.
      IF(KAEA.LT.1.) KAEA=1.
      STEX=KAEX*APPLD*(4./PI)/(EMX**2.-HDIA**2.)
      STEN=KAEN*APPLD*(4./PI)/(EMN**2.-HDIA**2.)
      STEA=KAEA*APPLD*(4./PI)/(G1**2.-HDIA**2.)
      GAMMA=.3*(PITCH/HE1)**.7
      WVAR1=((GAMMA*HI1/IRR)**.5)*.6
      WVAR2=(((ODIA-IJX)/(2.*IRR))**.5)*6.)-1
      WVAR3=4*GAMMA*HI1/IRR
      K2=WVAR1*WVAR2/((WVAR3+.09*(WVAR2)**2.))**.5)
      W0=1.-((PFANG+CLANG)/180.))**(1.+2.4*(IRR/(GAMMA*HI1))**.5)
      W1=1.667*((IJN/2./IRR)**.5)-.5
      W2=1.667*((IJX/2./IRR)**.5)-.5
      IF(IJA.GT.IJX.OR.(IJA.LT.IJN.AND.IJA.NE.0.)) G1=IJA
      IF(IJA.EQ.0..OR.(IJA.LE.IJX.AND.IJA.GE.IJN)) G1=IJX

```

```

W3=1.667*((G1/2./IRR)**.5)-.5
KAIX=1.+((K2-1.)*W1*W0/((K2-1.)**.2+W1**2.)**.5)*COS
*(2.*PI/3.-2.*PFRAD)
KAIN=1.+((K2-1.)*W2*W0/((K2-1.)**.2+W2**2.)**.5)*COS
*(2.*PI/3.-2.*PFRAD)
KAIA=1.+((K2-1.)*W3*W0/((K2-1.)**.2+W3**2.)**.5)*COS
*(2.*PI/3.-2.*PFRAD)
KNIX=1.+((K2-1.)*W1*W0/((K2-1.)**.2+W1**2.)**.5)
IF(KAIX.LT.1.) KAIX=1.
IF(KAIN.LT.1.) KAIN=1.
IF(KAIA.LT.1.) KAIA=1.
STIX=KAIX*APPLD*(4./PI)/(ODIA**2.-IJN**2.)
STIN=KAIN*APPLD*(4./PI)/(ODIA**2.-IJX**2.)
STIA=KAIA*APPLD*(4./PI)/(ODIA**2.-G1**2.)
RETURN
END

```

```

C
C *****
C *** SUBROUTINE TO CALCULATE VARIABLES USED IN HEYWOOD'S EQUATION ***
C *****
C
      SUBROUTINE HEYWD
      REAL*4 V,V2,V3,U1,U2,U3,G1,U4
      *D1EX,D1EN,D1EA,D1IX,D1IN,D1IA,P0,U5,U6,U7,U8,Y,Z,
      *SBEX(7),SBEN(7),SBEA(7),SBIX(7),SBIN(7),SBIA(7)
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
C
C      CALCULATION OF E PARAMETER
C
      V=(1.-COS((PI/3.)-PFRAD))
      V2=SIN((PFRAD+CLRAD)/2.)
      V3=COS(PFRAD)
      EEX=((HV-SEMAX-ERR*V)/V3)*V2
      EEN=((HV-SEMIN-ERR*V)/V3)*V2
      EEA=((HV-SEMIN-ERR*V)/V3)*V2
      EIX=((HV-SIMAX-IRR*V)/V3)*V2
      EIN=((HV-SIMIN-IRR*V)/V3)*V2
      EIA=((HV-SIMIN-IRR*V)/V3)*V2
C
C      CALCULATION OF M1
C
      U1=TAN(PI/4.-(PFRAD/2.))+TAN(PI/4.-(CLRAD/2.))-SIN(PI/3.-(PFRAD))
      *-SIN(PI/3.-CLRAD)
      U2=PITCH/2.
      U3=TAN(PFRAD)+TAN(CLRAD)
      M1EX=ERR*U1+U2+U3*(EPX-EMX)*.5
      M1EN=ERR*U1+U2+U3*(EPN-EMN)*.5
      IF(EPA.GT.EPX.OR.(EPA.LT.EPN.AND.EPA.NE.O.)) Z1=EPA
      IF((EPA.LE.EPX.AND.EPA.GE.EPN).OR.EPA.EQ.O.) Z1=EPN
      IF(EMA.GT.EMX.OR.(EMA.LT.EMN.AND.EMA.NE.O.)) Z2=EMA
      IF((EMA.LE.EMX.AND.EMA.GE.EMN).OR.EMA.EQ.O.) Z2=EMN
      G1=(Z1-Z2)*.5
      M1EA=ERR*U1+U2+U3*G1
      M1IX=IRR*U1+U2+U3*(IJN-IPN)*.5
      M1IN=IRR*U1+U2+U3*(IJX-IPX)*.5
      IF(IJA.GT.IJX.OR.(IJA.LT.IJN.AND.IJA.NE.O.)) Z1=IJA
      IF((IJA.LE.IJX.AND.IJA.GE.IJN).OR.IJA.EQ.O.) Z1=IJX
      IF(IPA.GT.IPX.OR.(IPA.LT.IPN.AND.IPA.NE.O.)) Z2=IPA
      IF((IPA.LE.IPX.AND.IPA.GE.IPN).OR.IPA.EQ.O.) Z2=IPX
      G1=(Z1-Z2)*.5
      M1IA=IRR*U1+U2+U3*G1
C
C      CALCULATE VALUES FOR THETA
C

```

```

IF(SERIES.EQ.4.OR.SERIES.EQ.5) THEN
U4=cos(PI/3.-CLRAD)-cos(PI/3.-PFRAD)
ETHETAX=ATAN((ERR*U4)/M1EX)
ETHETAN=ATAN((ERR*U4)/M1EN)
ETHETAA=ATAN((ERR*U4)/M1EA)
ITHETAX=ATAN((IRR*U4)/M1IX)
ITHETAN=ATAN((IRR*U4)/M1IN)
ITHETAA=ATAN((IRR*U4)/M1IA)

C
C
C
CALCULATE VALUES FOR D1

D1EX=M1EX/cos(ETHETAX)
D1EN=M1EN/cos(ETHETAN)
D1EA=M1EA/cos(ETHETAA)
D1IX=M1IX/cos(ITHETAX)
D1IN=M1IN/cos(ITHETAN)
D1IA=M1IA/cos(ITHETAA)
ELSE
D1EX=M1EX
D1EN=M1EN
D1EA=M1EA
D1IX=M1IX
D1IN=M1IN
D1IA=M1IA
ENDIF

C
C
C
CALCULATE VALUES FOR D' (EXT THRD)

P0=(EJN-IMX)*.05*cos(PFRAD)
DPEX(1)=(EJX-IMN)/4.+(IMN-EMX)/2.
DPEN(1)=(EJN-IMX)/4.+(IMX-EMN)/2.
IF(EMA.GT.EMX.OR.(EMA.LT.EMN.AND.EMA.NE.0.)) G1=EMA
IF(EMA.EQ.0..OR.(EMA.LE.EMX.AND.EMA.GE.EMN)) G1=EMN
DPEA(1)=(EJN-IMX)/4.+(IMX-G1)/2.
DPEX(2)=DPEX(1)+P0*.5629
DPEN(2)=DPEN(1)+P0*.5629
DPEA(2)=DPEA(1)+P0*.5629
DPEX(3)=DPEX(1)-P0*.5629
DPEN(3)=DPEN(1)-P0*.5629
DPEA(3)=DPEA(1)-P0*.5629
DPEX(4)=DPEX(1)+P0*1.11974
DPEN(4)=DPEN(1)+P0*1.11974
DPEA(4)=DPEA(1)+P0*1.11974
DPEX(5)=DPEX(1)-P0*1.11974
DPEN(5)=DPEN(1)-P0*1.11974
DPEA(5)=DPEA(1)-P0*1.11974
DPEX(6)=DPEX(1)+P0*1.6241
DPEN(6)=DPEN(1)+P0*1.6241
DPEA(6)=DPEA(1)+P0*1.6241
DPEX(7)=DPEX(1)-P0*1.6241

```

DPEN(7)=DPEN(1)-PO\*1.6241  
DPEA(7)=DPEA(1)-PO\*1.6241

C  
C  
C

CALCULATE HELIX AT POINT OF APPLIED LOAD

PTX(1)=N\*LE\*((PI\*(EMX+2.\*DPEX(1)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTN(1)=N\*LE\*((PI\*(EMN+2.\*DPEN(1)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTA(1)=N\*LE\*((PI\*(G1+2.\*DPEA(1)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTX(2)=N\*LE\*((PI\*(EMX+2.\*DPEX(2)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTN(2)=N\*LE\*((PI\*(EMN+2.\*DPEN(2)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTA(2)=N\*LE\*((PI\*(G1+2.\*DPEA(2)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTX(3)=N\*LE\*((PI\*(EMX+2.\*DPEX(3)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTN(3)=N\*LE\*((PI\*(EMN+2.\*DPEN(3)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTA(3)=N\*LE\*((PI\*(G1+2.\*DPEA(3)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTX(4)=N\*LE\*((PI\*(EMX+2.\*DPEX(4)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTN(4)=N\*LE\*((PI\*(EMN+2.\*DPEN(4)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTA(4)=N\*LE\*((PI\*(G1+2.\*DPEA(4)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTX(5)=N\*LE\*((PI\*(EMX+2.\*DPEX(5)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTN(5)=N\*LE\*((PI\*(EMN+2.\*DPEN(5)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTA(5)=N\*LE\*((PI\*(G1+2.\*DPEA(5)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTX(6)=N\*LE\*((PI\*(EMX+2.\*DPEX(6)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTN(6)=N\*LE\*((PI\*(EMN+2.\*DPEN(6)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTA(6)=N\*LE\*((PI\*(G1+2.\*DPEA(6)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTX(7)=N\*LE\*((PI\*(EMX+2.\*DPEX(7)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTN(7)=N\*LE\*((PI\*(EMN+2.\*DPEN(7)))\*\*2.+PITCH\*\*2.))\*\*.5  
PTA(7)=N\*LE\*((PI\*(G1+2.\*DPEA(7)))\*\*2.+PITCH\*\*2.))\*\*.5

C  
C  
C

CALCULATE VALUES FOR D' (INT THRD)

DPIX(1)=(IJN-EJX)/2.+(EJX-IMN)/4.  
DPIN(1)=(IJX-EJN)/2.+(EJN-IMX)/4.  
IF((IJA.LT.IJN.AND.IJA.NE.O.).OR.IJA.GT.IJN) G1=IJA  
IF(IJA.EQ.O..OR.(IJA.LE.IJX.AND.IJA.GE.IJN)) G1=IJX  
DPIA(1)=(G1-EJN)/2.+(EJN-IMX)/4.  
DPIX(2)=DPIX(1)+PO\*.5629  
DPIN(2)=DPIN(1)+PO\*.5629  
DPIA(2)=DPIA(1)+PO\*.5629  
DPIX(3)=DPIX(1)-PO\*.5629  
DPIN(3)=DPIN(1)-PO\*.5629  
DPIA(3)=DPIA(1)-PO\*.5629  
DPIX(4)=DPIX(1)+PO\*1.11974  
DPIN(4)=DPIN(1)+PO\*1.11974  
DPIA(4)=DPIA(1)+PO\*1.11974  
DPIX(5)=DPIX(1)-PO\*1.11974  
DPIN(5)=DPIN(1)-PO\*1.11974  
DPIA(5)=DPIA(1)-PO\*1.11974  
DPIX(6)=DPIX(1)+PO\*1.6241  
DPIN(6)=DPIN(1)+PO\*1.6241  
DPIA(6)=DPIA(1)+PO\*1.6241  
DPIX(7)=DPIX(1)-PO\*1.6241

```

DPIN(7)=DPIN(1)-PO*1.6241
DPIA(7)=DPIA(1)-PO*1.6241
C  CALCULATION OF B & A
U5=TAN(PI/4.-PFRAD/2.)
U6=SIN(PI/3.-PFRAD)
U7=TAN(PFRAD)
U8=COS(PFRAD)
Y=ERR
Z=IRR
DO 10 I=1,7
BEX(I)=(DPEX(I)-Y*V)/COS(ATAN((DPEX(I)*U7+Y*U5-Y*U6)/(DPEX(I)-Y*V)
*))
BEN(I)=(DPEN(I)-Y*V)/COS(ATAN((DPEN(I)*U7+Y*U5-Y*U6)/(DPEN(I)-Y*V)
*))
BEA(I)=(DPEA(I)-Y*V)/COS(ATAN((DPEA(I)*U7+Y*U5-Y*U6)/(DPEA(I)-Y*V)
*))
BIX(I)=(DPIX(I)-Z*V)/COS(ATAN((DPIX(I)*U7+Z*U5-Z*U6)/(DPIX(I)-Z*V)
*))
BIN(I)=(DPIN(I)-Z*V)/COS(ATAN((DPIN(I)*U7+Z*U5-Z*U6)/(DPIN(I)-Z*V)
*))
BIA(I)=(DPIA(I)-Z*V)/COS(ATAN((DPIA(I)*U7+Z*U5-Z*U6)/(DPIA(I)-Z*V)
*))
AEX(I)=(DPEX(I)-Y*U6)/U8-SIN(PFRAD+ETHETAX)*(D1EX/2.-Y*(U5-U6))
AEN(I)=(DPEN(I)-Y*U6)/U8-SIN(PFRAD+ETHETAN)*(D1EN/2.-Y*(U5-U6))
AEA(I)=(DPEA(I)-Y*U6)/U8-SIN(PFRAD+ETHETAA)*(D1EA/2.-Y*(U5-U6))
AIX(I)=(DPIX(I)-Z*U6)/U8-SIN(PFRAD+ITHETAX)*(D1IX/2.-Z*(U5-U6))
AIN(I)=(DPIN(I)-Z*U6)/U8-SIN(PFRAD+ITHETAN)*(D1IN/2.-Z*(U5-U6))
AIA(I)=(DPIA(I)-Z*U6)/U8-SIN(PFRAD+ITHETAA)*(D1IA/2.-Z*(U5-U6))
10 CONTINUE
C
C  CALCULATE KB (FILLET STRESS CONCENTRATION FACTOR)
C
KBEX=(1+.26*(EEX/Y))**.7
KBEN=(1+.26*(EEN/Y))**.7
KBEA=(1+.26*(EEA/Y))**.7
KBIX=(1+.26*(EIX/Z))**.7
KBIN=(1+.26*(EIN/Z))**.7
KBIA=(1+.26*(EIA/Z))**.7
C
C  CALCULATE SECOND COEFF TERM IN HEYWOOD EQ
C
T1X(1)=.2128*APPLD/PTX(1)/COS(PFRAD)
T1N(1)=.2128*APPLD/PTN(1)/COS(PFRAD)
T1A(1)=.2128*APPLD/PTA(1)/COS(PFRAD)
T1X(2)=.1953*APPLD/PTX(2)/COS(PFRAD)
T1N(2)=.1953*APPLD/PTN(2)/COS(PFRAD)
T1A(2)=.1953*APPLD/PTA(2)/COS(PFRAD)
T1X(3)=.1953*APPLD/PTX(3)/COS(PFRAD)
T1N(3)=.1953*APPLD/PTN(3)/COS(PFRAD)
T1A(3)=.1953*APPLD/PTA(3)/COS(PFRAD)

```

```

T1X(4)=.1428*APPLD/PTX(4)/COS(PFRAD)
T1N(4)=.1428*APPLD/PTN(4)/COS(PFRAD)
T1A(4)=.1428*APPLD/PTA(4)/COS(PFRAD)
T1X(5)=.1428*APPLD/PTX(5)/COS(PFRAD)
T1N(5)=.1428*APPLD/PTN(5)/COS(PFRAD)
T1A(5)=.1428*APPLD/PTA(5)/COS(PFRAD)
T1X(6)=.0554*APPLD/PTX(6)/COS(PFRAD)
T1N(6)=.0554*APPLD/PTN(6)/COS(PFRAD)
T1A(6)=.0554*APPLD/PTA(6)/COS(PFRAD)
T1X(7)=.0554*APPLD/PTX(7)/COS(PFRAD)
T1N(7)=.0554*APPLD/PTN(7)/COS(PFRAD)
T1A(7)=.0554*APPLD/PTA(7)/COS(PFRAD)

```

C  
C  
C

CALCULATE 1ST TERM INSIDE BRACKETS IN HEYWOODS EQUATION

```

DO 20 I=1,7
T2EX(I)=1.5*AEX(I)/EEX**2.
T2EN(I)=1.5*AEN(I)/EEN**2.
T2EA(I)=1.5*AEA(I)/EEA**2.
T2IX(I)=1.5*AIX(I)/EIX**2.
T2IN(I)=1.5*AIN(I)/EIN**2.
T2IA(I)=1.5*AIA(I)/EIA**2.

```

C  
C  
C

CALCULATE 2ND TERM INSIDE BRACKETS IN HEYWOOD EQUATION

```

T3EX(I)=.45/(BEX(I)*EEX)**.5
T3EN(I)=.45/(BEN(I)*EEN)**.5
T3EA(I)=.45/(BEA(I)*EEA)**.5
T3IX(I)=.45/(BIX(I)*EIX)**.5
T3IN(I)=.45/(BIN(I)*EIN)**.5
T3IA(I)=.45/(BIA(I)*EIA)**.5

```

C  
C  
C

CALCULATE 3RD TERM INSIDE BRACKETS IN HEYWOOD EQUATION

```

T4EX(I)=.5/(2.*EEX) /* NOTE: FOR LOAD NORMAL TO PF, PHI=30
T4EN(I)=.5/(2.*EEN)
T4EA(I)=.5/(2.*EEA)
T4IX(I)=.5/(2.*EIX)
T4IN(I)=.5/(2.*EIN)
T4IA(I)=.5/(2.*EIA)

```

C  
C  
C

CALCULATE ROOT STRESS FORM VALUES

```

SBEX(I)=KBEX*T1X(I)*(T2EX(I)+T3EX(I)+T4EX(I))
SBEN(I)=KBEN*T1N(I)*(T2EN(I)+T3EN(I)+T4EN(I))
SBEA(I)=KBEA*T1A(I)*(T2EA(I)+T3EA(I)+T4EA(I))
SBIX(I)=KBIX*T1X(I)*(T2IX(I)+T3IX(I)+T4IX(I))
SBIN(I)=KBIN*T1X(I)*(T2IN(I)+T3IN(I)+T4IN(I))
SBIA(I)=KBIA*T1A(I)*(T2IA(I)+T3IA(I)+T4IA(I))
20 CONTINUE

```

C  
C  
C

CALCULATE COMBINED TOTAL SB DUE TO PARABOLIC LOAD DISTRIBUTION

SBEXT=SBEX(1)+SBEX(2)+SBEX(3)+SBEX(4)+SBEX(5)+SBEX(6)+SBEX(7)

SBEXT=TLCF\*SBEXT

SBENT=SBEN(1)+SBEN(2)+SBEN(3)+SBEN(4)+SBEN(5)+SBEN(6)+SBEN(7)

SBENT=TLCF\*SBENT

SBEAT=SBEA(1)+SBEA(2)+SBEA(3)+SBEA(4)+SBEA(5)+SBEA(6)+SBEA(7)

SBEAT=TLCF\*SBEAT

SBIXT=SBIX(1)+SBIX(2)+SBIX(3)+SBIX(4)+SBIX(5)+SBIX(6)+SBIX(7)

SBIXT=TLCF\*SBIXT

SBINT=SBIN(1)+SBIN(2)+SBIN(3)+SBIN(4)+SBIN(5)+SBIN(6)+SBIN(7)

SBINT=TLCF\*SBINT

SBIAT=SBIA(1)+SBIA(2)+SBIA(3)+SBIA(4)+SBIA(5)+SBIA(6)+SBIA(7)

SBIAT=TLCF\*SBIAT

RETURN

END

```

C
C *****
C *** SUBROUTINE TO CALC HYDROSTATIC TENSION & PURE SHEAR ON AN ***
C *** OCTAHEDRAL PLANE ***
C *****
C
C SUBROUTINE OCT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
SOCTEX=(1./3.)*(SBEXT+STEX+SHEX)
SOCTEN=(1./3.)*(SBENT+STEN+SHEN)
SOCTEA=(1./3.)*(SBEA+STEA+SHEA)
SOCTIX=(1./3.)*(SBIXT+STIX)
SOCTIN=(1./3.)*(SBINT+STIN)
SOCTIA=(1./3.)*(SBIAT+STIA)
TOCTEX=(1./3.)*(SBEXT+STEX-SHEX)
TOCTEN=(1./3.)*(SBENT+STEN-SHEN)
TOCTEA=(1./3.)*(SBEAT+STEA-SHEA)
TOCTIX=(1./3.)*(SBIXT+STIX)
TOCTIN=(1./3.)*(SBINT+STIN)
TOCTIA=(1./3.)*(SBIAT+STIA)
RETURN
END

```

```

C
C *****
C ** SUBROUTINE TO CALCULATE STATIC SAFETY FACTORS WRT Y.S & T.S. ***
C ** AND LOAD CAPACITIES ***
C *****
C
C SUBROUTINE STATSF
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
SF1YEX=EYS/S(1,1)
SF1YEN=EYS/S(2,1)
SF1YEA=EYS/S(3,1)
SF1YIX=IYS/S(4,1)
SF1YIN=IYS/S(5,1)
SF1YIA=IYS/S(6,1)
SF2YEX=.577*EYS/S(7,1)
SF2YEN=.577*EYS/S(8,1)
SF2YEA=.577*EYS/S(9,1)
SF2YIX=.577*IYS/S(10,1)
SF2YIN=.577*IYS/S(11,1)
SF2YIA=.577*IYS/S(12,1)
SF1TEX=ETS/S(1,1)
SF1TEN=ETS/S(2,1)
SF1TEA=ETS/S(3,1)
SF1TIX=ITS/S(4,1)
SF1TIN=ITS/S(5,1)
SF1TIA=ITS/S(6,1)
SF2TEX=.577*ETS/S(7,1)
SF2TEN=.577*ETS/S(8,1)
SF2TEA=.577*ETS/S(9,1)
SF2TIX=.577*ITS/S(10,1)
SF2TIN=.577*ITS/S(11,1)
SF2TIA=.577*ITS/S(12,1)
SFYEX=AMIN1(SF1YEX,SF2YEX)
SFYEN=AMIN1(SF1YEN,SF2YEN)
SFYEA=AMIN1(SF1YEA,SF2YEA)
SFYIX=AMIN1(SF1YIX,SF2YIX)
SFYIN=AMIN1(SF1YIN,SF2YIN)
SFYIA=AMIN1(SF1YIA,SF2YIA)
SFTEX=AMIN1(SF1TEX,SF2TEX)
SFTEN=AMIN1(SF1TEN,SF2TEN)
SFTEA=AMIN1(SF1TEA,SF2TEA)
SFTIX=AMIN1(SF1TIX,SF2TIX)
SFTIN=AMIN1(SF1TIN,SF2TIN)
SFTIA=AMIN1(SF1TIA,SF2TIA)
SFY=AMIN1(SFYEX,SFYEN,SFYEA,SFYIX,SFYIN,SFYIA)
SFT=AMIN1(SFTEX,SFTEN,SFTEA,SFTIX,SFTIN,SFTIA)
CAPPLD(1)=LOAD(2)*SFYEX
CAPPLD(2)=LOAD(2)*SFTEX

```

```

CAPPLD(3)=LOAD(2)*SFYEN
CAPPLD(4)=LOAD(2)*SFTEN
CAPPLD(5)=LOAD(2)*SFYEA
CAPPLD(6)=LOAD(2)*SFTEA
CAPPLD(7)=LOAD(2)*SFYIX
CAPPLD(8)=LOAD(2)*SFTIX
CAPPLD(9)=LOAD(2)*SFYIN
CAPPLD(10)=LOAD(2)*SFTIN
CAPPLD(11)=LOAD(2)*SFYIA
CAPPLD(12)=LOAD(2)*SFTIA
CAPPLD(13)=AMIN1(CAPPLD(1),CAPPLD(3),CAPPLD(5),CAPPLD(7),CAPPLD(9)
*,CAPPLD(11))
CAPPLD(14)=AMIN1(CAPPLD(2),CAPPLD(4),CAPPLD(6),CAPPLD(8),CAPPLD(10)
*),CAPPLD(12))
LDYE=EYS/SSTRESS*LOAD(2)
LDYI=IYS/SSTRESS*LOAD(2)
LDTE=ETS/SSTRESS*LOAD(2)
LDTI=ITS/SSTRESS*LOAD(2)
RETURN
END

```

```

C
C *****
C *** SUBROUTINE TO GENERATE NOTCH SENSITIVITY FACTORS GIVEN RADIUS ***
C *** AND ULTIMATE STRENGTH OF THE MATERIAL ***
C *****
C
      SUBROUTINE NOTCH
      REAL*4 ARR(16,11)
      INTEGER*4 EC,IC
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      DATA ((ARR(I,J), I=1,16), J=1,11)/.0025,.005,.0075,.01,.015,.02,.0
      *3,.04,.05,.06,.07,.08,.1,.12,.14,.16,.741,.808,.835,.855,.881,.894
      *,.91,.92,.926,.932,.938,.944,.949,.954,.957,.963,.680,.756,.785,.8
      *10,.840,.855,.876,.890,.9,.908,.915,.922,.929,.935,.94,.945,.62,.7
      *03,.735,.764,.798,.815,.843,.861,.873,.883,.892,.901,.908,.917,.92
      *2,.926,.559,.651,.685,.719,.757,.776,.809,.831,.847,.859,.869,.879
      *,.888,.898,.904,.908,.494,.592,.632,.666,.706,.730,.765,.791,.810,
      *.824,.837,.846,.918,.926,.931,.935,.429,.532,.58,.613,.656,.684,.7
      *24,.751,.774,.79,.805,.814,.831,.843,.853,.86,.386,.468,.522,.553,
      *.599,.632,.678,.712,.735,.754,.766,.778,.798,.813,.833,.835,.356,.
      *42,.467,.496,.542,.574,.623,.659,.686,.704,.721,.737,.758,.775,.78
      *5,.797,.257,.347,.398,.434,.482,.519,.569,.607,.633,.655,.672,.688
      *,.709,.726,.739,.752,.079,.18,.247,.295,.366,.417,.491,.546,.582,.
      *615,.641,.667,.723,.76,.789,.81/
C
C SELECT PROPER NOTCH SENSITIVITY CURVES BASED ON MAT'L STRENGTHS
C
      IF(ETS.GT.200.) EC=2
      IF(ETS.GE.180..AND.ETS.LT.200.) EC=3
      IF(ETS.GE.160..AND.ETS.LT.180.) EC=4
      IF(ETS.GE.140..AND.ETS.LT.160.) EC=5
      IF(ETS.GE.120..AND.ETS.LT.140.) EC=6
      IF(ETS.GE.100..AND.ETS.LT.120.) EC=7
      IF(ETS.GE.80..AND.ETS.LT.100.) EC=8
      IF(ETS.GE.60..AND.ETS.LT.80.) EC=9
      IF(ETS.GE.50..AND.ETS.LT.60.) EC=10
      IF(ITS.GT.200.) IC=2
      IF(ITS.GE.180..AND.ITS.LT.200.) IC=3
      IF(ITS.GE.160..AND.ITS.LT.180.) IC=4
      IF(ITS.GE.140..AND.ITS.LT.160.) IC=5
      IF(ITS.GE.120..AND.ITS.LT.140.) IC=6
      IF(ITS.GE.100..AND.ITS.LT.120.) IC=7
      IF(ITS.GE.80..AND.ITS.LT.100.) IC=8

```

```
IF(ITS.GE.60..AND.ITS.LT.80.) IC=9
IF(ITS.GE.50..AND.ITS.LT.60.) IC=10
```

C  
C  
C

```
EVALUATE NOTCH SENSITIVITY VALUES (EXTERNAL THREAD)
```

```
IF(ERR.LT..0025) THEN
  EQ=(ARR(1,EC)/.0025)*ERR
  GOTO 30
ENDIF
```

```
DO 10, I=2,16
```

```
IF(ERR.GE.ARR(I-1,1).AND.ERR.LT.ARR(I,1)) GOTO 20
```

```
10 CONTINUE
```

```
WRITE(1,*) 'ERROR IN SUBROUTINE NOTCH.'
```

```
STOP
```

```
20 EQ=ARR(I-1,EC)+((ARR(I,EC)-ARR(I-1,EC))/(ARR(I,1)-ARR(I-1,1)))*(ER
  *R-ARR(I-1,1))
```

C  
C  
C

```
EVALUATE NOTCH SENSITIVITY VALUES (INTERNAL THREAD)
```

```
30 IF(IRR.LT..0025) THEN
```

```
  IQ=(ARR(1,IC)/.0025)*IRR
```

```
  GOTO 70
```

```
ENDIF
```

```
DO 40, I=2,16
```

```
IF(IRR.GE.ARR(I-1,1).AND.IRR.LT.ARR(I,1)) GOTO 60
```

```
40 CONTINUE
```

```
WRITE(1,*) 'ERROR IN SUBROUTINE NOTCH.'
```

```
STOP
```

```
60 IQ=ARR(I-1,IC)+((ARR(I,IC)-ARR(I-1,IC))/(ARR(I,1)-ARR(I-1,1)))*(IR
  *R-ARR(I-1,1))
```

```
70 RETURN
```

```
END
```

```

C
C *****
C *** SUBROUTINE TO CALCULATE THEORETICAL STRESS CONCENTRATION FACT ***
C *** AND MOD FACTOR DUE TO FATIGUE STRESS CONC FACTOR ***
C *****
C
      SUBROUTINE TSCF
      REAL*4 KTC(31,2)
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      DATA ((KTC(I,J),I=1,31),J=1,2)/.01,.015,.02,.025,.03,.035,.04,.045
      *,.05,.055,.06,.065,.07,.075,.08,.085,.09,.095,.1,.11,.12,.13,.14,.
      *15,.16,.17,.18,.19,.2,.25,.3,3.,2.9,2.65,2.55,2.4,2.3,2.2,2.1,2.05
      *,2.,1.92,1.9,1.85,1.8,1.77,1.75,1.72,1.7,1.68,1.63,1.6,1.57,1.54,1
      *.51,1.48,1.46,1.45,1.43,1.41,1.3,1.26/
      IF(ERR/EMN.LT..01) THEN
        KNEX=3.
        GOTO 30
      ENDIF
      DO 10, I=1,30
        IF(ERR/EMN.GE.KTC(I,1).AND.ERR/EMN.LT.KTC(I+1,1)) GOTO 20
10    CONTINUE
      STOP
20    KNEX=KTC(I,2)
30    IF(IRR/IMN.LT..01) THEN
      KNIX=3.
      GOTO 60
    ENDIF
      DO 40, I=1,30
        IF(IRR/IMN.GE.KTC(I,1).AND.IRR/IMN.LT.KTC(I+1,1)) GOTO 50
40    CONTINUE
      STOP
50    KNIX=KTC(I,2)
60    KQEX=1.+EQ*(KNEX-1.)
      KQEN=1.+EQ*(KNEX-1.)
      KQEA=1.+EQ*(KNEX-1.)
      KQIX=1.+IQ*(KNIX-1.)
      KQIN=1.+IQ*(KNIX-1.)
      KQIA=1.+IQ*(KNIX-1.)
      KPEX=(KQEX-1.)*(.12+.0038*(ETS-100.))+1.
      KPEN=(KQEN-1.)*(.12+.0038*(ETS-100.))+1.
      KPEA=(KQEA-1.)*(.12+.0038*(ETS-100.))+1.
      KPIX=(KQIX-1.)*(.12+.0038*(ITS-100.))+1.
      KPIN=(KQIN-1.)*(.12+.0038*(ITS-100.))+1.
      KPIA=(KQIA-1.)*(.12+.0038*(ITS-100.))+1.
      KFEX(1)=KPEX
      KFEN(1)=KPEN
      KFEA(1)=KPEA
      KFIX(1)=KPIX

```

```

KFIN(1)=KPIN
KFIA(1)=KPIA
KFEX(2)=KPEX+(KQEX-KPEX)*(ALOG10(3000.)-3.)/3.
KFEN(2)=KPEN+(KQEN-KPEN)*(ALOG10(3000.)-3.)/3.
KFEA(2)=KPEA+(KQEA-KPEA)*(ALOG10(3000.)-3.)/3.
KFIX(2)=KPIX+(KQIX-KPIX)*(ALOG10(3000.)-3.)/3.
KFIN(2)=KPIN+(KQIN-KPIN)*(ALOG10(3000.)-3.)/3.
KFIA(2)=KPIA+(KQIA-KPIA)*(ALOG10(3000.)-3.)/3.
KFEX(3)=KPEX+(KQEX-KPEX)/3.
KFEN(3)=KPEN+(KQEN-KPEN)/3.
KFEA(3)=KPEA+(KQEA-KPEA)/3.
KFIX(3)=KPIX+(KQIX-KPIX)/3.
KFIN(3)=KPIN+(KQIN-KPIN)/3.
KFIA(3)=KPIA+(KQIA-KPIA)/3.
KFEX(4)=KPEX+(KQEX-KPEX)*(ALOG10(40000.)-3.)/3.
KFEN(4)=KPEN+(KQEN-KPEN)*(ALOG10(40000.)-3.)/3.
KFEA(4)=KPEA+(KQEA-KPEA)*(ALOG10(40000.)-3.)/3.
KFIX(4)=KPIX+(KQIX-KPIX)*(ALOG10(40000.)-3.)/3.
KFIN(4)=KPIN+(KQIN-KPIN)*(ALOG10(40000.)-3.)/3.
KFIA(4)=KPIA+(KQIA-KPIA)*(ALOG10(40000.)-3.)/3.
KFEX(5)=KPEX+(KQEX-KPEX)*2./3.
KFEN(5)=KPEN+(KQEN-KPEN)*2./3.
KFEA(5)=KPEA+(KQEA-KPEA)*2./3.
KFIX(5)=KPIX+(KQIX-KPIX)*2./3.
KFIN(5)=KPIN+(KQIN-KPIN)*2./3.
KFIA(5)=KPIA+(KQIA-KPIA)*2./3.
KFEX(6)=KQEX
KFEN(6)=KQEN
KFEA(6)=KQEA
KFIX(6)=KQIX
KFIN(6)=KQIN
KFIA(6)=KQIA
KFEX(7)=KQEX
KFEN(7)=KQEN
KFEA(7)=KQEA
KFIX(7)=KQIX
KFIN(7)=KQIN
KFIA(7)=KQIA
RETURN
END

```

```

C
C *****
C *** SUBROUTINE TO CALCULATE FATIGUE LIFE SAFETY FACTORS ***
C *****
C
C SUBROUTINE USED NEWTON METHOD TO FIND INTERCEPT OF LIFE LINE AND
C SLOPE LINE. 2ND DEGREE POLYNOMIALS ARE USED TO DESCRIBE DATA CURVES
C
C SUBROUTINE FATIGUE
C REAL*4 C(7,3),SL(6)
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
DATA ((C(I,J),I=1,7),J=1,3)/83.6204,75.574,67.1299,61.0005,
*55.1154,48.4214,46.2044,-.648158,-.471915,-.314665,-.245179,
*-.24794,-.287679,-.313033,-.00188942,-.00284203,-.0035522,
*-.00360573,-.00303571,-.00205357,-.00156593/
DO 40 I=1,6 /* MAT'L CONDITIONS
SL(I)=ATAN(ALT(I)/MEAN(I))
DO 30 J=1,7 /* FATIGUE LIFE CURVES
X1=((SL(I)-C(J,2))+((C(J,2)-SL(I))**2-4.*C(J,3)*C(J,1))**.5)/(2.*
*C(J,3))
X2=((SL(I)-C(J,2))-((C(J,2)-SL(I))**2-4.*C(J,3)*C(J,1))**.5)/(2.*
*C(J,3))
X=AMAX1(X1,X2)
20 YVAL=(C(J,3)*X**2+C(J,2)*X+C(J,1))
IF(I.LE.3) THEN
YVAL=YVAL*ETS/100.
ELSE
YVAL=YVAL*ITS/100.
ENDIF
30 CONTINUE
40 CONTINUE
C LOAD CONSTANT
CL=.9 /* REVERSED AXIAL LOADS W/O BENDING
C SIZE EFFECT
CD=1.0 /* AXIAL LOAD
C SURFACE FINISH EFFECT
C MIRROR-POLISHED FINISH
IF(ESURF.EQ.1) ECF=1.
IF(ISURF.EQ.1) ICF=1.
C FINE GROUND FINISH
IF(ESURF.EQ.2.AND.ETS.LE.170.) ECF=.9
IF(ISURF.EQ.2.AND.ITS.LE.170.) ICF=.9
IF(ESURF.EQ.2.AND.ETS.GT.170.) ECF=-.002*ETS+1.24
IF(ISURF.EQ.2.AND.ITS.GT.170.) ICF=-.002*ITS+1.24
C MACHINED FINISH
IF(ESURF.EQ.3.AND.ETS.LE.200.) ECF=-.0012*ETS+.87
IF(ISURF.EQ.3.AND.ITS.LE.200.) ICF=-.0012*ITS+.87
IF(ESURF.EQ.3.AND.ETS.GT.200.) ECF=-.002*ETS+1.06

```

```

IF(ISURF.EQ.3.AND.ITS.GT.200.) ICF=-.002*ITS+1.06
C HOT ROLLED FINISH
IF(ESURF.EQ.4.AND.ETS.LE.140.) ECF=-.0035*ETS+.95
IF(ISURF.EQ.4.AND.ITS.LE.140.) ICF=-.0035*ITS+.95
IF(ESURF.EQ.4.AND.ETS.GT.140.) ECF=-.0018*ETS+.72
IF(ISURF.EQ.4.AND.ITS.GT.140.) ICF=-.0018*ITS+.72
C FORGED FINISH
IF(ESURF.EQ.5.AND.ETS.LE.120.) ECF=-.0037*ETS+.77
IF(ISURF.EQ.5.AND.ITS.LE.120.) ICF=-.0037*ITS+.77
IF(ESURF.EQ.5.AND.ETS.GT.120.) ECF=-.0016*ETS+.567
IF(ISURF.EQ.5.AND.ITS.GT.120.) ICF=-.0016*ITS+.567
IF(ESURF.EQ.1) ESURFS='MIRROR POLISH'
IF(ISURF.EQ.1) ISURFS='MIRROR POLISH'
IF(ESURF.EQ.2) ESURFS='FINE GROUND'
IF(ISURF.EQ.2) ISURFS='FINE GROUND'
IF(ESURF.EQ.3) ESURFS='MACHINED'
IF(ISURF.EQ.3) ISURFS='MACHINED'
IF(ESURF.EQ.4) ESURFS='HOT ROLLED'
IF(ISURF.EQ.4) ISURFS='HOT ROLLED'
IF(ESURF.EQ.5) ESURFS='FORGED'
IF(ISURF.EQ.5) ISURFS='FORGED'
C TEMPERATURE EFFECT
IF(TEMP.GT.160.) CT=620./(460.+TEMP)
IF(TEMP.LE.160.) CT=1.
C RELIABILITY FACTOR
IF(REL.EQ..5) CR=1.
IF(REL.EQ..9) CR=.897
IF(REL.EQ..95) CR=.868
IF(REL.EQ..99) CR=.814
IF(REL.EQ..999) CR=.753
C ESTIMATED SAFETY FACTORS FOR VARIOUS FATIGUE LIFE
FSF(1,1)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(1)
FSF(1,2)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(2)
FSF(1,3)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(3)
FSF(1,4)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(4)
FSF(1,5)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(5)
FSF(1,6)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(6)
FSF(1,7)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(7)
FSF(2,1)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(1)
FSF(2,2)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(2)
FSF(2,3)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(3)
FSF(2,4)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(4)
FSF(2,5)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(5)
FSF(2,6)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(6)
FSF(2,7)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(7)
FSF(3,1)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(1)
FSF(3,2)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(2)
FSF(3,3)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(3)
FSF(3,4)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(4)
FSF(3,5)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(5)

```

```

FSF(3,6)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(6)
FSF(3,7)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(7)
FSF(4,1)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(1)
FSF(4,2)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(2)
FSF(4,3)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(3)
FSF(4,4)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(4)
FSF(4,5)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(5)
FSF(4,6)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(6)
FSF(4,7)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(7)
FSF(5,1)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(1)
FSF(5,2)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(2)
FSF(5,3)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(3)
FSF(5,4)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(4)
FSF(5,5)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(5)
FSF(5,6)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(6)
FSF(5,7)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(7)
FSF(6,1)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(1)
FSF(6,2)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(2)
FSF(6,3)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(3)
FSF(6,4)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(4)
FSF(6,5)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(5)
FSF(6,6)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(6)
FSF(6,7)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(7)
FSF(7,1)=AMIN1(FSF(1,1),FSF(2,1),FSF(3,1),FSF(4,1),FSF(5,1),FSF(6,
*1))
FSF(7,2)=AMIN1(FSF(1,2),FSF(2,2),FSF(3,2),FSF(4,2),FSF(5,2),FSF(6,
*2))
FSF(7,3)=AMIN1(FSF(1,3),FSF(2,3),FSF(3,3),FSF(4,3),FSF(5,3),FSF(6,
*3))
FSF(7,4)=AMIN1(FSF(1,4),FSF(2,4),FSF(3,4),FSF(4,4),FSF(5,4),FSF(6,
*4))
FSF(7,5)=AMIN1(FSF(1,5),FSF(2,5),FSF(3,5),FSF(4,5),FSF(5,5),FSF(6,
*5))
FSF(7,6)=AMIN1(FSF(1,6),FSF(2,6),FSF(3,6),FSF(4,6),FSF(5,6),FSF(6,
*6))
FSF(7,7)=AMIN1(FSF(1,7),FSF(2,7),FSF(3,7),FSF(4,7),FSF(5,7),FSF(6,
*7))

```

```

C ESTIMATED ENDURANCE LIMITS
ESE=CD*ECF*CL*CT*CR*.5*ETS/KQEN
ISE=CD*ICF*CL*CT*CR*.5*ITS/KQIN
RETURN
END

```

```

C
C *****
C *** SUBROUTINE TO PROVIDE STATIC + FATIGUE ANALYSIS OUTPUT ***
C *****
C
      SUBROUTINE FOURPT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
$INSERT SYSCOM>A$KEYS
$INSERT SYSCOM>KEYS.F
      CHARACTER*34 TSTR
      CHARACTER*8 STR1,STR2
      EXTERNAL TNOUA
      CALL TNOUA(:115514,INTS(4))
      WRITE(1,*) ' *** THREADED JOINT STRESS ANALYSIS RESULT
*TS ***'
      WRITE(1,*) ' '
      IF(SERIES.EQ.5) THEN
        WRITE(STR1,'(F6.3)') IJN
        LEN1=INTL(NLEN$A(STR1,INTS(8)))
        WRITE(STR2,'(F5.4)') PITCH
        LEN2=INTL(NLEN$A(STR2,INTS(8)))
        LEN3=INTL(NLEN$A(SERSTR,INTS(10)))
        TSTR='THREAD TYPE: '//STR1(1:LEN1)//'- '//SERSTR(1:LEN3)//'- '//
*STR2(1:LEN2)
        LEN4=INTL(NLEN$A(TSTR,INTS(34)))
        GOTO 10
      ENDIF
      WRITE(STR1,'(F6.3)') BMJDIA
      LEN1=INTL(NLEN$A(STR1,INTS(8)))
      WRITE(STR2,'(I2)') N
      LEN2=INTL(NLEN$A(STR2,INTS(2)))
      LEN3=INTL(NLEN$A(SERSTR,INTS(10)))
      TSTR='THREAD TYPE: '//STR1(1:LEN1)//'- '//STR2(1:LEN2)//' ' '//
*SERSTR(1:LEN3)//'- '//CLASS(1:2)
      LEN4=INTL(NLEN$A(TSTR,INTS(34)))
10 IF(LEN4.LT.34) THEN
20 TSTR(1:LEN4+1)=TSTR(1:LEN4)//' '
      LEN4=LEN4+1
      IF(LEN4.LT.34) GOTO 20
      ENDIF
      WRITE(1,40) TSTR,'FILE NAME: ',FNAME
40 FORMAT(A34,10X,A11,A20)
      WRITE(1,50) 'WAIVER NO: ',WVN,'SCN: ',SCN,'PART NO: ',PN
50 FORMAT(A10,10X,A10,10X,A10,10X,A9,A10)
      WRITE(1,60) 'ANALYSIS: ',METHD,'DATE: ',DATE,'SUBCODE: ',SUBCODE
60 FORMAT(A10,A10,10X,A10,8X,A9,A10)
      WRITE(1,*) ' '
      WRITE(1,100) 'FLANK ANGLES(deg): PF/CF ',PFANG,'/',CLANG,' ROOT

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      *RADII(in): EXT/INT ',ERR, '/', IRR
100  FORMAT(A25,F5.2,A1,F5.2,1X,A27,F5.4,A1,F5.4)
      WRITE(1,140) 'HOLLOW DIA(EXT)(in): ',HDIA,'SECTOR: ',SECTOR,'ENGAG
      *EMENT LENGTH(in): ',LE
140  FORMAT(A21,F6.3,8X,A8,F5.3,2X,A23,F5.3)
      WRITE(1,160) 'EQUIV O.D.(INT)(in): ',ODIA,'LOAD FACTOR: ',TLCF,'AP
      *PLIED PRELOAD(kip): ',LOAD(1)
160  FORMAT(A21,F6.3,3X,A13,F5.3,3X,A21,F6.1)
      WRITE(1,180) 'INTERNAL PRESS(ksi): ',PRES(1),'TEMP(deg F): ',TEMP,
      *'MAX APPLIED LOAD(kip): ',LOAD(2)
180  FORMAT(A21,F6.3,3X,A13,I5,2X,A22,F6.1)
      WRITE(1,200) 'RELIABILITY(MEAN=0.5): ',REL,'MIN APPLIED LOAD(kip):
      *',LOAD(3)
200  FORMAT(20X,A23,F5.3,2X,A22,F6.1)
      WRITE(1,*) ' '
      WRITE(1,*) '          TENSILE STRENGTH(ksi)    YIELD STRENGTH(ksi
      *) SURFACE FINISH'
      WRITE(1,220) 'EXTERNAL',ETS,EYS,ESURFS
      WRITE(1,220) 'INTERNAL',ITS,IYS,ISURFS
220  FORMAT(A8,14X,F5.1,18X,F5.1,12X,A11)
      WRITE(1,*) ' '
      IF(EJA.GT.EJX.OR.(EJA.LT.EJN.AND.EJA.NE.O.)) WRITE(1,240) '*****
      * DEVIATING MAJOR DIA(in) EXT THRD = ',EJA,' *****'
      IF(EPA.GT.EPX.OR.(EPA.LT.EPN.AND.EPA.NE.O.)) WRITE(1,240) '*****
      * DEVIATING PITCH DIA(in) EXT THRD = ',EPA,' *****'
      IF(EMA.GT.EMX.OR.(EMA.LT.EMN.AND.EMA.NE.O.)) WRITE(1,240) '*****
      * DEVIATING MAJOR DIA(in) EXT THRD = ',EMA,' *****'
      IF(IJA.GT.IJX.OR.(IJA.LT.IJN.AND.IJA.NE.O.)) WRITE(1,240) '*****
      * DEVIATING MAJOR DIA(in) INT THRD = ',IJA,' *****'
      IF(IPA.GT.IPX.OR.(IPA.LT.IPN.AND.IPA.NE.O.)) WRITE(1,240) '*****
      * DEVIATING PITCH DIA(in) INT THRD = ',IPA,' *****'
      IF(IMA.GT.IMX.OR.(IMA.LT.IMN.AND.IMA.NE.O.)) WRITE(1,240) '*****
      * DEVIATING MAJOR DIA(in) INT THRD = ',IMA,' *****'
240  FORMAT(A53,F7.4,A19)
      WRITE(1,*) ' '
      WRITE(1,242) 'SHEAR CAP (kip) Y.S./T.S.: EXT = ',LDYE,'/',LDTE,'
      * INT= ',LDYI,'/',LDTI
242  FORMAT(A33,F9.2,A1,F9.2,A8,F9.2,A1,F9.2)
      WRITE(1,*) ' '
      WRITE(1,'(A80)') 'MATL  LOAD CAP(kip)  STATIC SF      SAFETY FACTOR
      *S FOR FATIGUE CYCLE RANGES'
      WRITE(1,'(A80)') 'COND   YS      TS      YS      TS      1*10E3 3*10E3 1*
      *10E4 4*10E4 1*10E5 1*10E6 1*10E7'
      WRITE(1,*) ' '
      WRITE(1,260) 'EMAX ',CAPPLD(1),'/',CAPPLD(2),SFYEX,'/',SFTEX,
      *FSF(1,1),FSF(1,2),FSF(1,3),FSF(1,4),FSF(1,5),FSF(1,6),FSF(1,7)
      WRITE(1,260) 'EMIN ',CAPPLD(3),'/',CAPPLD(4),SFYEN,'/',SFTEN,
      *FSF(2,1),FSF(2,2),FSF(2,3),FSF(2,4),FSF(2,5),FSF(2,6),FSF(2,7)
      WRITE(1,260) 'EACT ',CAPPLD(5),'/',CAPPLD(6),SFYEA,'/',SFTEA,
      *FSF(3,1),FSF(3,2),FSF(3,3),FSF(3,4),FSF(3,5),FSF(3,6),FSF(3,7)

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WRITE(1,260) 'IMAX  ',CAPPLD(7),'/',CAPPLD(8),SFYIX,'/',SFTIX,
*FSF(4,1),FSF(4,2),FSF(4,3),FSF(4,4),FSF(4,5),FSF(4,6),FSF(4,7)
WRITE(1,260) 'IMIN  ',CAPPLD(9),'/',CAPPLD(10),SFYIN,'/',SFTIN,
*FSF(5,1),FSF(5,2),FSF(5,3),FSF(5,4),FSF(5,5),FSF(5,6),FSF(5,7)
WRITE(1,260) 'IACT  ',CAPPLD(11),'/',CAPPLD(12),SFYIA,'/',SFTIA,
*FSF(6,1),FSF(6,2),FSF(6,3),FSF(6,4),FSF(6,5),FSF(6,6),FSF(6,7)
WRITE(1,'(A5)') 'OVER-'
WRITE(1,260) ' ALL  ',CAPPLD(13),'/',CAPPLD(14),SFY,'/',SFT,
*FSF(7,1),FSF(7,2),FSF(7,3),FSF(7,4),FSF(7,5),FSF(7,6),FSF(7,7)
200 FORMAT(A5,F6.1,A1,F6.1,1X,F5.2,A1,F5.2,1X,7(F7.4))
WRITE(1,*) ' '
WRITE(1,*) ' '
CALL TNOUA('      PRESS RETURN FOR PROGRAM CONTROL MENU',INTS(42))
READ(1,300) CONT
IF(CONT.NE.' ') GOTO 400
300 FORMAT(A1)
400 CALL TNOUA(:115614,INTS(4))
RETURN
END

```

\*\*\* THREADED JCINT STRESS ANALYSIS RESULTS \*\*\*

THREAD TYPE: 2.125-12 UN-3  
 WAIVER NO: RIW0000  
 ANALYSIS : Static+Fatigue  
 SCN: 0000  
 DATE: 25JUL84  
 FILE NAME: THRD.VEE  
 PART NO: 10895620  
 SUBCODE: EXAMPLE  
 FLANK ANGLES(deg): PF/CF 30.00/30.00  
 HOLLOW DIA(EXT)(in): 0.000  
 EQUIV O.D.(INT)(in): 5.000  
 INTERNAL PRESS(ksi): 0.000  
 RELIABILITY(MEAN=0.5): 0.500  
 ROOT RADII(in): EXT/INT .0104/.0104  
 SECTOR: 1.000  
 LOAD FACTOR: 1.500  
 TEMP(deg F): 250  
 ENGAGEMENT LENGTH(in): 1.500  
 APPLIED PRELOAD(kip): 0.0  
 MAX APPLIED LOAD(kip): 60.0  
 MIN APPLIED LOAD(kip): 0.0

|          |                       |                     |                |
|----------|-----------------------|---------------------|----------------|
|          | TENSILE STRENGTH(ksi) | YIELD STRENGTH(ksi) | SURFACE FINISH |
| EXTERNAL | 150.0                 | 120.0               | MACHINED       |
| INTERNAL | 150.0                 | 120.0               | MACHINED       |

\*\*\*\*\*  
 DEVIATING PITCH DIA(in) INT THRD = 2.0770  
 DEVIATING MAJOR DIA(in) INT THRD = 2.0500  
 \*\*\*\*\*

SHEAR CAP (kip) Y.S./T.S.: EXT = 585.58/ 731.98 INT= 585.58/ 731.98

| MATL COND | LOAD CAP(kip) |       | STATIC SF |      | SAFETY FACTORS FOR FATIGUE CYCLE RANGES |        |        |        |        |        |        |  |  |  |
|-----------|---------------|-------|-----------|------|-----------------------------------------|--------|--------|--------|--------|--------|--------|--|--|--|
|           | YS            | TS    | YS        | TS   | 1*10E3                                  | 3*10E3 | 1*10E4 | 4*10E4 | 1*10E5 | 1*10E6 | 1*10E7 |  |  |  |
| EMAX      | 155.3/        | 194.2 | 2.59/     | 3.24 | 1.9705                                  | 1.7761 | 1.6027 | 1.4408 | 1.3507 | 1.1671 | 1.1671 |  |  |  |
| EMIN      | 161.3/        | 201.6 | 2.69/     | 3.36 | 2.0461                                  | 1.8442 | 1.6643 | 1.4961 | 1.4025 | 1.2119 | 1.2119 |  |  |  |
| EACT      | 161.3/        | 201.6 | 2.69/     | 3.36 | 2.0461                                  | 1.8442 | 1.6643 | 1.4961 | 1.4025 | 1.2119 | 1.2119 |  |  |  |
| IMAX      | 308.9/        | 386.2 | 5.15/     | 6.44 | 3.9186                                  | 3.5319 | 3.1873 | 2.8653 | 2.6860 | 2.3209 | 2.3209 |  |  |  |
| IMIN      | 258.1/        | 322.6 | 4.30/     | 5.38 | 3.2737                                  | 2.9507 | 2.6628 | 2.3938 | 2.2440 | 1.9390 | 1.9390 |  |  |  |
| IACT      | 257.8/        | 322.3 | 4.30/     | 5.37 | 3.2701                                  | 2.9474 | 2.6598 | 2.3911 | 2.2414 | 1.9368 | 1.9368 |  |  |  |
| OVER-     |               |       |           |      |                                         |        |        |        |        |        |        |  |  |  |
| ALL       | 155.3/        | 194.2 | 2.59/     | 3.24 | 1.9705                                  | 1.7761 | 1.6027 | 1.4408 | 1.3507 | 1.1671 | 1.1671 |  |  |  |

PRESS RETURN FOR PROGRAM CONTROL MENU

\*\*\* THREAD DATA \*\*\*

1. WAIVER NO: RIW0000 2. SCN#: 0000 3. PART NO: 10895620  
 4. METHOD: Static+Fatigue 5. DATE MACH: 25JUL84 6. SUBCODE: EXAMPLE  
 7. BASIC DIA(in): 2.1250 8. THREADS/IN: 12.00 9. CLASS: 3

10. THREAD FORM: UN 11. HOLLOW DIA(in): 0.000  
 PF ANGLE(deg): 30.00 12. EQUIV O.D.(in): 5.000  
 CL ANGLE(deg): 30.00 13. ENGAGEMENT LENGTH(in): 1.50  
 EXT ROOT RADIUS(in): .0104 14. INTERRUPTED THRD FACTOR: 1.000  
 INT ROOT RADIUS(in): .0104 15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 150.00 17. T.S. INT MEMBER( ksi) 150.00  
 18. Y.S. EXT MEMBER(ksi): 120.00 19. Y.S. INT MEMBER( ksi) 120.00  
 20. SURF EXT MEMBER: MACHINED 21. SURF INT MEMBER: MACHINED

| EXTERNAL THREAD   | SPEC         | DEV    | VAR     |
|-------------------|--------------|--------|---------|
| 22. MAJOR DIA(in) | 2.1250-.0114 | 0.0000 | 0.00000 |
| 23. PITCH DIA(in) | 2.0709-.0046 | 0.0000 | 0.00000 |
| 24. MINOR DIA(in) | 2.0228-.0000 | 0.0000 | 0.00000 |
| INTERNAL THREAD   | SPEC         | DEV    | VAR     |
| 25. MAJOR DIA(in) | 2.1250+.0180 | 0.0000 | 0.00000 |
| 26. PITCH DIA(in) | 2.0709+.0059 | 2.0770 | 0.00020 |
| 27. MINOR DIA(in) | 2.0348+.0100 | 2.0500 | 0.00520 |

28. APPLIED PRELOAD(kip): 0.00 DECIMAL OF MAX ALLOWABLE: 0.00  
 29. APPROX TIGHTENING TORQUE(ft-lb): 0.00 FRICTION FACTOR: 0.20  
 30. AXIAL LOAD(kip): 60.00 (max) 0.00 (min)  
 31. INTERNAL PRESSURE(ksi): 0.00  
 32. TEMPERATURE(deg F): 250 32. FATIGUE DATA REL: .5000

ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):

\*\*\* THREADED JOINT STRESS ANALYSIS RESULTS \*\*\*

THREAD TYPE: 6.500-12 ACME-3C      FILE NAME: THRD.ACME  
 WAIVER NO: RIW1234      SCN: 6.7      PART NO: 12007766  
 ANALYSIS : Static+Fatigue      DATE: 20JUL84      SUBCODE: EXAMPLE

FLANK ANGLES(deg): PF/CF 14.50/14.50      ROOT RADII(in): EXT/INT .0058/.0058  
 HOLLOW DIA(EXT)(in): 5.600      SECTOR: 1.000      ENGAGEMENT LENGTH(in): 1.070  
 EQUIV O.D.(INT)(in): 7.000      LOAD FACTOR: 1.500      APPLIED PRELOAD(kip): 0.0  
 INTERNAL PRESS(ksi): 0.000      TEMP(deg F): 160      MAX APPLIED LOAD(kip): 150.0  
 RELIABILITY(MEAN=0.5): 0.500      MIN APPLIED LOAD(kip): 0.0

|                       |                     |                |
|-----------------------|---------------------|----------------|
| TENSILE STRENGTH(ksi) | YIELD STRENGTH(ksi) | SURFACE FINISH |
| EXTERNAL 154.0        | 125.0               | MACHINED       |
| INTERNAL 154.0        | 125.0               | MACHINED       |

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 \*\*\*\*\*

DEVIATING MAJOR DIA(in) INT THRD = 6.5200  
 DEVIATING PITCH DIA(in) INT THRD = 6.4800  
 DEVIATING MAJOR DIA(in) INT THRD = 6.4300

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 \*\*\*\*\*  
 \*\*\*\*\*

SHEAR CAP (kip) Y.S./T.S.: EXT = 1356.86/ 1671.65      INT= 1356.86/ 1671.65

| MATL COND | LOAD CAP(kip) |       | STATIC SF |      | SAFETY FACTORS FOR FATIGUE |        | CYCLE RANGES |                             |
|-----------|---------------|-------|-----------|------|----------------------------|--------|--------------|-----------------------------|
|           | YS            | TS    | YS        | TS   | 1*10E3                     | 3*10E3 | 1*10E4       | 4*10E4 1*10E5 1*10E6 1*10E7 |
| EMAX      | 281.3/        | 346.6 | 1.88/     | 2.31 | 1.6620                     | 1.5118 | 1.3755       | 1.2462 1.1733 1.0229 1.0229 |
| EMIN      | 245.1/        | 301.9 | 1.63/     | 2.01 | 1.4478                     | 1.3169 | 1.1983       | 1.0856 1.0221 0.8911 0.8911 |
| EACT      | 245.1/        | 301.9 | 1.63/     | 2.01 | 1.4478                     | 1.3169 | 1.1983       | 1.0856 1.0221 0.8911 0.8911 |
| IMAX      | 306.0/        | 376.9 | 2.04/     | 2.51 | 1.8075                     | 1.6441 | 1.4960       | 1.3553 1.2760 1.1125 1.1125 |
| IMIN      | 276.2/        | 340.2 | 1.84/     | 2.27 | 1.6315                     | 1.4841 | 1.3503       | 1.2234 1.1518 1.0042 1.0042 |
| IACT      | 248.3/        | 305.9 | 1.66/     | 2.04 | 1.4671                     | 1.3345 | 1.2142       | 1.1001 1.0357 0.9029 0.9029 |
| OVER-     |               |       |           |      |                            |        |              |                             |
| ALL       | 245.1/        | 301.9 | 1.63/     | 2.01 | 1.4478                     | 1.3169 | 1.1983       | 1.0856 1.0221 0.8911 0.8911 |

PRESS RETURN FOR PROGRAM CONTROL MENU

\*\*\* THREAD DATA \*\*\*

1. WAIVER NO: RIW1234 2. SCN#: 6.7 3. PART NO: 12007766  
 4. METHOD: Static+Fatigue 5. DATE MACH: 20JUL84 6. SUBCODE: EXAMPLE  
 7. BASIC DIA(in): 6.5000 8. THREADS/IN: 12.00 9. CLASS: 3C  
 10. THREAD FORM: ACME 11. HOLLOW DIA(in): 5.600  
 PF ANGLE(deg): 14.50 12. EQUIV O.D.(in): 7.000  
 CL ANGLE(deg): 14.50 13. ENGAGEMENT LENGTH(in): 1.07  
 EXT ROOT RADIUS(in): .0058 14. INTERRUPTED THRD FACTOR: 1.000  
 INT ROOT RADIUS(in): .0058 15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 154.00 17. T.S. INT MEMBER( ksi) 154.00  
 18. Y.S. EXT MEMBER(ksi): 125.00 19. Y.S. INT MEMBER( ksi) 125.00  
 20. SURF EXT MEMBER: MACHINED 21. SURF INT MEMBER: MACHINED

| EXTERNAL THREAD   | SPEC         | DEV    | VAR     |
|-------------------|--------------|--------|---------|
| 22. MAJOR DIA(in) | 6.5000-.0038 | 0.0000 | 0.00000 |
| 23. PITCH DIA(in) | 6.4430-.0111 | 0.0000 | 0.00000 |
| 24. MINOR DIA(in) | 6.4067-.0168 | 0.0000 | 0.00000 |
| INTERNAL THREAD   | SPEC         | DEV    | VAR     |
| 25. MAJOR DIA(in) | 6.5025+.0090 | 6.5200 | 0.00850 |
| 26. PITCH DIA(in) | 6.4583+.0112 | 6.4800 | 0.01050 |
| 27. MINOR DIA(in) | 6.4250+.0042 | 6.4300 | 0.00080 |

28. APPLIED PRELOAD(kip): 0.00 DECIMAL OF MAX ALLOWABLE: 0.00  
 APPROX TIGHTENING TORQUE(ft-lb): 0.00 FRICTION FACTOR: 0.20  
 29. AXIAL LOAD(kip): 150.00 (max) 0.00 (min)  
 30. INTERNAL PRESSURE(ksi): 0.00  
 31. TEMPERATURE(deg F): 160 32. FATIGUE DATA REL: .5000

NOTE: THREAD BACKLASH CONDITIONS ARE AS FOLLOWS.  
 BL TO SPEC: .0194 BL TO DEV: .0249

PRESS RETURN FOR PROGRAM CONTROL MENU

\*\*\* THREADED JOINT STRESS ANALYSIS RESULTS \*\*\*

THREAD TYPE: 6.500-12 STUB ACME-3      FILE NAME: THRD.ACME  
 WAIVER NO: RIW1234      SCN: 6.7      PART NO: 12007766  
 ANALYSIS : Static+Fatigue      DATE: 20JUL84      SUBCODE: EXAMPLE

FLANK ANGLES(deg): PF/CF 14.50/14.50      ROOT RADII(in): EXT/INT .0004/.0004  
 HOLLOW DIA(EXT)(in): 5.600      SECTOR: 1.000      ENGAGEMENT LENGTH(in): 1.070  
 EQUIV O.D.(INT)(in): 7.000      LOAD FACTOR: 1.500      APPLIED PRELOAD(kip): 0.0  
 INTERNAL PRESS(ksi): 0.000      TEMP(deg F): 160      MAX APPLIED LOAD(kip): 40.0  
 RELIABILITY(MEAN=0.5): 0.500      MIN APPLIED LOAD(kip): 0.0

|          |                       |                     |                |
|----------|-----------------------|---------------------|----------------|
|          | TENSILE STRENGTH(ksi) | YIELD STRENGTH(ksi) | SURFACE FINISH |
| EXTERNAL | 154.0                 | 125.0               | MACHINED       |
| INTERNAL | 154.0                 | 125.0               | MACHINED       |

\*\*\*\*\*  
 \*\*\*\*\*  
 \*\*\*\*\*  
 DEVIATING MAJOR DIA(in) INT THRD = 6.5300  
 DEVIATING PITCH DIA(in) INT THRD = 6.5100  
 DEVIATING MAJOR DIA(in) INT THRD = 6.5000  
 \*\*\*\*\*  
 \*\*\*\*\*  
 \*\*\*\*\*

SHEAR CAP (kip) Y.S./T.S.: EXT = 1361.25/ 1677.06      INT= 1361.25/ 1677.06

| MATERIAL | LOAD CAP(kip) |       | STATIC SF |      | SAFETY FACTORS FOR FATIGUE CYCLE RANGES |        |        |        |        |        |        |  |  |  |
|----------|---------------|-------|-----------|------|-----------------------------------------|--------|--------|--------|--------|--------|--------|--|--|--|
|          | YS            | TS    | YS        | TS   | 1*10E3                                  | 3*10E3 | 1*10E4 | 4*10E4 | 1*10E5 | 1*10E6 | 1*10E7 |  |  |  |
| EMAX     | 87.1/         | 107.3 | 2.18/     | 2.68 | 2.6021                                  | 2.5540 | 2.5032 | 2.4472 | 2.4115 | 2.3263 | 2.3263 |  |  |  |
| EMIN     | 67.4/         | 83.1  | 1.69/     | 2.08 | 2.0152                                  | 1.9780 | 1.9386 | 1.8953 | 1.8676 | 1.8017 | 1.8017 |  |  |  |
| EACT     | 67.4/         | 83.1  | 1.69/     | 2.08 | 2.0152                                  | 1.9780 | 1.9386 | 1.8953 | 1.8676 | 1.8017 | 1.8017 |  |  |  |
| IMAX     | 87.1/         | 107.3 | 2.18/     | 2.68 | 2.6037                                  | 2.5555 | 2.5047 | 2.4487 | 2.4130 | 2.3278 | 2.3278 |  |  |  |
| IMIN     | 67.4/         | 83.0  | 1.68/     | 2.08 | 2.0135                                  | 1.9762 | 1.9369 | 1.8936 | 1.8660 | 1.8001 | 1.8001 |  |  |  |
| IACT     | 64.7/         | 79.7  | 1.62/     | 1.99 | 1.9327                                  | 1.8969 | 1.8592 | 1.8176 | 1.7911 | 1.7278 | 1.7278 |  |  |  |
| OVER-    |               |       |           |      |                                         |        |        |        |        |        |        |  |  |  |
| ALL      | 64.7/         | 79.7  | 1.62/     | 1.99 | 1.9327                                  | 1.8969 | 1.8592 | 1.8176 | 1.7911 | 1.7278 | 1.7278 |  |  |  |

PRESS RETURN FOR PROGRAM CONTROL MENU

\*\*\* THREAD DATA \*\*\*

1. WAIVER NO: RIW1234  
 2. SCN#: 6.7  
 3. PART NO: 12007766  
 4. METHOD: Static+Fatigue  
 5. DATE MACH: 20JUL84  
 6. SUBCODE: EXAMPLE  
 7. BASIC DIA(in): 6.5000  
 8. THREADS/IN: 12.00  
 9. CLASS: 3

10. THREAD FORM: STUB ACME  
 PF ANGLE(deg): 14.50  
 CL ANGLE(deg): 14.50  
 EXT ROOT RADIUS(in): .0004  
 INT ROOT RADIUS(in): .0004

11. HOLLOW DIA(in): 5.600  
 12. EQUIV O.D.(in): 7.000  
 13. ENGAGEMENT LENGTH(in): 1.07  
 14. INTERRUPTED THRD FACTOR: 1.000  
 15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 154.00  
 17. T.S. INT MEMBER(ksi) 154.00  
 18. Y.S. EXT MEMBER(ksi): 125.00  
 19. Y.S. INT MEMBER(ksi) 125.00  
 20. SURF EXT MEMBER: MACHINED  
 21. SURF INT MEMBER: MACHINED

| EXTERNAL THREAD   | SPEC         | DEV    | VAR     |
|-------------------|--------------|--------|---------|
| 22. MAJOR DIA(in) | 6.5000-.0042 | 0.0000 | 0.00000 |
| 23. PITCH DIA(in) | 6.4588-.0178 | 0.0000 | 0.00000 |
| 24. MINOR DIA(in) | 6.4483-.0178 | 0.0000 | 0.00000 |
| INTERNAL THREAD   | SPEC         | DEV    | VAR     |
| 25. MAJOR DIA(in) | 6.5100+.0178 | 6.5300 | 0.00220 |
| 26. PITCH DIA(in) | 6.4792+.0178 | 6.5100 | 0.01300 |
| 27. MINOR DIA(in) | 6.4583+.0042 | 6.5000 | 0.03750 |

28. APPLIED PRELOAD(kip): 0.00  
 APPROX TIGHTENING TORQUE(ft-lb): 0.00  
 29. AXIAL LOAD(kip): 40.00 (max)  
 30. INTERNAL PRESSURE(ksi): 0.00  
 31. TEMPERATURE(deg F): 160

DECIMAL OF MAX ALLOWABLE: 0.00  
 FRICTION FACTOR: 0.20

32. FATIGUE DATA REL: .5000

NOTE: THREAD BACKLASH CONDITIONS ARE AS FOLLOWS.  
 BL TO SPEC: .0290  
 BL TO DEV: .0357  
 ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):

# \*\*\* THREADED JOINT STRESS ANALYSIS RESULTS \*\*\*

THREAD TYPE: 7.063- 6 BUTT-2  
 WAIVER NO: RIW1234  
 ANALYSIS : Static+Fatigue  
 FILE NAME: THRD.BUT1  
 SCN: 12345  
 DATE: 25JUL84  
 PART NO: 12007723  
 SUBCODE: EXAMPLE  
 FLANK ANGLES(deg): PF/CF 7.00/45.00 ROOT RADII(in): EXT/INT .0059/.0059  
 HOLLOW DIA(EXT)(in): 0.000 SECTOR: 0.480 ENGAGEMENT LENGTH(in): 3.180  
 EQUIV O.D.(INT)(in): 8.300 LOAD FACTOR: 1.500 APPLIED PRELOAD(kip): 0.0  
 INTERNAL PRESS(ksi): 0.000 TEMP(deg F): 200 MAX APPLIED LOAD(kip): 122.2  
 RELIABILITY(MEAN=0.5): 0.500 MIN APPLIED LOAD(kip): 0.0

|                       |                     |                |
|-----------------------|---------------------|----------------|
| TENSILE STRENGTH(ksi) | YIELD STRENGTH(ksi) | SURFACE FINISH |
| EXTERNAL 160.0        | 130.0               | MACHINED       |
| INTERNAL 120.0        | 95.0                | MACHINED       |

\*\*\*\*\*  
 DEVIATING MAJOR DIA(in) EXT THRD = 7.0300 \*\*\*\*\*  
 DEVIATING PITCH DIA(in) EXT THRD = 6.9000 \*\*\*\*\*

SHEAR CAP (kip) Y.S./T.S.: EXT = 6851.56/ 8432.69 INT= 5006.91/ 6324.52

| MATL COND | LOAD CAP(kip) |            | STATIC SF |        | SAFETY FACTORS FOR FATIGUE CYCLE RANGES |                             |
|-----------|---------------|------------|-----------|--------|-----------------------------------------|-----------------------------|
|           | YS            | TS         | YS        | TS     | 1*10E3 3*10E3 1*10E4                    | 4*10E4 1*10E5 1*10E6 1*10E7 |
| EMAX      | 712.0/ 876.3  | 5.83/ 7.17 | 3.5687    | 3.2472 | 2.9553                                  | 2.6782 2.5219 2.1993 2.1993 |
| EMIN      | 664.7/ 818.1  | 5.44/ 6.69 | 3.3316    | 3.0315 | 2.7590                                  | 2.5003 2.3544 2.0532 2.0532 |
| EACT      | 654.2/ 805.1  | 5.35/ 6.59 | 3.2790    | 2.9836 | 2.7154                                  | 2.4608 2.3172 2.0208 2.0208 |
| IMAX      | 460.8/ 582.1  | 3.77/ 4.76 | 3.0711    | 2.7289 | 2.4318                                  | 2.1610 2.0128 1.7170 1.7170 |
| IMIN      | 432.1/ 545.8  | 3.54/ 4.47 | 2.8796    | 2.5586 | 2.2801                                  | 2.0262 1.8873 1.6099 1.6099 |
| IACT      | 432.1/ 545.8  | 3.54/ 4.47 | 2.8796    | 2.5586 | 2.2801                                  | 2.0262 1.8873 1.6099 1.6099 |
| OVER-     |               |            |           |        |                                         |                             |
| ALL       | 432.1/ 545.8  | 3.54/ 4.47 | 2.8796    | 2.5586 | 2.2801                                  | 2.0262 1.8873 1.6099 1.6099 |

PRESS RETURN FOR PROGRAM CONTROL MENU

\*\*\* THREAD DATA \*\*\*

1. WAIVER NO: RIW1234 2. SCN#: 12345 3. PART NO: 12007723  
 4. METHOD: Static+Fatigue 5. DATE MACH: 25JUL84 6. SUBCODE: EXAMPLE  
 7. BASIC DIA(in): 7.0625 8. THREADS/IN: 6.00 9. CLASS: 2

10. THREAD FORM: BUTT 11. HOLLOW DIA(in): 0.000  
 PF ANGLE(deg): 7.00 12. EQUIV O.D.(in): 8.300  
 CL ANGLE(deg): 45.00 13. ENGAGEMENT LENGTH(in): 3.18  
 EXT ROOT RADIUS(in): .0059 14. INTERRUPTED THRD FACTOR: 0.480  
 INT ROOT RADIUS(in): .0059 15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 160.00 17. T.S. INT MEMBER(ksi) 120.00  
 18. Y.S. EXT MEMBER(ksi): 130.00 19. Y.S. INT MEMBER(ksi) 95.00  
 20. SURF EXT MEMBER: MACHINED 21. SURF INT MEMBER: MACHINED

| EXTERNAL THREAD   | SPEC         | DEV    | VAR     |
|-------------------|--------------|--------|---------|
| 22. MAJOR DIA(in) | 7.0552-.0080 | 7.0300 | -.01720 |
| 23. PITCH DIA(in) | 6.9552-.0109 | 6.9000 | -.04430 |
| 24. MINOR DIA(in) | 6.8343-.0246 | 0.0000 | 0.00000 |
| INTERNAL THREAD   | SPEC         | DEV    | VAR     |
| 25. MAJOR DIA(in) | 7.0834+.0247 | 0.0000 | 0.00000 |
| 26. PITCH DIA(in) | 6.9625+.0109 | 0.0000 | 0.00000 |
| 27. MINOR DIA(in) | 6.8625+.0080 | 0.0000 | 0.00000 |

28. APPLIED PRELOAD(kip): 0.00 DECIMAL OF MAX ALLOWABLE: 0.00  
 APPROX TIGHTENING TORQUE(ft-lb): 0.00 FRICTION FACTOR: 0.20  
 29. AXIAL LOAD(kip): 122.20 (max) 0.00 (min)  
 30. INTERNAL PRESSURE(ksi): 0.00  
 31. TEMPERATURE(deg F): 200 32. FATIGUE DATA REL: .5000

ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):

# \*\*\* THREADED JOINT STRESS ANALYSIS RESULTS \*\*\*

THREAD TYPE: 3.750- 6 BUTT-2  
 WAIVER NO: RIW1234  
 ANALYSIS : Static+Fatigue  
 FILE NAME: THRD.BUT2  
 SCN: 12345  
 DATE: 25JUL84  
 PART NO: 12007723  
 SUBCODE: EXAMPLE  
 FLANK ANGLES(deg): PF/CF 7.00/45.00 ROOT RADII(in): EXT/INT .0059/.0059  
 HOLLOW DIA(EXT)(in): 0.000 SECTOR: 0.480 ENGAGEMENT LENGTH(in): 2.830  
 EQUIV O.D.(INT)(in): 6.000 LOAD FACTOR: 1.500 APPLIED PRELOAD(kip): 0.0  
 INTERNAL PRESS(ksi): 0.000 TEMP(deg F): 200 MAX APPLIED LOAD(kip): 76.0  
 RELIABILITY(MEAN=0.5): 0.500 MIN APPLIED LOAD(kip): 0.0

|                       |                     |                |
|-----------------------|---------------------|----------------|
| TENSILE STRENGTH(ksi) | YIELD STRENGTH(ksi) | SURFACE FINISH |
| EXTERNAL 160.0        | 130.0               | MACHINED       |
| INTERNAL 120.0        | 95.0                | MACHINED       |

\*\*\*\*\* DEVIATING MAJOR DIA(in) INT THRD = 3.6000 \*\*\*\*\*

|                    |            |                                         |          |         |        |          |                                    |
|--------------------|------------|-----------------------------------------|----------|---------|--------|----------|------------------------------------|
| SHEAR CAP (kip)    | Y.S./T.S.: | EXT =                                   | 3295.77/ | 4056.34 | INT=   | 2408.45/ | 3042.25                            |
| MATL LOAD CAP(kip) | STATIC SF  | SAFETY FACTORS FOR FATIGUE CYCLE RANGES |          |         |        |          |                                    |
| COND               | YS         | TS                                      | 1*10E3   | 3*10E3  | 1*10E4 | 4*10E4   | 1*10E5 1*10E6 1*10E7               |
| EMAX               | 312.1/     | 384.2                                   | 4.11/    | 5.05    | 2.5157 | 2.2390   | 2.0833 1.8879 1.7777 1.5504 1.5504 |
| EMIN               | 293.1/     | 360.7                                   | 3.86/    | 4.75    | 2.3622 | 2.1494   | 1.9562 1.7727 1.6693 1.4558 1.4558 |
| EACT               | 293.1/     | 360.7                                   | 3.86/    | 4.75    | 2.3622 | 2.1494   | 1.9562 1.7727 1.6693 1.4558 1.4558 |
| IMAX               | 243.0/     | 306.9                                   | 3.20/    | 4.04    | 2.6037 | 2.3135   | 2.0617 1.8321 1.7065 1.4557 1.4557 |
| IMIN               | 227.5/     | 287.4                                   | 2.99/    | 3.78    | 2.4382 | 2.1665   | 1.9307 1.7157 1.5980 1.3632 1.3632 |
| IACT               | 227.5/     | 287.4                                   | 2.99/    | 3.78    | 2.4382 | 2.1665   | 1.9307 1.7157 1.5980 1.3632 1.3632 |
| OVER-              |            |                                         |          |         |        |          |                                    |
| ALL                | 227.5/     | 287.4                                   | 2.99/    | 3.78    | 2.3622 | 2.1494   | 1.9307 1.7157 1.5980 1.3632 1.3632 |

PRESS RETURN FOR PROGRAM CONTROL MENU.

\*\*\* THREAD DATA \*\*\*

1. WAIVER NO: RIW1234 2. SCN#: 12345 3. PART NO: 12007723  
 4. METHOD: Static+Fatigue 5. DATE MACH: 25JUL84 6. SUBCODE: EXAMPLE  
 7. BASIC DIA(in): 3.7500 8. THREADS/IN: 6.00 9. CLASS: 2  
 10. THREAD FORM: BUTT 11. HOLLOW DIA(in): 0.000  
 PF ANGLE(deg): 7.00 12. EQUIV O.D.(in): 6.000  
 CL ANGLE(deg): 45.00 13. ENGAGEMENT LENGTH(in): 2.83  
 EXT ROOT RADIUS(in): .0059 14. INTERRUPTED THRD FACTOR: 0.480  
 INT ROOT RADIUS(in): .0059 15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 160.00 17. T.S. INT MEMBER( ksi) 120.00  
 18. Y.S. EXT MEMBER(ksi): 130.00 19. Y.S. INT MEMBER( ksi) 95.00  
 20. SURF EXT MEMBER: MACHINED 21. SURF INT MEMBER: MACHINED

| EXTERNAL THREAD   | SPEC         | DEV    | VAR     |
|-------------------|--------------|--------|---------|
| 22. MAJOR DIA(in) | 3.7432-.0050 | 0.0000 | 0.00000 |
| 23. PITCH DIA(in) | 3.6432-.0102 | 0.0000 | 0.00000 |
| 24. MINOR DIA(in) | 3.5223-.0239 | 0.0000 | 0.00000 |
| INTERNAL THREAD   | SPEC         | DEV    | VAR     |
| 25. MAJOR DIA(in) | 3.7709+.0239 | 0.0000 | 0.00000 |
| 26. PITCH DIA(in) | 3.6500+.0102 | 0.0000 | 0.00000 |
| 27. MINOR DIA(in) | 3.5500+.0050 | 3.6000 | 0.04500 |

28. APPLIED PRELOAD(kip): 0.00 DECIMAL OF MAX ALLOWABLE: 0.00  
 APPROX TIGHTENING TORQUE(ft-lb): 0.00 FRICTION FACTOR: 0.20  
 29. AXIAL LOAD(kip): 76.00 (max) 0.00 (min)  
 30. INTERNAL PRESSURE(ksi): 0.00  
 31. TEMPERATURE(deg F): 200 32. FATIGUE DATA REL: .5000

ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):

\*\*\* THREADED JOINT STRESS ANALYSIS RESULTS \*\*\*

THREAD TYPE: 14.057-PF20--.3750 FILE NAME: THRD.PF20  
 WAIVER NO: RIW1234 SCN: 12345 PART NO: 12007723  
 ANALYSIS : Static+Fatigue DATE: 25JUL84 SUBCODE: XXXX

FLANK ANGLES(deg): PF/CF 20.00/45.00 ROOT RADII(in): EXT/INT .0450/.0450  
 HOLLOW DIA(EXT)(in): 6.100 SECTOR: 0.480 ENGAGEMENT LENGTH(in): 3.530  
 EQUIV O.D.(INT)(in): 15.560 LOAD FACTOR: 1.500 APPLIED PRELOAD(kip): 0.0  
 INTERNAL PRESS(ksi): 25.100 TEMP(deg F): 160 MAX APPLIED LOAD(kip): 746.5  
 RELIABILITY(MEAN=0.5): 0.500 MIN APPLIED LOAD(kip): 0.0

|          | TENSILE STRENGTH(ksi) | YIELD STRENGTH(ksi) | SURFACE FINISH |
|----------|-----------------------|---------------------|----------------|
| EXTERNAL | 160.0                 | 130.0               | MACHINED       |
| INTERNAL | 120.0                 | 95.0                | MACHINED       |

\*\*\*\*\* DEVIATING PITCH DIA(in) INT THRD = 13.8540 \*\*\*\*\*  
 \*\*\*\*\* DEVIATING MAJOR DIA(in) INT THRD = 13.7120 \*\*\*\*\*

SHEAR CAP (kip) Y.S./T.S.: EXT = 15445.86/ 19010.29 INT= 11287.36/ 14257.72

| MTRL COND | LOAD CAP(kip) |            | STATIC SF |        | SAFETY FACTORS FOR FATIGUE |        | CYCLE RANGES |        |        |
|-----------|---------------|------------|-----------|--------|----------------------------|--------|--------------|--------|--------|
|           | YS            | TS         | YS        | TS     | 1*10E3                     | 3*10E3 | 1*10E4       | 4*10E4 |        |
| EMAX      | 5376.3/6617.0 | 7.20/ 8.86 | 2.5310    | 2.2758 | 2.0493                     | 1.8387 | 1.7217       | 1.4844 | 1.4844 |
| EMIN      | 5291.1/6512.1 | 7.09/ 8.72 | 2.4909    | 2.2397 | 2.0169                     | 1.8095 | 1.6944       | 1.4608 | 1.4608 |
| EACT      | 5291.1/6512.1 | 7.09/ 8.72 | 2.4909    | 2.2397 | 2.0169                     | 1.8095 | 1.6944       | 1.4608 | 1.4608 |
| IMAX      | 2016.7/2547.5 | 2.70/ 3.41 | 2.2070    | 1.9094 | 1.6636                     | 1.4489 | 1.3350       | 1.1148 | 1.1148 |
| IMIN      | 1983.8/2505.9 | 2.66/ 3.36 | 2.1709    | 1.8782 | 1.6365                     | 1.4252 | 1.3132       | 1.0966 | 1.0966 |
| IACT      | 1976.5/2496.6 | 2.65/ 3.34 | 2.1629    | 1.8713 | 1.6304                     | 1.4199 | 1.3083       | 1.0925 | 1.0925 |
| OVER-     |               |            |           |        |                            |        |              |        |        |
| ALL       | 1976.5/2496.6 | 2.65/ 3.34 | 2.1629    | 1.8713 | 1.6304                     | 1.4199 | 1.3083       | 1.0925 | 1.0925 |

PRESS RETURN FOR PROGRAM CONTROL MENU

\*\*\* THREAD DATA \*\*\*

1. WAIVER NO: RIW1234 2. SCN#: 1234E 3. PART NO: 12007723  
 4. METHOD: Static+Fatigue 5. DATE MACH: JUL84 6. SUBCODE: XXXX  
 7. DATUM DIA(in): 13.8490 8. PITCH: 0.3750

10. THREAD FORM: PF20 11. HOLLOW DIA(in): 6.100  
 PF ANGLE(deg): 20.00 12. EQUIV O.D.(in): 15.560  
 CL ANGLE(deg): 45.00 13. ENGAGEMENT LENGTH(in): 3.53  
 EXT ROOT RADIUS(in): .0450 14. INTERRUPTED THRD FACTOR: 0.480  
 INT ROOT RADIUS(in): .0450 15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 160.00 17. T.S. INT MEMBER(ksi) 120.00  
 18. Y.S. EXT MEMBER(ksi): 130.00 19. Y.S. INT MEMBER(ksi) 95.00  
 20. SURF EXT MEMBER: MACHINED 21. SURF INT MEMBER: MACHINED

| EXTERNAL THREAD   | SPEC          | DEV     | VAR     |
|-------------------|---------------|---------|---------|
| 22. MAJOR DIA(in) | 14.0000-.0050 | 0000    | 0.00000 |
| 23. PITCH DIA(in) | 13.8490-.0000 | 0.0000  | 0.00000 |
| 24. MINOR DIA(in) | 13.6410-.0100 | 0.0000  | 0.00000 |
| INTERNAL THREAD   | SPEC          | DEV     | VAR     |
| 25. MAJOR DIA(in) | 14.0570+.0100 | 0.0000  | 0.00000 |
| 26. PITCH DIA(in) | 13.8490+.0000 | 13.8540 | 0.00500 |
| 27. MINOR DIA(in) | 13.6980+.0050 | 13.7120 | 0.00900 |

28. APPLIED PRELOAD(kip): 0.00 DECIMAL OF MAX ALLOWABLE: 0.00  
 APPROX TIGHTENING TORQUE(ft-lb): 0.00 FRICTION FACTOR: 0.20  
 29. AXIAL LOAD(kip): 746.50 (max) 0.00 (min)  
 30. INTERNAL PRESSURE(ksi): 25.10  
 31. TEMPERATURE(deg F): 160 32. FATIGUE DATA REL: .5000

PRESS RETURN FOR PROGRAM CONTROL MENU