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MSFC CRACK GROWTH ANALYSIS COMPUTER PROGRAM, VERSION II (USERS MANUAL)

By Matthew Creager
Del West Associates, Inc.
Woodland Hills, California 91364

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NASA - GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812
An updated version of the George C. Marshall Space Flight Center Crack Growth Analysis Program is described. The updated computer program has significantly expanded capabilities over the original one. This increased capability includes an extensive expansion of the library of stress intensity factors, plotting capability, increased design iteration capability, and the capability of performing proof test logic analysis.

The technical approaches used within the computer program are presented and the input and output formats and options are described. Details of the stress intensity equations, example data, and example problems are presented in the Appendix.
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FOREWORD

The computer program described in this manual was developed under Contract Numbers NAS8-31101 and NAS8-31624. These Contracts were monitored by C. Bianca of the George C. Marshall Space Flight Center. K. Roper performed all the computer program coding.
The author would like to acknowledge the informative technical discussions held with J. E. Collipriest, Jr., R. M. Ehret, and A. F. Liu during the course of this work.
INTRODUCTION

In order to include the important consideration of structural failure due to the presence of flaws and crack-like defects in aerospace hardware; it is necessary to have a computer program capable of performing crack growth analysis that is easy to use and generally applicable. The need for a computer program (as opposed to simple hand calculations) arises from the complexity of growth descriptions required for crack growth analysis of real materials in complex structure under a variety of loading and environmental conditions. The MSFC crack growth computer program developed by Del West was designed to meet this need.

The MSFC crack growth computer program calculates crack growth for part through cracks, through the thickness cracks and cracks which are transitioning from part through cracks to through the thickness cracks. The computer program has been written to be flexible in its operation and to be easily adapted and changed as fracture mechanics technology changes and/or the design usage of the program changes.

The computer program is essentially an integration routine which calculates crack growth from an initial defect size and terminates calculation when the crack is sufficiently large for a critical condition (instability or rapid growth) to be reached. The initial defect size may be designated by the user or established
by the computer program on the basis of proof test logic. In addition, if a design life is not met for a particular structure, the program has the capability of varying the thickness of the structure or initial defect size so as to establish the geometry which will meet the design requirements.

During the period when a crack is a part through crack, crack growth in the depth and surface directions may be different due to variations in stress intensity factors and/or directional dependence of material properties. The MSFC computer program considers both of these effects and hence incorporates realistic crack shape changes. During the period when a crack is transitioning from a part through crack to a through the thickness crack, the crack lengths on the backside and the frontside are different. The MSFC computer program tracks the growth of these two dimensions separately; evaluating the stress intensity factors at each surface until these dimensions are the same and the crack has completed its transition to a through the thickness crack.

The computer program allows two different methods of load input. For each step in the loading block, the user specifies either:

1. Maximum Stress, Minimum Stress, Number of Cycles or
2. Maximum Stress, Stress Ratio, Number of Cycles. It should be noted that if crack growth mechanisms other than fatigue are
being considered (e.g., static stress corrosion) the appropriate rate variable can be used instead of cycles (e.g., time at load) in conjunction with appropriate material constants as described below to perform a wide range of phenomenological studies.

The use of a limit load (a load which may be higher than any load in the actual spectrum) to determine the end of design life is a common practice. The MSFC computer program has therefore been written to consider a separate limit load (apart from those in the spectrum) and to determine when it causes failure. However, after failure due to limit load occurs, the crack growth calculation continues. The limit load failure information is included in the output.

The crack growth rate material properties may presently be input into the program in any of four formats: (1) Paris equation with upper and lower cutoffs in stress intensity factor; (2) Forman equation with upper and lower cutoffs in stress intensity factor; (3) Collipriest-Ehret equation with additional upper and lower cutoffs in stress intensity factor; (4) tabulated as a function of stress intensity range and stress ratio. An important feature of the material property description is that different material properties (crack growth equations, fracture properties, yield stress, etc.) may be designated for each step in the loading spectrum. Thus varying temperatures and environments may be considered.
The MSFC crack growth computer program has the capability of utilizing any one of three crack growth retardation models. Of course, the effects of retardation on crack growth will not be considered if the user does not request it. The three models presently available are: (1) Willenborg; (2) Wheeler; (3) Grumman Closure Model.

The module which performs stress intensity calculations currently includes stress intensity equations for the following geometries:

1) Crack in a finite width finite thickness plate - part through crack, transition crack, through crack.
2) ASTM E399 compact specimen - through crack.
3) Single crack emanating from a hole - corner crack, internal crack, transition crack, through crack.
4) Two cracks emanating from a hole - corner crack, internal crack, transition crack, through crack.
5) Single crack emanating from a pin loaded lug - corner crack, internal crack, transition crack, through crack.
6) Two cracks emanating from a pin loaded lug - corner crack, internal crack, transition crack, through crack.
7) Crack emanating from a notch - corner crack, internal crack, transition crack, through crack.
8) Cracks emanating from double notches - corner crack, internal crack, transition crack, through crack.
9) Cracks emanating from shoulder radii - corner crack, internal crack, transition crack, through crack.

As many runs (each with varying input conditions) as desired may be stacked. As additional runs are made, only that section of data which is changed (i.e., loads, material properties, or geometry) need be reentered. Output format can include tabulated and/or plotted data. Minimum tabulated output for each run consists of information on input data and failure (crack lengths, cycles, etc.) as well as crack lengths, stress intensity factors, and crack growth rates for the first and last cycle of each stress level in the first load block applied as a part through crack, transitional crack or through crack. Additional information (crack lengths, stress intensity factors, and crack growth rates) for particular blocks and loading steps may be requested by the user. The plotted output consists of plots of surface and crack depth lengths plotted against the number of loading blocks and cycles. The user may specify plotting increments or simply use increments chosen by the computer program.

A flow chart showing all subroutines is presented in Figure 1, and a description of each subroutine's primary function is presented in Table I.
Figure 1 - Subroutines
<table>
<thead>
<tr>
<th>SUBROUTINE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAIN</td>
<td>Reads Input, Sequences Runs, Performs Design Iterations, Calls Proof Test Module, Calls Appropriate Crack Growth Module.</td>
</tr>
<tr>
<td>PROOF</td>
<td>Calculates initial flaw size based on proof test logic.</td>
</tr>
<tr>
<td>PTCGRW</td>
<td>Calculates crack growth for a part through crack.</td>
</tr>
<tr>
<td>TRANS</td>
<td>Calculates crack growth for a transitional crack.</td>
</tr>
<tr>
<td>TCGROW</td>
<td>Calculates crack growth for a through crack.</td>
</tr>
<tr>
<td>KANAL</td>
<td>Evaluates all stress intensity factors</td>
</tr>
<tr>
<td>DAMAGE</td>
<td>Calculates crack growth rates</td>
</tr>
<tr>
<td>INTP</td>
<td>Interpolates stress intensity or crack growth rate tables.</td>
</tr>
<tr>
<td>RETARD</td>
<td>Modifies input to damage to account for retardation effects.</td>
</tr>
</tbody>
</table>
In addition to the basic crack growth analysis program, a companion program which formats the crack growth data for plotting on the SC4020 plotter is included in the program package. The functional flow of the computer program package is indicated in Figure 2.
Figure 2 - Functional Flow
TECHNICAL APPROACH

The essence of the crack growth analysis procedure consists of:

1) Establishing an initial defect size: Either directly as input or as a result of proof test logic, or as a result of a design iteration.

2) Considering each loading step in a load block in turn.

3) Evaluating stress intensity factors, using the stresses from the step under consideration.

4) Using these stress intensity factors (and previous loading history if retardation is considered) to calculate crack growth rate.

5) Consider a small amount of growth (1% of current crack size) and calculate the number of cycles it takes to grow that amount. If that amount exceeds the number of cycles not yet consumed in the step than only those remaining cycles are used and a corresponding crack growth increment is calculated.

6) Crack lengths are incremented, cycle count is incremented.

7) This process is continued until all cycles in the step are considered. The next step is then called. At the end of a block the first step is called again.

8) The calculation ends when:
   a) The critical stress intensity (either at the surface or at the depth of a crack) is exceeded.
   b) There is no crack growth ($<10^{-8}$ in.) for an entire block.
   c) The crack growth rate goes to infinity (when using the Forman equation for crack growth rate).
d) The maximum number of blocks is exceeded.

9) All input and all output data are in units compatible with Kips and inches. (e.g., Ksi, Ksi√in. and in/cycle.)

SUBROUTINES

The subroutine operations are each described below. Since MAIN serves primarily as a calling routine, it will be clearest if we describe MAIN last.

PROOF

The proof test module uses an iteration scheme of successive bisections and inverse parabolic interpolation to solve the nonlinear equations that arise in defining the crack size that will cause an applied stress intensity factor due to the proof load to equal the critical stress intensity factor. The critical condition is checked at both the depth and surface of a part through crack. The smallest crack size that produces criticality is the result. The critical stress intensity factors used for the proof test may be different than those used to predict the end of service life.
Thus, changes in environments and their concomitant changes in material properties may be accounted for (e.g., a cryogenic proof test). Either the crack depth \(a\), the surface length \(c\) or the shape \(a/c\) for a part through crack may be kept constant for the proof test calculation.

**PTCGRW, TRANS, TCGROW**

The subroutines PTCGRW, TRANS, and TCGROW calculate the crack growth increments, return to MAIN for information on the next loading step, consider when to end the calculation and transfer to each other (PTCGRW + TRANS + TCGROW) as required. For a part through crack PTCGRW performs these functions until TRANS is called. TRANS is called when the crack depth equals the plate thickness. TRANS performs these functions while the crack is transitioning to a through crack and calls TCGROW when the back surface length exceeds 95% of the front surface length. TCGROW performs these functions when the crack is a through crack and may be called by TRANS or in those cases when a through crack is considered initially it is called from MAIN.

**KANAL**

KANAL is a subroutine which returns factors, which when multiplied by the appropriate loading term yields stress intensity factors. Thus the loading input must be compatible with the crack configuration considered. For the configurations currently in the program
the corresponding name (RTYP0) and required load description are
given in Table II. The geometrical arrangement of each configura-
tion is given in Figure 3. Detailed descriptions of the stress
intensity factors are given in the Appendix.

DAMAGE

The subroutine DAMAGE currently contains three equations and a
 provision for tabulated data for calculating crack growth rate.
In all cases the independent variables are the effective stress
intensity factor, KE, and the effective stress ratio, RE. When
retardation is not used KE is simply the stress intensity range
(KMAX - KMIN) and RE is simply the stress ratio. When retarda-
tion is used, KE and RE are calculated in RETARD.

The following equations all contain material property constants
designated by D(NC,I,J). NC indicates whether the surface (NC = 1)
or depth (NC = 2) is being considered. I distinguishes the
various constants in that equation and indicates the order of
the constant on the input cards. J is the material type number
which is also input with end loading step. In order to call out
the proper equation the corresponding equation name (NEQ) must
be specified during input. Note that each material type could
use a different NEQ.
## TABLE II - Stress Intensity Factors in Kanal

<table>
<thead>
<tr>
<th>KTYPEO(1)</th>
<th>KTYPEO(2)</th>
<th>Configuration</th>
<th>Load Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>PTC - center crack</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>Single corner crack at hole</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>Double corner crack at hole</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>Single internal crack at hole</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>Double internal crack at hole</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>General tabular description</td>
<td>As required by tabular description</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>Single corner crack pin loaded lug</td>
<td>Pin load</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>Double corner crack pin loaded lug</td>
<td>Pin load</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>Single internal crack pin loaded lug</td>
<td>Pin load</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>Double internal crack pin loaded lug</td>
<td>Pin load</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>Corner crack at single notch</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>13</td>
<td>Corner cracks at double notch</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>Internal crack at single notch</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>Internal cracks at double notches</td>
<td>Gross stress</td>
</tr>
<tr>
<td>KTYPO(1)</td>
<td>KTYPO(2)</td>
<td>Configuration</td>
<td>Load Description</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>--------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>1</td>
<td>16</td>
<td>Corner crack at Gross stress shoulder</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>Internal crack at Gross stress shoulder</td>
<td>Gross stress</td>
</tr>
<tr>
<td>2</td>
<td>1-17</td>
<td>Appropriate transition crack corresponding to through crack case - see KTYPO(1)=3 List</td>
<td>As described in corresponding KTYPO(1)=3 List</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Center through Crack</td>
<td>Gross stress</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Compact Specimen (ASTM E399-74)</td>
<td>Pin load</td>
</tr>
<tr>
<td>3</td>
<td>3 or 5</td>
<td>Single through crack at hole</td>
<td>Gross stress</td>
</tr>
<tr>
<td>3</td>
<td>4 or 6</td>
<td>Double through crack at hole</td>
<td>Gross stress</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>General tabular description</td>
<td>As required by tabular description</td>
</tr>
<tr>
<td>3</td>
<td>8 or 10</td>
<td>Single through crack - pin loaded lug</td>
<td>Pin load</td>
</tr>
<tr>
<td>3</td>
<td>9 or 11</td>
<td>Double through crack pin loaded lug</td>
<td>Pin load</td>
</tr>
<tr>
<td>3</td>
<td>12 or 14</td>
<td>Through crack at single notch</td>
<td>Gross stress</td>
</tr>
<tr>
<td>3</td>
<td>13 or 15</td>
<td>Through cracks at double notches</td>
<td>Gross stress</td>
</tr>
<tr>
<td>3</td>
<td>16 or 17</td>
<td>Through cracks at shoulder</td>
<td>Gross stress</td>
</tr>
</tbody>
</table>
Center Crack

Compact Specimen

Single Crack at Hole

Double Crack at Hole

Figure 3(a) - Configuration Planforms
General Tabular Description

Figure 3(a) Cont.
Cracks at Shoulder Radii

Figure 3(a) Cont.

19
Figure 3b - Configuration Crosssections
The use of "J" allows various loading steps to use different crack growth rate equations and thus variations in environment and crack growth phenomenon (fatigue or stress corrosion) can be accounted for.

The Collipriest-Ehret equation is:

\[
\frac{da}{dn} = C_1 \exp \left[ C_2 \tanh^{-1} \left( \frac{\ln(KE^2/(1-RE))}{\ln(1-RE) D(NC,3,J)/D(NC,4,J)} \right) \right]
\]

\[
C_2 = \ln \left( \frac{D(NC,3,J)}{D(NC,4,J)} \right)^\frac{D(NC,2,J)}{2}
\]

\[
C_1 = D(NC,1,J) \left[ D(NC,3,J) D(NC,4,J) \right]^{\frac{D(NC,2,J)}{2}}
\]

where

- \( D(NC,1,J) \) Crack growth rate coefficient
- \( D(NC,2,J) \) Dimensionless coefficient relating to midrange slope.
- \( D(NC,3,J) \) Critical stress intensity (upper asymptote)
- \( D(NC,4,J) \) Threshold stress intensity range (lower asymptote)
The Paris equation is:
\[ \frac{da}{dn} = D(NC,1,J) K E^{D(NC,2,J)} \]

The Forman equation is:
\[ \frac{da}{dn} = \frac{D(NC,1,J) K E^{D(NC,2,J)}}{(1-RE) D(NC,3,J)-K E} \]

where
- \( D(NC,1,J) \) Crack growth rate coefficient
- \( D(NC,2,J) \) Crack growth rate exponent
- \( D(NC,3,J) \) Critical stress intensity (upper asymptote)

Tabulated data is in input as a function of stress intensity range and stress ratio. If retardation is to be used, the variables are effective stress intensity range and effective stress ratio. The computer program performs linear interpolation in stress ratio and logarithmic interpolation in stress intensity range. This results in a "Paris Equation" fit between consecutive data points at a constant stress ratio. All stress ratios between the highest given in the Table and 1.0 use the crack growth rate at the highest stress ratio data supplied. The lowest stress ratio required by the loading spectrum must be within the range of the input data.

The format for crack growth data input is shown in Figure 4. For this mode of crack growth description only three material
types may be used. Thus, there is the possibility of supplying 6 Tables (surface/depth direction for each material type)

\[
\begin{array}{cccc}
  & \text{RE(NT,1)} & \text{RE(NT,2)} & \cdots & \text{RE(NT,m)} \\
\text{KE(NT,1)} & \frac{d a}{d n}(NT,1,1) & \frac{d a}{d n}(NT,1,2) & \frac{d a}{d n}(NT,1,2) & \frac{d a}{d n}(NT,1,m) \\
\text{KE(NT,2)} & \cdots & \cdots & \cdots & \cdots \\
\text{KE(NT,k)} & \frac{d a}{d n}(NT,k,1) & \frac{d a}{d n}(NT,k,2) & \frac{d a}{d n}(NT,k,2) & \frac{d a}{d n}(NT,k,m) \\
\end{array}
\]

\(t < 25, m < 25\)

NT goes from 1 to 6 and is set automatically by the computer program and takes on values according to the following Table:

**TABLE III**

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Growth Direction</th>
<th>NT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Surface</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Depth</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Surface</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Depth</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Surface</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Depth</td>
<td>6</td>
</tr>
</tbody>
</table>
The subroutine RETARD currently contains three retardation models. In each of these a crack tip plastic zone $r_y$ is calculated according to the equation

$$r_y = \frac{1}{(2\pi)P_z} \times \frac{K_{\text{max}}^2}{\sigma_{\text{ys}}^2}$$

where $P_z$ is a constant depending on the degree of plane stress versus plane strain. For plane stress $P_z = 1$. For plane strain $P_z = 3$.

The following is the retardation equation number for each retardation model.

<table>
<thead>
<tr>
<th>NRET</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Willenborg Model (Ref. 1)</td>
</tr>
<tr>
<td>2</td>
<td>Wheeler Model (Ref. 2)</td>
</tr>
<tr>
<td>3</td>
<td>Grumman Closure Model (Ref. 3)</td>
</tr>
</tbody>
</table>

The Willenborg retardation model calls for no constants other than $P_z$. The only material property input for this model is therefore

$$CR(NC,1,J) = P_z$$

The "Wheeler" model in this computer program is actually a variation of the model originally presented by Wheeler. Wheeler used a modification to the crack growth rate to produce a retardation effect and we have used a modification to the dependent
variable KE. If the Paris equation is used for crack growth rate the "Wheeler" model in this computer program is identical to the model presented in Ref. The input material properties for this model are

\[
\begin{align*}
CR(NC,1,J) &= P_z \\
CR(NC,2,J) &= m/n
\end{align*}
\]

where \( m \) is identical to the "m" used in Ref. and \( n \) is the exponent in the Paris equation (i.e., if the "Wheeler m" were 5 and the Paris "n" 4, the input value for \( CR(NC,2,J) \) is 1.25).

The details of the Grumman Closure model are too complex to be described here. The input is described below.

<table>
<thead>
<tr>
<th>Input Quantity</th>
<th>Name in Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR(NC,1,J)</td>
<td>( P_z )</td>
</tr>
<tr>
<td>CR(NC,2,J)</td>
<td>( C_f - 1 )</td>
</tr>
<tr>
<td>CR(NC,3,J)</td>
<td>( C_f^o )</td>
</tr>
<tr>
<td>CR(NC,4,J)</td>
<td>( P )</td>
</tr>
<tr>
<td>CR(NC,5,J)</td>
<td>NSAT</td>
</tr>
<tr>
<td>CR(NC,6,J)</td>
<td>( v_1 )</td>
</tr>
<tr>
<td>CR(NC,7,J)</td>
<td>( B )</td>
</tr>
</tbody>
</table>

INTP

INTP is a subroutine which interpolates tabular data. It is called from either KANAL or DAMAGE. When called from KANAL it will use the appropriate input Table and linearly inter-
polate in both (a) and (c) for part through cracks and linearly in (c) for through and transition cracks to obtain values of stress intensity factors. When called from DAMAGE it will use the appropriate input Table and interpolate linearly in stress ratio and logarithmically in stress intensity to obtain crack growth rates.

MAIN

MAIN reads all input data; controls calling sequences of subroutines PROOF, PTCGRW, TRANS and TCGROW; performs iterations on thickness or initial crack size to obtain desired crack growth lives; and controls output.
INPUT

There are 27 distinct data input card formats. These are described below and illustrated on pages 36 and 37. Pages 38 and 39 show when each card type is required. The superscript x designates fixed point numbers. All others are floating point.

<table>
<thead>
<tr>
<th>CARD TYPE</th>
<th>FIELD</th>
<th>NOMENCLATURE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-80</td>
<td>TITLE</td>
<td>Any alphanumeric description of group of runs.</td>
</tr>
<tr>
<td>2</td>
<td>1-4</td>
<td>NRUNS&lt;sup&gt;x&lt;/sup&gt;</td>
<td>Total number of runs (one run corresponds to a unique set of input data.)</td>
</tr>
<tr>
<td>2</td>
<td>5-10</td>
<td>NBLOCK&lt;sup&gt;x&lt;/sup&gt;</td>
<td>Maximum number of blocks to be considered. Crack growth calculation ceases when the number of blocks exceeds this number.</td>
</tr>
<tr>
<td>2</td>
<td>11-14</td>
<td>MBLOCK&lt;sup&gt;x&lt;/sup&gt;</td>
<td>Block interval for which additional data will be printed (e.g., 3 would imply that blocks 3, 6, 9, 12,...etc. would have data printed out).</td>
</tr>
<tr>
<td>2</td>
<td>15-18</td>
<td>MSTEP&lt;sup&gt;x&lt;/sup&gt;</td>
<td>Step interval for which additional data will be printed (in the blocks called out above).</td>
</tr>
<tr>
<td>3</td>
<td>1-10</td>
<td>CSTRS</td>
<td>Constant multiplier for stress inputs. Allows stress spectrum to be varied by changing one number only. (e.g., one run with this constant 1.1, will show the effect of varying the stress 10%).</td>
</tr>
<tr>
<td>3</td>
<td>11-14</td>
<td>NSUP&lt;sup&gt;x&lt;/sup&gt;</td>
<td>Constant for suppression of retardation in crack growth analysis. If zero, retardation is not considered. If retardation is to be considered, constant must be 1.</td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>NOMENCLATURE</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>3</td>
<td>15-18</td>
<td>NLOAD^x</td>
<td>Constant to indicate whether new load data is to be input. If zero, (or any number not equal to 1) load data will not be read in and load data from previous run will be used. If it is 1, card types 4 and 5 must follow.</td>
</tr>
<tr>
<td>3</td>
<td>19-22</td>
<td>NGEOM^x</td>
<td>Constant to indicate whether new geometry data is to be input. If zero (or any number other than 1) geometry data will not be read in and geometry data from previous run will be used. If it is 1, card types 6 and 7 must be read in.</td>
</tr>
<tr>
<td>3</td>
<td>23-26</td>
<td>NMAT^x</td>
<td>Constant to indicate whether new material data is to be input. If zero (or any number other than 1) material data will not be read in and material data from previous run will be used. If it is 1, card types 8, 9, 10, and 11, 12, 13, if needed must be read in.</td>
</tr>
<tr>
<td>3</td>
<td>27-30</td>
<td>ITERTP^x</td>
<td>Parameter that identifies variables for iteration to find geometry that survives the desired life. If ITERTP = 1, the thickness is varied. If ITERTP = 2, the surface crack length is varied and the crack depth (if a part through crack) is kept constant. If ITERTP = 3, the crack depth is varied and the surface length is kept constant. If ITERTP = 4, the crack shape is kept constant and both the crack depth and surface length are varied. Field may be left blank if ITER is zero (or blank).</td>
</tr>
<tr>
<td>3</td>
<td>31-34</td>
<td>ITER^x</td>
<td>Maximum number of iterations to find thickness or crack size that produces the desired life. May not exceed 10, may be left blank. Next two items on card three may be left blank, if ITER equals zero (or blank).</td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>NOMENCLATURE</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>3</td>
<td>35-44</td>
<td>PIT</td>
<td>Parameter to control rate of convergence on design iteration. Usually set to exponential power in Paris crack growth equation for crack growth data. When other crack growth equation is used, approximate value of a &quot;Paris exponent&quot; will be sufficient. Must always be greater than 1.</td>
</tr>
<tr>
<td>3</td>
<td>45-54</td>
<td>BLIFE</td>
<td>Desired life in blocks.</td>
</tr>
<tr>
<td>3</td>
<td>55-58</td>
<td>NPROOF</td>
<td>Parameter that identifies variables in proof test logic. If zero (or blank) no proof test logic is performed. If 1, the crack surface and depth of a part through crack is varied and the shape held constant; if 2 the surface crack length of a through crack is varied; if 3 the crack depth of a part through crack is varied and the surface crack length is held constant; if 4 the surface crack length is varied and the depth is held constant.</td>
</tr>
<tr>
<td>3</td>
<td>59-62</td>
<td>IPlot</td>
<td>Parameter to indicate whether output is to be plotted. If zero (or blank) data is not plotted. Any other value produces a plot of crack lengths versus blocks and cycles.</td>
</tr>
<tr>
<td>3</td>
<td>63-72</td>
<td>PCYC(1)</td>
<td>Interval in cycles between plotted data points. If zero, plotted points will correspond to tabular output.</td>
</tr>
<tr>
<td>4</td>
<td>1-4</td>
<td>NSTEP</td>
<td>Number of steps in load blocks.</td>
</tr>
<tr>
<td>4</td>
<td>5-8</td>
<td>IR</td>
<td>Zero if input format includes minimum stress, 1 if input format includes stress ratio.</td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>NOMENCLATURE</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>4</td>
<td>9-18</td>
<td>SIGLM</td>
<td>Limit stress for additional end of life determination. Failure due to limit load does not terminate crack growth calculation.</td>
</tr>
<tr>
<td>5</td>
<td>1-10</td>
<td>SMAX</td>
<td>Maximum stress.</td>
</tr>
<tr>
<td>5</td>
<td>11-20</td>
<td>SMIN</td>
<td>Minimum stress if IR = 0, stress ratio of IR = 1.</td>
</tr>
<tr>
<td>5</td>
<td>21-30</td>
<td>UNIT</td>
<td>Number of cycles or alternate rate variable.</td>
</tr>
<tr>
<td>5</td>
<td>31-34</td>
<td>TYPE*</td>
<td>Material property data type to be used.</td>
</tr>
<tr>
<td>6</td>
<td>1-4</td>
<td>KTYPO(1)*</td>
<td>Initial crack type; 1 corresponds to a part through crack; 2 corresponds to a transition crack and 3 corresponds to a through crack.</td>
</tr>
<tr>
<td>6</td>
<td>5-8</td>
<td>KTYPO(2)*</td>
<td>Parameter which specifies geometry (e.g., corner crack at hole) See page 17 for geometry descriptions.</td>
</tr>
<tr>
<td>7</td>
<td>1-10</td>
<td>W</td>
<td>Plate width.</td>
</tr>
<tr>
<td>7</td>
<td>11-20</td>
<td>TH</td>
<td>Plate thickness</td>
</tr>
<tr>
<td>7</td>
<td>21-30</td>
<td>CO</td>
<td>Initial half surface length for part through crack or through crack. Corresponds to initial value of &quot;C&quot; in Figure 3.</td>
</tr>
<tr>
<td>7</td>
<td>30-40</td>
<td>AO</td>
<td>Initial crack depth for a part through crack. May be left zero for through cracks.</td>
</tr>
<tr>
<td>7</td>
<td>41-50</td>
<td>H</td>
<td>Configuration dimension as described on pages 17 through 19.</td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>NOMENCLATURE</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
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<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>7</td>
<td>51-60</td>
<td>RAD</td>
<td>Hole or notch radius or notch height as described on pages 17 through 19.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cards 8-14 are only used when KTYPO(2) is set equal to 7.</td>
</tr>
<tr>
<td>8</td>
<td>1-4</td>
<td>NKTMX</td>
<td>Number of sets of stress intensity tables. For PTC there are 2 tables per set. The first table of each set is for surface stress intensity factors. The second table is for the stress intensity at the depth. See Appendix for a description of the tables. For through cracks there is one table per set. Three is the maximum number of sets allowed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78-80 If letters &quot;END&quot; appear in this field the value in field 1-10 is the last entry in the list.</td>
</tr>
<tr>
<td>9</td>
<td>1-10</td>
<td>C1(NT,I)</td>
<td>Values of surface crack length for table NT surface stress intensity factor. Maximum number of values is 25.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78-80 If letters &quot;END&quot; appear in this field the value in field 1-10 is the last entry in the list.</td>
</tr>
<tr>
<td>10</td>
<td>1-10</td>
<td>A1(NT,J)</td>
<td>Values of crack depth for table NT of surface stress intensity factor. Maximum number of values is 25. These are not read in if crack is a through crack.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78-80 If letters &quot;END&quot; appear in this field the value in field 1-10 is the last entry in the list.</td>
</tr>
<tr>
<td>11</td>
<td>1-10</td>
<td>F1(NT,I,J)</td>
<td>Table of surface stress intensity factor coefficients at above crack lengths. Each series of cards is for a constant value of surface crack length (e.g., if the configuration is a through crack each card will contain one table value).</td>
</tr>
<tr>
<td></td>
<td>11-20</td>
<td></td>
<td>etc.</td>
</tr>
<tr>
<td>12</td>
<td>1-10</td>
<td>C2(NT,I)</td>
<td>Values of surface crack length for table NT depth stress intensity factor. Maximum number of values is 25.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78-80 If letters &quot;END&quot; appear in this field the value in field 1-10 is the last entry in the list.</td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>NOMENCLATURE</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>13</td>
<td>1-10</td>
<td>A2(NT,J)</td>
<td>Values of crack depth for table NT of depth stress intensity factor. Maximum number of values is 25. These are not read in if crack is a through crack. If letters &quot;END&quot; appear in this field the value in field 1-10 is the last entry in the list.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>78-80</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1-10</td>
<td>F2(NT,I,J)</td>
<td>Table of depth stress intensity factor coefficients at above crack lengths. Each series of cards is for a constant value of depth crack length (e.g., if the configuration is a through crack each card will contain one table value).</td>
</tr>
<tr>
<td></td>
<td>11-20</td>
<td>etc.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1-4</td>
<td>N[J]</td>
<td>Number of material property types.</td>
</tr>
<tr>
<td>16</td>
<td>1-10</td>
<td>SIGYS</td>
<td>Yield stress.</td>
</tr>
<tr>
<td>16</td>
<td>11-14</td>
<td>NEQ[X]</td>
<td>Equation to be used for crack growth. 1 = Collipriest-Ehret, 2 = Paris, 3 = Forman, 4 = table.</td>
</tr>
<tr>
<td>16</td>
<td>15-18</td>
<td>NRET</td>
<td>Model to be used for retardation 0 = none, 1 = Willenborg, 2 = Wheeler, 3 = Grumman Closure (not debugged).</td>
</tr>
<tr>
<td>16</td>
<td>19-22</td>
<td>NDUF[X]</td>
<td>Constant to indicate whether crack growth properties are the same in depth and surface directions. If constant = 1, they are not and two sets of D's and CR's (see cards 20, 21, 22, 24, and 26) must be input.</td>
</tr>
<tr>
<td>16</td>
<td>23-32</td>
<td>KCRC</td>
<td>Critical stress intensity in surface direction (upper cutoff).</td>
</tr>
<tr>
<td>16</td>
<td>33-42</td>
<td>KOC</td>
<td>Threshold stress intensity in surface direction (lower cutoff).</td>
</tr>
<tr>
<td>16</td>
<td>43-52</td>
<td>KCRA</td>
<td>Critical stress intensity in depth direction. Need not be input if crack is a through crack.</td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>NOMENCLATURE</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>16</td>
<td>53-62</td>
<td>KOA</td>
<td>Threshold stress intensity in depth direction. Need not be input if crack is a through crack</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cards 17 - 22 only used when NEQ = 4</td>
</tr>
<tr>
<td>17</td>
<td>1-10</td>
<td>KE(NT,I)</td>
<td>Values of stress intensity factor range for table of crack growth rates. Maximum number is 25. If letters &quot;END&quot; appear in this field, value in field 1-10 is last entry in list.</td>
</tr>
<tr>
<td>78-80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>1-10</td>
<td>RE(NT,J)</td>
<td>Values of stress ratios for crack growth rate table. At least one is required. Maximum number is 25. If letters &quot;END&quot; appear in this field, value in field 1-10 is last entry in list.</td>
</tr>
<tr>
<td>78-80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>1-10</td>
<td>DCDN(NT,I,J)</td>
<td>Values of surface crack growth rate corresponding to above stress intensity values and stress ratios. Each series of cards is for a constant value of stress intensity range (e.g., if 4 values of RE were to be used, each card type 15 would have 4 entries).</td>
</tr>
<tr>
<td>11-20</td>
<td>etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1-10</td>
<td>KE(NT,I)</td>
<td>Values of stress intensity factor range for table of crack growth rates. Maximum number is 25. If letters &quot;END&quot; appear in this field, value in field 1-10 is last entry in list.</td>
</tr>
<tr>
<td>78-80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1-10</td>
<td>RE(NT,J)</td>
<td>Values of stress ratios for crack growth rate table. At least one is required. Maximum number is 25. If letters &quot;END&quot; appear in this field, value in field 1-10 is last entry in list.</td>
</tr>
<tr>
<td>78-80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>NOMENCLATURE</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>-------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>22</td>
<td>1-10</td>
<td>DADN(NT,I,J)</td>
<td>Values of depth crack growth rate corresponding to above stress intensity values and stress ratios. Each series of cards is for a constant value of stress intensity range (e.g., if 4 values of RE were to be used, each card type 15 would have 4 entries).</td>
</tr>
<tr>
<td>23</td>
<td>1-10</td>
<td>D(1,I,J)</td>
<td>Constants in crack growth equations—surface direction. See text for description of constants. If letters &quot;END&quot; appear in this field, value in field 1-10 is last entry in list.</td>
</tr>
<tr>
<td>24</td>
<td>1-10</td>
<td>D(2,I,J)</td>
<td>Constants in crack growth equation—depth direction. If NDUP ≠ 1, card is not used. See text for description of constants. If letters &quot;END&quot; appear in this field, value in field 1-10 is last entry in list.</td>
</tr>
<tr>
<td>25</td>
<td>1-10</td>
<td>CR(1,I,J)</td>
<td>Constants in retardation equation—surface direction. See text for description of constants. If letters &quot;END&quot; appear in this field, value in field 1-10 is last entry in list.</td>
</tr>
<tr>
<td>26</td>
<td>1-10</td>
<td>CR(2,I,J)</td>
<td>Constants in retardation equation—depth direction. If NDUP ≠ 1, card is not used. See text for description of constants. If letters &quot;END&quot; appear in this field, value in field 1-10 is last entry in list.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Card 27 is not used if NPROOF = 0</td>
</tr>
<tr>
<td>27</td>
<td>1-10</td>
<td>FIXED</td>
<td>Value of quantity which remains constant during proof test evaluation.</td>
</tr>
<tr>
<td>27</td>
<td>11-20</td>
<td>KCPRF</td>
<td>Value of critical surface stress intensity factor for proof test.</td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>NOMENCLATURE</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>27</td>
<td>21-30</td>
<td>KAPRF</td>
<td>Value of critical stress intensity at depth for proof test.</td>
</tr>
<tr>
<td>27</td>
<td>31-40</td>
<td>XLOW</td>
<td>Lower bound on variable in proof test (smallest expected value on crack size or shape).</td>
</tr>
<tr>
<td>27</td>
<td>41-50</td>
<td>XUP</td>
<td>Upper bound on variable in proof test (largest expected value on crack size or shape).</td>
</tr>
<tr>
<td>27</td>
<td>51-60</td>
<td>PROOFX</td>
<td>Proof stress (or load).</td>
</tr>
<tr>
<td>27</td>
<td>61-70</td>
<td>IEND</td>
<td>Number of iterations to find crack size in proof test. If zero or blank, default condition sets number of iterations to 100.</td>
</tr>
</tbody>
</table>
### All Numeric Fields are in either E10.0, 14 or 16 Formats

<table>
<thead>
<tr>
<th>Card Type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0, 14, or 16 Formats</td>
<td>T</td>
<td>T</td>
<td>T</td>
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<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
</tbody>
</table>

**Card Type:**

1. Title
2. Keywords
3. Details
4. Steps
5. Summary
6. Attributes
7. Notes
8. Method
9. C1 (NT, 1)
10. A1 (NT, 2)
11. F1 (NT, 1, J)
12. C2 (NT, 1)
13. A2 (NT, 2)
All Numeric Fields are in either E10.0, 14 or 16 Formats

<table>
<thead>
<tr>
<th>Card Type</th>
<th>F2(NL,I,J)</th>
<th>F2(NL,J,J)</th>
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</thead>
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</tr>
<tr>
<td>15</td>
<td>M1</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>SIGS</td>
<td>NED</td>
</tr>
<tr>
<td>17</td>
<td>RE(NL,I)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>RE(NL,J)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>DCON(NL,I,J)</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>RE(NL,I)</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>RE(NL,J)</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>DWIN(NL,I,J)</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>D(1,1,J)</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>D(2,1,J)</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>CR(1,1,J)</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>CR(2,1,J)</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>FIXED</td>
<td></td>
</tr>
</tbody>
</table>

Last type 27 card only + END
Last type 18 card only + END
Last type 20 card only + END
Last type 21 card only + END
Last type 23 card only + END
Last type 24 card only + END
Last type 25 card only + END
Last type 26 card only + END

Card Type
<table>
<thead>
<tr>
<th>.CARD TYPE</th>
<th>FIELD</th>
<th>WHEN INPUT DATA REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-80</td>
<td>Once for each session</td>
</tr>
<tr>
<td>2</td>
<td>1-16</td>
<td>Once for each session.</td>
</tr>
<tr>
<td>3</td>
<td>1-26</td>
<td>Once for each run.</td>
</tr>
<tr>
<td>3</td>
<td>27-54</td>
<td>Whenever an iteration on thickness to meet design life is desired.</td>
</tr>
<tr>
<td>3</td>
<td>55-58</td>
<td>Whenever proof test logic is used.</td>
</tr>
<tr>
<td>3</td>
<td>59-72</td>
<td>Whenever plotted output is required.</td>
</tr>
<tr>
<td>4</td>
<td>1-18</td>
<td>Whenever NLOAD = 1.</td>
</tr>
<tr>
<td>5</td>
<td>1-34</td>
<td>NSTEP times when NLOAD = 1.</td>
</tr>
<tr>
<td>6</td>
<td>1-8</td>
<td>Whenever NGEOM = 1.</td>
</tr>
<tr>
<td>7</td>
<td>1-60</td>
<td>Whenever NGEOM = 1.</td>
</tr>
<tr>
<td>8</td>
<td>1-4</td>
<td>Whenever KTYPO(2) = 7.</td>
</tr>
<tr>
<td>9</td>
<td>1-10</td>
<td>*Whenever KTYPO(2) = 7.</td>
</tr>
<tr>
<td>10</td>
<td>1-10</td>
<td>*Whenever KTYPO(2) = 7 and KTYPO(1) = 1.</td>
</tr>
<tr>
<td>11</td>
<td>1-80</td>
<td>*Whenever KTYPO(2) = 7. NKTMX Times</td>
</tr>
<tr>
<td>12</td>
<td>1-10</td>
<td>*Whenever KTYPO(2) = 7 and KTYPO(1) = 1.</td>
</tr>
<tr>
<td>13</td>
<td>1-10</td>
<td>*Whenever KTYPO(2) = 7 and KTYPO(1) = 1.</td>
</tr>
<tr>
<td>14</td>
<td>1-80</td>
<td>*Whenever KTYPO(2) = 7 and KTYPO(1) = 1.</td>
</tr>
<tr>
<td>15</td>
<td>1-4</td>
<td>Whenever NMAT = 1.</td>
</tr>
<tr>
<td>CARD TYPE</td>
<td>FIELD</td>
<td>WHEN INPUT DATA REQUIRED</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>17</td>
<td>1-10</td>
<td>*Whenever NEQ = 4.</td>
</tr>
<tr>
<td>18</td>
<td>1-10</td>
<td>*Whenever NEQ = 4.</td>
</tr>
<tr>
<td>19</td>
<td>1-80</td>
<td>*Whenever NEQ = 4.</td>
</tr>
<tr>
<td>20</td>
<td>1-10</td>
<td>*Whenever NEQ = 4 and NDUP = 1.</td>
</tr>
<tr>
<td>21</td>
<td>1-10</td>
<td>*Whenever NEQ = 4 and NDUP = 1.</td>
</tr>
<tr>
<td>22</td>
<td>1-8</td>
<td>*Whenever NEQ ≠ 4 and NDUP = 1.</td>
</tr>
<tr>
<td>23</td>
<td>1-10</td>
<td>*Whenever NEQ ≠ 4 and NMAT = 1.</td>
</tr>
<tr>
<td>24</td>
<td>1-10</td>
<td>*Whenever NEQ ≠ 4 and NDUP = 1 and NMAT = 1.</td>
</tr>
<tr>
<td>25</td>
<td>1-10</td>
<td>*Whenever NEQ ≠ 4 and NMAT = 1 and NRET ≠ 0.</td>
</tr>
<tr>
<td>26</td>
<td>1-10</td>
<td>*Whenever NEQ ≠ 4 and NMAT = 1 and NRET ≠ 0.</td>
</tr>
<tr>
<td>27</td>
<td>1-70</td>
<td>*Whenever NPROOF ≠ 0</td>
</tr>
</tbody>
</table>

* Indicates card types that may be repeated.
CONTROL OF OUTPUT

In addition to information describing the input data and final fracture, the computer program output consists of crack lengths, stress intensity factors, crack growth rates, and cycle counts. These are printed out for the first and last cycle in the step. This data is always printed for each step of the first block encountered in any of the growth modules (PTCGRW, TRANS or TCGROW). This data may also be printed out for additional blocks and steps as desired by the user. These additional blocks and steps are controlled by specifying the increment for blocks and steps for which printout will be made by MBLOCK and MSTEP respectively. Thus, if every step in every other block is wanted, MBLOCK is set equal to 2 and MSTEP is set equal to 1.

Plotted output is supplied when IPLOT is a value not equal to one. Typical plotted output is presented in the Appendix. The spacing of each data point in the plot is set by the user through PCYC(1). PCYC(1) is the increment in cycles between successive data points. If PCYC(1) is zero, the plotted data points will correspond to the tabulated data points as described above. Sample output is shown in Figure 4.
Figure 4 — Sample Plotted Output

CHECK ON PART-THRU CRACK INTERPOLATION
INPUT FOR ADDITIONAL RUNS

A full set of input data is not necessary for each additional run. The use of a stress multiplier constant (CSTRS) allows all the stress to be varied by a constant percentage without inputting any additional input cards other than card type 3. If the stresses are to be used directly as they are on card type 5, CSTRS is input as 1.

The input constant NSUP allows retardation to be suppressed on subsequent runs. That is if a run is made that considers retardation, the following run will perform the same analysis without retardation if NSUP = 0. When retardation is considered NSUP must be set equal to 1. Obviously the order of running the cases must be retarded, followed by unretarded.

In order to control whether loading data, geometry data, or material properties are to be read in for a particular run, the constants NLOAD, NGEOM, NMAT must be input. If data is to be read in, the appropriate constant must be 1, it it is not to be read in, the appropriate constant is 0. If data is not read in, data from the previous run is used. Obviously, for the first run NLOAD, NGEOM AND NMAT must all be 1.
ITERATION ON THICKNESS AND INITIAL CRACK SIZE

For a given design life (in blocks) the computer program will search for the thickness or initial crack size which will meet that life requirement. The number of iterations attempted is input by the user. The maximum that this may be is ten. This computer program ceases its search when the allowed number of iterations is exceeded or the computed life lies between 100% and 105% of the design life. Life is arbitrarily defined as the number of blocks completed plus the number of steps completed/total number of steps + cycles completed in the current step/total number of cycles in the step.

In addition to inputting the number of iterations and the design life, an exponent which will control the rate of convergence to the correct thickness or initial crack size must be inserted. When the Paris equation is used with zero threshold for a through the thickness crack, the use of the exponent of the Paris equation for the convergence parameter should result in a convergence to the correct solution in a single cycle. Any constant equal to or greater than the "Paris coefficient" should insure convergence.
PROOF TEST LOGIC

For given values of the fracture toughness and applied proof test load, the computer program will find the largest crack size that will not fail due to the proof load. Since the applied stress intensity factor for a part through crack depends on two geometric variables, the crack depth and surface crack length; one variable must be fixed by the user and the computer program will find the critical value for the other variable. Either the crack depth, surface crack length or crack shape \((a/c)\) may be fixed.
REFERENCES


APPENDIXES
The following data for use in the Collipriest/Ehret equation (NEQ = 1) is typical data for the materials listed. The data is included for example purposes only and caution is advised with regard to design implications of the data presented. The crack growth rate is in in/cycle and the stress intensity factor is in Ksi $\sqrt{\text{in}}$.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2024-T851</td>
<td>$1.6 \times 10^{-9}$</td>
<td>3.45</td>
<td>38.0</td>
<td>3.4</td>
</tr>
<tr>
<td>2124-T851</td>
<td>$3.3 \times 10^{-10}$</td>
<td>4.0</td>
<td>31.0</td>
<td>3.5</td>
</tr>
<tr>
<td>2219-T87 (70°F)</td>
<td>$2.2 \times 10^{-9}$</td>
<td>3.3</td>
<td>40.0</td>
<td>5.5</td>
</tr>
<tr>
<td>2219-T87 (-320°F)</td>
<td>$8.9 \times 10^{-12}$</td>
<td>4.82</td>
<td>50.0</td>
<td>5.5</td>
</tr>
<tr>
<td>7075-T6</td>
<td>$4.4 \times 10^{-8}$</td>
<td>2.53</td>
<td>33.0</td>
<td>3.0</td>
</tr>
<tr>
<td>7075-T76</td>
<td>$6.3 \times 10^{-9}$</td>
<td>3.0</td>
<td>30.0</td>
<td>3.0</td>
</tr>
<tr>
<td>7075-T73</td>
<td>$1.07 \times 10^{-8}$</td>
<td>2.67</td>
<td>40.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Ti-6Al-4VSTA</td>
<td>$6.8 \times 10^{-10}$</td>
<td>3.3</td>
<td>50.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Ti-6Al-4V Annealed</td>
<td>$5.7 \times 10^{-10}$</td>
<td>3.18</td>
<td>84.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Inconnel 718 (STA)</td>
<td>$4.0 \times 10^{-10}$</td>
<td>2.7</td>
<td>115.0</td>
<td>15.0</td>
</tr>
<tr>
<td>D6AC</td>
<td>$7.5 \times 10^{-10}$</td>
<td>2.74</td>
<td>90.0</td>
<td>6.0</td>
</tr>
</tbody>
</table>
A series of five computer sessions are presented below. The flexibility and generality of the MSFC crack growth program make it impractical to present all possible variations here. However, the following examples which include many multiple run sessions cover a broad spectrum of the program's capability.

In addition to showing the card images for each example input, we have included the card type represented by each line in the input data.

Example 1 - 2219 Al 70 deg and -320 deg part-thru and center crack.

Sample input data for a series of two runs is given on page B-6. The first run is a part through crack subjected to a series of two loads of 1000 cycles each. The material properties associated with each load level are different so as to model the effect of temperature variations. The second run is the same except that the initial crack configuration is a through the thickness center cracked panel. No output beyond the normally supplied out is requested for these runs. The output is shown on pages B-7 through B-10.
Example 2 - D6AC - Retard/No Retard/with DaDt

A second example consisting of a series of three runs is presented on pages B-12 through B-21. Page B-11 is the input for these three runs. For these runs data on every other block is requested and the output was rather extensive. All the information was not needed here and therefore only the first and last page of output of those runs discussed are reproduced. Note that only the third run requires 2 material property types, but that both sets of material data are read in the first run. This simplifies the data input by making it unnecessary to input any material property data for run 3.

The first run has two loading steps, calls for a retardation model (Willenborg) and requests a maximum of three iterations to find a thickness compatible with the design life. A rather low (compared to the "Paris exponent") convergence exponent of 2 was used. The output for the first iteration is shown on pages B-13 through B-14 and the report on the iteration is shown on page B-15. Due to the use of the excessively low value of the convergence exponent, the thickness has not converged to the appropriate value. Note, however, that the information is still quite useful and that a simple hand plot of the result will show the correct thickness.

In the second run retardation was suppressed and no iteration was requested. Note that the life for a thickness of .5 inches
goes from 194 blocks with retardation to 114 blocks without retardation.

In the third run a step which simulated a 480 second hold at a constant load with a resulting sustained load crack growth was included. The crack growth model was assumed to follow a "Paris" format (NEQ = 2) with an exponent of 1 and an appropriate constant was assumed. As can be seen by the results, the life was reduced further under these assumptions.

**Example 3 - D6AC Iteration on Crack Size/Proof Test.**

In this two run example, a part through crack under a single level of loading was considered. The output requested was for every tenth block. In the first run a design iteration in crack size in which the crack shape remains constant was called for. In this case the convergence parameter chosen was appropriate and the design conditions were met in the first iteration. The output for the initial run, the first iteration and the iteration report are given on pages B-23 through B-26.

In the second run a proof loading was considered. The output for this is given on pages B-27 and B-28.

**Example 4 - D6AC Pin Loaded Lug with Plotting.**

In this single run session a pin loaded lug with two internal cracks was considered. Plotted output every 500 (nominal)
cycles was requested. Tabulated data every 10 blocks was also requested. Note that the input loading is 50 Kips (not 50 Ksi). As can be seen by the data output the cracks transition to through cracks halfway through their crack growth lives. The data to be plotted is shown on page B-34. The first column is "a", the second "c" and the third is the number of cycles.

Example 5 - Tabular Input Examples

In this example; three runs, each requiring tabular input data of different types is shown. In the first run a part through crack using the solutions for the stress intensity factor which are in the program was considered. However, the crack growth rate data was input as a table. Three values of stress ratio and eight values of stress intensity range were used.

In the second run, the same material properties as in the first run were considered but the geometry was changed to a through crack that required a tabular input. The tabular input chosen was picked to simulate the consideration of two factors (e.g., the effect of a stiffener and the effect of a finite width) the first table decreases and then increases, the second table increases monotonically. Note that the number of tables input (2) is determined by the numerical value on the type 8 card and the
and the fact that this is a through crack.

In the last example, the geometry is changed once again. This time we have a part through crack that requires tabular input. Note that although the type 8 card value of NKTMX is 1, two tables are required since this is a part through crack.
<table>
<thead>
<tr>
<th>Run</th>
<th>Card Type</th>
<th>Column Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ORIGINAL PAGE IS OF POOR QUALITY</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>END</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>END</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Run 1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Run 2</td>
<td></td>
</tr>
</tbody>
</table>
## Load Input Data

<table>
<thead>
<tr>
<th>RUN</th>
<th>1 of 2 Runs</th>
<th>2219 AL 70 DEG AND -320 DEG PART-THRU CRACK AND CENTER CRACK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stress Factor</strong></td>
<td>1.000E 00</td>
<td></td>
</tr>
<tr>
<td><strong>Limit Stress</strong></td>
<td>3.000E 01</td>
<td></td>
</tr>
<tr>
<td><strong>Step</strong></td>
<td><strong>Max Stress</strong></td>
<td><strong>Min Stress</strong></td>
</tr>
<tr>
<td>1</td>
<td>3.000E 01</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>3.000E 01</td>
<td>0.0</td>
</tr>
</tbody>
</table>

## Geometry Input Data

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<th>PTC</th>
<th>Width</th>
</tr>
</thead>
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<tr>
<td></td>
<td>1</td>
<td>0.900E 01</td>
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<tr>
<td>Additional Dimension</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Radius/Notch Depth</td>
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<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>3.000E 00</td>
<td></td>
</tr>
<tr>
<td>Crack Depth</td>
<td>3.000E 01</td>
<td></td>
</tr>
<tr>
<td>Half Crack Length</td>
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<td></td>
</tr>
</tbody>
</table>

## Material Input Data

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Yield Strength</th>
<th>Growth Equation</th>
<th>Retardation Model</th>
<th>Stress Intensity (Surface)</th>
<th>Stress Intensity (Depth)</th>
<th>Critical Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5.000E 01</td>
<td>1</td>
<td>0</td>
<td>4.000E 01</td>
<td>3.500E 00</td>
<td>4.000E 01</td>
</tr>
<tr>
<td>2</td>
<td>7.000E 01</td>
<td>1</td>
<td>0</td>
<td>5.000E 01</td>
<td>3.500E 00</td>
<td>5.000E 00</td>
</tr>
</tbody>
</table>

## Crack Growth Rate Constants

<table>
<thead>
<tr>
<th>Constant Number</th>
<th>Material Type</th>
<th>Crack Growth Rate</th>
<th>Retardation Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>1</td>
<td>2.200E-09</td>
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</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3.500E 00</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>4.000E 00</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>8.800E 12</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>4.500E 00</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4.500E 00</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>4.500E 00</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4.500E 00</td>
<td>0.0</td>
</tr>
<tr>
<td>BLOCK</td>
<td>STEP</td>
<td>CYCLES</td>
<td>CRACK LENGTH (IN)</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>--------</td>
<td>-------------------</td>
</tr>
<tr>
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<td>1</td>
<td>0.0</td>
<td>2.000E-01</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>0.0</td>
<td>2.637E-01</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1.000E 03</td>
<td>2.637E-01</td>
</tr>
</tbody>
</table>

Limit load fracture occurs in the 3 block 1 step after 6.139E 02 cycles.

Critical K at depth has been exceeded in the 3 block and the 1 step after 6.139E 02 cycles.
**Input Data**

**Stress Factor:** 1.000E-00
**Limit Stress:** 3.000E-01

**Step Data**

<table>
<thead>
<tr>
<th>Step</th>
<th>Max Stress</th>
<th>Min Stress</th>
<th>Units (Cycles)</th>
<th>Material Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.000E-01</td>
<td>0.0</td>
<td>1.000E-03</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3.000E-01</td>
<td>0.0</td>
<td>1.000E-03</td>
<td>2</td>
</tr>
</tbody>
</table>

**Geometry Data**

<table>
<thead>
<tr>
<th>Crack Type</th>
<th>TC</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.000E-00</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Material Data**

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Yield Strength</th>
<th>Growth Equation</th>
<th>Retardation Model</th>
<th>Critical Stress Intensity (Surface)</th>
<th>Threshold Stress Intensity (Surface)</th>
<th>Critical Stress Intensity (Depth)</th>
<th>Threshold Stress Intensity (Depth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.000E+01</td>
<td>1</td>
<td>0</td>
<td>4.000E+01</td>
<td>3.000E+00</td>
<td>4.000E+01</td>
<td>3.000E+00</td>
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<tr>
<td>2</td>
<td>7.000E+01</td>
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</tbody>
</table>

**Equation Constants**

<table>
<thead>
<tr>
<th>Constant Number</th>
<th>Material Type</th>
<th>Crack Growth Rate</th>
<th>Retardation Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2.200E-09</td>
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</tr>
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<td>4.000E-01</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>3.500E-00</td>
<td>0.0</td>
</tr>
<tr>
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<td>2</td>
<td>8.900E-12</td>
<td>0.0</td>
</tr>
<tr>
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<td>4.820E-01</td>
<td>0.0</td>
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<tr>
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<td>2</td>
<td>5.000E-01</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>5.500E-00</td>
<td>0.0</td>
</tr>
<tr>
<td>RUN</td>
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</tr>
<tr>
<td>-----</td>
<td>---</td>
<td>------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HALF CRACK STEP CYCLES</th>
<th>CRACK LENGTH (IN)</th>
<th>KMAX (KSI ROOT-IN)</th>
<th>GROWTH RATE (IN/CYCLE)</th>
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LIMIT LOAD FRACTURE OCCURS IN THE 1 BLOCK 1 STEP AFTER 3.69E02 CYCLES.

CRITICAL R AT SURFACE HAS BEEN EXCEEDED IN THE 1 BLOCK AND THE 1 STEP AFTER 3.69E02 CYCLES.
<table>
<thead>
<tr>
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<th>Retardation Model</th>
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<th>Critical Stress Intensity (Surface)</th>
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### Constant Material Crack Growth Rate Retardation Model

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<td>CRACK DEPTH (IN)</td>
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</table>

**Note:** The image contains a table with columns for block step, cycles, half surface crack length, crack depth, Kmax-surface, Kmax-depth, surface growth rate (in/cycle), and depth growth rate (in/cycle). The values in the table represent various stages of a crack analysis, likely for a mechanical or engineering context.
<table>
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<tr>
<th>Step</th>
<th>Load (kN)</th>
<th>Fracture (mm)</th>
<th>Load at Fracture (kN)</th>
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LIMIT LOAD FRACTURE OCCURS IN THE 184 BLOCK 1 STEP AFTER 3.190E 00 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 195 BLOCK AND THE 1 STEP AFTER 1.633E 00 CYCLES
<table>
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<th>C</th>
<th>LIFE</th>
<th>REQUIRED LIFE</th>
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<th>Material Type</th>
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### Geometry Input Data

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<td>Radial/Notch Depth</td>
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<td>Thickness</td>
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<td>Crack Depth</td>
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<td>Half Crack Length</td>
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### Material Input Data

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<th>Retardation Model</th>
<th>Critical Stress Intensity (Surface) (MPa)</th>
<th>Threshold Stress Intensity (Surface) (MPa)</th>
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### Crack Growth Rate and Retardation Model Constants

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<th>Crack Growth Rate (Depth)</th>
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<td>CRACK DEPTH (IN)</td>
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### Limit Load Fracture Occurs in the 106 Block 1 Step After 3,200f 00 Cycles

Critical K at Depth has been Exceeded in the 115 Block and the 1 Step After 5,410f-01 Cycles
### Load Input Data

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### Geometry Input Data

- **Crack Type**: PTC - 1
- **Width**: 9.900E-01
- **Additional Dimension**: 0.0
- **Radius of Notch Depth**: 0.0
- **Thickness**: 5.000E-01
- **Crack Depth**: 5.000E-02
- **Half Crack Length**: 7.500E-02

### Material Input Data

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<th>Retardation</th>
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<th>Stress Intensity (Surface)</th>
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**Table: CRACK IS A PART THRU CRACK**

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<th>CRACK DEPTH (IN)</th>
<th>KM&amp;-SURFACE (KSI ROOT-IN)</th>
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**Notes:**
- B1.200
- CRACK IS A PART THRU CRACK
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**LIMIT LOAD FRACTURE OCCURS IN THE 95TH BLOCK 7 STEP AFTER 0.0 CYCLES**

**CRITICAL R 1T DEPTH HAS BEEN EXCEEDED IN THE 104 BLOCK AND THE 7 STEP AFTER 2.179E 00 CYCLES**
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### Crack Iteration on Crack Size / Proof Test

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</table>

**Notes:**
- Run 1: Crack size iteration starts with an initial guess of 1.0 and iterates to a final value of 1.5.
- Run 2: Crack size iteration starts with an initial guess of 1.0 and iterates to a final value of 1.5.

---

**Card Type:**
- **1:** CRACK ITERATION ON CRACK SIZE / PROOF TEST

**Column Number:**
- **2:** 1000
- **3:** 10
- **4:** 1
- **5:** 0.1
- **6:** 0.4
- **7:** 0.8
- **8:** 1.2
- **9:** 1.5

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**END**
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### MATERIAL INPUT DATA

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### Crack Growth Rate and Retardation Model

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### Iteration Parameters

| Design Life     | 2.000E+02 |
| Convergence Exponent | 4.000E+00 |
| Iteration Number | 3         |
| Iteration Type  | 4         |
## Crack Size / Proof Test

Crack is a part thru crack

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**Limit Load Fracture Occurs in the 1 Block 1 Step After 1.526E-01 Cycles**

Critical K at Depth has been Exceeded in the 111 Block and the 1 Step After 2.168E-01 Cycles
**Run 1**  
**PLAC ITERATION ON CRACK SIZE / PROOF TEST**

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<th>HALF SURFACE CRACK LENGTH (IN)</th>
<th>CRACK DEPTH (IN)</th>
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**LIMIT LOAD FRACATURE OCCURS IN THE 189 BLOCK 1 STEP AFTER 1.570E01 CYCLES**

**CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 210 BLOCK AND THE 1 STEP AFTER 6.695E00 CYCLES**
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RUN 2 OF 2 RUNS

LOAD INPUT DATA

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STEP MAX STRESS MIN STRESS UNITS (CYCLES) MATERIAL TYPE

| 1 1.200E 02 0.0 2.500E 01 |

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MATERIAL INPUT DATA

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### Block Iteration on Crack Size / Proof Test

**Crack is a Part Thru Crack**

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<th>Cycles</th>
<th>Half Surface Crack Length (in)</th>
<th>Crack Depth (in)</th>
<th>Kmax-Surface (ksi root-in)</th>
<th>Kmax-Depth (ksi root-in)</th>
<th>Surface Growth Rate (in/cycle)</th>
<th>Depth Growth Rate (in/cycle)</th>
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**Limit Load Fracture Occurs In the 1 Block 1 Step After 0.0 Cycles**

**Critical K at Depth Has Been Exceeded In the 26 Block And The 1 Step After 1.289E 01 Cycles**
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**END**
## LOAD INPUT DATA

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**RUN 1**

**P6AC PIN LOADED LUG WITH PLOTTING**

**CRACK IS A PART THRU CRACK**

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<th>KMAX-DEPTH (KSI ROOT-IN)</th>
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**Limit Load Fracture Occurs in the** Block 9 Step 1 after 8,015 cycles.

**Critical K at Surface Has Been Exceeded in the** Block 20 Step 1 after 7,241 cycles.
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MARS
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**Run 1**

| 10.1   | 1.1          |
| 10.2   | 1.2          |
| 10.3   | 1.3          |
| 10.4   | 1.4          |

**Run 2**

| 11.1   | 1.1          |
| 11.2   | 1.2          |
| 11.3   | 1.3          |
| 11.4   | 1.4          |

**Run 3**

| 12.1   | 1.1          |
| 12.2   | 1.2          |
| 12.3   | 1.3          |

**END**
**LOAD INPUT DATA**

- **STRESS FACTOR**: 1.000E 00
- **LIMY STRESS**: 1.800E 02
- **STEP MAX STRESS MIN STRESS UNITS CYCLES MATERIAL TYPE**
  - 1: 1.200E 02 0.0 2.500E 01 1

**GEOMETRY INPUT DATA**

- **CRACK TYPE**: PTC - 1
- **WIDTH**: 9.900E 01
- **ADDITIONAL DIMENSION**: 0.0
- **RADIUS NOTCH DEPTH**: 0.0
- **THICKNESS**: 2.000E-01
- **CRACK DEPTH**: 5.000E-02
- **HALF CRACK LENGTH**: 7.500E-02

**MATERIAL INPUT DATA**

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<th>YIELD STRENGTH</th>
<th>GROWTH EQUATION</th>
<th>RETARDATION MODEL</th>
<th>CRITICAL STRESS INTENSITY (SURFACE)</th>
<th>THRESHOLD CRITICAL STRESS INTENSITY (SURFACE)</th>
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LIMIT LOAD FRACTURE OCCURS IN THE 173 BLOCK 1 STEP AFTER 0.0 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 326 BLOCK AND THE 1 STEP AFTER 1.233E 01 CYCLES
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### Geometry Input Data

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### Material Input Data
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<th>RETARDATION MODEL</th>
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**TABLE 7**

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**TABLE 8**

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**Limit Load Fracture Occurs In The 7 Block 1 Step After 0.0 Cycles**

**Critical K At Surface Has Been Exceeded In The 90 Block And The 1 Step After 5.458E+00 Cycles**
### Load Input Data

- **Stress Factor**: 1.000E 00
- **Limit Stress**: 1.000E 02

### Geometry Input Data

- **Crack Type**: PTC - 7
- **Width**: 9.000E 01
- **Additional Dimension**: 0.0
- **Radius/Notch Depth**: 0.0
- **Thickness**: 9.000E-01
- **Crack Depth**: 5.000E-02
- **Half Crack Length**: 7.500E-02

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### Material Input Data

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- **Critical Stress Intensity (Surface)**: 9.000E 01
- **Stress Intensity (Surface)**: 6.000E 00
- **Threshold Stress Intensity (Depth)**: 4.000E 01
- **Critical Stress Intensity (Depth)**: 6.000E 00

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LIMIT LOAD FRACTURE OCCURS IN THE 24 BLOCK 1 STEP AFTER 2.287E01 CYCLES.

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 46 BLOCK AND THE 1 STEP AFTER 5.148E01 CYCLES.
APPENDIX C

STRESS INTENSITY FACTORS

Through Cracks*

Center crack

\[ K_c = \frac{\sigma}{\pi c} \sqrt{c \text{sec} \frac{\pi c}{W}} \]  \text{(Ref. C-1)}

Compact specimen, ASTM E399-74,

\[ K_c = \frac{P}{t h W} \left[ 29.6 \left( \frac{c}{W} \right)^{1/2} - 185.5 \left( \frac{c}{W} \right)^{3/2} + 655.7 \left( \frac{c}{W} \right)^{5/2} - 1017.0 \left( \frac{c}{W} \right)^{7/2} + 6.38.9 \left( \frac{c}{W} \right)^{7/2} \right] \]  \text{(Ref. C-2)}

Single through crack at hole.

\[ K_c = \frac{\sigma B F_c F_w}{\pi c} \]

\[ F_b = e^{(1.2133-2.205 s + .6451 s^2)} \]

\[ s = c/(\text{Rad} + c) \]

\[ F_w = \sqrt{\text{sec} \left( \pi \frac{c+2 \text{Rad}}{2 (W-c)} \right)} \]

\( F_b \) is an equation which fits Bowie's (Ref.C-3) numerical data for the effect of the hole. \( F_w \) is a modification of Feddersen's (Ref.C-1) equation to account for the affect of finite width. The distance \((W-c)\) is twice the distance from the closest edge to the midpoint of the hole and crack length. The effective half crack length in \( F_w \) is \( \frac{c+2 \text{Rad}}{2} \).

* See Figure 3 for geometry definitions.
Double through crack at hole.

\[ K_c = \sigma \frac{F_b F_w}{\pi c} \]

\[ F_b = e^{(1.2133-2.086+.8727 s^2)} \]

\[ S = \frac{D}{(Rd+C)} \]

\[ F_w = \sqrt{\sec \frac{\pi (c+Rd)}{W}} \]

\( F_b \) is an equation which fits Bowie's (Ref.C-3) numerical data for the effect of the hole. \( F_w \) is a modification to Feddersen's (Ref.C-1) equation to account for the affect of finite width. \( (c+Rd) \) is used as an equivalent half crack length in \( F_w \).

General tabular description

\[ K_c = P \frac{F(c)}{\pi c} \]

\( F(c) \) is tabular input data.

\( P \) is applied load compatible with \( F(c) \)

Since numerical data may be generated by using a number of solutions (e.g., effect of hole and effect of width), the program has the capability of combining a number of tables to generate \( F(c) \). As many as three tables \( F1(c), F2(c), F3(c) \) may be input and \( F(c) \) is set equal to the interpolated value of

\[ F(c) = F1(c)x F2(c) x F3(c) \]

The format for the stress intensity factor table is:
If only one table is read in, $F_2=F_3=1$. $f_1$ and $f_2$ and $f_3$ must be $\leq 25$.

**Pin loaded lug - two through cracks**

\[
K_c = \left[ \frac{p}{2th} \right] \left[ \frac{1.05}{\sqrt{\pi Z}} \times \phi_p + \frac{\sqrt{\tau}}{W} \phi_c \right]
\]

\[
\phi_c = \frac{1}{2} \left[ \phi_{c,c} + \phi_{c,H} \right] \times F_B
\]

\[
F_B = e^{(1.2133-2.086 \times 5 + 0.8727 \times S^2)}
\]

\[
\phi_{c,c} = \frac{1}{\sqrt{1-2Z}} \times f_2(Z/b)
\]

\[
\phi_{c,H} = 1 - 0.08(\frac{2Z}{H}) + 2.69(\frac{2Z}{H}) - 0.91(\frac{2Z}{H})^3
\]

\[
\phi_{p,w} = \frac{1}{\sqrt{1-2Z}} \left[ 1 - 0.5(\frac{2Z}{W}) + 0.957(\frac{2Z}{W})^2 - 0.16(\frac{2Z}{W})^3 \right]
\]

\[
\phi_{p,c} = \frac{1}{\sqrt{1-2Z}} f_1(Z/b)
\]

\[
Z = \text{Rad} + C
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<th>( f_1 )</th>
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</table>

**TABLE C1- Functions for Pin Loaded Lug**
The stress intensity factor is composed of two basic parts, that due to the uniform stress \( \frac{P}{Wth} \) and that due to the pin load \( P \). The subscript \( \sigma \) in the equations, applies to the former and the subscript \( P \) refers to the latter.

The 1.05 factor on the pin load portion is there to account for the extra driving force due to the presence of Mode II stress intensity factors as well as Mode I.

The pin load and uniform stress portions of the expression are composed of factors accounting for the effect of the hole (subscripted by \( B \)), the effect of the circular end (subscripted by \( C \)) for the effect of the straight sides (subscripted by \( S \)). The latter contains effects of the finite width (subscripted by \( w \)), and height subscripted by \( H \).
The expression for the effect of the hole has been described above. \( \phi_{c,s} \) combines Feddersen's width effect and a tabular description of the effect of the height taken from the data of Fichter (Ref. C-4). \( \phi_{c,c} \) is a tabular description of pg. 11.6 of (Ref. C-5). \( \phi_{p,c} \) is a tabular description of pg. 11.9 of Ref. (C-5) \( \phi_{p,w} \) is taken from Ref. (C-5) and \( \phi_{p,w} \) is the width effect presented by Tada (Ref. C-7). The effective half crack length used in Rad + C.

**Pin loaded Lug - single through crack**

\[ K_c = \frac{p}{2th} \left[ \frac{1}{9} (\frac{z+e}{z-e}) \sqrt{\frac{z-e}{z+e}} \phi_p + \frac{\sqrt{c}}{w} \phi_c \right] \]

\[ \phi_c = \frac{1}{2} \left( \phi_{c,c} + \phi_{c,s} \right) F_B \]

\[ F_B = \exp \left( 1.2133 - 2.225 z^2 + .6451 z^4 \right) \]

\[ s = c/Rad + C \]

\[ \phi_{c,s} = \sqrt{\sec \frac{b}{2B}} \cdot F_3 \cdot (Z/H) \]

\[ b' = \frac{w}{2} - \frac{c}{2} \]

\[ \phi_{c,c} = \frac{1}{\sqrt{1 - \frac{z}{B}}} F_2 \cdot (Z/b') \]

\[ \phi_p = \frac{1}{4} \left[ \phi_{p,c} + \phi_{p,H} \phi_{p,w} \right] \]
\[ \phi_{p,h} = 1 - 0.08 \left( \frac{2z_H}{H} \right)^2 + 2.69 \left( \frac{2z_H}{H} \right)^2 - 0.99 \left( \frac{2z_H}{H} \right)^3 \]

\[ \phi_{p,h} = \frac{1}{1 - \frac{Z}{b'}} \left[ 1 - 0.5 \left( \frac{Z}{b'} \right) + 0.957 \left( \frac{Z}{b'} \right)^2 - 0.16 \left( \frac{Z}{b'} \right)^3 \right] \]

\[ \phi_{p,c} = \frac{1}{1 - \frac{Z}{b'}} F1(Z/B') \]

\[ Z = \frac{C+2Rad}{2} \]

\[ e = C/2 \]

The above exceptions are generated in a similar manner to the double crack case except that:

a) The single crack expression for the hole effect is used.

b) The effective half crack length is \( (C+2Rad)/2 \).

c) The effective half width is taken to be \( \frac{w}{2} - \frac{C}{2} \)

**Double crack at double notch**

\[ K_c = \phi \sqrt{\pi c} f_4 \left( S, \text{height}/b \right) F_w \] (See Table C-2)

\[ S = c/b+c \]

\[ F_w = \left[ 1 + 1.122 \left( \cos \left( \frac{b+c}{w} \right) \right)^4 \right] \frac{\sqrt{\frac{w}{\pi (b+c)}}}{1.122} \tan \left( \frac{\pi (b+c)}{w} \right) \]

Where \( F_w \) is a modification of the double edge cracked tensile formula given by Tada (pg. 2.7) (Ref. C-5).
### Table C-2

Function for Cracks at Notches

<table>
<thead>
<tr>
<th>$f_4 (S, \text{height}/b)$</th>
<th>.01</th>
<th>.05</th>
<th>.1</th>
<th>.2</th>
<th>.3</th>
<th>.4</th>
<th>.6</th>
<th>.8</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>11.22</td>
<td>5.02</td>
<td>3.55</td>
<td>2.51</td>
<td>2.05</td>
<td>1.77</td>
<td>1.45</td>
<td>1.25</td>
<td>1.122</td>
</tr>
<tr>
<td>.25</td>
<td>9.5</td>
<td>5.02</td>
<td>3.55</td>
<td>2.51</td>
<td>2.05</td>
<td>1.77</td>
<td>1.45</td>
<td>1.25</td>
<td>1.122</td>
</tr>
<tr>
<td>.333</td>
<td>8.4</td>
<td>5.02</td>
<td>3.55</td>
<td>2.51</td>
<td>2.05</td>
<td>1.77</td>
<td>1.45</td>
<td>1.25</td>
<td>1.122</td>
</tr>
<tr>
<td>.5</td>
<td>5.8</td>
<td>4.1</td>
<td>3.5</td>
<td>2.51</td>
<td>2.05</td>
<td>1.77</td>
<td>1.45</td>
<td>1.25</td>
<td>1.122</td>
</tr>
<tr>
<td>1</td>
<td>3.5</td>
<td>3</td>
<td>2.8</td>
<td>2.4</td>
<td>2.0</td>
<td>1.77</td>
<td>1.45</td>
<td>1.25</td>
<td>1.122</td>
</tr>
<tr>
<td>2</td>
<td>2.3</td>
<td>2.2</td>
<td>2.2</td>
<td>2</td>
<td>1.8</td>
<td>1.7</td>
<td>1.35</td>
<td>1.25</td>
<td>1.122</td>
</tr>
<tr>
<td>4</td>
<td>1.5</td>
<td>1.45</td>
<td>1.4</td>
<td>1.35</td>
<td>1.3</td>
<td>1.25</td>
<td>1.2</td>
<td>1.18</td>
<td>1.122</td>
</tr>
<tr>
<td>$\infty$</td>
<td>1.122</td>
<td>1.122</td>
<td>1.122</td>
<td>1.122</td>
<td>1.122</td>
<td>1.122</td>
<td>1.122</td>
<td>1.122</td>
<td>1.122</td>
</tr>
</tbody>
</table>
F₄ (S, height/b) is a table constructed from the curves presented by Tada (pg. 1.13) for a crack emanating from an edge notch is a semi-infinite sheet.

**Single crack at single edge notch.**

\[
K_c = \phi \sqrt{\pi c} f_4(S, \text{height}/b) F_w
\]

\[
F_w = \left[ 0.752 + 2.02\left(\frac{b+c}{W}\right) + 3.7\left(1 - \sin^{\frac{\pi}{2W}}(b+c)\right) \right] \sqrt{\frac{2W}{\pi(b+c)\tan\frac{\pi(b+c)}{2W}}} \]

\[
S = \frac{c}{b+c}
\]

Where \(F_w\) is a modification of the single edge cracked tensile formula given by Tada (pg. 2.11, Ref. C-5).

**Cracks coming out of shoulder**

\[
K_c = \phi \sqrt{\pi c} f_4(S, g) F_w \quad \text{(See Table C-2)}
\]

\[
F_w = \left[ 1 + 0.122\left(\cos\left(\frac{\pi(b'+c)}{W}\right)\right) \right] \sqrt{\frac{w}{\pi(b'+c)\tan\frac{\pi(b'+c)}{W}}} \frac{1.122}{1.122}
\]

\[
g = f_5\left(\frac{\text{rad}}{d}, \frac{w}{d}\right) \quad \text{(See Table C-3)}
\]

\[
b' = \frac{(w-d)}{z}
\]

\[
S = \frac{c}{c+b'}
\]

The above solution for the stress intensity factor is based on using the solution for the case of cracks coming out of a doubly

C-9
### TABLE C-3

<table>
<thead>
<tr>
<th>(\frac{\text{Rad}}{d}) w/d</th>
<th>1.01</th>
<th>1.02</th>
<th>1.05</th>
<th>1.07</th>
<th>1.1</th>
<th>1.15</th>
<th>1.2</th>
<th>1.3</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>.02</td>
<td>1.75</td>
<td>1.2</td>
<td>.95</td>
<td>.87</td>
<td>.82</td>
<td>.75</td>
<td>.55</td>
<td>.44</td>
<td>3.6</td>
<td>2.6</td>
<td>.18</td>
</tr>
<tr>
<td>.04</td>
<td>3</td>
<td>1.75</td>
<td>1.38</td>
<td>1.25</td>
<td>1.12</td>
<td>1.15</td>
<td>1.15</td>
<td>1.1</td>
<td>1.35</td>
<td>1.7</td>
<td>3</td>
</tr>
<tr>
<td>.06</td>
<td>4</td>
<td>2.8</td>
<td>1.85</td>
<td>1.63</td>
<td>1.5</td>
<td>1.5</td>
<td>1.45</td>
<td>1.42</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>.08</td>
<td>4.5</td>
<td>3.5</td>
<td>2</td>
<td>2</td>
<td>1.87</td>
<td>2</td>
<td>1.85</td>
<td>1.84</td>
<td>3.5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>.1</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2.7</td>
<td>2.3</td>
<td>2.6</td>
<td>2.25</td>
<td>3.3</td>
<td>4.4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>.12</td>
<td>6</td>
<td>4.3</td>
<td>3.3</td>
<td>3.1</td>
<td>3</td>
<td>4.4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>6.5</td>
<td>9</td>
</tr>
<tr>
<td>.14</td>
<td>7</td>
<td>4.7</td>
<td>3.6</td>
<td>3.5</td>
<td>3.5</td>
<td>5</td>
<td>6.3</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>.18</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>6.5</td>
<td>7.5</td>
<td>7.5</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>.22</td>
<td>8.5</td>
<td>6</td>
<td>4.5</td>
<td>4.4</td>
<td>4.5</td>
<td>7.5</td>
<td>8.5</td>
<td>8.5</td>
<td>9</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>.26</td>
<td>9</td>
<td>6.5</td>
<td>4.75</td>
<td>4.7</td>
<td>4.75</td>
<td>8.5</td>
<td>8.5</td>
<td>9.5</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>.3</td>
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<td>7</td>
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<td>5</td>
<td>9.5</td>
<td>9.5</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

**f5 (\(\frac{\text{Rad}}{d}\) w/d)**
notched plate, whose notch dimensions are chosen such that the	notch depth is equal to \((W-d)/2\) and the notch height is such
that the stress concentration factor in the shoulder is the same
as that at the notch. The table used to generate "g" is developed
using the stress concentrations for a shoulder fillet (Ref. (C-6)
and the stress concentration factor for a notch in a finite width
plate.

**Part Through Cracks**

Basic Part through crack solution.

\[
\begin{align*}
    B &= \text{minimum} \ (a,c) \\
    K_c &= \sigma \sqrt{EB} \ F(a/c,2) \\
    K_a &= \sigma \sqrt{EB} \ F(a/c,1)
\end{align*}
\]

(See Table C-4)

Where the function \(F\) is given in Table C-4 and accounts for the
effect of crack shape.

The stress intensity equations for part through cracks in varying
geometries were constructed using the above relations, the through
crack equations for each geometry and the following rules.

1) The effect of the back surface on the stress intensity
factor at the crack depth is considered for the center
part through crack. This factor is
### TABLE C-4

Part Through Crack Shape Factors

<table>
<thead>
<tr>
<th>a/c</th>
<th>F(a/c,1)</th>
<th>F(a/c,2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.122</td>
<td>0</td>
</tr>
<tr>
<td>.04</td>
<td>1.11</td>
<td>0.17</td>
</tr>
<tr>
<td>.07</td>
<td>1.10</td>
<td>0.27</td>
</tr>
<tr>
<td>.12</td>
<td>1.08</td>
<td>0.37</td>
</tr>
<tr>
<td>.15</td>
<td>1.07</td>
<td>0.42</td>
</tr>
<tr>
<td>.21</td>
<td>1.04</td>
<td>0.5</td>
</tr>
<tr>
<td>.34</td>
<td>0.97</td>
<td>0.6</td>
</tr>
<tr>
<td>.58</td>
<td>0.84</td>
<td>0.71</td>
</tr>
<tr>
<td>.72</td>
<td>0.77</td>
<td>0.74</td>
</tr>
<tr>
<td>.775</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>.86</td>
<td>0.75</td>
<td>0.76</td>
</tr>
<tr>
<td>1.0</td>
<td>0.655</td>
<td>0.775</td>
</tr>
<tr>
<td>1.25</td>
<td>0.65</td>
<td>0.82</td>
</tr>
<tr>
<td>1.49</td>
<td>0.63</td>
<td>0.86</td>
</tr>
<tr>
<td>1.785</td>
<td>0.61</td>
<td>0.9</td>
</tr>
<tr>
<td>2.325</td>
<td>0.57</td>
<td>0.96</td>
</tr>
<tr>
<td>3.45</td>
<td>0.5</td>
<td>0.975</td>
</tr>
<tr>
<td>5.0</td>
<td>0.43</td>
<td>0.99</td>
</tr>
<tr>
<td>6.66</td>
<td>0.38</td>
<td>0.998</td>
</tr>
<tr>
<td>10.0</td>
<td>0.31</td>
<td>1.0</td>
</tr>
<tr>
<td>25.0</td>
<td>0.17</td>
<td>1.0</td>
</tr>
<tr>
<td>50.0</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>100.0</td>
<td>0.15</td>
<td>1.0</td>
</tr>
<tr>
<td>10000.0</td>
<td>0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
\[
M_{\text{back}} = 1 + \frac{1}{0.502} \left[ 0.089 \left( \frac{a}{t} \right) - 0.2315 \left( \frac{a}{t} \right)^2 - 0.3873 \left( \frac{a}{t} \right)^3 + 5.28 \left( \frac{a}{t} \right)^4 - 9.11 \left( \frac{a}{t} \right)^5 + 5.233 \left( \frac{a}{t} \right)^6 \right] \\
\times \left[ 1.109 - 9.142 \left( \frac{a}{2c} \right) + 41.56 \left( \frac{a}{2c} \right)^2 - 86.55 \left( \frac{a}{2c} \right)^3 + 65.5 \left( \frac{a}{2c} \right)^4 \right]^{4/3} \quad (\text{Ref. C-7})
\]

For cracks coming out of holes, notches and radii, there is strong evidence (Ref. C-8) that the effect of the back surface effect is minimal and therefore it has not been included.

2) In using those parts of the through crack equation that deal with the effect of a local stress concentration (such as the Bowie correction factor \( F_B \)) the effect of the stress concentration at both the surface and depth of the crack is evaluated by using the leading crack position. The use of other positions (and therefore higher factors) has been shown to be an overestimate of the effect.

3) In accounting for the affects of finite widths, the actual position of the portion of the crack front for which the stress intensity is being evaluated is used in calculating the effect of the finite width.

4) For an embedded flow, care is taken that the free edge of the notch or hole is not accounted for twice (i.e., through the basic ptc equation and through the through crack equations)
thus, it is necessary to factor out 1.122 from the combination of ptc and through crack equations.

5) For the embedded flaws, the roles of $F(a/c,2)$ and $F(a/c,1)$ with respect to the stress intensity at the depth and surface are switched.

6) "a" is always taken to be in the thickness direction. "c" is always perpendicular to the thickness directions and identical to the through crack definition of "c".
Transition Crack

\[ K_c = K_c \left( \frac{C+C_b}{2} \right) \]

where

\[ K_c \left( \frac{C+C_b}{2} \right) \]

is the appropriate through crack equation with "c" replaced by \( \left( \frac{C+C_b}{2} \right) \)

\[ K_a = \sqrt{ \left( \frac{C_b}{C} \right) \left[ 1 - \left( 1 - \left( \frac{C_b}{C} \right)^2 \right)^2 \right] } \]

\( K_c \) is the stress intensity for the leading portion of the crack front and \( K_a \) is the stress intensity for the trailing portion. The above equation is an approximate expression developed by R.M. Ehret (Ref.C-9) which predicts observed crack growth behavior.
INITIALIZE FOR ALL RUNS

DO 10 I = 1, 2
DO 10 J = 1, 10
NTAR(J) = 0
DO 10 K = 1, 10
D(I, J, K) = 0
10 CR(I, J, K) = 0
PI = 3.1415927

READ TITLE & CONTROL INFO FOR ALL RUNS
NRUNS = # RUNS TO BE MADE
MBLOCK = MAX BLOCKS PER RUN
MSTEP = PRINT FREQ (STEPS)
READ (5, 5001) (TITL(I), I = 1, 20)
READ (5, 5002) NRUNS, MBLOCK, MSTEP
IF (MLOCK) 30, 20, 30
20 MBLOCK = MBLOCK + 1
30 DO 32 I = 1, 14
    IF (TITL(I).EQ. PD3(I)) GO TO 34
32 CONTINUE
34 IF (1.6E-13) GO TO 100
II = (13 - I) / 2 + 1
K = 14 - I - II
II = 14 - II
D-1
I2=I1-I+1
DO 36 L1=I2,11
L=I1+I2-L1
J=L-K
TITL(L)=TITL(J)
TITL(J)=PD3(1)
36 CONTINUE

C READ CONTROL INFO FOR INDIVIDUAL RUN

C CSTRS = STRESS MULTIPLIER      NSUP = 0 TO SUPPRESS RETARDATION
C NLOAD = 1 FOR LOAD INPUT         NGEOM = 1 FOR GEOMETRY INPUT
C NMAT == 1 FOR MATERIAL INPUT     NPROOF= 1 FOR PROOF INPUT
C ITERP= ITERATION TYPE (OPT)     ITER = # OF ITERATIONS
C PIT = CONVERGENCE PARAM          BLIFE = DESIRED LIFE IN BLOCKS
C PLOT > 0 TO GENERATE PLOT        PCYCLES(1)=PLOT FREQ (CYCLES) (OPT)

100 READ (5,5003) CSTRS,NSUP,NLOAD,NGEOM,NMAT,ITERP,ITER,PIT,BLIFE,
2 NPROOF,IPLLOT,PCYC(1)
IF (ITERP.LE.1) GO TO 110
IF (ITERP.EQ.0) GO TO 4020
IF (ITER>1) GO TO 4020
110 DO 120 K=1,10
120 NRET(K)=NSUP*NRET(K)
ITCNT=0
IF (IPLOT.EQ.0) GO TO 130
IPLLOT=1
IF (PCYC(1).EQ.0) GO TO 130
IPLLOT=2
130 IF (ITER-10) 800,810,140
140 ITER=10

C READ LOAD INPUT

800 IF (NLOAD-1) 910,810,910
810 READ (5,5004) NSTEP,IR,SIGLM
IF (MSTEP-(CONSTEP+1)) 820,830,820
820 IF (MSTEP) 840,830,840
830 MSTEP=NSTEP+1
840 DO 850 I=1,NSTEP
850 READ (5,5005) SMAX(I),SMIN(I),UNIT(I),TYPE(I)
IF (IR-1) 880,860,880
860 DO 870 I=1,NSTEP
870 SMIN(I)=SMIN(I)*SMAX(I)
880 IF (CSTRS) 890,910,890
890 SIGLM = CSTRS*SIGLM
DO 900 I=1,NSTEP
900 SMIN=SMIN(I)
900 SMAX=SMAX(I)

C READ GEOMETRY INPUT

910 IF (NGEOM-1) 1100,920,1100
920 READ (5,5004) KTYP0
READ (5,5006) W,TH,CO,A0,H,RAD
OTH=TH
OA0=A0
OCO=CO
IF (KTYP0(1).LT.1) GO TO 4030
IF (KTYP0(1).GT.3) GO TO 4030
D-2
IF (KTYPO(2).LT.1) GO TO 4060
IF (KTYPO(2).GT.17) GO TO 4060
IF (KTYPO(2).EQ.7) GO TO 940
IF (KTYPO(2).EQ.16) GO TO 930
IF (KTYPO(2).EQ.17) GO TO 930
GO TO 1100
930 C1B1 = FUNTS(RAD/H,W/H)
GO TO 1100
C
READ X,Y,TABLE ARRAYS(1-6) FOR INTERPOLATION
C
NKTMX = ONE HALF # ARRAY ELEMENTS
C
940 READ(5,5002) NKTMX
IF (NKTMX.LT.1) GO TO 980
IF (NKTMX.LT.14) GO TO 990
980 WRITE(6,6024) NKTMX
STOP
990 N'TABLE=6
N1=1
N2=2*NKTMX
DO 1090 NT=N1,N2
IF (A0.NE.0.) GO TO 1000
I=MOD(NT,2)
IF (I.NE.0.) GO TO 1000
X(NT,1)=0.
Y(NT,1)=0.
NOX(NT)=1
NOY(NT)=1
TABLE(NT,1,1) = 0.
GO TO 1090
1000 READ(5,5009) X(NT,1),LFEND
I=1
IF (LFEND.EQ.KEND) GO TO 1030
DO 1020 I=2,25
READ(5,5009) X(NT,1),LFEND
IF (X(NT,1).LE.Y('NT-1,1)) GO TO 1000
1020 IF (LFEND.EQ.KEND) GO TO 1030
1030 NOX(NT)=I
IF (A0.NE.0.) GO TO 1040
Y(NT,1)=0.
Y(NT,2)=1.
I=2
GO TO 1070
1040 READ(5,5009) Y(NT,1),LFEND
I=1
IF (LFEND.EQ.KEND) GO TO 1070
DO 1060 I=2,25
READ(5,5009) Y(NT,1),LFEND
IF (Y(NT,1).LE.Y('NT-1,1)) GO TO 1000
1060 IF (LFEND.EQ.KEND) GO TO 1070
1070 NOY(NT)=I
I1=NOX(NT)
I2=NOY(NT)
DO 1080 I=1,I1
READ(5,5008) (TABLE(NT,1,I3), I3=1,I2)
IF (A0.NE.0.) GO TO 1080
TABLE(NT,1,2) = TABLE(NT,1,1)
1080 CONTINUE
1090 CONTINUE

C READ MATERIAL INPUT
C
1100 IF (NMAT-1) 1490,1110,1490
1110 READ (5,5002) NJ
NTABLE=6
C
DO 1450 J=1,NJ
C
NTAB(J)=0
READ (5,5007) SIGYS(J),NEQ(J),NRE(J),NDUP,
1 KCRC(J),KOC(J),KCRA(J),KOA(J)
NRE(J)=NSUP*NRE(J)
IF (NEQ(J).NE.4) GO TO 1240
C
READ X,Y,TABLE ARRAYS(7-12) FOR NEQ(J)=4 & J<4
C
NTABLE=NTABLE+1
IF (NTABLE.GT.12) GO TO 1340
NTAB(J)=NTABLE
IF (J.GT.3) GO TO 1240
N1=NTAB(J)
N2=N1+1
DO 1230 NT=N1,N2
IF (NDUP.EQ.1) GO TO 1140
I=MOD(NT,2)
IF (I.NE.0) GO TO 1140
I=NT-1
NOX(NT)=NOX(I)
NCY(NT)=NCY(I)
I1=NOX(I)
I2=NCY(I)
DO 1120 I3=1,I2
1120 Y(NT,I3)=Y(I1,I3)
DO 1130 I3=1,I1
X(NT,I3)=X(I1,I3)
DO 1130 I4=1,I2
1130 TABLE(NT,I3,I4)=TABLE(I1,I3,I4)
GO TO 1230
C
READ X ARRAY
C
1140 READ(5,5009) X(NT,1),LEND
I=1
IF (LEND.EQ.KEND) GO TO 1170
DO 1160 I=2,LEND
READ(5,5009) X(NT,1),LEND
IF (X(NT,1).LE.X(NT,I-1)) GO TO 4000
1160 IF (LEND.EQ.KEND) GO TO 1170
GO TO 4010
1170 NOX(NT)=1
C
READ Y ARRAY
C
1180 READ(5,5009) Y(NT,1),LEND
I=1
IF (LEND.EQ.KEND) GO TO 1200
DO 1190 I=2,LEND
1190 CONTINUE

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00002250
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00002270
00002280
00002290
00002300
00002310
00002320
READ(5,5009) Y(NT,I),LEND
IF (Y(NT,I),LE,Y(NT,I-1)) GO TO 4000
1190 IF (LEND,EQ,KEND) GO TO 1200
GO TO 4010
1200 NCY(NT)=1
11=NCX(NT)
12=NCY(NT)
DO 1210 I=1,11
1210 READ(5,5008) TABLE(NT,I,13), I3=1,12
I3=NCY(NT)
I2+I3+1
NCY(NT)=I2
Y(NT,I2)=1.
DO 1220 I=1,11
1220 NCY(TA='LF(T,NT)')=12
CONTINUE( NCY(T) )=0,
GO TO 1340
C READ D ARRAY FOR NEG(J) NOT = 4
C
1240 DO 1250 I=1,10
D(I,1,J)=0
1250 D(I2,I,J)=0
DO 1260 I=1,10
READ (5,5009) D(I,I,J),LEND
1260 IF (LEND,EQ,KEND) GO TO 1270
GO TO 4070
1270 IF ('CHM-1) 1280,1300,1280
1280 DO 1290 I=1,10
1290 D(I2,I,J)=D(I,I,J)
GO TO 1340
1300 DO 1310 I=1,10
READ (5,5009) D(I2,I,J),LEND
1310 IF (LEND,EQ,KEND) GO TO 1340
GO TO 4070
1340 IF (NRF(T,J)) 1350,1450,1350
1350 DO 1360 I=1,10
CR(I,I,J)=0
1360 CR(I2,I,J)=0
DO 1370 I=1,10
READ (5,5009) CR(I,I,J),LEND
1370 IF (LEND,EQ,KEND) GO TO 1380
GO TO 4070
1380 IF (NDUP-1) 1390,1410,1390
1390 DO 1400 I=1,10
1400 CR(I2,I,J)=CR(I,I,J)
GO TO 1450
1410 DO 1420 I=1,10
READ (5,5009) CR(I2,I,J),LEND
1420 IF (LEND,EQ,KEND) GO TO 1450
GO TO 4070
1450 CONTINUE
C READ PROOF INPUT DATA
C
1490 IF (NPROF,EQ,0) GO TO 1500
READ(5,5010) FIXED, KCPRF,KAPRF,XLFW,XUP,PROCX,KEND
C INCREMENT RUN # & VERIFY COMPLETE INPUT
1500 NR=NR+1
IF (NR-1) 1510, 1510, 1530
1510 I=NLOAD+NLOAD+NLOAD
IF (I=3) 4050, 1520, 4050
1520 DCSTEPS=DCSTEPS
ONSTEP=ONSTEP
GO TO 1620
1530 IF (NLOAD=1) 1540, 1520, 1540
1540 IF (DCSTEPS=DCSTEPS) 1550, 1620, 1550
1550 IF (DCSTEPS) 1580, 1560, 1580
1560 DO 1570 I=1,ONSTEP
SMIN(I)=SMIN(I)*DCSTEPS
1570 SMA(I)=SMA(I)*DCSTEPS
SIGLM = CSTRS*SIGLM
DCSTEPS=DCSTEPS
GO TO 1620
1580 DO 1590 I=1,ONSTEP
SMIN(I)=SMIN(I)/DCSTEPS
1590 SMA(I)=SMA(I)/DCSTEPS
SIGLM = SIGLM/DCSTEPS
DCSTEPS=DCSTEPS
IF (CSTRS) 1600, 1620, 1600
1600 DO 1610 I=1,ONSTEP
SMIN(I)=SMIN(I)*CSTRS
1610 SMA(I)=SMA(I)*CSTRS
SIGLM = CSTRS*SIGLM
1620 HNSTEPS=NSTEPS
HSIGLM=SIGLM
HCSTEPS=CSTEPS
DO 1622 I=1,HNSTEPS
HMIN(I)=HMIN(I)
1622 HMAX(I)=HMAX(I)
1625 IF (IPLAT=1) GO TO 1630
K=NGLOK+MSTOP
IF (K.EQ.0) GO TO 4040
K=NSTEPS/MSTEP
IF (K.EQ.0) GO TO 4040
C
C DISPLAY ALL INPUT FOR EACH ITERATION OF EACH RUN
C
C 1630 WRITE(6,8002) NR,NRUNS,TITL
C
C DISPLAY LOAD INPUT
C
C WRITE(6,8003) CSTRS,SIGLM
BICYCLE=0.
DO 1640 J1=1,NSTEP
BICYCLE = BICYCLE + UNI(J1)
1640 WRITE(6,8004) J1,SMAX(J1),SMIN(J1),UNIT(J1),TYPE(J1)
C
C DISPLAY GEOMETRY INPUT
C
C WRITE(6,8005) KTN(KTYP0(1),1),KTN(KTYP0(1),2),KTNPO(2),W,H,RAD,TH
IF (KTNPO(1)=3) 1650, 1650, 1660
1650 WRITE(6,8007) CO
GO TO 1665
1660 WRITE(6,8006) AO
WRITE(6,8007) CO
1665 IF (KTNPO(2)=7) GO TO 1750
N1=2*NKTMX
DO 1740 NT=1,N1
I1=MOD(NT,2)
IF (I1.EQ.0) GO TO 1670
WRITE(6,8014) NT
GO TO 1680
1670 WRITE(6,8017) NT
1680 CONTINUE
I2=MOD(NT)
I1=MOD(NT)
J1=1
J2=8
1690 IF (J2-J2) 1710,1710,1700
1700 J2=J2
1710 WRITE(6,8015) (Y(NT,I3), I3=J1,J2)
DO 1720 I=1,I1
1720 WRITE(6,8016) X(NT,I), (TABLE(NT,I,I3), I3=J1,J2)
IF (I2-J2) 1730,1740,1700
1730 J1=J1+8
J2=J2+8
GO TO 1690
1740 CONTINUE
C C DISPLAY MATERIAL INPUT
C 1750 WRITE(6,8008)
DO 1760 J1=1,NJ
WRITE(6,9006) J1, SICVS(J1), NEQ(J1), NRFT(J1), KRRC(J1), KRRT(J1)
1 KCRA(J1), K4A(J1)
1760 CONTINUE
C C DISPLAY D & CR ARRAYS IF ANY
C K=0
DO 1840 J1=1,NJ
IF (NEQ(J1).NE.0) GO TO 1770
IF (J1.GT.3) GO TO 1770
GO TO 1840
1770 IF (K.GT.0) GO TO 1780
K=K+1
WRITE(6,8010)
1780 DO 1830 J2=1,10
IF (D(J1,J2,J1)) 1820,1740,1820
1790 IF (D(J2,J1,J1)) 1820,1800,1820
1800 IF (CR(J1,J2,J1)) 1820,1810,1820
1810 IF (CR(J2,J1,J1)) 1820,1830,1820
1820 WRITE(6,8011) J2,J1,D(1,J2,J1),C(2,J2,J1),
1 CR(1,J2,J1),CR(2,J2,J1)
1830 CONTINUE
1840 CONTINUE
C C DISPLAY TABLES 7-12 IF ANY
C DO 1910 J=1,NJ
IF (NEQ(J).NE.4) GO TO 1910
IF (J.GT.3) GO TO 1910
N1=NTAB(J)
N2=N1+1
DO 1900 NT=N1,N2
WRITE(6,8019) J,NT
1900 CONTINUE
1910 CONTINUE
D-7
I2=NOY(NT)
I1=NOX(NT)
J1=1
J2=8

1850 IF (J2-J2) 1870,1870,1860
1860 J2=12
1870 WRITE(6,8020) (V(NT,I3), I3=J1,J2)
DO 1880 I=1,II
1880 WRITE(6,8021) X(NT,I), (TABLE(NT,I,I3), I3=J1,J2)
IF (I2-J2) 1890,1900,1890
1890 J1=J1+8
J2=J2+8
GO TO 1850
1900 CONTINUE
1910 CONTINUE

C DISPLAY PROOF INPUT IF ANY
C
1920 IF (NPROOF) 1940,1940,1920
1930 WRITE(6,8018) NPROOF,P01(N1,XLOW,PROOFX,P01(N1),XUP,KCPRE,
1 PD2(NPROOF),PD3(NPROOF),FIXED,KAPRE,IEEND
1940 IF (ITFIP) 1960,1960,1950
1950 K=ITCNT+1
1960 CONTINUE

C INITIALIATION FOR EACH RUN
C
ICK(1)=0
ICK(2)=20
ICD(1)=0
ICD(2)=20
IRC(1)=0
IRC(2)=20
INC=.01
ING=0
BLOCK=1
I=1
ITRANS=0
IPRN(1)=-1
IPRN(2)=-1
IPRN(3)=-1
IPRN(4)=2*NSTEP
FLAG1=0
CUME=0
KTYPE(1)=KTYPE(1)
KTYPE(2)=KTYPE(2)
PCYC(2)=PCYC(1)
IFAIL=0
CUMSUM=0.
IF (NPROOF) 1980,1980,1970
1970 CALL PROOF(A0,C0,XLOW,XUP,IEEND,NPROOF)
1980 CONTINUE
C=C0
A=A0
DA=A0
C WRITE TITLE, #CYCLES/BLOCK, & FIRST DATA POINT IF PLOT WANTED
C
IF (IPLOT.EQ.0) GO TO 2000
WRITE(7,7010) (TITL(I), I=1,15), BCYCLE
WRITE(7,7000) A,C,CUMSUM
C BEGINNING OF EACH STEP, EACH BLOCK
C
2000 IF (MOD(BLOCK, MBLCK)) 2050,2010,2050
2010 IF (MOD(I,MSTEP)) 2050,2020,2050
2020 GO 2040 K=1,3
IF (IPRN(K)-IPRN(4)) 2040,2030,2040
2030 IPRN(K)=IPRN(K)-2
2040 CONTINUE
2050 IF (ITRANS-1) 2070,2060,2070
2060 CALL TRANS
GO TO 2100
2070 KT=KTYPE(1)
GO TO (2090,2060,2080), KT
2080 CALL TCGRW
GO TO 2100
2090 CALL PTGRW
C HAS THE RUN ENDED?
C
2100 MORE=0
IF (ICR(1)+1) 2310,2310,2200
2200 CUME = 0
I=I+1
C IS THIS THE LAST STEP OF THIS BLOCK?
C
2210 BLOCK=BLOCK+1
IF (KTYPE(1).GT.1) GO TO 2230
IF (A-DA)2300,2330,2300
2230 IF (C-CC) 2300,2240,2300
2240 IF (DXTNP-1,E-8) 2250,2300,2300
2250 IF (DXTNP-1,E-8) 2260,2300,2300
2260 IF (ITRANS-1) 2270,2260,2270
2270 IF (KTYPE(1).GT.1) GO TO 2290
2290 IF (DXTNP-1,E-8) 2290,2300,2300
2290 WRITE(A,6620)
ING=1
GO TO 2310
2300 CA=A
DC=C
I=1
C IS THIS THE LAST BLOCK OF THIS RUN?
C  IF (BLOCK-NBLOCK) 2000,2000,2310  00005270
C  ARE THERE ITERATIONS?  00005280
C  2310 IF (ITER) 3000,3000,2320  00005290
C  ITERATION CALCULATIONS  00005300
C  2320 ITCNT=ITCNT+1  00005310
C       THICK(ITCNT)=TH  00005320
C       AI(ITCNT)=AO  00005330
C       CI(ITCNT)=CO  00005340
C       LIFE(ITCNT)=FLOAT(BLOCK-1)+FLOAT(I)/FLOAT(NSTEP)  00005350
C       LIFE(ITCNT)=LIFE(ITCNT)-((UNIT(I)-CUME)/UNIT(I))/FLOAT(NSTEP)  00005360
C       PCTLF(ITCNT)=LIFE(ITCNT)*100./BLIFE  00005370
C       IF (LIFE(ITCNT).EQ.C.) GO TO 2435  00005380
C       DIF=PCTLF(ITCNT)/100.  00005390
C       IF (DIF-.991,2340,2340,2330  00005400
C  2330 IF (DIF-1.05) 2440,2340,2340  00005410
C  2340 IF (ITCNT-ITER) 2350,2440,2340  00005420
C  2350 MORE=1  00005430
C       IF (ITERTP.GT.1) GO TO 2400  00005440
C       DIF=(BLIFE/LIFE(ITCNT))**((1./PIT)  00005450
C       TH=TH*DIF  00005460
C       IF(CSTTR)=2.380,2380,2340  00005470
C  2360 CSTTR=1./DIF  00005480
C       DO 2370 K=1,ONSTEP  00005490
C       S=SMIN(K)=SMIN(K)*CSTTR  00005500
C  2370 S=SMAX(K)=SMAX(K)*CSTTR  00005510
C       SIGLM=SIGLM*CSTTR  00005520
C       DCSTTR=CSTTR  00005530
C       DO TO 3000  00005540
C  2380 CSTTR=CSTTR/DIF  00005550
C       DO 2390 K=1,ONSTEP  00005560
C       S=SMIN(K)/DCSTTR*CSTTR  00005570
C  2390 S=SMAX(K)/DCSTTR*CSTTR  00005580
C       SIGLM=SIGLM/DCSTTR*CSTTR  00005590
C       DCSTTR=CSTTR  00005600
C       DO TO 3000  00005610
C  2400 DIF=(LIFE(ITCNT)/BLIFE)**((2./(PIT-2.))  00005620
C       GO TO (2350,2410,2420,2430), ITERTP  00005630
C  2410 CO=CO*DIF  00005640
C       GO TO 3000  00005650
C  2420 AO=AO*DIF  00005660
C       GO TO 3000  00005670
C  2430 AO=AO*DIF  00005680
C       GO TO 3000  00005690
C  2430 A0VCO=AO/CO  00005700
C       GO TO 3000  00005710
C  2430 A0=AO*DIF  00005720
C       GO TO 3000  00005730
C  2430 AODVCO=AO/CO  00005740
C       GO TO 3000  00005750
C  2430 AO=AOVCO*CO  00005760
C       GO TO 3000  00005770
C  2435 WRITE(6,6160)  00005780
C       MORE=0  00005790
C  2440 WRITE(6,6021)  00005800
C       DO 2450 K=1,ITCNT  00005810
C  2450 WRITE(6,6022) THICK(K),AI(K),CI(K),LIFE(K),PCTLF(K)  00005820
C       CSTRS=HCSTRS  00005830
C       NSTEP=HNSTEP  00005840
C       SIGLM=HSIGLM  00005850
C       DO 2455 I=1,NSTEP  00005860
C       SMIN(I)=HMIN(I)  00005870
2445 SMAX(I)=HMAX(I)
TH=OTH
CO=CO0
AO=OA0
IF (ING-1) 3000,2460,3000
2460 WRITE(6,8013)
C
C WRITE FINAL DATA FOR PLOT IF ANY
C
2000 IF (IPLT.EQ.0) GO TO 3040
WRITE(7,7000) A,C,CUMSUM
WRITE(7,7020)
IF (IFAIL.GT.2) GO TO 3015
IF (IFAIL.GT.0) GO TO 3010
WRITE(7,7030)
GO TO 3020
3010 WRITE(7,7040) FL(IFAIL,1),FL(IFAIL,2),BLOCK,I,CUMF,CUMSUM
GO TO 3020
3015 WRITE(7,7070) (FL(IFAIL,II), II=1,3),BLOCK,I,CUMF,CUMSUM
3020 IF (ITER.EQ.0) GO TO 3030
WRITE(7,7050) THICK(1TCNT),AL(I),CN(1TCNT)
GO TO 3040
3030 WRITE(7,7060)
C
C IS THIS THE LAST RUN?
C
3040 IF (MORE.EQ.1) GO TO 1625
IF (NFRMINS) 3950,3990
3050 IF (1CR(1)+1) 3060,100,3060
3060 IF (FLAG1) 100,100,3070
3070 WRITE(6,6014) IBLCK,ISTEP,CUMELM
GO TO 100
3990 STOP
4000 WRITE(6,6100)
STOP
4010 WRITE(6,6110)
STOP
4020 WRITE(6,6120)
STOP
4030 WRITE(6,6130)
STOP
4040 WRITE(6,6150)
STOP
4050 WRITE(6,6160)
STOP
4060 WRITE(6,6170)
STOP
4070 WRITE(6,6180)
STOP
5001 FORMAT(20A4)
5002 FORMAT(14,16,214)
5003 FORMAT(E10.0,6I4,2E10.0,C214,E10.0)
5004 FORMAT(214,E10.0)
5005 FORMAT(3E10.0,14)
5006 FORMAT(6E10.0)
5007 FORMAT(E10.0,3I4,2F10.0)
5008 FORMAT(6E10.0)
5009 FORMAT(E10.0,6F4,6A4)
5010 FORMAT(6E10.0,A4)
6001 FORMAT(34H1INCOMPLETE INPUT SET, JOB ABENDED)
6019 FORMAT(35HOLIK'T LOAD FRACTURE OCCURS IN THE ,16, 7H BLOCK , 00006390
1 14,12H STEP AFTER ,1PE12.3, 7H CYCLES) 00006400
6020 FORMAT(1H0H00 GROWTH ) 00006410
6021 FORMAT(2$H1 ITERATION RESULTS ,//49X,
1 11HPERCENT OF ,/2OH THICKNESS A,11X,1HC,9X, 00006430
2 20HLIFE REQUIRED LIFE ,//) 00006440
6022 FORMAT(1P4E12.3,0PF9.2) 00006410
6024 FORMAT(1H0,18HNKTX OUT OF RANGE) 00006460
6100 FORMAT(1H0,35HX OR Y INPUT NOT IN ASCENDING ORDER) 00006470
6110 FORMAT(1H0,19HMORE THAN 25 X OR Y) 00006480
6120 FORMAT(1H0,9*INCORRECT VALUE FOR ITERP = 'I',14) 00006490
6130 FORMAT(1H0,92INCORRECT VALUE FOR KTYPE = 'I',14) 00006500
6140 FORMAT(1H0,2OHMORE THAN 10 D OR CR) 00006510
6150 FORMAT(1H0, 1 55HPLT REQUESTED BUT FREQUENCY OF DATA POINTS NOT DEFINED) 00006520
6160 FORMAT(1H0,23HCALCULATED LIFE IS ZERO,1H , 00006540
1 27HITERATIONS CAN NOT PROCEED ) 00006550
7000 FORMAT(4HDATA,1P3E12.3) 00006560
7010 FORMAT(4HTITL,4X,15A4,1PF12.3) 00006570
7020 FORMAT(4HHDRS) 00006580
7030 FORMAT(4HHDR1,4HHDR2,4HHDR3) 00006590
7040 FORMAT(4HHDR1,5X,4HHDR2,4HHDR3,6X)
1 6H BLOCK,5X,4HHDR1,5X,4HHDR2,5X,4HHDR3,6X,
2 14HTOTAL CYCLES =,1E10,3) 00006600
7050 FORMAT(4HHDR4,4HHDR5,4HHDR6,4HHDR7)
1 6H BLOCK,5X,4HHDR1,5X,4HHDR2,5X,4HHDR3,6X,
2 14HTOTAL CYCLES =,1E10,3) 00006610
7060 FORMAT(4HHDR4,4HHDR5,4HHDR6,4HHDR7) 00006620
7070 FORMAT(4HHDR1,3X,25HFRACTURE OCCURRED DURING ,3A4,4HHDR2,6X)
1 6H BLOCK,5X,4HHDR1,5X,4HHDR2,5X,4HHDR3,6X,
2 14HTOTAL CYCLES =,1E10,3) 00006630
8002 FORMAT(4HHDR1,4X,4H4RUN,1X,15HSTRESS FACTOR ,1PE12.3,1H ,5X,
1 15HLIMIT STRESS ,E12,3,1H0,5X, 00006640
262HSTEP MAX STRESS MIN STRESS UNITS(CYCLES) MATERIAL TYPE ,00006670
3/1) 00006690
8003 FORMAT(4HHDR1,5X,15HSTRESS FACTOR ,1PE12.3,1H ,5X,
1 15HLIMIT STRESS ,E12,3,1H0,5X, 00006650
2 20HDESIGN LIFE ,IPF12.1,1H ,5X, 00006660
3 20HCONVERGENCE EXponent ,1E12.3,1H ,5X, 00006670
4 20HTHEORETICAL CRACK LENGTH ,1PE12.3) 00006680
8004 FORMAT(1H0,4X,14,2X,1PE12.3,E13,3,2X,E12,3,8X,14) 00006700
8005 FORMAT(1H0,19HGEOMETRY INPUT DATA,/1H0,5X,20HCRACK TYPE
do not proceed ) 00006710
1 2A4,14/1H ,5X,20HWIDTH ,1PE12.3) 00006720
2/1H,5X,20HADDITIONAL DIMENSION,E12,3, 00006730
3/1H,5X,20HCRACK LENGTH ,1PE12.3) 00006740
4/1H,5X,20HTHICKNESS ,1PE12.3) 00006750
8006 FORMAT(1H0,5X,20HCRACK DEPTH ,1PE12.3) 00006760
8007 FORMAT(1H0,5X,20HCRACK LENGTH ,1PE12.3) 00006770
8008 FORMAT(1H0,5X,20HADDITIONAL CRACK LENGTH ,1PE12.3) 00006780
8009 FORMAT(1H0,5X,20HADDITIONAL CRACK LENGTH ,1PE12.3) 00006790
256HMATERIAL YIELD GROWTH RETARDATION STRESS , 00006800
363HINTENSITY STRESS INTENSITY STRESS INTENSITY STRESS INTENSITY00006810
4,1H ,7X,42HCRACK TYPE STRENGTH EQUATION MODEL,9X, 00006820
59H(SURFACE),9X,9H(SURFACE),5X,7H(DEPTH),11X,7H(DEPTH) /)
8009 FORMAT(1H0,6X,14,4X,1PE12.3,5X,14,8X,14,8X,E12,3,3(6X,E12,3)) 00006830
8010 FORMAT(1H0,21X,1H, 17HNUMBER TYPE,6X, 00006840
342HSURFACE DEPTH SURFACE DEPT 00006850
8011 FORMAT(1H0,2X,1X,6X,14,3X,1PE13.3) 00006860
8012 FORMAT(1H0,19HTHERMAL PARAMETERS,1H0,5X,
1 20HDESIGN LIFE ,1PE12.3/1H ,5X, 00006870
2 20HCONVERGENCE EXponent,E12,3/1H ,5X, 00006880
3 20HTHEORETICAL CRACK LENGTH ,8X,14/1H ,5X, 00006890
4 20HTHERMAL PARAMETERS,1H0,8X,14) 00006900
D-12
8013 FORMAT(1H-,18P|TERATIONS STOPPED,(/H ,
  1 33H LAST PERCENTAGE LIFE IS INCORRECT,
  2 /1H ,2HNO GROWTH HAS OCCURRED)
8014 FORMAT(1H0,1OH TABLE ,14,\$; BETA C\$
8015 FORMAT(1H0,12X,4H A=,7(1PF11.3,4x),E11.3)
8016 FORMAT(1H ,2HC=,1PF10.3,8E15.3)
8017 FORMAT(1H0,10H TABLE ,14,\$; BETA A\$
8018 FORMAT(1H-,16HPROOF INPUT DATA,71H0,5X,10HPROOF TYPE,9X,14,
  1 7X,4HLowe,A4,1PE12.3,\(1H ,5X,5HPROOF,6X,1E12.3,7X,4HUPPE,A4,\$
  2 E12.3,\(1H ,5X,11HPKC PROOF ,E12.3,7X,2A,\(1E12.3,\(1H ,5X,\$
  3 11HKJ PROOF ,E12.3,7X,16P|TERATION LIMIT ,14)
8019 FORMAT(1H0,5X,13HMATERIAL TYPE,14,5X,5HTABLE,14)
8020 FORMAT(1H0,14X,4H RE=,7(1PF11.3,4x),E11.3)
8021 FORMAT(1H ,4HDKE=,1PF10.3,8E15.3)
END

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SUBROUTINE PROOF(A0,CO,XLOW,XUP,IEND,NPROOF)
   COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPKF,KAPRF,
      PROOFX,NKTMX,NCX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYCl2)
   REAL KAPRF,KAPRF
   EXTERNAL FC1,FC2,FC3,FC4,FC5,FC6,FC7
   IF (IEND.NE.0) GO TO 10
   IEND=100
   10 GO TO (100,200,300,400),NPROOF

C 100 CONTINUE
   CALL RTMI(A1,ZERO,FC1,XLOW,XUP,001,IEND,IER)
   CALL MESS1(IER,A1,XUP)
   IERC=IER
   CALL RTMI(A2,ZERO,FC2,XLOW,XUP,001,IEND,IER)
   CALL MESS2(IER,A2,XUP)
   IERC=IERC*IER
   IF (IERC.NE.0) GO TO 2000
   AO=AMINI(A1,A2)
   CO=AO/FIXED
   GO TO 1000

200 CONTINUE
   CALL RTMI(CO,ZERO,FC3,XLOW,XUP,001,IEND,IER)
   CALL MESS2(IER,CO,XUP)
   IF (IERC.NE.0) GO TO 2000
   GO TO 1000

300 CONTINUE
   CALL RTMI(A1,ZERO,FC4,XLOW,XUP,001,IEND,IER)
   CALL MESS1(IER,A1,XUP)
   IERC=IER
   CALL RTMI(A2,ZERO,FC5,XLOW,XUP,001,IEND,IER)
   CALL MESS2(IER,A2,XUP)
   IERC=IERC*IER
   IF (IERC.NE.0) GO TO 2000
   AO=AMINI(A1,A2)
   CO=FIXED
   GO TO 1000

400 CONTINUE
   CALL RTMI(C1,ZERO,FC6,XLOW,XUP,001,IEND,IER)
   CALL MESS1(IER,C1,XUP)
   IERC=IER
   CALL RTMI(C2,ZERO,FC7,XLOW,XUP,001,IEND,IER)
   CALL MESS2(IER,C2,XUP)
   IERC=IERC*IER
   IF (IERC.NE.0) GO TO 2000
   AO=AMINI(C1,C2)
   CO=FIXED
   GO TO 1000

1000 RETURN

2000 STOP
END
SUBROUTINE MESS1(IER, X, XUP)
IF (IER.NE.1) GO TO 600
X=XUP
WRITE(6,6010)
GO TO 700
600 IF (IER.NE.2) GO TO 700
X=XUP
WRITE(6,6020)
700 RETURN
6010 FORMAT(1HO,4SHPROOF LOAD CALCULATION AT DEPTH HAS NOT CONVERGED) 00000100
6020 FORMAT(1HO,39HBOUNDS ON VARIABLE ARE NOT APPROPRIATE.,/1H, 00000110
  1 54HEITHER CRITICAL STRESS INTENSITY AT DEPTH IS LESS THAN, 00000120
  2 22H KPROOF AT LOWER BOUND./1H, 26H OR GREATER THAN KPROOF, 00000130
  3 15H AT UPPER BOUND) 00000140
END

D-15
SUBROUTINE MESS2(IER,X,XUP)
IF (IER.NE.1) GO TO 600

   X=XUP
   WRITE(6,6010)
   GO TO 700
600 IF (IER.NE.2) GO TO 700
   X=XUP
   WRITE(6,6020)
700 RETURN

6010 FORMAT('FORMALIH6,'HPROOF LOAD CALCULATION AT SURFACE HAS NOT CONVERGED')
6020 FORMAT('FORMALIH9,39HBOUNDS ON VARIABLE ARE NOT APPROPRIATE.../IH ',
   '1 S6HEITHER CRITICAL STRESS INTENSITY AT SURFACE IS LESS THAN,',
   '2 22H KPROOF AT LOWER BOUND,/IH ,26H OR GREATER THAN KPROOF,',
   '3 15H AT UPPER BOUND')
END
SUBROUTINE RTMI(X,F,FCT,XLI,XRI,EPN,IFND,IER)

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SUBROUTINE RTMI

PURPOSE
TO SOLVE GENERAL NONLINEAR EQUATIONS OF THE FORM FCT(X)=0
BY MEANS OF MUELLER'S ITERATION METHOD.

USAGE
CALL RTMI (X,F,FCT,XLI,XRI,EPN,IFND,IER)
PARAMETER FCT REQUIRES AN EXTERNAL STATEMENT.

DESCRIPTION OF PARAMETERS
X   - RESULTANT ROOT OF EQUATION FCT(X)=0.
F   - RESULTANT FUNCTION VALUE AT ROOT X.
FCT  - NAME OF THE EXTERNAL FUNCTION SUBPROGRAM USED.
XLI  - INPUT VALUE WHICH SPECIFIES THE INITIAL LEFT BOUND OF THE ROOT X.
XRI  - INPUT VALUE WHICH SPECIFIES THE INITIAL RIGHT BOUND OF THE ROOT X.
EPN  - INPUT VALUE WHICH SPECIFIES THE UPPER BOUND OF THE ERROR OF RESULT X.
IFND - MAXIMUM NUMBER OF ITERATION STEPS SPECIFIED.
IER  - RESULTANT ERROR CODE AS FOLLOWS
IER=0 - NO ERROR,
IER=1 - NO CONVERGENCE AFTER IFND ITERATION STEPS FOLLOWED BY IFDS SUCCESSIVE STEPS OF BISECTION,
IER=2 - BASIC ASSUMPTION FCT(XLI) FCT(XRI) LESS THAN OR EQUAL TO ZERO IS NOT SATISFIED.

REMARKS
THE PROCEDURE ASSUMES THAT FUNCTION VALUES AT INITIAL Bounds XLI AND XRI HAVE NOT THE SAME SIGN. IF THIS BASIC ASSUMPTION IS NOT SATISFIED BY INPUT VALUES XLI AND XRI, THEN THE PROCEDURE IS BYPASSED AND GIVES THE ERROR MESSAGE IER=2.

SUBRoutines AND FUNCTION SUBPROGRAMS REQUIRED
THE EXTERNAL FUNCTION SUBPROGRAM FCT(X) MUST BE FURNISHED BY THE USER.

METHOD
SOLUTION OF EQUATION FCT(X)=0 IS DONE BY MEANS OF MUELLER'S ITERATION METHOD OF SUCCESSIVE BISECTIONS AND INVERSE PARABOLIC INTERPOLATION, WHICH STARTS AT THE INITIAL BOUNDS. CONVERGENCE IS QUADRATIC IF THE DERIVATIVE AT ROOT X IS NOT EQUAL TO ZERO. ONE ITERATION STEP REQUIRES TWO EVALUATIONS OF FCT(X). FOR TEST ON SATISFACTORY ACCURACY SEE FORMULAE (2,4) OF MATHEMATICAL DESCRIPTION. FOR REFERENCE, SEE G. K. KRISTIANSEN, ZERO OF ARBITRARY FUNCTION, BIT, VOL. 3 (1963), PP. 205-206.

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PREPARE ITERATION
IER=0
XL=XL1  
XR=XR1  
X=XL  

TOL=X  
F=FCT(TOL)  
IF(F)1,16,1  
1  
FL=F  
X=XR  
TOL=X  
F=FCT(TOL)  
IF(F)2,16,2  
2  
FR=F  
IF(SIGN(1.,FL)*SIGN(1.,FR))25,3,25  

C BASIC ASSUMPTION FL*FR LESS THAN 0 IS SATISFIED.  
C GENERATE TOLERANCE FOR FUNCTION VALUES.  
3  I=0  
TOLF=100.*EPS  
C  
C START ITERATION LOOP  
4  I=I+1  
C  
C START BISECTION LOOP  
DO 13 K=1,IEND  
X=.5*(XL+XR)  
TOL=X  
F=FCT(TOL)  
IF(F)5,16,5  
5  IF(SIGN(1.,F)+SIGN(1.,FR))7,6,7  
C  
C INTERCHANGE XL AND XR IN ORDER TO GET THE SAME SIGN IN F AND FR  
6  TOL=XL  
   XL=XR  
   XR=TOL  
   TOL=FL  
   FL=FR  
   FR=TOL  
7  TOL=F-FL  
   A=F*TOL  
   A=A+A  
   IF(A-FR*(FR-FL))8,9,9  
8  IF(I-EIND)17,17,9  
9  FR=F  
C  
C TEST ON SATISFACTORY ACCURACY IN BISECTION LOOP  
TOL=EPS  
A=ABS(XR)  
IF(A-1.)11,11,10  
10  TOL=TOL*A  
11  IF(ABS(XR-XL)-TOL)12,12,13  
12  IF(ABS(FR-FL)-TOLF)14,14,13  
13  CONTINUE  
C  
C END OF BISECTION LOOP  
C  
C NO CONVERGENCE AFTER IEND ITERATION STEPS FOLLOWED BY IEND  
C SUCCESSIVE STEPS OF BISECTION OR STEADILY INCRRASING FUNCTION  
C VALUES AT RIGHT ROUNDS. ERROR RETURN.  
IER=1
14 IF(ABS(FR)-ABS(FL))<1e-16 RETURN
15 X=XL
F=FL
16 RETURN

C COMPUTATION OF ITERATED X-VALUE BY INVERSE PARABOLIC INTERPOLATION

17 A=FR-F
DX=(X-XL)*FL*(1.+F*(A-TOL)/(A*(FR-FL)))/TOL
XM=X
FM=F
X=XL-DX
TOL=X
F=FCT(TOL)
18 IF(F)<1.318,16,19

C TEST ON SATISFACTORY ACCURACY IN ITERATION LOOP

19 TOL=EPS
A=ABS(X)
19 IF(A<1.120,20,19
20 IF(A<1.120,20,19
21 IF(A<1.120,20,19

C PREPARATION OF NEXT BISECTION LOOP

22 IF(SIGN(1./F)*SIGN(1./FL))>24,23,24
23 XR=X
FR=F
GO TO 4
24 XL=X
FL=F
XR=XM
FR=FM
GO TO 4

C END OF ITERATION LOOP

C ERROR RETURN IN CASE OF WRONG INPUT DATA

25 IFR=2
RETURN

END
FUNCTION FCTI(AF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
1 PRODFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
COMMON A,AP(2),ALIM,AOL(2),C,CLM,C(2,10,10),CO,CUME,
1 CUMELM,CIB1,D(2,10,10),DK,DKF,DX,FA,FC,H,INC,KCL,KC1,KOL,
2 KOA,KOC,KCRA,KCRC,KMAX,DA,OC,P1,R,RAD,RE,RYOL(2),RCL(2),
3 SIG,SIglm,SIgY,SIgS(10),SMIN(122),SMAX(122),TH,
4 UNIT(122),W,DCTMP,DELTMP,DXTMP,
5 ALOWN,BLOCK,FLAG1,1,ICD(2),ICK(2),IGR(2),IERROR,IFIRST,IPRN(4),
6 ISTEP,ITRANS,J,K,TYPe(2),NC,NEQ(10),NR,NREF(10),TITL
INTEGER ALOWN,BLOCK,FLAG1,TYPe(122),TITL(20)
REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
REAL KCPRF,KAPRF
A=AF
C=A/FIXED
CALL KANAL
FCTI=-KAPRF*AF*PRODFX
RETURN
END
FUNCTION FCT2(AF)
COMMN X(12, 25), Y(12, 25), TABLE(12, 25), FIXED, KCPRF, KAPRF
1 PROOFX, NKTMX, NOX(12), NOY(12), NTAB(10), IPILOT, IFAIL, CUMSUM, PCYC(2) 
COMM A, AP(2), ALIM, ACL(2), C, CB, CLIM, CR(12, 10, 10), CO, CI, ME, 
1 CUMELM, CIBI, D(2, 10, 10), D, DKE, DJX, FA, FC, H, INC, KCL, KCI, KUL, 
2 KOA, KOC, KCRA, KRC, KMAX, OA, NC, P1, P, RAD, RE, RVCL(2), RUL(2), 
3 SIG, SIGLM, SIGY, SIGYS(10), SMIN(422), SMAX(422), TH, 
4 UNIT(422), W, DCTMP, DLTMP, DXTMP, 
5 ALONN, BLOCX, FLAG1, I, ICD(2), ICK(2), ICR(2), IBLCK, IFIRST, IPRN(4), 
6 ISTEP, ITRANS, J, KTYPE(2), NC, NCQ(10), NR, NRET(10), TYPE, TITL 
INTEGER ALONN, BLOCX, FLAG1, TYPE(422), TITL(20), 
REAL KCL, KCI, KKC(10), KOC(10), KCPA(10), KCR(10), KMAX, INC 
REAL KCPRF, KAPRF 
A=AF 
C=A/FIXED 
CALL KANAL 
FCT2=KCPRF+FC*PRLOCFX 
RETURN 
END
FUNCTION FCT3(CF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,00000390
1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPL,TFAIL,CUMSUM,PCYC(2)00000400
COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,00000410
1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KDL,00000420
2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,P1,R,RAD,RE,RYOL(2),ROL(2),00000430
3 SIG,SIGTH,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,00000440
4 UNIT(422),W,DCTMP,DELTMP,DXTMP,00000450
5 ALOWN,BLOCK,FLAG1,I,TCD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),00000460
6 ISTEP,ITRAN,S,J,TYPE(2),NC,NEG(10),NR,NREF(10),TYPE,TITL00000470
INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)00000480
REAL KCL,KC1,KDL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC00000490
REAL KCPRF,KAPRF00000500
C=CF00000510
CALL KANAL00000520
FCT3=KCPRF+FC*PROOFX00000530
RETURN00000540
END00000550
FUNCTION FC14(AF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,00000050
1 PROOFX,NKTRY,NIX(12),NOY(12),NTAB(10),IPL0T,IFAIL,CHMSUM,PCYC(2) 00000050
COMMON A,AP(2),ALIM,ACL(2),C,CE,CLIM,CR(2,10,10),CO,CLMF,00000600
1 CUMELM,C1B1,D12,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KCI,KOL,00000610
2 KOA,KOC,KCRA,KCRC,KMAX,CA,OC,PI,R,RAD,RE,RVOL(2),RCL(2),00000620
3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(-22),SMA(422),TH,00000630
4 UNIT(422),W,DCTMP,DELTMP,XTMP,00000640
5 ALOWN,BLOCK,FLAG1,I,ICOD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),00000650
6 ISTEP,ISTRANS,J,KTYP(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20) 00000660
REAL KCL,KCI,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
REAL KCPRF,KAPRF
A=AF
C=FIXED
CALL KANAL
FC14=-KAPRF*FA*PROOFX
RETURN
END
FUNCTION FCTS(AF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPF,KAPRF,
1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLDT,IFAIL,CUMSUM,PCYC(2)
COMMON A,AP(2),ALIM,ADL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KCI,KOL,
2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2)
3 SIG(SIGL,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH
4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
5 ALOWN,BLOCK,FLAG1,ICD(2),ICK(2),IRC(2),IBLOCK,IFIRST,IPRN(4)
6 1STEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
REAL KCL,KCI,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
REAL KCPF,KAPRF
A=AF
C=FIXED
CALL KANAL
FCT5=-KCPF*FC*PROOFX
RETURN
END
FUNCTION FCT6(CF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
1 PROOFX,NKTMX,NOX(12),NDY(12),NTAB(10),TPILOT,IFAIL,CUMSUM,PCYC(2)
COMMON A,AP(2),ALIM,ADL(2),C,CP,CLIM,CR(2,10,10),CO,CUMF,
1 CUMELM,C1810,D12(10),DK,DKO,DXDX,FA,FC,H,INC,KCL,KCL1,KOL,
2 KOO,KGRC,SKRA,SRCA,SRCR,SMAX,DA,DC,PI,R,RAD,RE,RYCL(2),ROL(2),
3 SIG,SLCM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
4 UNIT(422),W,DCFMP,DELTMP,DXTMP,
5 AALON,BLOCK,FLAG1,ICK(2),ICR(2),IBLOCK,IFPST,IPRN(4),
6 ISTEP,ITRANS,J,KTYPE(2),NC,HEU(10),NR,NRT1(10),TYPE,TITL
INTEGER AALON,BLOCK,FLAG1,TYPE(422),TITL(20)
REAL KCL,KCL1,KOK,KOA(10),KGС(10),KCR(10),KCR(10),KMAX,INC
REAL KCPRF,KAPRF
C=CF
A=FIXED
CALL KANAL
FCT6=-KAPRF+FA*PR10FX
RETURN
END
FUNCTION FCT7(CF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CMUMM,PCYC(2)
COMMON A,AP(2),ALIM,ADL(2),C,CB,CLIM,CR(2,10,10),CO,CLIMF,
1 CUMELM,C1151,D(2,10,10),DK,DKF,DXDX,FA,FC,H,INC,KCL,KC1,KCL,
2 KOA,KOC,KCRA,KCRC,KMAX,DA,OC,P1,R,RAD,RE,RYOL(2),RPL(2),
3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
5 ALOWN,BLOCK,FLAG1,I,IGD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
6 ISTEP,ITFANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
REAL KCPRF,KAPRF
C=CF
A=FIXED
CALL KANAL
FCT7=-KCPRF*FC*PDCOFX
RETURN
END
SUBROUTINE PTRGWH
COMMON X(12, 25), Y(12, 25), TABLE(12, 25, 25), FIXED, KCPRF, KAPRF,
1 PROOFX, NTKMX, NDX(12), NDY(12), NTAB(10), IFAIL, CUMSUM, PCYC(2)
COMMON A, AP(2), ALIM, AOL(7), C, CB, CLIM, CR(2, 10, 10), CO, CUME,
1 CUMELM, C1IB, D12, 10, 10), DK, DKE, DXDX, FA, FC, H, INC, KCL, KEL
2 KG, KCC, KCR, KMAX, CA, OC, PI, RF, RRA, RE, RYOL(2), ROL(2),
3 SIG, SIGLM, SIGY, SIGYS(10), SMIN(12), SMAX(12), TH,
4 UNIT(422), wDCTMP, DELTMP, DXTMP,
5 ALONH, BLOCQ, FL1G1, I, ICM(2), lCK2), ICR(2), IBLOCK, IFIRST, PR1N(4),
6 ISTEP, ITFG, A, KTYPE(2), NC, HEQ(10), NR, NRET(10), TYPE, TITL
INTEGER ALON, BLOCQ, FL1G1, TYPE(22), TITL(20)
REAL KCL, KCI, KOL, KCA(10), KOC(10), KCR, KMAX
PEAL INC, KA, KC, KCPRF, KCPRF
K=0
1FIRST=1
J=TYPE(I)
1025 DEL=INC*A
IF (NRET(I)) 1050, 1050, 1030
1030 IF (ABS(RYOL(2))=CCI) 1050, 1050, 1038
1038 IF (DEL=.1*RYOL(2)) 1050, 1050, 1060
1040 DEL=1.1*RYOL(2)
1050 A=A+DEL
KT=KTYPE(2)
GO TO (1054, 1054, 1054, 1054, 1054, 1056, 1056, 1056, 1056, 1056, 1056, 1056, 1056)
A=A-DEL/2
C NOT INTERNAL TYPE CRACK
1054 TEMP=TH
GO TO 1058
C INTERNAL TYPE CRACK
C 1056 TEMP=TH/2
1058 IF (ABS(A-DEL-TEMP)-1.E-6) 1060, 1060, 1070
1060 IF (KTYPE(2)=E07) GO TO 1065
1065 WRITE(6, 6110)
ICR(1)=-1
CUMSUM=CUMSUM+CUM
RETURN
1070 IF (A-TEMP) 1090, 1090, 1080
1080 DEL=TEMP-A+DEL
A=TEMP
1090 SIGY=SIGYS(J)
IF (FLA1) 1130, 1130, 1130
1100 R=0
SIG=SIGLM
CALL KANAL
IF (SIGLM*FA-KCRA(J)) 1110, 1110, 1120
1110 IF (SIGLM*FC-KCR(J)) 1130, 1130, 1170
1120 FLA1=1
ALIM=A
CLIM=C
IBLOCK=BLOCQ
ISTEP=I
CUMELM=CUME
1130 A=A-DEL/2
SIG=SMAX(1)
R=SMIN(1)/SMAX(1)
CALL KANAL
A=A-DEL/2
KA=FA*SIG
KC=FC*SIG
DKA=(1-R)*KA
DKC=(1-R)*KC
IF (KA=KCRA(J)) 1140,1140,1150
1140 IF (KC-KCRC(J)) 1160,1160,1153
1150 IF (FLAG1) 1152,1152,1151
1151 WRITE(6,6019) IBLOCK,ISTEP,CUMELM
1152 WRITE (6,6002) BLOCK,I,CUME
IFAIL=1
CUMSUM=CUMSUM+SUM
ICRT(I)=0
RETURN
1153 IF (FLAG1) 1155,1155,1154
1154 WRITE(6,6019) IBLOCK,ISTEP,CUMELM
1155 WRITE (6,6003) BLOCK,I,CUME
IFAIL=2
CUMSUM=CUMSUM+SUM
ICRI(I)=0
RETURN
1160 IF (KOA(J)-DKA) 1160,1160,1170
1170 DADX=0
IF (KKC(J)-DKC) 1190,1190,1172
1172 K=1
Dadx=0
GO TO 1211
1180 KMAX=KA
DK=DKA
NC=2
CALL DAMAGE
IF (DXD) 1191,1192,1182
1182 CONTINUE
DADX=DADX
IF (KOC(J)-DKC) 1190,1200,1200
1190 KMAX=KC
DK=DKC
NC=1
CALL DAMAGE
IF (DXD) 1191,1192,1192
1191 ICRI(I)=0
CUMSUM=CUMSUM+SUM
WRITE(6,6100)
RETURN
1192 CONTINUE
DADX=DADX
GO TO 1210
1200 DADX=0
1210 AVAIL=UNIT(I)-CUME
IF (A*C*DADX&DADX,EQ.0) GO TO 1211
ADJ=5.*DADX/A/(DADX/C)
IF (ADJ.GE.1.) GO TO 1211
DEL=ADJ*DEL
1211 IF (IPRN(N1)-IPRN(N4)) 1201,1202,1205
1202 WRITF(6,8002) NR,TITL
WRITE(6,8003)
IPRN(1) = 0
DFLMP = 0.
DCTMP = 0.
DXTMP = 0.

1203 IF (IFIRST-1) 1205, 1204, 1205
1204 IFIRST = 0
IPRN(1) = IPRN(1) + 1
WRITE(6, 8004) BLOCK, I, CUNF, C, A, KC, KA, DCDX, DADX
IF (K) 5000, 1205, 5000
1205 CONTINUE
IF (ALOWN-1) 1230, 1220, 1230
1220 DX = 1
DEL = DADX
DC = DCDX
GO TO 1260
1230 IF (DADX) 1235, 1265, 1235
1235 IF (DEL/DADX-AVAIL) 1250, 1250, 1240
1240 DELTMP = DELTMP + AVAIL* DADX
IF (A) 1241, 1242, 1241
1241 IF (DELTMP/A-1.E-4) 1244, 1244, 1247
1242 A = A + DELTMP
DFLMP = 0.
1244 DCTMP = DCTMP + AVAIL* DCDX
IF (C) 1245, 1246, 1246
1245 IF (DCTMP/C-1.E-4) 5000, 5000, 1248
1246 C = C + DCTMP
DCTMP = 0.
GO TO 5000
1250 DX = DEL/DADX
DC = DX*DCDX
GO TO 1260
1255 UC = INC* C
IF (FRYL(1)-1.E-4) 1258, 1258, 1258
1258 UC = MINU(1*FRYL(1), DC)
1255 IF (DCDX) 5000, 5000, 1259
1259 DX = DC/DCDX
DEL = DX* DADX
GO TO 1240
1260 IF (DX-AVAIL) 1280, 1280, 1270
1270 DELTMP = DELTMP + AVAIL * DADX
IF (A) 1271, 1272, 1271
1271 IF (DELTMP/A-1.E-4) 1274, 1274, 1272
1272 A = A + DELTMP
DFLMP = 0.
1274 DCTMP = DCTMP + AVAIL* DCDX
IF (C) 1275, 1276, 1275
1275 IF (DCTMP/C-1.E-4) 5000, 5000, 1276
1276 C = C + DCTMP
GO TO 5000
1280 DELTMP = DELTMP + DEL
IF (A) 1281, 1282, 1281
1281 IF (DELTMP/A-1.E-4) 1284, 1284, 1282
1282 A = A + DELTMP
DFLMP = 0.
1284 DCTMP = DCTMP + DC
IF (C) 1285, 1286, 1285
1285 IF (DCTMP/C-1.E-4) 1288, 1288, 1286
1286 C = C + DCTMP
DCTMP = 0.
1288 DXTMP=DXTMP+DX
    IF (IPLOT.NE.2) GO TO 1300
    CUMTMP=CUMSUM+CUME
    IF (CUMTMP.LT.PCYC(2)) GO TO 1300
    WRITE(7,7000) A,C,CUMTMP
    PCYC(2)=PCYC(2)+PCYC(1)
1300 IF (CUME) 1269,1290,1289
1289 IF (DXTMP/CUME-1,E-4) 1025,1025,1290
1290 CUME=CUME+DXTMP
      DXTMP=0.
      GO TO 1025
5000 CONTINUE
    CUME=UNIT(I)
    CUMSUM=CUMSUM+UNIT(I)
    IF (IPLOT.NE.2) GO TO 5005
    IF (CUMSUM.LT.PCYC(2)) GO TO 5005
    WRITE(7,7000) A,C,CUMSUM
    PCYC(2)=PCYC(2)+PCYC(1)
5005 IF (IPRN(1)-IPRN(4)) 5010,5020,5020
5010 IPRN(1) = IPRN(1)+1
      WRITE(7,8005) BLOCK,I,CUME,C,A,KC,KD,DCDX,DADX
      IF (IPLOT.NE.1) GO TO 5020
      WRITE(7,7000) A,C,CUMSUM
5020 CONTINUE
      RETURN
6002 FORMAT(5H0CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE,I6,
      1 14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES )
6003 FORMAT(5H0CRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE,I6,
      1 14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES )
6019 FORMAT(35HOLIMIT LOAD FRACTURE OCCURS IN THE ,I6,7H BLOCK ,
      1 14,12H STEP AFTER ,1PE12.3,7H CYCLES )
6100 FORMAT(1H0,29HCRACK GROWTH RATE IS NEGATIVE,/1H ,
      1 46HACCEPTABLE END OF LIFE IF FORMUN EQUATION USED)
6110 FORMAT(1H0,46HCRACK IN TRANSITION. NEED TABLES FOR ANALYSIS.)
7000 FORMAT(1HDATA,1P3E12.3)
8002 FORMAT(5H1RUN ,14,5X,20A4,/1H0,50X,26HCRACK IS A PART THRU CRACK,
      1 /1H0,42X,12HHALF SURFACE,50X,7HSURFACE,9X,5HDEPTH)
8003 FORMAT(1H0,12X,45HRACK STEP CYCLES CRACK LENGTH ,
      1 156HCRACK DEPTH KMAX-SURFACE KMAX-DEPTH GROWTH RATE,4X,
      211HGROWTH RATE /1H ,14,6X,4H(IN),11X,4H(IN),6X,13H(KSI ROOT-IN),2X,
      313H(KSI ROOT-IN),4X,10H(IN/CYCLE),5X,10H(IN/CYCLE) ,/)
8004 FORMAT(10H ,16,3X,14,7(3X,1PE12.3))
8005 FORMAT(10H ,16,3X,14,7(3X,1PE12.3))
END
SUBROUTINE TRANS
COMMON X(12,25), Y(12,25), TABLE(12,25,25), FIXED, KCPRF, KAPRF,
1 PROFUX, NKTMX, NOX(12), NCV(12), NTAB(10), IPILOT, FFAIL, CUMSUM, PCYC(2)
COMMOM A, AP(2), ALIM, AOL(2), CXCB, CLIM, CR(2,10,10), CO, CUMF,
1 CUMEMX, CIB(1), D(2,10,10), DK, DKE, DXDX, FA, FC, H, INC, KCL, KCR, KOL,
2 KOA, KOC, KCRA, KCRF, KMAX, GA, GC, P, R, RAD, RE, RYOL(2), ROL(2),
3 SIG, SIGLM, SICY, SICYC(10), SMIN(22), SMAX(22), TH,
4 UNIT(4,22), WDCTMP, DELTMP, DXTMP,
5 AOW, BLOCX, FLAG1, I, ICW(2), ICK(2), ICR(2), IBLOCK, IFIRST, IPRN(4),
6 ISTEP, ITRANS, J, KTYPE(2), NC, NEW(10), NR, PRET(10), TYPE, TITL
INTEGER AOW, BLOCX, FLAG1, TYPE(42), ONSTEP, TITL(20)
REAL KCL, KCI, KOL, KOA(10), KCRA(10), KCPRF, KAPRF
K=0
IFIRST=1
IF (TRANS=1) 10,180,10
CONTINUE
TRANS=1
KORIC=KTYPE(1)
KTYPE(1)=3
FLAG2=0
CALL KAMAL
IF (FC*SMAK(I)-KCRF(I)) 110,110,110
WRITE(6,6021) BLOCK,1,CUME
CUMSUM=CUMSUM*CUMF
FAIL=3
ICR(1)=-1
IF (TRANS=1) 10,180,10
RETURN
110 IF (FLAG1) 140,120,140
120 IF (FC*SIGLM-KCRF(J)) 140,140,130
130 FLAG3=1
ALIM=A
CLIM=C
IBLOCK=BLOCK
ISTEP=1
CUMFLM=CUME
140 CR=0
KTYPE(1)=KORIC
SICY=SICYC(I)
SIG=SMAK(I)
R=SMIN(1)/S10
CALL KAMAL
IF (FA*SIG-KCRM(1)) 180,180,160
140 CR=CR+.02*C
FLAG2=1
IF (CR-C) 150,170,170
170 WRITE(6,6022) BLOCK,1,CUME
WRITE(6,6022) CR, C
FAIL=4
ICR(1)=-1
CUMSUM=CUMSUM+CUMF
RETURN
180 DEL=INC*C
IF (PRET(J)) 200,209,201
200 IF (AM(RYOL(I))=.0001) 209,209,202
202 IF (DFL-1*RYOL(I)) 200,200,205
205 DEL=1*RYOL(I)
209 CR=CS+DEL
IF (CR-.95*C) 220,220,210
210 ITRANS=0
IF (KTYPE(I).NE.2) GO TO 215
KTYPE(I)=3
CALL TCGROW
RETURN

215 WRITE (6,6110)
   ICR(I)=-1
   CUMSUM=CUMSUM+CUMF
RETURN

220 CONTINUE
   SIG=SIGLM
   CALL KANAL
   IF (SIGLM*FC-KCRC(J)) 1110,1110,1120
1110 IF (SIGLM*FC-KCRC(J)) 1130,1130,1120
1120 FLAGI=1
   CBLIM=CB
   CLIM=C
   IBLOCK=BLOCK
   ISTEP=I
   CUMELM=CUME
1130 CB=CB-DEL/2
   SIG=SMAX(I)
   R=SMIN(I)/SMAX(I)
   CALL KANAL
   CR=CB-DEL/2
   KA=FA*SIG
   KC=FC*SIG
   DKAI=(1-R)*KA
   DKCI=(1-R)*KC
   IF (KA-KCRC(J)) 1140,1140,1150
1140 IF (KC-KCRC(J)) 1160,1160,1153
1150 IF (FLAGI) 1152,1152,1151
1151 WRITE (6,6019) IPLOCK,ISTEP,CUMELM
1152 WRITE (6,6002) BLOCK,1,CUME
   CUMSUM=CUMSUM+CUME
   IFAIL=1
   ICR(I)=-1
RETURN
1153 IF (FLAGI) 1155,1155,1154
1154 WRITE (6,6019) IPLOCK,ISTEP,CUMELM
1155 WRITE (6,6003) BLOCK,1,CUME
   CUMSUM=CUMSUM+CUME
   IFAIL=2
   ICR(I)=-1
RETURN
1160 IF (KOC(J)-DKA) 1180,1170,1170
1170 DADX=0
   IF (KOC(J)-DKC) 1190,1172,1172
1172 K=1
   GO TO 1209
1180 KMAX=KA
   DK=DKA
   NC=1
   CALL DAMAGE
IF (DADX) 1192,1184,1184
1184 DADX=DADX
   IF (KOC(J)-DKC) 1190,1200,1200
1190 KMAX=KC
   DK=DKC
   NC=1
   CALL DAMAGE
IF (DXDX) 1192,1194,1194
1192 ICR(1)=1
WRITE(6,6100)
CUMSUM=CUMSUM+CUME
RETURN
1194 DCX=DXDX
GO TO 1210
1200 DCX=0
1210 AVALI=UNIT(I)-CUME
1209 IF (IPRN(3)-IPRN(4)) 1211,1215,1215
1211 IF (IPRN(3)) 1212,1213,1213
1212 WRITE(6,8002) NF,TITL
WRITE(6,8003)
IPRN(3)=0
DELTMP=0.
DCTMP=0.
DXTMP=0.
1213 IF (IFIRST-1) 1215,1214,1215
1214 IFIRST=0
IPRN(3)=IPRN(?)+1
WRITE(6,8004) BLOCK,1,CUME,C,CB,KC,KA,DCDX,DADX
IF (K) 5000,1216,5000
1215 CONTINUE:
IF (ALOWN-1) 1230,1220,1230
1220 DX=1
DEL=DADX
DC=DCDX
GO TO 1230
1230 IF (DXDX) 1235,1255,1235
1235 IF (DEL/DADX-AVALI) 1250,1250,1240
1240 DELTMP=DELTMP+AVAIL*DAOX
IF (CE) 1241,1247,1241
1241 IF (DELTMP/CE-1.E-4) 1244,1244,1247
1242 CB=CH+DELTMP
DELTMP=0.
1244 DCTMP=DELTMP+AVAIL*DCDX
IF (C) 1245,1246,1245
1245 IF (DCTMP/C-1.E-4) 5000,5000,12-6
1246 C=C+DCTMP
DCTMP=0.
GO TO 5000
1250 DX=DEL/DADX
DC=DX*DCDX
GO TO 1260
1255 DC=INC*L
IF (RYVL(1)-1.E-4) 1258,1258,1256
1256 IF (NRFT(J)) 1257,1257,1257
1257 DC=A-MINT,1*RYVL(1),0C
1258 IF (DCDX) 5000,5000,1259
1259 DX=DC/DCDX
DEL=DX/DADX
1260 IF (DX-AVALI) 1280,1280,1270
1270 DELTMP=DELTMP+AVAIL*DAOX
IF (CE) 1271,1272,1271
1271 IF (DELTMP/CE-1.E-4) 1274,1274,1272
1272 CE=CE+DELTMP
DELTMP=0.
1274 DCTMP=DELTMP+AVAIL*DCDX
IF (C) 1275,1276,1275
1275 IF (DCTMP/C-1.E-4) 5000,5000,1276
1276 C=C+DCTMP
DCTMP=0.
GO TO 5000
1280 DELTMP=DELTMP+DEL
IF (CB) 1281, 1282, 1281
1281 IF (DELTMP/CB-1.E-4) 128A, 1284, 1282
1282 CB=CB+DELTMP
DELTMP=0.
1284 DCTMP=DCTMP+DC
IF (C) 1285, 1286, 1285
1285 IF (DCTMP/C-1.E-4) 1288, 1288, 1286
1286 C=C+DCTMP
DCTMP=0.
1288 DXTMP=DXTMP+DX
IF (IPLT.NF.2) GO TO 1300
CUMTMP=CUMSUM+CUMF
IF (CUMTMP>PCYC(2)) GO TO 1300
WRITE(7,7000) A,C,CUMTMP
PCYC(2)=PCYC(2)+PCYC(1)
1300 IF (CUMF) 1289, 1290, 1290
1289 IF (DXTMP/CUMF-1.E-4) 180, 180, 1290
1290 CUME=CUME+DXTMP
DXTMP=0.
GO TO 180
5000 CONTINUE
CUME=UNIT(I)
CUMSUM=CUMSUM+CUMF
IF (IPLT.NF.2) GO TO 5005
IF (CUMSUM>PCYC(2)) GO TO 5005
WRITE(7,7000) A,C,CUMSUM
PCYC(2)=PCYC(2)+PCYC(1)
5005 IF (IPRN(3)-IPRN(4)) 5010, 5020, 5020
5010 IPRN(3)=IPRN(3)+1
WRITE(6,RO05) BLOCK, I, CUME, C, CB, KC, KA, DCDX, DADX
IF (IPLT.NF.1) GO TO 5020
WRITE(7,7000) A,C,CUMSUM
5020 CONTINUE
RETURN
"FORMAT(45HCRTTICAL K AT DEPTH HAS BEEN EXCEEDED IN THE, I6,
1 14H BLOCK AND THE, I4, 11H STEP AFTER, 1PE12.3, 7H CYCLES )
6003 FORMAT(45HCRTTICAL K AT SURFACE HAS BEEN EXCEEDED IN THE, I6,
1 14H BLOCK AND THE, I4, 11H STEP AFTER, 1PE12.3, 7H CYCLES )
6019 FORMAT(35HOLIIMT LOAD FRACTURE OCCURS IN THE, I6, 7H BLOCK ,
1 14, 12H STEP AFTER, 1PE12.3, 7H CYCLES )
6021 FORMAT(4HFRACTURE OCCURS DURING BREAKTHROUGH IN THE ,
1 16, 14H BLOCK AND THE, I4, 11H STEP AFTER, 1PE12.3, 7H CYCLES )
6022 FORMAT(4HFRACTURE OCCURS DURING TRANSITION IN THE ,
1 16, 14H BLOCK AND THE, I4, 11H STEP AFTER, 1PE12.3, 7H CYCLES )
6023 FORMAT(6HOCR = :1PE12.3, 7H C = :E12.3)
6100 FORMAT(1HO, 29HCRACK GROWTH RATE IS NEGATIVE, /1H ,
1 46HACCEPTABLE END OF LIFE IF FROM MON EQUATION USED)
6110 FORMAT(1HO, 50HCRACK BECOMING THRU-Crack. NEED TABLES FOR ANALYSIS, /2HS.)
7000 FORMAT(4HDATA, 1P3E12.3)
8002 FORMAT(5HIRUN, 14, 5X, 20A4, /1HO, 50X ,
130HCRACK IS A CRACK IN TRANSITION, /1HO, 43X ,
225HFRONT HALF BACK, 38X, 5HFRONT, 9X, 4HBRAK)
6003 FORMAT(1H, 12X, 45H BLOCK STEP CYCLES CRACK LENGTH ,
160HCRACK LENGTH KMFRONT KMFRONT KMFRONT GROWTH RATE ,
211H GROWTH RATE, /1H, 46X, (IN), 11X, 4H(IN), 6X, 13H(KSI ROOT-IN),
D-34
SUBROUTINE T1CGROW
COMON X(12,25), Y(12,25), TABLE(12,25), FIXED, KCPRF, KAPRF,
1 PROOF, NKTMX, NOX(12), NOI(12), NTAB(10), IPILOT, IFAIL, CUMSUM, PCYC(2)
COMON A, AP(2), ALIM, ALO(2), C, CB, CLIM, CR(2,10,10), CO, CUME,
1 CUMELM, C1B(1,10,10), DK, DKE, DXDX, FA, FC, H, INC, KCL, KC1, KDL,
2 KOA, KOC, KRC, KRC, KMAX, DA, OC, PI, R, RAD, RE, RYCL(2), RUL(2),
3 SIG, SIGLM, SIGY, SIGYS(10), SMIN(422), SMAX(422), TH,
4 UNIT(422), W, DCTMP, DLTMP, DXTMP,
5 ALONV, BLOCK, FLAG1, I, ICD(2), ICK(2), ICR(2), IBLOCK, IFIRST, IPRN(4),
6 ISTEP, ITRANS, J, KTYPE(2), NC, NEO(10), NR, NRET(10), TYPE, TITL
INTEGER ALOW, BLOCK, FLAG1, I, ICD(2), ICK(2), ICR(2), IBLOCK, IFIRST, IPRN(4),
REAL KCL, KCI, KOC(10), KOC(10), KCRA(10), KRC(10), KMAX
REAL INC, KC, KAPRF, KCPRF
IFIRST = 1
1000 J = TYPE(1)
1025 DEL = INC * C
IF (NRET(J)) 1050, 1050, 1030
1030 IF (ABS(RYCL(1)) < 0.0001) 1050, 1050, 1038
1038 IF (DFL < -1 * RYCL(1)) 1050, 1050, 1040
1040 DEL = -1 * RYCL(1)
1050 C = C + DEL
SIGY = SIGYS(J)
IF (FLAG1) 1130, 1100, 1130
1100 R = 0
SIG = SIGLM
CALL KANAL
IF (SIGLM = FC - KRC(J)) 1130, 1130, 1120
1120 FLAG1 = 1
CLIM = C
IBLOCK = BLOCK
ISTEP = 1
CUMFLM = CUMFM
1130 C = C - DEL / 2
SIG = SMAX(1)
R = SMIN(1) / SMAX(1)
CALL KANAL
C = C - DEL / 2
KC = FC * SIG
DKC = (1 - R) * KC
IF (KC - KRC(J)) 1160, 1160, 1153
1153 IF (FLAG1) 1155, 1155, 1154
1154 WRITE(6, 6019) IBLOCK, ISTEP, CUMELM
1155 WRITE(6, 6003) BLOCK, I, CUME
IFAIL = 2
CUMSUM = CUMSUM + CUME
ICR(J) = -1
RETURN
1160 IF (KOC(J) + DKC) 1190, 1170, 1170
1170 DCDX = 0
GO TO 1180
1180 KMAX = KC
DK = DKC
NC = I
CALL DAMAGE
DCDX = DDXD
1180 IF (IPRN(2) = IPRN(4)) 1191, 1195, 1195
1191 IF (IPRN(2)) 1192, 1193, 1193
1192 WRITE(6, 8002) NR, TITL
WRITE(6, 8003)
IPRN(2) = 0
D-36
DELTMP=0.
DXTMP=0.

1193 IF (IFIRST-1) 1195,1194,1195
1194 IFRST=0
1195 CONTINUE
IF (DCDX) 1200,5000,1210

1200 ICR(1)=-1
WRITE(6,9000)
CUMSUM=CUMSUM+CUME
RETURN

1210 AVALF=UNIT(I)-CUMF
IF (ALOWN-1) 1230,1220,1230

1220 DX=1
DEL=CDCX
GO TO 1200

1230 DX=DEL/CDCX
IF (DX-AVAIL) 1280,1280,1270

1270 DXTMP=DELTMP+AVAIL+DCDX
IF (C) 1271,1272,1271

1271 IF (DELTMP/C-1.E-4) 5000,5000,1272

1272 C=C+DELTMP
DELTMP=0.
GO TO 5000

1280 DXTMP=DELTMP+DEL
IF (C) 1281,1282,1281

1281 IF (DELTMP/C-1.E-4) 1284,1284,1282

1282 C=C+DELTMP
DELTMP=0.

1284 DXTMP=DXTMP+DX
IF (IPLOT,NF,2) GO TO 1300
CUMTMP=SUMSUM+CUME
IF (CUMTMP,LT,PCYC(2)) GO TO 1300
WRITE(7,7000) A,C,CUMTMP
PCYC(2)=PCYC(2)+PCYC(1)

1300 IF (CUMF) 1285,1286,1285

1285 IF (DXTMP/CUME-1.E-4) 1025,1025,1026

1286 CUME=CUME+DXTMP
DXTMP=0.
GO TO 1025

5000 CONTINUE
CUMSUM=CUMSUM+UNIT(I)
CUME=UNIT(I)
IF (IPLOT,NF,2) GO TO 5005
IF (CUMSUM,LT,PCYC(2)) GO TO 5005
WRITE(7,7000) A,C,CUMSUM
PCYC(2)=PCYC(2)+PCYC(1)

5005 IF (IPRN(2)=IPRN(4)) 5010,500,5020
5010 IPRN(2)=IPRN(2)+1
WRITE(6,9000) BLOCK,I,CUME,C,KC,DCDX
IF (IPLOT,NF,1) GO TO 5020
WRITE(7,7000) A,C,CUMSUM

5020 CONTINUE
RETURN

6003 FORMAT(47HOCRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE,16,
 1 14H BLOCK AND THE,14,11H STEP AFTER,1PE12,3,7H CYCLES )
6019 FORMAT(35HOLIMIT LOAD FRACTURE OCCURS IN THE,16,7H BLOCK ,
 1 14,12H STEP AFTER,1PE12,3,7H CYCLES )
6100 FORMAT(1HC,29HCRAK GROWTH RATE IS NEGATIVE,1/1H ,
D-37
1 46HACCEPTABLE END OF LIFE IF FORMAN EQUATION USED) 00001210
7000 FORMAT(4HDATA,1PE12.3) 00001220
8002 FORMAT(5H1RUN,14,5X,20A4,1H0,50X,24HCRACK IS A THROUGH CRACK, 00001230
1/1H0,46X,4HHALF,25X,5HCRACK) 00001240
8003 FORMAT(1H,12X,45HBLOCK STEP CYCLES CRACK LENGTH, 00001250
14X,4PKMAX,7X,11H-GROWTH RATE,1H,6X,4H(IN),6X,13H(KSI ROOT-IN)), 00001260
24X,10H(IN/CYCLE),//) 00001270
8004 FORMAT(10H,16,3X,14,7(3X,1PE12.3)) 00001280
8005 FORMAT(10H,16,3X,14,7(3X,1PE12.3)) 00001290
END
00001300
SUBROUTINE DAMAGE

COMMON X(12,25),Y(12,25),TABLE(12,25),KCL(12,25),KCP(12,25),KPRF(12,25),
1 PRCFX,NKTHX,NOX(12),NOY(12),NTAB(10),IPL(1),IFAIL,COMS,PCYC(2)
COMMON A,AP(2),ALIM,ALDT(2),C,CG,CMH,CR(2,10),CC,CUME(2)
1 CUMELM,K1B(12,10,10),DK,DKE,DXSY,FC,FC,H,INC,KCL,KCL(2),KCL(2),
2 KOD,KOC,KCRC,KCRC,KMAX,CA,OC,PI,R,RAD,RE,RYCL(2),RCL(2),
3 SIG(SIGM),SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
4 UN(422),UC,DELTM,DEXTMP,
5 ALAUN,BLOCK,FLAG1,J,ICD(2),ICK(2),ICR(2),INBLOCK,IFIRST,IPRN(4),
6 ISTEP,TRANS,J,ICR(2),NC,NEQ(10),NR,NRRT(10),TYPE,TITL
INTEGER ALAUN,BLOCK,FLAG1,TYPE(422),TITL(20)
REAL KCL,KCL(2),KCL(2),KCRC(10),KCRC(10),KCRC(10),KCRC(10),KMAX,INC
REAL KO,KCR,KCP,KPPR,KPPF

1

DKE = (1. - RE) * KMAX

IF (NEQ(J)) 700, 700, 10
10 IF (NEQ(J) = 4) 20, 20, 700
20 J1 = NEQ(J)
       GO TO (30, 200, 300, 400), J1

COLLIPRIEST—EHRET EQUATION

30 CD = D(NC, 1, J)
       PN = D(NC, 2, J)
       KG = D(NC, 3, J)
       KCR = D(NC, 4, J)
       IF (NRRT(1)) 60, 90, 60

80 CALL RETARD

90 CC1 = ALOG(KCRC/KO)
       CC2 = CC1 * PN/2.
       CC1 = PN/2.
       CC1 = (KCR * KO) * CC1
       CC1 = CD * CC1
       Ti1 = (1. - RE) * KCR * KO
       Ti1 = (DKR**2) / Ti1
       Ti1 = ALOG(TI1)
       T2 = (1. - RE) * KCR * KO
       T2 = ALOG(T2)
       T1 = T1 / T2
       T3 = T1 + T2
       T2 = 0.5 * ALOG(T3)
       T1 = CC1 * T2
       T2 = EXP(T1)
       DXSY = CC1 * T2
       GO TO 600

PARIS EQUATION

200 IF (NC = 2) 220, 270, 220

210 CD = D(2, 1, J)
       PN = D(2, 2, J)
       GO TO 250

270 CD = D(1, 1, J)
       PN = D(1, 2, J)
       GO TO 260

260 CALL RETARD

270 DXSY = 1
       IF (DKR - KCC(J)) 271, 275, 275

271 IF (NC = 1) 275, 272, 275

D-39
GO TO 600
275 IF (DK(1-OA(J)) 276, 278, 278
276 IF (NC-2) 278, 277, 278
277 DXD=O
GO TO 600
278 DXDEXCD*DK**PN
GO TO 600
C
FORMAN EQUATION
C
300 DXD=-1
IF (DK(1-OA(J)) 310, 330, 330
310 IF (NC-1) 330, 320, 330
320 DXD=O
GO TO 600
330 IF (DK(1-OA(J)) 340, 360, 360
340 IF (NC-2) 360, 350, 360
350 DXD=O
GO TO 600
360 IF ((1.-RE)*D(NC,3,J)-DK) 370, 370, 380
370 WRITE(6,6001)
GO TO 600
380 DXD = D(NC,1,J)*DK**D(NC,2,J)
DXD = DXD/((1.-RE)*D(NC,3,J)-DK)
GO TO 600
C
INTERPOLATION MODEL
C
400 NT=NTAB(J)
IF (NC.EQ.1) GO TO 402
NT=NT+1
402 IF (NR(1,J)) 420, 420, 410
410 CALL RETARD
420 IF (NT.LT.13) GO TO 430
WRITE(6,6002)
STOP
430 CALL INTP(NT,DK,RE,2,DXD)
RETURN
600 RETURN
700 WRITE (6,1000) NEQ(J)
STOP
1000 FORMAT (I10,NEQ(J), =I13,13H OUT OF RANGE)
6001 FORMAT(39PHOCRACK GROWTH RATE HAS GONE TO INFINITY)
6002 FORMAT(I10D, NT IS GREATER THAN 12)
END
SUBROUTINE RETARD
COMMND XX(12,25),YY(12,25),TABLE(12,25,25),FIXED,KCP,FP,KAPRF,00000010
1 PROOFX,NKTMX,NQX(12),NOY(12),NTAB(10),IPLXT,IFAIL,CUMSUM,PCYC(2)00000020
COMMND A,AP(2),ALIM,ACL(2),C,CR,CLIM,CR(10,10),C0,CUMF,00000040
1 CMELM,C1B1,DI(12,10),DK,DKE,DDOX,FA,FC,H,INC,KCL,KCL1,KCL2,00000050
KO,KOC,KCR,KCRC,KMAX,CA,NC,P1,R,RAD,RE,RYOL(2),RUL(2),00000060
3 SIG,SIGL,SIGY,SIGY(10),SMIN(422),SMAX(422),TH,00000070
4 UNIT(422),N,NTMP,DELTM,DXTMP,00000080
5 ALON,ALOCK,FLAG1,1,ICD(2),IC(2),ICR(2),ILOCK,IFIRST,IPRN(4),00000090
6 ISTEP,ITRANJ,J,KTYPE(2),NC,NEW(10),NR,NRET(10),TYPE,TITL00000100
INTEGER ALOK,ALOCK,FLAG1,ICD(2),ICR(2),ILOCK,IFIRST,IPRN(4),00000110
REAL KCL,KCL1,KCL2,KCR,KCRC,KMAX,INC00000120
REAL KAP,KNINE,KCZ,KMAX,KCP,FP,KAPRF,00000130
PZ=CRINC,1,J)00000140
IF (NRET(J)) 500,500,10
10 IF (NRET(J)-3) 20,20,500
20 J1=NRET(J)
10 IF (NC-1) 22,21,??
21 X=C
10 GO TO 23
22 X=4
23 CONTINUE
10 GO TO (46,206,300), J1

C
C WILLENBORG MODEL
C
30 RY=(KMAX/SIGY)**2
   RI=CR(NC,1,J)*2.*PI
   R1=1./RI
   RY=RY*RI
   IF (RY-AP(NC)+X) 50,40,40
   40 AP(NC)=X+RY
   RYOL(NC)=RY
   50 KAP=2.*PI*(AP(NC)-X)
   KAP=SORT(KAP)*SIGY
   KMAXF=2*KMAX-K1P
   KMINE=1+RI*KMAX-KAP
   IF (KMINE) 60,60,70
   60 KMINE=0
   70 IF (KMAXF) 50,80,90
   80 KMAXF=0
   90 DKE=KMAXF-KMINE
   RE=KMINE/KMAXF
   GO TO 430

C
C WHEELER MODEL
C
200 RY=(KMAX/SIGY)**2
   RI=CR(NC,1,J)*2.*PI
   R1=1./RI
   RY=RY*RI
   IF (RY-AP(NC)+X) 220,210,210
   210 AP(NC)=X+RY
   RYOL(NC)=RY
   220 DKE=RY*(AP(NC)-X)
   DKE=DKE**CR(NC,2,J)
   DKE=DKE*(1.0-K)*KMAX
   RE=RE
   GO TO 430

C
GRUMMAN CLOSURE MODEL

300 ALOWN=0
P2=CR(NC,1,J)
CFM1 = CR(NC,2,J)
CF0 = CR(NC,3,J)
P = CR(NC,4,J)
NSAT = CR(NC,5,J)
GAM1 = CR(NC,6,J)
BG = CR(NC,7,J)
RY=(KMAX/SICY)**2
R1=P2*2*PI
R1=1./R1
RY=R1*RY
CF2=CFM1+(CF0-CFM1)*(1+R)**P
KC2=CF2*KMAX
IF (R*KMAX-ROL(NC)*KOL) 310,320,320
310 ROL(NC)=R*KMAX/KOL
CF1=CFM1+(CF0-CFM1)*((1+ROL(NC)))**P
KC1=CF1*KOL
ACL(NC)=X
GO TO 400
320 IF (KMAX-KCL) 320,330,340
330 DKE=0
RE=0
GO TO 430
340 IF (KCI-KCL) 340,350,360
350 IF (AP(NC)-X-RY) 360,370,370
360 KCL=KCI-(KCI-KC2)*(X-ACL(NC))/RYCL(NC))**BC
GO TO 400
370 KCL=KCI
GO TO 400
380 IF (CUME+1-NSAT) 390,370,370
390 GAM=GAM1+(1-GAM1)*CUME/INSAT-1)
KCL=GAM*KMAX
ALOWN=1
400 DKE=KMAX-KCL
RE=KCL/KMAX
IF (AP(NC)-X-RY) 410,420,420
410 IF (KMAX-KOL) 430,430,420
420 KCI=KCI
KOL=KMAX
ROL(NC)=R
ACL(NC)=X
RYCL(NC)=RY
AP(NC)=ACL(NC)+RYCL(NC)
430 RETURN
500 WRITE(6,1600) NRET(J)
1000 FORMAT(11HONRET(J) = 13,13H OUT OF RANGE)
STOP
END
SUBROUTINE INTPNT(INT, XT, YT, INTPQX, F)
COMMON X(12,25), Y(12,25), TABLE(12,25), FIXED, KCPRF, KAPRF,
1 PROFX, NKTMX, NOX(12), NOY(12), NTAB(10), IPILOT, IFAIL, CUMSUN, PEY(2)
REAL KCPRF, KAPRF
NEND=0
NUMX=NOX(INT)
NUMY=NOY(INT)
IF (X(INT,1).GT.XT) GO TO 5
IF (X(INT,NUMX).GE.XT) GO TO 10
5 WRITE(6,6010) XT, NT
NEND=1
10 IF (Y(INT,1).GT.YT) GO TO 15
IF (Y(INT,NUMY).GE.YT) GO TO 20
15 WRITE(6,6020) YT, NT
NEND=1
20 IF (NEND) 30,40,30
30 STOP
40 DO 50 IJ=2,NUMX
IF (XT.LT.X(INT,1,1)) GO TO 50
50 CONTINUE
50 NX=IJ
DO 70 IJ=2,NUMY
IF (YT.LT.Y(INT,1,1)) GO TO 70
70 CONTINUE
80 NY=IJ
IF (INTPEQ.EQ.1) GO TO 100
IF (INTPEQ.EQ.2) GO TO 200
WRITE(6,6030)
STOP
C
C FOUR POINT LINEAR BIVARIATE INTERPOLATION
C
100 NXM1=NX-1
NYM1=NY-1
P=X(INT,NX)-X(INT,NXM1)
P=(XT-X(INT,NXM1))/P
Q=Y(INT,NY)-Y(INT,NYM1)
Q=(YT-Y(INT,NYM1))/Q
F00=TABLE(INT,NXM1,NYM1)
F10=TABLE(INT,NX,NYM1)
F01=TABLE(INT,NX,NYM1)
F11=TABLE(INT,NX, NY)
F=(1.-P)*(1.-Q)*F00 + P*(1.-Q)*F10
F=F + Q*(1.-P)*F01 + P*Q*F11
RETURN
C
C FOUR POINT LOG-LINEAR BIVARIATE INTERPOLATION
C
200 NXM1=NX-1
NYM1=NY-1
P=ALOG(XT/X(INT,NXM1))
P=P/ALOG(X(INT,NX)/X(INT,NXM1))
Q=Y(INT,NY)-Y(INT,NYM1)
Q=(YT-Y(INT,NYM1))/Q
F00=ALOG(TABLE(INT,NXM1,NYM1))
F10=ALOG(TABLE(INT,NX,NYM1))
F01=ALOG(TABLE(INT,NXM1,NY))
F11=ALOG(TABLE(INT,NX, NY))
F=(1.-P)*(1.-Q)*F00 + P*(1.-Q)*F10
F=F + Q*(1.-P)*F01 + P*Q*F11
RETURN

ORIGINAL PAGE IS OF POOR QUALITY
F=EXP(F)
RETURN
6010 FORMAT(1HO, 4HX = 1PE12.3, 26H IS OUT OF RANGE OF TABLE ,I4) 00000610
6020 FORMAT(1HO, 4HY = 1PE12.3, 26H IS OUT OF RANGE OF TABLE ,I4) 00000620
6030 FORMAT(1HO, Z1HERROR IN CALL TO INTP)
END

00000630
00000640
00000650
00000660
SUBROUTINE KANAL
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXFD,KCPF,KAPRF,
1 PROCX,NKMX,NMX(12),NMY(12),NTAB(10),IPL0T,IFAIL,CUMSUM,PCYC(2)
COMMON A,AP(2),ALIM,AOL(2),C,C5,C5LIM,CR(2,10,10),CUMCUM,
1 CUMFLM,C1BL1(2,10,10),DK,DKF,DXDX,FA,FC,H,INC,KCL,KC1,KCL,
2 KOA,KOC,KCRA,KCRC,KMAX,GA,OC,P,F,PAD,PE,RYCL(2),ROL(2),
3 SIG,SIGLM,SICY,SIGYS(10),SMIN(10),SMAX(422),TH,
4 UNIT(422),WDCMP,DELTMP,DXTMP,
5 ALCWH,FLCCK,FLAG1,I,ICD(2),ICK(2),ICK(2),IBLOCK,IFIRST,IPRN(4),
6 ISTEP,TRANS,J,KT,KCL(2),KCL(2),KNC,FC(10),NR,NPET(10),TYPE,TITL
INTEGER ALCWH,FLCCK,FLAG1,I,ICD(2),ICK(2),ICK(2),IBLOCK,IFIRST,IPRN(4),
REAL KCL,KC1,KCL,KOA(10),KOC(10),KCL(10),KCL(10),KMAX,KNC
REAL KCPF,KAPRF
C
KT=KTYPE(1)
GO TO (1000,2000,3000),KT
C
C
PART THROUGH CRACK
C
1000 KT=KTYPE(2)
GO TO (1020,1040,1060,1080,1100,1120,1140,1160,1180,1200,1220),
1 1240,1260,1280,1300,1320,1340),KT
C
C
PTC 01 - CENTER CRACK
C
1020 IF (C) 1070,1022,1024
1022 C=1.E-20
IC74 B=AMIN1(A,C)
B=SORT(PI*B)
ADV=POS(A/C)
FSUP=FUN1(AVCC,2)
FDYP=FUN1(AVCC,1)
FC=0.5*FSUP/SORT(COS(PI*C/W))
WJ=A/YTH
W2=(W2*P+W1-2315*W1**2-3675*W1**3+5.2*W1**4)
W2=(W2=P+W1**5+5.233*W1**6)
W1=A/YTH
FA=1.10C-9.142*W1+4.126*W1**2-8.55*W1**3+6.5*W1**4
PH124=PH12*(W1*FA/S502)+1.
PH12=PH124*(1.+12*(1.-W1)**2)
FA=FA*FDYP*PH12
GO TO 4000
C
C
PTC 02 - NO COMPACT CRACK FOR PART-THROUGH
C
1040 WRITE(6,6002)
STOP
C
C
PTC 03 - SINGLE CORNER CRACK AT MPF
C
1060 CONTINUE
B=AMIN1(A,C)
FA=SORT(PI*B)
FE=1.2133-2.265*(C/(C+RAD))+.6451*(C/(C+RAD))**2
FH=EXP(FB)
FS1=1./COS(PI*RAD/W)
FA=FA*SORT(FE*1.*FB)
ADV=POS(A/C)
FS1=FUN1(AVCC,1)
FS2=FUN1(AVCC,2)

ORIGINAL PAGE IS OF POOR QUALITY.
FA=FA*FS1
FC=PI*(C+2.*RAD)/(2.*(W-C))
FC=SQRT(1./COS(FC))*FB*SQRT(P1*B)*FS2
GO TO 4000

C

PTC 04 - DOUBLE CORNER CRACK AT HOLE

1080 CONTINUE

FA=FA*FS1
FC=PI*(C+2.*RAD)/(2.*(W-C))
FC=SQRT(1./COS(FC))*FB*SQRT(P1*B)*FS2
GO TO 4000

C

PTC 05 - SINGLE INTERNAL CRACK AT HOLE

1100 CONTINUE

FA=FA*FS1
FC=PI*(C+2.*RAD)/(2.*(W-C))
FC=SQRT(1./COS(FC))*FB*FS2
GO TO 4000

C

PTC 06 - DOUBLE INTERNAL CRACK AT HOLE

1120 CONTINUE

FA=FA*FS1
FC=PI*(C+2.*RAD)/(2.*(W-C))
FC=SQRT(1./COS(FC))*FB*FS2
GO TO 4000

C

PTC 07 - INTERPOLATION MODEL - PART-THROUGH CRACK

1140 FA=SQRT(P1*A)
FC=FA
NT=0
1142 NT=NT+1
CALL INTP(NT,C,A,1,FCC)
NT=NT+1
CALL INTP(NT,C,A,1,FAA)
\[ F_C = F_C \times F_C \]
\[ F_A = F_A \times F_A \]
\[ IF = \text{INT} - \text{NKT} \times 2 \]
\[ 1142, -4000, 4000 \]

C

**PTC 09 - PIN LOADED LUG, SINGLE CORNER CRACK**

\[ Z = (C + 2 \times \text{RAD}) / 2 \]
\[ E = C / 2 \]
\[ F = E / 2 \]
\[ R = A - E \]
\[ F_S = 2 \times \text{RAD} \]
\[ F_S = 7 / \text{BP} \]
\[ PHCP = \text{FUNT1}(F_S) \]
\[ PHCP = \text{PHCP} / \text{SORT}(1 - F_S) \]
\[ PHCP = 1.08 \times F_S + 2.69 \times F_S^{**2} - 49 \times F_S^{**3} \]
\[ PHCP = 1.08 \times F_S + 2.69 \times F_S^{**2} - 16 \times F_S^{**3} \]
\[ PHCP = \text{PHHP} / \text{SORT}(1 - F_S) \]
\[ PHCP = \text{PHCP} \times \text{PHHP} / \text{PHWP} / 2 \]
\[ PHCP = \text{PHCP} \times \text{PHHP} / \text{PHWP} / 2 \]
\[ PHCP = \text{PHCP} \times \text{PHHP} / \text{PHWP} / 2 \]

D-47
\[ B = \frac{W}{2} \]
\[ Z = R A D + C \]
\[ P H C P = F U N T 1 (Z / B) \]
\[ F S 1 = 2. * Z / W \]
\[ F S 2 = 2. * Z / H \]
\[ P H W P = 1. - 0.5 * F S 1 + 0.957 * F S 1 * 2 - 0.16 * F S 1 * 3 \]
\[ P H W P = P H W P / S O R T (1. - F S 1) \]
\[ P H W P = 1. - 0.08 * F S 2 + 2.69 * F S 2 * 2 - 0.91 * F S 2 * 3 \]
\[ P H P = (P H C P + P H W P * P H H P) / 2. \]

**PTC 10 - PIN LOADED LUG, SINGLE INTERNAL CRACK**

\[ 1200 \]
\[ Z = (C / 2. + 2. * R A D) / 2. \]
\[ E = C / 2. \]
\[ B = W / 2. \]
\[ B P = B - E \]
\[ F S 1 = 2. * Z / H \]
\[ F S 2 = Z / B P \]
\[ P H C P = F U N T 1 (F S 2) \]
\[ P H C P = P H C P / S O R T (1. - F S 2) \]
\[ P H W P = 1. - 0.08 * F S 1 + 2.69 * F S 1 * 2 - 0.99 * F S 1 * 3 \]
PHCP=1.0+*FS2+.9*7*FS2**2-.16*FS2**3
PHHP=PHCP/SQRT(1.-FS2)
PHS=(PHCP+PHHP)/2.*
PHD=PHP*SORT(1.+(7*E)/(2.-E)/W.*
PHGS=FUNCT2(FS2)
PHCS=PHCS/SQRT(1.-FS2)
PHSL=FUNCT2(FS1)
PHSS=PHSS*SQRT(1./COS(P1*Z/(2.*P.)))
S=0/(C+RAD)
FHP=EXP(1.-2133-2.*205*5+.6451*5.*S)
PHD=(PHCS+PHSS)*FHP/2.*
FCP=PHS+SORT(P1*C)/(2.*W*TH)
FC=FCP+PHP*SQRT((7-E)/(2.*E))/SORT(P1*Z)/(2.*H)
DI=AMIN1(A,C)
ADVC=A/C
FS=SQRT(P1*C)/SQRT(P1*C)
FA=FUNCT1(ADVC,1)
FC=FCFA/1.122*FS.
Z=(C+2.*RAD)/2.*
E=C/2.*
D=W/2.*
F=6-E
FS1=2.*Z/M
FS2=RAD/YB
PHCP=FUNCT1(FS2)
PHCP=PHCP/SQRT(1.-FS2)
PHHP=1.08*FS1+.6451*FS1**2-.9*FS1**3
PHHP=1.+5*FS2+.9*7*FS2**2-.16*FS2**3
PHHP=PHHP/SQRT(1.-FS2)
PHD=(PHCP+PHHP)/2.*
PHCS=FUNCT2(FS2)
PHCS=PHCS/SQRT(1.-FS2)
PHSS=FUNCT3(FS1)
PHSS=PHSS*SQRT(1./COS(P1*Z/(2.*R.)))
S=C/(C+RAD)
FHP=EXP(1.2133-2.*205*5+.6451*5.*S)
PHD=(PHCS+PHSS)*FHP/2.*
FCP=PHS+SORT(P1*C)/(2.*W*TH)
FC=FCP+PHP*SQRT((7-E)/(2.*E))/SORT(P1*Z)/(2.*H)
FA=FUNCT1(ADVC,1)
FA=FCFA/1.122*FS-
GO TO 4000

C
PIC 11 - PIN LOADED LUG, TWO INTERNAL CRACKS

C
1220 S=W/2.*
Z=RAD+C
PHCP=FUNCT1(Z/B)
FS1=2.*Z/W
FS2=2.*Z/H
PHCP=PHCP/SQRT(1.-FS1)
PHHP=1.+5*FS1+.6451*FS1**2-.16*FS1**3
PHHP=PHHP/SQRT(1.-FS1)
PHHP=1.+5*FS2+.6451*FS2**2-.16*FS2**3
PHD=(PHCP+PHHP)/2.*
PHCS=FUNCT2(Z/B)
PHCS=PHCS/SQRT(1.-FS1)
PHCS=FUNCT3(FS2)
PHSS=PHSS*SQRT(1./COS(P1*Z/W))

D-49
\[ S = \frac{C}{(R_A + C)} \]
\[ F_B = \exp(1.2133 - 2.086S + 0.8727S^2) \]
\[ P_H = (P_H \times P_H) + P_C \]
\[ F_C = 1.05 + P_H / (2.046 + S^2) \]
\[ D_1 = A_M / (A_1, A_C) \]
\[ A_D = A_C / P_H \]
\[ F_S = \sqrt{1.101P_H + P_S} / (2.046 + W_{TH}) \]
\[ F_A = \text{FUN}_1(A_1, A_C) \]
\[ F_A = \frac{F_A}{1.122} \]
\[ B = W / 2 \]
\[ Z = \text{RAD} + C \]
\[ F_S_1 = \text{RAD} / B \]
\[ P_H = \text{FUN}_1(F_S_1) \]
\[ F_S_2 = 2.0 / Z / H \]
\[ P_H = \text{PH} / \text{SORT}(1., -F_S_1) \]
\[ P_H = 1.05 + P_H / (2.046 + S^2) \]
\[ F_C = 1.05 + P_H / (2.046 + S^2) \]
\[ F_B = \exp(1.2133 - 2.086S + 0.8727S^2) \]
\[ P_H = (P_H \times P_H) + P_C \]
\[ F_S_1 = A_M / (A_1, A_C) \]
\[ F_S_2 = 2.0 / Z / H \]
\[ P_H = \text{FUN}_1(A_1, A_C) \]
\[ F_A = \text{FUN}_1(A_1, A_C) \]
\[ F_A = \frac{F_A}{1.122} \]
\[ B = W / 2 \]
\[ Z = \text{RAD} + C \]
\[ F_S_1 = \text{RAD} / B \]
\[ P_H = \text{FUN}_1(F_S_1) \]
\[ F_S_2 = 2.0 / Z / H \]
\[ P_H = (P_H \times P_H) / F_B \]
\[ F_Q = 1.05 + P_H / (2.046 + S^2) \]
\[ F_Q = F_0 + P_H / (2.046 + S^2) \]
\[ F_A = \text{FUN}_1(A_1, A_C) \]
\[ F_A = \frac{F_A}{1.122} \]
\[ B = W / 2 \]
\[ Z = \text{RAD} + C \]
\[ F_S_1 = \text{RAD} / B \]
\[ P_H = \text{FUN}_1(F_S_1) \]
\[ F_S_2 = 2.0 / Z / H \]
\[ P_H = (P_H \times P_H) / F_B \]
\[ F_Q = 1.05 + P_H / (2.046 + S^2) \]
\[ F_Q = F_0 + P_H / (2.046 + S^2) \]
\[ F_A = \text{FUN}_1(A_1, A_C) \]
\[ F_A = \frac{F_A}{1.122} \]
\[ B = W / 2 \]
\[ Z = \text{RAD} + C \]
\[ F_S_1 = \text{RAD} / B \]
\[ P_H = \text{FUN}_1(F_S_1) \]
\[ F_S_2 = 2.0 / Z / H \]
\[ P_H = (P_H \times P_H) / F_B \]
\[ F_Q = 1.05 + P_H / (2.046 + S^2) \]
\[ F_Q = F_0 + P_H / (2.046 + S^2) \]
\[ F_A = \text{FUN}_1(A_1, A_C) \]
\[ F_A = \frac{F_A}{1.122} \]
\[ B = W / 2 \]
\[ Z = \text{RAD} + C \]
\[ F_S_1 = \text{RAD} / B \]
\[ P_H = \text{FUN}_1(F_S_1) \]
\[ F_S_2 = 2.0 / Z / H \]
\[ P_H = (P_H \times P_H) / F_B \]
\[ F_Q = 1.05 + P_H / (2.046 + S^2) \]
\[ F_Q = F_0 + P_H / (2.046 + S^2) \]
\[ F_A = \text{FUN}_1(A_1, A_C) \]
\[ F_A = \frac{F_A}{1.122} \]
1246 FO=1.122*SORT(B)*FW
1248 FA=FO*SORT(PI*D1)/SORT(PI*C)*FU:P1(ADVVC,1)
   GO TO 4000
C
C PTC 13 - DOUBLE CORNER CRACK AT DOUBLE NOTCH
C
1260 B=H
   FS2=.752+2.02*((B+C)/(W/2.))+.37*(1.-SIN(PI*(B+C)/W))**3
   FW=FS2/COS(PI*(B+C)/W)/1.122
   FW=FW*SORT(W/PI/(B+C)*TAN(PI*(B+C)/W))
   FS1=RAD/B
   IF (FS1.LT. .01) GO TO 1264
   S=C/(B+C)
   FC =FUNT4(S,FS1)
   FC=FC*FW*SORT(PI*C)
   GO TO 1264
1262 FC=1.122*SORT(B+C)*FW
1264 ADVVC=A/C
   D1=AMIN1(A,C)
   FW=(1.+1.122*COS(PI*(B+C)/W))**3*COS(PI*(B+C)/W)
   FC=FC*FW/FS2
   FC=FC*SORT(PI*D1)/SORT(PI*C)*FUNK1(ADVVC,2)
   FS2=.752+2.02*((B+C)/(W/2.))+.37*(1.-SIN(PI*(B+C)/W))**3
   FW=FS2/COS(PI*(B+C)/W)/1.122
   FW=FW*SORT(W/PI)/(PI/(B+C)*TAN(PI*(B+C)/W))
   FS1=RAD/B
   IF (FS1.LT. .01) GO TO 1264
   S=C/(B+C)
   FC =FUNT4(S,FS1)
   FC=FC*FW*SORT(PI*C)
   GO TO 1264
C
C PTC 14 - SINGLE INTERFAL CRACK AT SINGLE NOTCH
C
1280 B=H
   FS2=.752+2.02*((B+C)/(W/2.))+.37*(1.-SIN(PI*(B+C)/W))**3
   FW=FS2/COS(PI*(B+C)/W)/1.122
   FW=FW*SORT(W/2.+PI/(B+C)*TAN(PI*(B+C)/W)/2.))
   FS1=RAD/B
   IF (FS1.LT. .01) GO TO 1292
   S=C/(B+C)
   FC =FUNT4(S,FS1)
   FC=FC*FW*SORT(PI*C)
   GO TO 1294
1282 FC=1.122*SORT(B+C)*FW
1284 ADVVC=A/C
   D1=AMIN1(A,C)
   FC=FC*SORT(PI*D1)/SORT(PI*C)*FUNK1(ADVVC,1)/1.122
C
C FS2=.752+2.02*((B+C)/(W/2.))+.37*(1.-SIN(PI*(B+C)/W))**3
   FW=FS2/COS(PI*(B+C)/W)/1.122
   FW=FW*SORT(W/2.+PI/(B+C)*TAN(PI*(B+C)/W)/2.))
   FS1=RAD/B
   IF (FS1.LT. .01) GO TO 1286
S=C/B
FQ =FUNT4(S,FS1)
FQ=FQ*FW*SQR(P*C)
GO TO 1288

1286 FA=FQ*SORT(P*D1)/SORT(P*C)*FUnP1(ADV1C,2)/1.122
GO TO 4000

C
PTC 15 - DOUBLE INTERNAL CRACK AT DOUBLE NOTCH

1300 B=H
FS2=.752+2.02*((B+C)/(W/2))+.37*(1.-SIN(P*(B+C)/W))**3
FW=FS2/COS(P*(B+C)/W)/1.122
FQ=FW*SORT(W/P*(B+C)*TAN(P*(B+C)/W))
FS1=RAVD/B
IF (FS1.LT. .01) GO TO 1302
S=C/(B+C)
FC=FUN4(S,FS1)
FC=FC*FW*SORT(P*C)
GO TO 1304

1302 FC=1.122*SORT(B+C)*FW

1304 ADV1C=A/C
D1=AMINI(A,C)
FW=(1.+1.122*(COS(P*(R+C)/W))**4)*COS(P*(B+C)/W)
FC=FC*FW/FS2
FC=FC*SORT(P*D1)/SORT(P*C)*FUnP1(ADV1C,1)/1.122
FS2=.752+2.02*(B/(W/2)+.37*(1.-SIN(P*(B+C)/W))**3
FW=FS2/COS(P*(B+C)/W)/1.122
FQ=FW*SORT(W/P/B*TAN(P*(B+C)/W))
FS1=RAVD/B
IF (FS1.LT. .01) GO TO 1306
S=C/B
FQ =FUn4(S,FS1)
FQ=FQ*FW*SORT(P*C)
GO TO 1308

1306 FC=1.122*SORT(B+C)*FW

1308 CONTINUE
FW=(1.+1.122*(COS(P*(B+C)/W))**4)*COS(P*(B+C)/W)
FC=FC*FW/FS2
FA=FC*SORT(P*D1)/SORT(P*C)*FUnP1(ADV1C,2)/1.122
GO TO 4000

C
PTC 16 - CORNER CRACK OUT NF SHOULDER

1320 B1=(W-H)/2.
S1=C/(C+B1)
FC=W/P*(C+B1)*TAN(P*(C+B1)/W)
FC=SORT FC
FC=FC*(1.+1.122*(COS(P*(C+B1)/W))**4)/1.122
FC=FC*SORT(P*C)*FUnT4(S1,C1B1)
ADV1C=A/C
D1=AMINI(A,C)
FC=FC*SORT(P*D1)/SORT(P*C)*FUnP1(ADV1C,2)
B1=(W-H)/2.
S1=C/B1
FC=W/P/B1*TAN(P*B1/W)
FC=FQ*(1.+1.122*(COS(P/B1/W))**4)
FA=FQ*SORT(P+C)*FUnP1(S1,C1B1)
FA=FQ*SORT(P*D1)/SORT(P*C)*FUnP1(ADV1C,1)
GO TO 4000

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PTC 17 - INTERNAL CRACK OUT OF SHOULDER

1340 B1 = (W-H)/2
S1 = C/(C+B1)
FC = w/PI/(C+B1)*TAN(PI*(C+B1)/W)
FC = SORT(FC)
FC = FC*(1.122*(COS(PI*(C+B1)/W))^4)/1.122
FC = FC*SCRT(PI*C)*FINT((S1,C1B1)
ACVC = A/C
D1 = MIN1(A,C)
FC = FC*SCRT(PI*D1)/SCRT(PI*C)*FINT(ACVC,1)
B1 = (W-H)/2
S1 = C/B1
FC = w/PI/B1*TAN(PI*B1/W)
FC = FC*(1.122*(COS(PI*B1/W))^4)
FC = FC*SCRT(PI*C)*FINT(S1,C1B1)
FA = FC*SCRT(PI*D1)/SCRT(PI*C)*FINT(ACVC,2)
GO TO 4000

C

TRANSITION CRACK

2000 CHOPLD = C
C = (C+B1)/2

C

KT = KTYPE(2)
GO TO (3020,3040,3060,3080,3100,3120,3140,3160,3180,3200,3220,3240,3260,3280,3300,3320,3340,3360,3380,3400,3420,3440,3460)

C

2100 C = CHOPLD
FA = 1.0 - SORT(1.0 - (CF/C)**2)
FA = CF/(C*FA)
FA = SORT(FA)*FC
GO TO 4000

C

THROUGH CRACK EQUATIONS

3000 KT = KTYPE(2)
GO TO (3020,3040,3060,3080,3100,3120,3140,3160,3180,3200,3220,3240,3260,3280,3300,3320,3340,3360,3380,3400,3420,3440,3460)

C

TC 01 - CENTER CRACKED PANEL

3020 Z = PI*C
C = SORT(Z)
Z = COS(Z/W)
Z = 1.0/Z
Z = SORT(Z)
FC = 1.0/Z
FA = FC
IF (KTYPE=1.0) GO TO 2100
GO TO 4000

C

TC 02 - COMPACT SPECIMEN

3040 W1 = C/W
W2 = SORT(W1)
FC = 15.4*W2 - 145.5*W1*W2
W2 = W2*W1*W1
FC = FC + 655.7*W2 - 1017.9*W2*W1

D-53

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\[ N_2 = W_2^* \]
\[ W_1 * N_1 \]
\[ FC = FC + 638.9 * W_2 \]
\[ FC = FC / TH \]
\[ FC = FC / \text{SORT}(W) \]
\[ FA = 0 \]
\[ \text{IF (KTYPE(1).EQ.2) GO TO 2100} \]
\[ \text{GO TO 4000} \]

**TC 03, 05 - SINGLE THROUGH CRACK AT HOLE**

\[ s = C / (R + A) \]
\[ FB = \text{EXP}(1.2133 - 2.205 * S + .6451 * S * S) \]
\[ FC = \text{COS}\left((C + 2.*RAD) * \text{PI} / (2.*W - C)\right) \]
\[ FC = \text{SORT}(1./FC) \]
\[ FC = FC * \text{SORT}(PI*C) * FB \]
\[ FA = 0 \]
\[ \text{IF (KTYPE(1).EQ.2) GO TO 2100} \]
\[ \text{GO TO 4000} \]

**TC 04, 06 - DOUBLE THROUGH CRACK AT HOLE**

\[ s = C / (R + A) \]
\[ FB = \text{EXP}(1.2133 - 2.205 * S + .6451 * S * S) \]
\[ FC = \text{COS}\left((C + 2.*RAD) * \text{PI} / (2.*W - C)\right) \]
\[ FC = \text{SORT}(1./FC) \]
\[ FC = FC * \text{SORT}(PI*C) \]
\[ FA = 0 \]
\[ \text{IF (KTYPE(1).EQ.2) GO TO 2100} \]
\[ \text{GO TO 4000} \]

**TC 07 - INTERPOLATION MODEL - THROUGH CRACK**

**TC 08, 10 - PIN LOADED LUG, SINGLE THROUGH CRACK**

\[ Z = (C + 2.*RAD) / 2 \]
\[ F = C / 2 \]
\[ B = W / 2 \]
\[ BP = B - F \]
\[ FS1 = Z * Z / W \]
\[ FS2 = Z / BP \]

\[ \text{PCH} = \text{FUNT1}(FS2) \]
\[ \text{PCH} = \text{PCH} / \text{SORT}(1.-FS2) \]
\[ \text{PPHP} = 1.08 * FS1 + 2.60 * FS1 * FS2 + 0.99 * FS1 * FS2 + 0.95 * FS2 + 2.016 * FS2 + 2 * FS2 \]
\[ \text{PPHP} = \text{PPHP} / \text{SORT}(1.-FS2) \]
\[ \text{PHP} = (\text{PCH} * \text{PPHP}) / 2 \]
\[ \text{PHP} = \text{PHP} * \text{SORT}(1.+(Z+E)/(Z-E))/9. \]
\[ \text{PHCS} = \text{FUNT2}(FS2) \]
\[ \text{PHCS} = \text{PHCS} / \text{SORT}(1.-FS2) \]
\[ \text{PNS} = \text{FUNT3}(FS1) \]
\[ \text{PNS} = \text{PNS} * \text{SORT}(1./\text{COS}(PI*Z/(2.*BP))) \]
\[ S = C / (C + RAD) \]
\[ FB = \text{EXP}(1.2133 - 2.205 * S + .6451 * S * S) \]
\[ \text{PHS} = (\text{PHCS} * \text{PNS}) * FB / 2 \]
FCP = PHS * SQRT(PI*C) / (2.*W*TH)  
FC = FCP + PHP * SQRT((Z-F)/(Z+F)) / SQRT(PI*Z) / (2.*TH)  
FA = 0.  
IF (KTYPE(1).EQ.2) GO TO 2100  
GO TO 4000  

TC 09, 11 - PIN LOADED LUG, DOUBLE THROUGH CRACKS  

3180 G = W / 2.  
Z = RAD + C  
PHCP = FUNT2(Z/B)  
FS1 = 2.*Z/W  
FS2 = 2.*Z/H  
PHCP = PHCP / SQRT(1.-FS1)  
PHWP = 1.*FS1 + 957*FS1**2 - 16*FS1**3  
PHWP = PHWP / SQRT(1.-FS1)  
PHWP = 1.*FS1**2 + 2.66*FS2**2 - 91*FS2**3  
PHP = (PHCP + PHWP + PHHP) / 2.  
PHHC = FUNT2(Z/B)  
PHCS = PHCS / SQRT(PI*Z)  
PHSS = PHSS / SQRT(1./COS(PI*Z/W))  
S = C / (RAD + C)  
FF = EXP(1.2133 - 2.06*FS + 927*FS**2)  
PHS = (PHCS + PHSS) / FF / 2.  
FC = FS1/PHP / (Z*TH*SQRT(PI*Z))  
FC = FC + PHP / SQRT(PI*C) / (2.*W*TH)  
FA = 0.  
IF (KTYPE(1).EQ.2) GO TO 2100  
GO TO 4000  

TC 12, 14 - SINGLE CRACK AT SINGLE NOTCH  

3240 R = H  
FS2 = .752 + 2.*((E + C)/W) + .37*(1.-SIN((PI*(R+C))/W*2.))**3  
FW = FS2 / COS(PI*(R+C))/W/2.) / 1.122  
FW = FW / SQRT((W_PI/(R+C)*TAN(PI*(R+C))/W))  
FS1 = RAD / B  
IF (FS1.LT. .01) GO TO 3242  
S = C / (R+C)  
FC = FUNT4(S, FS1)  
FC = FC * FW * SQRT(PI*C)  
GO TO 3244  

3242 FC = 1.122 * SQRT(B+C) * FW  
3244 FA = 0.  
IF (KTYPE(1).EQ.2) GO TO 2100  
GO TO 4000  

TC 13, 15 - DOUBLE CRACK AT DOUBLE NOTCH  

3260 R = H  
FS2 = .752 + 2.*((E + C)/(W*2.)) + .37*(1.-SIN((PI*(R+C))/W**2.))**3  
FW = FS2 / COS(PI*(R+C))/W/1.122  
FW = FW / SQRT(W_PI/(R+C)*TAN(PI*(R+C))/W))  
FS1 = RAD / B  
IF (FS1.LT. .01) GO TO 3262  
S = C / (R+C)  
FC = FUNT4(S, FS1)  
FC = FC * FW * SQRT(PI*C)  
GO TO 3264  

D-55
I
3262 FC=1.122*SQR(B+C)*FW  
3264 FA=0.  
FW=(1.+122*(COS(PI*(E+C)/W))**4)*COS(PI*(B+C)/W)  
FC=FC*FW/FS2  
IF KTYPE1.EQ.2) GO TO 2100  
GO TO 4000  
C
C TC 16,17 - CRACK OUT OF SHOULDER  
C
3320 B1=(W-H)/2.  
S1=C/(C+B1)  
FC=W/PI/(C+B1)*TAN(PI*(C+B1)/W)  
FC=FC*(1.+122*(COS(PI*(C+B1)/W))**4)/1.122  
FC=FC*SQRT(PI*C)*FNT4(S1,C1B1)  
FA=0.  
IF KTYPE1.EQ.2) GO TO 2100  
GO TO 4000  
C
4000 RETURN  
6002 FORMAT(1HC,'NO COMPACT CRACK FOR PART-THROUGH')  
END
```plaintext
FUNCTION FUMPI(X,IX)
DIMENSION ADVC(25),FUNS(25,2)
C
DATA ADVC /0.,.04,.07,.12,.15,.21,.34,.58,.72,.775,.86,.9,.15,1.25,1.49,1.785,2.375,3.45,5.6,6.6,10.,25.,50.,100.,1000.,10000.,10600,1/
DATA FUNS /1.122,1.11,1.1,1.08,1.07,1.04,0.97,0.84,0.77,0.75,0.71,0.655,0.65,0.63,0.61,0.57,0.54,0.43,0.35,0.31,0.17,0.1,0.05,0.,0.,
2 0.,0.,17.,27.,37.,42.,5.,6.,71.,74.,75.,76.,775.,775.,82.,86.,
3 9.,96.,975.,99.,998.,1.,1.,1.,1.,1.,1./
C
IF (ADVC(1).GT.X) GO TO 5
IF (ADVC(25).GE.X) GO TO 10
5 WRITE (*,6000) X
STOP
10 DO 20 I=2,24
IF (X.LT.ADV(I)) GO TO 30
20 CONTINUE
I=2+
30 J=I-1
T=ADVC(I)-ADVC(J)
T=(X-ADVC(I))/T
FUMPI=FUNS(J,IX)+T*(FUNS(I,IX)-FUNS(J,IX))
RETURN
C
6000 FORMAT(1X0,*FUMPI: X= *,1DF12.3,* IS OUT OF RANGE*)
END
```

**ORIGINAL PAGE IS OF POOR QUALITY**
FUNCTION FUNT1(X)

C DIMENSION VALUE(14),FUNS(14)

C DATA VALUE /0.06,0.12,0.19,0.34,0.48,0.54,0.6,0.72,0.8,0.86,0.96,1/
C DATA FUNS /1.06,1.06,1.24,1.3,1.36,1.38,1.395,1.395,1.38,1.36,1.32,1.297/

C IF (VALUE(1).GT.X) GO TO 5
C IF (VALUE(14).GE.X) GO TO 10
C 5 WRITE(6,6000) X
C STOP
C 10 DO 20 I=2,14
C IF (X.LE.VALUE(I)) GO TO 30
C CONTINUE
C I=14
C 30 J=I-1
C T=VALUE(I)-VALUE(J)
C T=(X-VALUE(I))/T
C FUNT1=FUNS(J)+T*(FUNS(I)-FUNS(J))
C RETURN

C 6000 FORMAT(1HO,*FUNT1: X = '1PE12.3,* IS OUT OF RANGE!)
C END
FUNCTION FINT2(X)
C
DIMENSION VALUE(16),FUNS(16)
C
DATA VALUE /0,1,2,3,4,5,6,7,8,9,10,11,12,13,
1 14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30/
C
DATA FUNS /1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20/
1 21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40/
C
IF (VALUE(1).GT.X) GO TO 5
IF (VALUE(16).GT.X) GO TO 10
5 WRITE(6,6000) X
STOP
10 DO 20 I=2,16
IF (X.LE.VALUE(I)) GO TO 30
20 CONTINUE
I=16
30 J=I-1
T=VALUE(J)-VALUE(I)
T=(X-VALUE(J))/T
FINT2=FUNS(J)+T*(FUNS(1)-FUNS(J))
RETURN
C
6000 FORMAT(10H,'FINT2: X = ',1PE12.3,' IS OUT OF RANGE')
END
FUNCTION FUNT3(X)
C
DIMENSION VALUE(16), FUNS(16)
C
DATA VALUE /0., 1.666, 2., 2.25, 3.333, 5., 5.714, 6.315, 8., 8.888, 10.909, 1.2632, 1.6, 2.1819, 2.6666, 4.8007/
C
1 1
DATA FUNS /1., 1.057, 1.0666, 1.075, 1.0916, 1.25, 1.3333, 1.4166, 1.625, 1.75, 2., 2.24, 2.72, 3.64, 4.416, 8.16/
C
IF (VALUE(I).GT.X) GO TO 5
IF (VALUE(I).GE.X) GO TO 10
5 WRITE(6,6000) X
STOP
10 DO 20 I=2,16
1 IF (X.LE.VALUE(I)) GO TO 30
20 CONTINUE
I=16
30 J=I-1
T=VALUE(I)-VALUE(J)
FUNT3=FUNS(J)+T*(FUNS(I)-FUNS(J))
RETURN
C
6000 FORMAT(1HO,'FUNT3: X = ',1PE12.3,' IS OUT OF RANGE*')
END
FUNCTION FUN4(S,R)

DIMENSION SVAL(S),RVAL(R),TABL(R,C)

DATA SVAL /0.01,0.05,1.2,3.4,6.8,1/
DATA RVAL /0.02,0.25,3.33,5.1,2.14,1.01/
DATA TABL /1.12,1.35,2.35,1.51,1.22/

IF (S.LT.SVAL(1)) GO TO 1000
IF (S.GT.SVAL(S)) GO TO 1000
IF (R.LT.RVAL(1)) GO TO 2000
IF (R.GT.RVAL(8)) GO TO 2000

DO 10 IS=2,9
   IF (S.LT.SVAL(IS)) GO TO 20
10 CONTINUE
   IS=9
20 DO 30 IR=2,6
   IF (R.LT.RVAL(IR)) GO TO 40
30 CONTINUE
   IR=8
40 ISM1=IS-1
   IRM1=IR-1
   PS=SVAL(IS)-SVAL(ISM1)
   PS=(S-SVAL(ISM1))/PS
   PR=RVAL(IR)-RVAL(IRM1)
   PR=(R-RVAL(IRM1))/PR
   FUN4=1-PS/(1-PR)*TABL(ISM1,ISM1)+PS*(1-PR)*TABL(IRM1,IS)
   FUN4=PR*TABL(IS,IR)
RETURN

1000 WRITE(6,6000) S
STOP
2000 WRITE(6,6000) R
STOP

6000 FORMAT(1HC,FUNT4: S = ',1PE12.3, I S O U T O F R A N G E *)
6005 FORMAT(1HC,FUNT4: R/B = ',1PE12.3, I S O U T O F R A N G E *)
END
FUNCTION FUNT5(R, S)

C

DIMENSION SVAL(11), RVAL(11), TABL(11,11)

C

DATA SVAL /1.0, 1.02, 1.05, 1.07, 1.1, 1.15, 1.2, 1.3, 1.5, 2.0, 3.0/
DATA RVAL /0.02, 0.04, 0.06, 0.08, 0.1, 0.12, 0.14, 0.16, 0.2, 0.26, 0.3/
DATA TABL /1.75, 3.0, 4.0, 4.5, 5.5, 6.0, 7.0, 8.0, 8.5, 9.0, 9.5/

1 1.2, 1.75, 2.8, 3.5, 4.0, 4.3, 4.7, 5.0, 6.0, 6.5, 7.0
2 0.95, 1.38, 1.85, 2.3, 3.3, 3.6, 4.0, 4.5, 5.0, 5.5, 6.0
3 0.87, 1.25, 1.63, 2.0, 2.7, 3.1, 3.5, 4.0, 4.5, 5.0, 5.5
4 0.82, 1.12, 1.5, 1.87, 2.3, 3.3, 3.6, 4.0, 4.5, 5.0, 5.5
5 0.75, 1.15, 1.5, 2.0, 2.4, 2.9, 3.5, 4.0, 4.5, 5.0, 5.5
6 0.71, 1.1, 1.45, 1.85, 2.25, 2.5, 3.25, 3.5, 4.0, 4.5, 5.0
7 0.55, 1.1, 1.42, 1.84, 2.25, 2.5, 3.25, 3.5, 4.0, 4.5, 5.0
8 0.44, 1.35, 2.3, 3.5, 4.0, 4.5, 5.0, 6.0, 8.0, 9.0, 10.0
9 0.36, 1.7, 2.5, 3.5, 4.0, 5.0, 6.0, 6.5, 7.0, 9.0, 10.0
A 0.18, 3.5, 5.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 12.0

C

IF (S.GT.SVAL(11)) GO TO 1000
IF (R.GT.RVAL(11)) GO TO 2000
IF (S.GE.SVAL(1)) GO TO 5
S=1.01
IF (R.GE.RVAL(1)) GO TO 6
R=.02
6 CONTINUE

C

DO 10 IS=2, 11
IF (S.LT.SVAL(IS)) GO TO 20
10 CONTINUE
IS=11
20 DO 30 IR=2, 11
IF (R.LT.RVAL(IR)) GO TO 40
30 CONTINUE
IR=11
40 ISM1=IS-1
IRM1=IR-1
PS=SVAL(IS)-SVAL(ISM1)
PS=(S-SVAL(ISM1))/PS
PR=RVAL(IR)-RVAL(IRM1)
PR=(R-RVAL(IRM1))/PR
FUNT5=(1.-PS)*(1.-PR)*TABL(IRM1,ISM1)+PS*(1.-PR)*TABL(IRM1,IS)
FUNT5=FUNT5+PR*(1.-PS)*TABL(IR,ISM1)+PS*PR*TABL(IS,IR)
RETURN

C

1000 WRITE(6,6000) S
STOP
2000 WRITE(6,6005) R
STOP

C

6000 FORMAT(1HO,'FUNT5: W/H = ',1PE12.3,' IS OUT OF RANGE')
6005 FORMAT(1HO,'FUNT5: RAD/H = ',1PE12.3,' IS OUT OF RANGE')
END
PROGRAM SCPLCT

PROGRAM SCPLCT(INPUT,OUTPUT,TAPER=INPUT,TAPES=INPUT,
TAPE6=OUTPUT,PLT)

THE ROUTINE GENERATE PLTS ON AN SC4020 FROM A PREVIOUSLY
GENERATED DATA FILE

CONSTANTS AND DATA DECLARATIONS

INTEGER CDTITL,CDDATA,CDEND,CDHDR1,CDHDR2,CDHDR3,CDHDR4
INTEGER CDHDR5,CDHDR6,Y1SYM,Y2SYM
INTEGER TITLE(6),FHDRS(4,6)
INTEGER TITLE(9),FHDRS(13,6)
INTEGER CDTYPE,NOPTS,NPLTS,NLABS,MAXPTS,CAMRAS,AADARY(4)
INTEGER NPLTUS,PFLG,RX1,RX2,RX3,RX4,RX5,RY1,RY2,RY3,RY4
INTEGER BI+1,RI+1

MAX OF 200 DATA POINTS

REAL XVAL(2,1),Y1VAL(201),Y2VAL(201)
REAL XMAX,Y<AX,YMIN,YMIN
REAL XMAXIN,XMAXIN,XMININ,YMININ
REAL XINCIN,YINCIN,XINC,YINC
REAL CYPHLK,X1,Y1,Y2
REAL XBI+1,AH
REAL YMATST(4)

CALL CDTITL/4HTITL/
CALL CDDATA/4HDATA/
CALL CDEND/4HEND/
CALL CDHDR1/4HDHDR1/
CALL CDHDR2/4HDHDR2/
CALL CDHDR3/4HDHDR3/
CALL CDHDR4/4HDHDR4/
CALL CDHDR5/4HDHDR5/
CALL CDHDR6/4HDHDR6/
CALL Y1SYM/1SYM/
CALL Y2SYM/1SYM/
CALL MXOPTS/200/
CALL YMATST/.1.5.1.5.1.

INITIALIZE

XMIN = 0.
YMIN = 0.
NPLTS = 1

READ PARAMETER CARD

REAL (5,100) XMAXIN,XMAXIN,XINCIN,YINCIN,CAMRAS,
AADARY

1000 FOR AT (4F1.4,4.4A6)

PRINT INPUT SPECIFICATIONS

WHILE (6.20.0)
```
PROGRAM SCPLLOT

2000 FOR AT (/# INPUT SPECIFICATIONS# )/
   WRITE (6,2010) XMAXIN,YMAXIN,XINCI N,YINCIN,CAMRAS,
   ADARY
2010 FOR AT (/# MAXIMUM X =, 1PE10.3/
   # MAXIMUM Y =, 1PE10.3/
   # INCREMENT X =, 1PE10.3/
   # INCREMENT Y =, 1PE10.3/
   # CAMRAS =, 13/
   # SPECIAL INSTRUCTIONS =, 4A6/////)  
65 DEF ULT SETTING* IF NOT INPUT
   IF (CAMRAS .LE. 0) CAMRAS = 35
70 START PLOT
   CALL IDENT (CAMRAS,ADARY)
   INITIAL READ
75 READ (A,1014,END=999) CUTYPE,TITLE,CYPPLK
   READ (A,1014) CUTYPE,TITLE,CYPPLK
   IF (EOF(8)) 999,35
80 MAIN PGM LOGIC
   CALL PRINTV (-20,20HAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA,300,100)
   CALL PRINTV (-20,20HBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBB,2R0,100)
   CALL PRINTV (-20,20HCCCCCCCCCCCCCCCCCCCCCCCCC,260,100)
   CALL PRINTV (-20,20HDDDDDDDDDDDDDDDDDDDDDDDDDD,240,100)
   CALL PRINTV (-20,20HEEEEEEEEEEEEEEEEEEEEEEEEEE,220,100)
   CALL PRINTV (-20,20HFFFFFFFFFFFFFFFFFFFFF,200,100)
   CALL FRAMEV(3)
30 CONTINUE
90 NPOINTS = NPOINTS + 1
   INPUT DATA FOR A PLOT
95 READ (A,1014,END=999) CUTYPE,TITLE,CYPPLK
   READ (A,1014) CUTYPE,TITLE,CYPPLK
   IF (EOF(8)) 999,32
1010 FOR AT (A4,9X,9A10,A4,9X,E9.0)
1020 FOR AT (A4,9X,9A6,9X,E9.0)
32 CONTINUE
100 ADVANCE FRAME FOR NEXT PLOT
   CALL FRAMEV(3)
35 CONTINUE
105 IF NOT TITLE CALL - SEG ERROR
   IF (CUTYPE .NE. CUTITL) GO TO 970
   NPOINTS = 0
110 XMAX = 0.
```

PROGRAM SCPLCT

YMAX = 0.

MAIN DATA READ LOOP

50 CONTINUE

NQPTS = NQPTS + 1

READ (*,102) COTYPE,Y1VAL(NQPTS),Y2VAL(NQPTS),XVAL(NQPTS)

1020 FOR AT (A4,3E12.3)

CHECK FOR END OF DATA VALUES

IF (COTYPE .EQ. CDEND) GO TO 100

ERROR IF NOT DATA CARD

IF (COTYPE .NE. CDATA) GO TO 980

ERROR IF MAX DATA POINTS EXCEEDED

IF (NQPTS .GT. NQPTS) GO TO 975

ACCUMULATE MAX DATA VALUES

XMAX = AWHX(XM*X.XVAL(NQPTS))

YMAX = AWHX(YM*X.Y1VAL(NQPTS).Y2VAL(NQPTS))

GO TO 50

100 CONTINUE

ADJUST NUMBER OF DATA POINTS COUNTER

NQPTS = NQPTS - 1

READ HEADER CARDS

READ (*,103) COTYPE.(FHDRS(I,1),I = 1,2)

1030 FOR AT (A4,7A10,AA)

C1030 FOR AT (A4,12A6,AA)

IF (COTYPE .NE. CDHDR1) GO TO 985

READ (*,103) COTYPE.(FHDRS(I,2),I = 1,2)

IF (COTYPE .NE. CDHDR2) GO TO 985

READ (*,103) COTYPE.(FHDRS(I,3),I = 1,2)

IF (COTYPE .NE. CDHDR3) GO TO 985

READ (*,103) COTYPE.(FHDRS(I,4),I = 1,2)

IF (COTYPE .NE. CDHDR4) GO TO 985

READ (*,103) COTYPE.(FHDRS(I,5),I = 1,2)

IF (COTYPE .NE. CDHDR5) GO TO 985

READ (*,103) COTYPE.(FHDRS(I,6),I = 1,2)

IF (COTYPE .NE. CDHDR6) GO TO 985

SET UP PARM FOR THIS GRAPH

IF INPUT MAXS LI! CALCULATED MAXS - INPUTS ARE OVERRIDDEN

150 CONTINUE

IF (XMAXIN .GE. XMAX) GO TO 158

ORIGINAL PAGE IS OF POOR QUALITY
PROGRAM SCPLCT

I = 0

170 CONTINUE
I = I + 1
IF (I .GT. 100) GO TO 965
IF (10**I .LT. XMAX) GO TO 152
XMAX = 10**I
GO TO 160

175 CONTINUE
XMAX = XMAX

160 CONTINUE
IF (YMAX .GE. YMAX) GO TO 168

180 CONTINUE
YMAX = YMAX

162 CONTINUE
I = 0

164 CONTINUE
I = I + 1
IF (I .GT. 100) GO TO 965
IF (10**I .LT. YMAX) GO TO 164
YMAX = 10**I
GO TO 170

168 CONTINUE
YMAX = YMAX

200 CONTINUE

205 CONTINUE
XINC = XMAX / 10.
GO TO 180

210 CONTINUE
IF (XMAX/XINC .GT. 10.) GO TO 172
XINC = XINC

215 CONTINUE
YINC = YINC

180 CONTINUE
IF (YINC .GT. 0.) GO TO 185

220 CONTINUE
PROGRAM SCPLCT

YINC = YMAX / 10.
GO TO 190

C
C IF SPECIFIED INCREMENT WOULD ALLOW MORE THAN 10 TIC MARKS
C OVERRIDE
C
185 CONTINUE
IF (YMAX/YINC .GT. 10.) GO TO 182

C
C OUTPUT CALCULATED SPECIFICATIONS
C
190 CONTINUE
WHITE (6*2020) UPLOTS•NDPTS•XMAX•YMAX•XINC•YINC•CYPRLK
2020 FORMAT (13//# SPECIFICATIONS FOR PLOT #,13//
215 # NUMBER OF DATA PTS = *# 13/
220 # MAXIMUM X = *# 1P710.3/
225 # MAXIMUM Y = *# 1P710.3/
230 # INCREMENT X = *# 1PE10.3/
235 # INCREMENT Y = *# 1PE10.3/
240 # CYCLES PER BLOCK = *# 1PE10.3/

C
C DEFINE AND SET SCALING FACTORS FOR PLOTTING AREA
C
200 CONTINUE
CALL XSCALV (XMIN•XMAX•150.50)
CALL YSCALV (YMIN•YMAX•150.50)

C
C DRAW SQUARE SURROUNDING PLOT AREA
C
250

C
C 220 CONTINUE
C
C GET RASTER COORDS OF ENDPOINTS
C
250 CALL XSCALV (XMIN•RX1•ERRFLG)
255 CALL YSCALV (YMIN•RY1•ERRFLG)
260 RX1 = IXV(XMIN)
RX2 = IXV(XMAX)
RY1 = IYV(YMIN)
RY2 = IYV(YMAX)

C
C DRAW SQUARE
C
265 CALL XAXSTP (RX1•RY1•RX2)
270 CALL YAXSTP (RY2•RY1•RY2)
CALL XAXSTP (RX1•RY2•RX2)
CALL YAXSTP (RX1•RY1•RY1)
CALL XAXISV (RX1•RY1•RX2)
CALL YAXISV (RX2•RY1•RY2)
CALL XAXISV (RX1•RY2•RX1)
CALL YAXISV (RX1•RY2•RY1)

C
C DRAW TITLE (ASSUME CENTERED ON INPUT)
CALL RITE2V (56.13,1023.90,1.54,1,TITLE,ERRFLG)

DRAW AXIS TITLES

CALL PRINTV (-6.6HCYCLES,RX1+390,RY1=40)
CALL PRINTV (-6.6HBLOCKS,RX1+390,RY2+43)
CALL APRNTV (0,-14,-6,6MINCHES,RX1-125,RY1+454)

DRAW INFO LINES

SET UP TO DRAW INFO LINES ABOVE OR BELOW CENTER DEPENDING ON INITIAL VALUES OF DATA

RY3 = 950
IF ((Y2VAL(1) + Y1VAL(1)) / 2.0 .GT. YMAX / 2.) RY3 = 295
DO 260 I = 1,6
CALL PRINTV (76,FHCRS(I),RX1.16,PY3)
RY3 = RY3 - 15

260 CONTINUE

DRAW SYMBOL LEGEND

RY3 = RY3 - 10
CALL PRINTV (-13,13HSYMBOLS: A = *RX1+16,RY3)
CALL PRINTV (1,Y1SYM,RX1+124,RY3)
RY3 = RY3 - 15
CALL PRINTV (-13,13H C = *RX1+16,RY3)
CALL PRINTV (1,Y2SYM,RX1+124,RY3)

GENERATE TIC MARKS AND LABELS

LABEL AND TIC MARK ORIGIN (0,0)

CALL LINE2V (RX1-4,RY1+8.0)
CALL LINE2V (RX1+RY1-4.0,0.8)
CALL PRINTV (-1.1H,RX1+RY1-16)
CALL PRINTV (-1.1H0,RX1-16,RY1)

DRAW X AXIS LABELS

X1 = XMIN
NLXELS = XMAX / XINC - .99
DO 340 I = 1,NLXELS

GET NEXT TIC MARK VALUE

X1 = X1 + XINC
CALL XSCLVL1 (X1,RX3,ERRFLG)
RX3 = 1XV(X1)

DRAW TIC MARK

CALL LINE2V (RX3,RY1-4,0,8)
PROGRAM SCPLOT

CALL LAHLV (X1, X3-35, HY1-1A, -2*1+1)  

compute block label value

R1 = X1 / CYPBLK
R2 = R1 + 1
XH1 = R1 * CYPBLK
XH2 = R2 * CYPBLK

get value closest to cycle tic mark

IF (ABS(XH2-X1) "GT. ABS(X1-XH1) ) GO TO 320
XH1 = XH2
R1 = R2

320 CONTINUE

IF MORE THAN ONE HALF A CYCLE TIC MARK AWAY DON'T DRAW

IF (XH1 "GT. X1 + XINC/2. OR. XH1 "LT. X1 - XINC/2.) GO

get raster cooruds

CALL XSCLV1 (XH1, R1, ERRFLG)
R1 = IXV(XH1)

360 DRAW TIC MARK

CALL LINE2V (RB1, RY2-4, 0, 8)

365 LABEL TIC MARK

XH1 = R1
CALL LAHLV (XH1, RB1-35, RY2+12, -2*1+1)

340 CONTINUE

last tic mark at xmax (unless unusual user increment specified)

CALL XSCLV1 (X INC, RX3, ERRFLG)
RX3 = IXV(X INC)
IF (ABS(RX3-RX2), "GT. 5) GO TO 360

CALL LINE2V (RX2, PY1-4, 0, 8)
CALL LAHLV (XMAX, RX2-35, PY1-18, -2*1+1)

DRAW LAST BLOCK LABEL IF IN PLOT AREA

compute block label value

R1 = XMAX / CYPBLK
XH1 = R1 * CYPBLK

D-69
PROGRAM SCPLOT

C IF MORE THAN ONE HALF A CYCLE TIC MARK AWAY DON'T DRAW
C IF (XBI .LT. XMAX - XINC/2.) GO TO 360

390 C GET RASTER COORDS
C CALL XSCLV1 (XBI,RB1,ERRFLG)
   RH1 = IXV(XBI)
C CALL LINE2V (RB1,RY2-4,0,8)
   RH1 = B1
C CALL LAHLV (XBI,RB1-35,RY2+12,-2,1,1)

C DRAW Y AXIS LABELS

400 C CONTINUE
360 C CONTINUE
   Y1 = YMIN
   NLABLS = YMAX / YINC -.99
   DO 380 I = 1, NLABLS
      YI = Y1 + YINC
   380 C CONTINUE
C CALI YSCLVI (Y1,R3,ERRFLG)
   RY3 = IYV(Y1)
C DRAw TIC MARK

410 C CALL LINE2V (RX1-4,R3,8,0)
C LABEL TIC MARK
C CALL LAHLV (Y1,RX1-92,R3,-3,1,1)

415 C LAST TIC MARK AT YMAX (UNLESS UNUSUAL USER INCREMENT SPECIFIED

420 C CALL YSCLVI (Y1+YINC,R3,ERRFLG)
   RY3 = IYV(Y1+YINC)
   IF (IAHS(RY3-RY2) .GT. 5) GO TO 400
C CALL LINE2V (RX1-4,RY2+8,0)
C CALL LAHLV (YMAX,RX1-92,RY2+3,1,1)

425 C PLOT DATA

400 C CONTINUE

430 C CALL XSCLV1 (XVAL(1),RX3,ERRFLG)
C CALL YSCLVI (Y1VAL(1),R3,ERRFLG)
C CALL YSCLVI (Y2VAL(1),R4,ERRFLG)
   RX3 = IXV(XVAL(1))
   RY3 = IYV(Y1VAL(1))
   RY4 = IYV(Y2VAL(1))

435 C PLOT SYMBOL AT FIRST DATA POINT (BOTH Y VALUES)
C CALL PLOT (RX3,R3,Y1SYM)
C CALL PLOT (RX3,R4,Y2SYM)

440 C CALL PLOT (RX3,R3,20)

D-70
Program SCPLCT

C CALI PLOTV (RX3*RY4*29)
IF (NDPTS * LE. 1) GO TO 431

445

C LOOK FOR REST OF DATA POINTS

GO 430 I = 2*NDPTS

C GET COORDS OF NEXT POINT

CALL XSLVL1 (XVAL(I)*RX1*ERRFLG)
CALL YSLVL1 (Y1VAL(I)*RY1*ERRFLG)
CALL YSLVL1 (Y2VAL(I)*RY2*ERRFLG)

RX1 = IXY(XVAL(I))
RY1 = IYV(Y1VAL(I))
RY2 = IYV(Y2VAL(I))

C PLOT SYMBOL AT DATA POINT (FOR BOTH Y VALUES)

CALL PLOTV (RX1*RY1*YSYM)
CALL PLOTV (RX1*RY2*YSYM)
CALL PLOTV (RX1*RY1*20)
CALL PLOTV (RX1*RY2*29)

465

C DRAW LINE FROM PREVIOUS POINT TO THIS POINT

CALL LINEV(RX3*RY3*RX1*RY1)
CALL LINEV (RX3*RY4*RX1*RY2)

C SET UP FOR NEXT POINT

RX3 = RX1
RY3 = RY1
RY4 = RY2

470

430 CONTINUE

431 CONTINUE

C GO TO NEXT PLOT

GO .0 30

C MAX OF 10**100 EXCEEDED

965 CONTINUE

WRITE (5,2990)

2990 FORMAT (/# MAX VALUE OF 10**100 EXCEEDED#)
GO TO 945

C FIRST CARD IN DATA GROUP NOT A TITLE CARD

C CONTINUE

970 CONTINUE

WRITE (5,3000)

3000 FORMAT (/# MISSING TITLE CARD - DATA SEQUENCE ERROR#)
GO TO 945

C MAX DATA POINTS EXCEEDED

D-71
C 975 CONTINUE
   WRITE (6,3010) NDPTS
3010 FORMAT (/1X,I4,9 DATA POINT MAXIMUM EXCEEDED)
   GO TO 995

C C DATA CARD EXPECTED BUT NOT READ
C 980 CONTINUE
   WRITE (6,3020)
3020 FORMAT (/9C_ MISSING EXPECTED DATA CARD - DATA SEQUENCE ERROR)
   GO TO 995

C C HDR CARD MISSING
C 985 CONTINUE
   WRITE (6,3040)
3040 FORMAT (/9C_ MISSING HDR CARD - DATA SEQUENCE ERROR)
   GO TO 995

C C GENERAL ERROR TERMINATION
C 995 CONTINUE
   WRITE (6,3040)
3040 FORMAT (/9C_ *** RUN TERMINATED ***)
   CALL ENDJOB
   STOP 777

C C ENDJOB
999 CONTINUE
   CALL ENDJOB
   STOP

525 END