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

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August 1976

Prepared for
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 I
## SUBROUTINE FUNCTIONS

<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 \(\text{PTCGRW} \rightarrow \text{TRANS} \rightarrow \text{TCGROW}\) 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 (RTYPO) 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>
<thead>
<tr>
<th>KTYPO(1)</th>
<th>KTYPO(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 shoulder</td>
<td>Gross stress</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>Internal crack at shoulder</td>
<td>Gross stress</td>
</tr>
<tr>
<td>2</td>
<td>1-17</td>
<td>Appropriate transition crack</td>
<td>As described in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>corresponding to through KTYPO(1)-3</td>
<td>KTYPO(1)=3 List</td>
</tr>
<tr>
<td></td>
<td></td>
<td>crack case - see KTYPO(1)=3 List</td>
<td></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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>description</td>
<td>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>
Figure 3(a) - Configuration Planforms
## General Tabular Description

**Single Crack Pin Loaded Lug**

<table>
<thead>
<tr>
<th><strong>Component</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Width of lug.</td>
</tr>
<tr>
<td>H/2</td>
<td>Distance from lug to crack.</td>
</tr>
</tbody>
</table>

**Double Crack Pin Loaded Lug**

<table>
<thead>
<tr>
<th><strong>Component</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Width of lug.</td>
</tr>
<tr>
<td>H/2</td>
<td>Distance from lug to crack.</td>
</tr>
</tbody>
</table>

---

**Figure 3(a) Cont.**
Figure 3(a) Cont.

Cracks at Shoulder Radii
Corner Crack

Corner Crack in Transition

Through Crack

Embedded Crack

Embedded Crack in Transition

Through Crack

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:

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

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

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

where

- \(D(NC,1,J)\) is the crack growth rate coefficient.
- \(D(NC,2,J)\) is the dimensionless coefficient relating to midrange slope.
- \(D(NC,3,J)\) is the critical stress intensity (upper asymptote).
- \(D(NC,4,J)\) is the threshold stress intensity range (lower asymptote).
The Paris equation is:
\[
\frac{da}{dn} = D(NC,1,J) KE^{D(NC,2,J)}
\]

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

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)

\[
\begin{array}{cccc}
\text{RE(NT,1)} & \text{RE(NT,2)} & \cdots & \text{RE(NT,m)} \\
\text{KE(NT,1)} & \frac{\text{da}}{\text{dn}}(\text{NT,1,j}) & \frac{\text{da}}{\text{dn}}(\text{NT,1,m}) \\
\text{KE(NT,2)} & \frac{\text{da}}{\text{dn}}(\text{NT,2,j}) & \frac{\text{da}}{\text{dn}}(\text{NT,2,m}) \\
\vdots & \vdots & \vdots & \vdots \\
\text{KE(NT,k)} & \frac{\text{da}}{\text{dn}}(\text{NT,k,j}) & \frac{\text{da}}{\text{dn}}(\text{NT,k,m}) \\
\end{array}
\]

\[t \leq 25, \; m \leq 25\]

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

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

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>Retardation Model</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Willenborg Model</td>
<td>(Ref. 1)</td>
</tr>
<tr>
<td>2</td>
<td>Wheeler Model</td>
<td>(Ref. 2)</td>
</tr>
<tr>
<td>3</td>
<td>Grumman Closure Model</td>
<td>(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_0} )</td>
</tr>
<tr>
<td>CR(NC,4,J)</td>
<td>( P )</td>
</tr>
<tr>
<td>CR(NC,5,J)</td>
<td>( \nu_{1} )</td>
</tr>
<tr>
<td>CR(NC,6,J)</td>
<td>( B )</td>
</tr>
<tr>
<td>CR(NC,7,J)</td>
<td></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-
interpolate 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 lin-
earily in stress ratio and logarithmically in stress intensity
to obtain crack growth rates.

MAIN

MAIN reads all input data; controls calling sequences of sub-
routines PROOF, PTGROW, 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>NBLCK&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</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</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</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</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</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</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>
<td>-------</td>
<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>
</tbody>
</table>

Cards 8-14 are only used when KTYPO(2) is set equal to 7.

<table>
<thead>
<tr>
<th>8</th>
<th>1-4</th>
<th>NKTMX</th>
<th>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.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>9</th>
<th>1-10</th>
<th>C1(NT,I)</th>
<th>Values of surface crack length for table NT surface stress intensity factor. Maximum number of values is 25.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>10</th>
<th>1-10</th>
<th>A1(NT,J)</th>
<th>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.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>11</th>
<th>1-10</th>
<th>F1(NT,I,J)</th>
<th>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).</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>12</th>
<th>1-10</th>
<th>C2(NT,I)</th>
<th>Values of surface crack length for table NT depth stress intensity factor. Maximum number of values is 25.</th>
</tr>
</thead>
</table>

If letters "END" appear in this field the value in field 1-10 is the last entry in the list.
<table>
<thead>
<tr>
<th>CARD TYPE</th>
<th>FIELD</th>
<th>NOMENCLATURE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<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>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>NJ^x</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</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. 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>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>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>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>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>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.</td>
</tr>
<tr>
<td>24</td>
<td>1-10</td>
<td>D(2,I,J)</td>
<td>Constants in crack growth equations - depth direction. If NDUP ≠ 1, card is not used. See text for description of constants.</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.</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.</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>
</tbody>
</table>

Card 27 is not used if NPROOF = 0.
<table>
<thead>
<tr>
<th>CARD TYPE</th>
<th>FIELD</th>
<th>NOMENCLATURE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<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>Title</th>
<th>WENG</th>
<th>NLOCK</th>
<th>NLOCK</th>
<th>NTER</th>
<th>CSTRS</th>
<th>NSUP</th>
<th>NLOAD</th>
<th>NMORM</th>
<th>NMAT</th>
<th>ITERP</th>
<th>ITER</th>
<th>F17</th>
<th>BLIFF</th>
<th>NPROOF</th>
<th>IFLAT</th>
<th>FTC(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 5 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 6 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 7 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 8 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 9 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 10 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 11 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 12 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Type</th>
<th>last type 13 card only + E.N.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
All Numeric Fields are in either E10.0, 14 or 16 Formats

<table>
<thead>
<tr>
<th>Card Type</th>
<th>Field 1</th>
<th>Field 2</th>
<th>Field 3</th>
<th>Field 4</th>
<th>Field 5</th>
<th>Field 6</th>
<th>Field 7</th>
<th>Field 8</th>
<th>Field 9</th>
<th>Field 10</th>
<th>Field 11</th>
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Card Type
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<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>
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<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>
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<td>1-4</td>
<td>Whenever KTYPO(2) = 7.</td>
</tr>
<tr>
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<td>1-10</td>
<td>Whenever KTYPO(2) = 7.</td>
</tr>
<tr>
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<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</td>
</tr>
<tr>
<td>12</td>
<td>1-10</td>
<td>Whenever KTYPO(2) = 7 and KTYPO(1) = 1.</td>
</tr>
<tr>
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<td>Whenever KTYPO(2) = 7 and KTYPO(1) = 1.</td>
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<td>Whenever KTYPO(2) = 7 and KTYPO(1) = 1.</td>
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<td>Whenever NMAT = 1.</td>
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<td>CARD TYPE</td>
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<td>WHEN INPUT DATA REQUIRED</td>
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</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>
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<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>
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<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 print out 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.
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, if 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
CRACK GROWTH RATE DATA

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>
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<td>31.0</td>
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A-1
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.
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Run 1

Run 2
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### Geometry Input Data

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### Material Input Data

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### Crack is a Part Thru Crack

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<th>CRACK DEPTH (IN)</th>
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**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**
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### Step Max Stress Min Stress Units (Cycles) Material Type

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## Material Input Data

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Limit load fracture occurs in the 1 block 1 step after 3.69E 02 cycles.

Critical K at surface has been exceeded in the 1 block and the 1 step after 3.69E 02 cycles.
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- **Stress Factor**: 1.000E 00
- **Limit Stress**: 1.800E 02

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### Geometry Input Data

- **Crack Type**: TEC = 1
- **Width**: 9.900E 01
- **Additional Dimension**: 0.0
- **Radius/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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- **Convergence Exponent**: 2.000E 00
- **Iteration Number**: 1
- **Iteration Type**: 1
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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 1.835E 00 CYCLES
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<th>Retardation Model</th>
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**Limit Load Fracture Occurs in the 104 Block 1 Step After 3,200,000 Cycles**

**Critical K at Depth Has Been Exceeded in the 115 Block and the 1 Step After 5,410,000 Cycles**
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DATAC-RETARD / NO RETARD / WITH DANT
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**LIMIT LOAD FRACTURE OCCURS IN THE 959 BLOCK IN STEP 1 AFTER 0.0 CYCLES**

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**LIMIT LOAD FRACTURE OCCURS IN THE 91 BLOCK 1 STEP AFTER 1.526E 01 CYCLES**

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Limit load fracture occurs in the 18th block 1 step after 1.570e00 cycles.
Critical K at depth has been exceeded in the 21st block and the 1 step after 6.695e00 cycles.
**RUN 2 OF 2 RUNS**

**LOAD INPUT DATA**

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**STEP**

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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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### P.I.M. LOADED LUG WITH PLOTTING

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End
### RUN 1 OF 1 RUNS

**DAAC PIN LOADED LUG WITH PLOTTING**

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### Material Input Data

#### Material Type | Yield Strength | Growth Equation | Retardation Model | Stress Intensity (Surface) | Stress Intensity (Depth) | Threshold Stress Intensity (Surface) | Threshold Stress Intensity (Depth) |
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<th>KMAX-FRONT (KSI)</th>
<th>KMAX-RACK (KSI)</th>
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CRACK IS A THROUGH CRACK

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LIMIT LOAD FRACURE OCCURS IN THE 9 BLOCK 1 STEP AFTER 8,085 02 CYCLES

CRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE 20 BLOCK AND THE 1 STEP AFTER 7,241E 02 CYCLES
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**MRS1**

**MRS2** CRITICAL X AT SURFACE EXCEEDED

**MRS3** 20 BLOCK 1 STEP 7.241E 02 CYCLE

**MRS4** TOTAL CYCLES = 1.972E 04
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Run 2 |  
Run 3 |  

**Card Type** | **Column Number**
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B-36 |  

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### Tabular Input Examples

#### 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: PIC
- 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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LIMIT LOAD FRACTURE OCCURS IN THE 123 BLOCK 1 STEP AFTER 0.0 Cycles
CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 326 BLOCK AND THE 1 STEP AFTER 1.23E+01 Cycles
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### Geometry Input Data

**Crack Type**: TC-7

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| Half Crack Length | 7.500E-02 |

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<th>RETARDATION MODEL</th>
<th>CRITICAL STRESS INTENSITY (SURFACE)</th>
<th>THRESHOLD STRESS INTENSITY (SURFACE)</th>
<th>CRITICAL STRESS INTENSITY (DEPTH)</th>
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### CRACK IS A THROUGH CRACK

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<th>CYCLES</th>
<th>HALF CRACK LENGTH (IN)</th>
<th>KMAX (ksi root-IN)</th>
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### CRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE 90 BLOCK AND THE 1 STEP AFTER 5.458E 00 CYCLES
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### Material Input Data

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<th>Retardation Model</th>
<th>Critical Stress Intensity (Surface)</th>
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### TANSMAL INPUT EXAMPLES

**CRACK IS A PART THRU CRACK**

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>STEP</th>
<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>
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<th>DEPTH GROWTH RATE (in/cycle)</th>
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**LIMIT LOAD FRACTURE OCCURS IN THE 24 BLOCK 1 STEP AFTER 2.287E 01 CYCLES**

**CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 90 BLOCK AND THE 1 STEP AFTER 5.148E 01 CYCLES**
APPENDIX C
STRESS INTENSITY FACTORS
Through Cracks*

Center crack

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

Compact specimen, ASTM E399-74,

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

Single through crack at hole.

\[
K_c = \sigma \sqrt{\pi c} F_B F_W \quad (\text{Ref. C-3})
\]

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

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

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

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

\[ K_c = \sigma \ F_b \ F_w \ \sqrt{\pi c} \]
\[ F_b = e^{(1.2133-2.086+.8727 S^2)} \]
\[ S = D/(Rad+C) \]
\[ F_w = \frac{\sec \frac{\pi(c+Rad)}{W}}{W} \]

\( F_b \) 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. \((c+Rad)\) is used as an equivalent half crack length in \( F_w \).

General tabular description

\[ K_c = P \ F(c) \ \sqrt{\pi c} \]
\( F(c) \) 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 \( F_1(c), F_2(c), F_3(c) \) may be input and \( F(c) \) is set equal to the interpolated value of

\[ F(c) = F_1(c) \times F_2(c) \times F_3(c) \]

The format for the stress intensity factor table is:

C-2
If only one table is read in, F2=F3=1.  $k_1$ and $k_2$ and $k_3$ must be ≤ 25.

**Pin loaded lug - two through cracks**

\[
K_c = \left[ \frac{p}{2\text{th}} \left( \frac{0.05}{\pi Z} \right) + \phi_p + \phi_c \right]
\]

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

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

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

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

\[
Z = \text{Rad} + C
\]
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<th>$f_1$</th>
<th></th>
<th></th>
<th>$\frac{Z}{b}$, or $\frac{Z}{b_{w/2}}$</th>
<th>$f_2$</th>
<th>$2z/H$</th>
<th>$f_3$</th>
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<td>1.00</td>
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**TABLE CI- Functions for Pin Loaded Lug**
The stress intensity factor is composed of two basic parts, that due to the uniform stress \((P/Wth)\) 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. \( \phi_{\sigma, s} \) combines Feddersen's width effect and a tabular description of the effect of the height taken from the data of Fichter (Ref. C-4). \( \phi_{\sigma, c} \) 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) \( \phi_{p, H} \) 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**

\[
K_c = \frac{P}{2h} \left[ 1 + \frac{1}{9} \frac{z+e}{z-e} \sqrt{\frac{z-e}{z+e}} \phi_p + \frac{\sqrt{\pi c}}{w} \phi_c \right]
\]

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

\[
F_B = e \left( 1.2133 - 2.225 S^2 + .6451 S^2 \right)
\]

\[
S = \frac{c}{\text{Rad} + C}
\]

\[
\phi_{\sigma, s} = \sqrt{\sec \frac{\pi z}{2B}}, F_3 \ (Z/H)
\]

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

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

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

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

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

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

\[
e = \frac{C}{2}
\]

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 \((C + 2 \text{Rad})/2\).

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

**Double crack at double notch**

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

\[
S = c/b + c
\]

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

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**

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<th>.2</th>
<th>.3</th>
<th>.4</th>
<th>.6</th>
<th>.8</th>
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<td>2.51</td>
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<td>3.55</td>
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<td>1.45</td>
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</tr>
<tr>
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<td>2.05</td>
<td>1.77</td>
<td>1.45</td>
<td>1.25</td>
<td>1.122</td>
</tr>
<tr>
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<td>5.8</td>
<td>4.1</td>
<td>3.5</td>
<td>2.51</td>
<td>2.05</td>
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<td>1.122</td>
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<tr>
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<td>3</td>
<td>2.8</td>
<td>2.4</td>
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<tr>
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<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>
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<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>
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<tr>
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<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>
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</table>
F4 (S, height/b) is a table constructed from the curves presented by Tada (pg. 19.13) for a crack emanating from an edge notch is a semi-infinite sheet.

**Single crack at single edge notch.**

\[
K_c = \phi_g \sqrt{\pi C} f_4(S, \text{height}/b) F_w \\
F_w = \left[ 0.752 + 2.02 \left( \frac{b+c}{W} \right) + 0.37 \left( 1 - \sin \frac{\pi (b+c)}{2W} \right) \right] \sqrt{\frac{2W}{\pi (b+c) \tan \frac{\pi (b+c)}{2W}}} \\
S = c/b+c
\]

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**

\[
K_c = \phi_g \sqrt{\pi C} f_4(S, g) F_w \quad \text{(See Table C-2)} \\
F_w = \left[ 1 + 0.122 \cos \left( \frac{\pi (b+c)}{W} \right) \right] \sqrt{\frac{W}{\pi (b+c) \tan \frac{\pi (b+c)}{W}}} \\
g = f_5(\frac{\text{rad}}{d}, w/d) \quad \text{(See Table C-3)} \\
b' = (w-d)/z \\
S = c/c+b'
\]

The above solution for the stress intensity factor is based on using the solution for the case of cracks coming out of a doubly
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<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>
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<td>1.85</td>
<td>1.84</td>
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<td>2.6</td>
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<td>8</td>
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<td>6</td>
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<td>4.4</td>
<td>4.5</td>
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<td>9</td>
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<tr>
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<td>5</td>
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<td>9.5</td>
<td>10</td>
<td>11</td>
<td>12</td>
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</tr>
</tbody>
</table>

**TABLE C-3**
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.

\[
B = \text{minimum } (a,c)
\]

\[
K_c = c \frac{\sqrt{a}}{g} F(a/c, 2)
\]

(See Table C-4)

\[
K_a = c \frac{\sqrt{a}}{g} F(a/c, 1)
\]

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>
<thead>
<tr>
<th>( a/c )</th>
<th>( F(a/c,1) )</th>
<th>( F(a/c,2) )</th>
</tr>
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<tr>
<td>0.04</td>
<td>1.11</td>
<td>0.17</td>
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<tr>
<td>0.07</td>
<td>1.10</td>
<td>0.27</td>
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<tr>
<td>0.12</td>
<td>1.08</td>
<td>0.37</td>
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<td>0.15</td>
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<td>0.34</td>
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<td>0.77</td>
<td>0.74</td>
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<tr>
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<td>0.75</td>
<td>0.75</td>
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<td>0.86</td>
<td>0.75</td>
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<td>1.49</td>
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<td>0.86</td>
</tr>
<tr>
<td>1.785</td>
<td>0.61</td>
<td>0.9</td>
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<td>2.325</td>
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<td>0.31</td>
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<td>25.0</td>
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<tr>
<td>50.0</td>
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</tr>
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<td>1.0</td>
</tr>
<tr>
<td>10000</td>
<td>0</td>
<td>1.0</td>
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</tbody>
</table>

**TABLE C-4**

Part Through Crack Shape Factors
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 \( \frac{C+C_b}{2} \)

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

\( K_c \) 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.
COMMON X(12,25), Y(12,25), TA9LE(12,25), FIXED, KCPF, KAPRF, 0600010
1 PROFX, NMTX, NOX(12), NOY(12), NTA(10), IPRINT, IFAIL, CUMSUM, PCFYEC(2) 0000020
COMMON A4, AP(2), AL(2), AO(2), C, CB, CL, CR(2, 10, 10), CN, CUMF, 0600030
1 CUME, CM, CSH(2, 10, 10), DK, DKE, DX, FA, FC, FN, INC, KCL, KL, KOL, 0000040
2 KOC, KOK, KCF, KCR, KMAX, CA, NC, P1, RI, RAD, RE, RVOL(2), ROL(2), 0000050
3 SIG, SIGM, SICY, SIGS(10), SMIN(422), SMAX(422), TH, 0000060
4 UNIT(422), W, DCTMP, DFLTMP, DXTMP, 0000070
5 ALOW, BLOCK, FLAG1, I, ICD(2), ICK(2), ICRI(2), IDLCK, IFIRST, IPRM(4), 0000080
6 ISTEP, TRANS, J, KTYPE(2), NC, NEQ(10), NP, NRET(10), TYPF, TITL 0000090
DIMENSION THICK(10), PCTLF(10), A(10), CI(10) 0000100
DIMENSION FL(4, 3), KTYPO(2), KTN(3, 2) 0000110
DIMENSION HMIN(-22), HMAX(-22) 0000111
INTEGER ALCW, BLOCK, FLAG1, TYPE(-22), CNSTEP, TITL(20) 0000120
INTEGER HNSTEP
INTEGER PD1(2), PD2(4), PD3(4)
REAL KCL, KCI, KOL, KOC(10), KCR(10), KCF, KCR(10), KMAX, INC
REAL LIFE(10), KCPF, KAPRF
DATA PD1 /4HR A, 4HR C /
DATA PD2 /4HC, 4HFI, 4HC, 4HA /
DATA PD3 /4HC, 4HC, 4HC, 4HA /
DATA FL /4JEP, 4HSRF, 4HBRA, 4HTH, 4HACF, 4HKTH, 4HNSIT, 4HSIT /
DATA KTBE /4H PT, 4HTRAN, 4H TE, 4HC, 4HC, 4HC, 4HC, 4HC /
DATA KEND /4H END /
C
INITIALIZE FOR ALL RUNS
C
DO 10 I=1, 2
DO 10 J=1, 10
DO 10 K=1, 10
10 CR(I, J, K)=0
C
PI=3.1415927
DCTMP=0.
DFTMP=0.
DNSTEP=-1
NR=0
C
READ TITLE & CONTROL INFO FOR ALL RUNS
C
NRUNS = # RUNS TO BE MADE NBLCK= MAX BLOCKS PER RUN
MALLOC= PRINT FREQ (BLOCKS) MSTEP = PRINT FREQ (STEPS)
C
READ (5, 5001) (TITL(I), I=1, 20)
READ (5, 5002) NRUNS, NBLCK, MALLOC, MSTEP
IF (MALLOC) 30, 20, 30
20 MALLOC=NALLOC+1
C
CENTER TITLE
C
30 DO 32 I=1, 14
IF (TITLE(I).EQ. PD3(I)) GO TO 34
32 CONTINUE
GO TO 100
34 IF (I.GE.13) GO TO 100
II=(13-I)/2+1
K=14-I-II
I1=14-I1
I2=I1-I+1
DO 36 L1=I2,11
L=I1+I2-11
J=L-K
TITL(I)=TITL(J)
TITL(J)=PD3(I)
36 CONTINUE

C READ CONTROL INFO FOR INDIVIDUAL RUN
C
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 ITERTP = 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)
C
100 READ (5,5003) CSTRS,NLOAD,NGEOM,NMAT,ITERTP,ITER,PIT,BLIFE,
1 NPROOF,IPLOT,PCYCLES
IF (ITER.LT.1) GO TO 110
IF (ITERTP.EQ.0) GO TO 4020
IF (ITERTP.GT.4) GO TO 4020
110 DO 120 K=1,10
120 NRET(K)=NSUP*NRET(K)
ITCNT=0
IF (IPLOT.EQ.0) GO TO 130
IPLOT=1
IF (PCYC(1).EQ.0) GO TO 130
IPLOT=2
130 IF (ITER=-10) 800,800,140
140 ITER=10
C
C READ LOAD INPUT
C
800 IF (NLOAD-1) 910,810,910
810 READ (5,5004) NSTEP,IR,SIGLM
IF (MSTEP-0(NSTFP+1)) 820,830,820
820 IF (MSTEP) 840,830,840
830 NSTFP=NSTFP+1
840 DO 850 I=1,NSTEP
850 READ (5,5005) SMAX(I),SMIN(I),UNIT(I),TYPE(I)
IF (IR=1) 860,840,880
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
SMIN(I)=CSTRS*SMIN(I)
900 SMAX(I)=CSTRS*SMAX(I)
C
C READ GEOMETRY INPUT
C
910 IF (NGEOM-1) 1100,920,1100
920 READ (5,5004) KTYPO
READ (5,5006) W,TH,CO,A0,H,RAD
OTH=TH
OAO=A0
OCO=CO
IF (KTYPO(1).LT.1) GO TO 4030
IF (KTYPO(1).GT.3) GO TO 4030
IF (KTYPO(2).LT.1) GO TO 4060
IF (KTYPO(2).LT.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 CIB1 = FUNTS(RAD/H,W/H)
GO TO 1100

C READ X,Y,TABLE ARRAYS(1-6) FOR INTERPOLATION

C NKTMX = ONE HALF # ARRAY ELEMENTS

940 READ(5,5002) NKTMX
IF (NKTMX.LT.1) GO TO 980
IF (NKTMX.LT.4) GO TO 990

980 WRITF(6,6024) NKTMX
STOP

990 NTABLE=6
N1=1
N2=2*NKTMX
DC 1090 NT=N1,N2
IF (A0,NE.0.) GO TO 1000
I=MOD(NT,2)
IF (I,NE.0.) GO TO 1000
X(N1,1)=0.
Y(N1,1)=0.
NOX(N1)=1
NOY(N1)=1
TABLE(N1,1,1) = 0.
GO TO 1090

1000 READ(5,5009) X(N1,1),LFEND
I=1
IF (LFEND.EQ.KEND) GO TO 1020
GO 1020 I=2,25
READ(5,5009) X(N1,1),LFEND
IF (X(N1,1).LE.Y(N1,1-1)) GO TO 4000

1020 IF (LFEND.EQ.KEND) GO TO 1030
GO TO 4010

1030 NOX(N1)=I
IF (AC,NE.0.) GO TO 1040
Y(N1,1)=0.
Y(N1,2)=1.
I=2
GO TO 1070

1040 READ(5,5609) Y(N1,1),LFEND
I=1
IF (LFEND.EQ.KEND) GO TO 1070
DO 1060 I=2,25
READ(5,5609) Y(N1,1),LFEND
IF (Y(N1,1).LT.Y(N1,1-1)) GO TO 4000

1060 IF (LFEND.EQ.KEND) GO TO 1070
GO TO 4010

1070 NOY(N1)=I
I1=NOX(N1)
I2=NOY(N1)
DC 1080 I=1,I1
READ(5,5008) (TARLF(N1,I3), I3=1,I2)
IF (AC,NE.0.) GO TO 1080
TARLF(N1,I,2) = TABLE(N1,I,1)
1080 CONTINUE
1090 CONTINUE

C READ MATERIAL INPUT

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),NEO(J),NRET(J),NDUP,
1 KCRCT(J),KOCR(J),KCRAT(J),KOAR(J)
NRET(J)=NSUP*NRET(J)
IF (NEO(J).NE.4) GO TO 1240

C

READ X,Y, TABLE ARRAYS(7-12) FOR NEO(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
NI=NTAB(J)
N2=NI+1
DO 1230 NT=NI,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)=NOY(I)
I1=NOX(I)
I2=NOY(I)
DO 1120 I3=1,I2

1120 Y(NT,I3)=Y(I1,I3)
DO 1130 I3=1,I1
X(NT,I3)=X(I,13)
DO 1130 I4=1,I2
1130 TABLE(NT,I3,I4)=TABLE(I,I3,I4)
GO TO 1230

C

READ X ARRAY

1140 READ(5,5009) X(NT,1),LEND
I=1
IF (LEND.EQ.KEND) GO TO 1170
DO 1160 I=2,25
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

READ(5,5009) Y(NT,1),LEND
I=1
IF (LEND.EQ.KEND) GO TO 1200
DO 1190 I=2,25
READ(5,5009) YNT(I),LEND
IF Y(YNT(I),LE,YNT(I-1)) GO TO 4000
1190 IF (LEND.EQ.KEND) GO TO 1200
GO TO 4010
1200 NCYNT(I)=1
11=NCX(NT)
12=NCYNT(I)
DO 1210 I=1,11
1210 READ(5,5008) (TABLE(NT,I,13), I3=1,12)
I3=NCYNT(I)
12=I3+1
NCYNT(I)=I2
YNT(I2)=1.
DO 1220 I=1,11
1220 TABLE(NT,I,12)=TABLE(NT,1,13)
1230 CONTINUE
NTABLE=NTABLE+1
GO TO 1340
C READ D ARRAY FOR N(J) NOT = 4
C
1240 DO 1250 I=1,10
D(I,J)=0
1250 D(2,I,J)=0
DO 1260 I=1,10
READ(5,5009) T(1,I,J),LEND
1260 IF (LEND.EQ.KEND) GO TO 1270
GO TO 4070
1270 IF ('"END"') 1280,1300,1280
1280 DO 1290 I=1,10
1290 D(2,I,J)=D(1,I,J)
GO TO 1340
1300 DO 1310 I=1,10
READ(5,5009) T(2,I,J),LEND
1310 IF (LEND.EQ.KEND) GO TO 1340
GO TO 4070
1340 DO 1360 I=1,10
1350 CR(I,I,J)=0
1360 CR(2,I,J)=0
DO 1370 I=1,10
READ(5,5009) CR(1,I,J),LEND
1370 IF (LEND.EQ.KEND) GO TO 1380
GO TO 4070
1380 DO 1390 I=1,10
1390 CR(2,I,J)=CR(1,I,J)
GO TO 1450
1400 DO 1410 I=1,10
READ(5,5009) CR(2,I,J),LEND
1410 IF (LEND.EQ.KEND) GO TO 1450
GO TO 4070
1450 CONTINUE
C READ PROOF INPUT DATA
C
1460 IF (NPROF.EQ.0) GO TO 1500
READ(5,5010) FIXED, KCPFRF,KAPRF,XLOW,XUP,PROCX,KEND
C INCREMENT RUN # & VERIFY COMPLETE INPUT
D-5
C
1500 NR=NR+1
1510 IF (NR-1) 1510,1510,1530
1520 DCSTRS=CSTRS
ONSTEP=NSTEP
GO TO 1620
1530 IF (NLAD=1) 1540,1520,1540
1540 IF (DCSTRS-CSTRS) 1550,1620,1550
1550 IF (DCSTRS) 1580,1560,1580
1560 DO 1570 I=1,ONSTEP
SMIN(I)=SMIN(I)*CSTRS
1570 SMAX(I)=SMAX(I)*CSTRS
SIGLM = CSTRS*SIGLM
DCSTRS=CSTRS
GO TO 1620
1580 DO 1590 I=1,ONSTEP
SMIN(I)=SMIN(I)/DCSTRS
1590 SMAX(I)=SMAX(I)/DCSTRS
SIGLM = SIGLM/DCSTRS
DCSTRS=CSTRS
IF (CSTRS) 1600,1620,1600
1600 DO 1610 I=1,ONSTEP
SMIN(I)=SMIN(I)*CSTRS
1610 SMAX(I)=SMAX(I)*CSTRS
SIGLM = CSTRS*SIGLM
T620 HNSTEP=NSTEP
HSMILM=SIGLM
HCSTRS=CSTRS
DO 1622 I=1,HNSTEP
HMIN(I)=SMIN(I)
1622 HMAX(I)=SMAX(I)
1625 IF (IPLT,NE.1) GO TO 1630
K=NBLOCK/MBLOCK
1630 WRITE(6,8002) NR,NRUNS,TITL
C
1630 WRITE(6,8003) CSTRS,SIGLM
BCYCLE=0.
DO 1640 J1=1,NSTEP
BCYCLE = BCYCLE + UNIT(J1)
1640 WRITE(6,8004) J1,SMAX(J1),SMIN(J1),UNIT(J1),TYPE(J1)
C
1650 WRITE(6,8005) KTN(KTYP0(1),1),KTN(KTYP0(1),2),KTYP0(2),W,H,RAD,TH
IF (KTN(1)=3) 1660,1650,1660
1660 WRITE(6,8007) CO
GO TO 1665
1660 WRITE(6,8006) A0
WRITE(6,8007) CO
1665 IF (KTN(2).NE.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-J1) 1710,1710,1700
1700 J2=I2
1710 WRITE(6,8015) (Y(NT,13), I3=J1,J2)
DO 1720 I=1,I1
1720 WRITE(6,8016) X(NT,1),TABLE(NT,1,13), I3=J1,J2)
IF (I2-J2) 1730,1740,1730
1730 J1=J1+8
J2=J2+8
CC TO 1690
1740 CONTINUE
C DISPLAY MATERIAL INPUT
C
1750 WRITE(6,8008)
DO 1760 J1=1,NJ
WRITE(6,9009) J1,SCVX(J1),NEQ(J1),NRFV(J1),KCR(J1),KOC(J1),
1 KCRA(J1),KX(J1)
1760 CONTINUE
C DISPLAY D & CR ARRAYS IF ANY
C
K=0
DO 1840 J1=1,NJ
IF (NEQ(J1).LT.-1) 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(1,J2,J1)) 1820,1740,1820
1790 IF (D(2,J2,J1)) 1820,1800,1820
1800 IF (CR(J1,J2,J1)) 1820,1810,1820
1810 IF (CR(2,J2,J1)) 1820,1830,1820
1820 WRITE(6,8011) J2,J1,D(1,J2,J1),D(2,J2,J1),
1 CR(J1,J2,J1),Cr(2,J2,J1)
1830 CONTINUE
1840 CONTINUE
C DISPLAY TABLES 7-12 IF ANY
C
DO 1910 J=1,NJ
IF (NEQ(J).LT.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...
I2=N0Y(NT)
I1=N0X(NT)
J1=1
J2=8
1850 IF (J2-J2) 1870,1870,1860
1860 J2=12
1870 WRITE(6,8020) (Y(NT,I3), I3=J1,J2)
DO 1880 I=1,11
1880 WRITE(6,8021) X(NT,I), (TABLE(NT,I,I3), I3=J1,J2)
IF (J2-J2) 1890,1900,1890
1890 J1=J1+8
J2=J2+8
GO TO 1850
1900 CONTINUE
1910 CONTINUE
C
C DISPLAY PROOF INPUT IF ANY
C
1920 IF (NPROOF) 1940,1940,1920
1930 N1=NPROOF+1
N1=MOD(N1,2) + 1
IF ITEND10, GO TO 1930
IEND=100
1930 WRITE(6,8018) NPROOF,PD1(N1),XLLOW,PROOFX,PD1(N1),XUP,KCPF,
1 PD2(NPROOF),PD3(NPROOF),FIXED,KCPF,IEND
1940 IF (ITF) 1960,1960,1950
1950 K=ITCNT+1
WRITE(6,8012) BLIFE,PIT,K,ITERTP
1960 CONTINUE
C
C INITIALIZATION FOR EACH RUN
C
ICK(1)=0
ICK(2)=20
ICD(1)=0
ICD(2)=20
ICR(1)=0
ICR(2)=20
INC=0.01
INC=0
BLOCC8=1
I=1
ITRANS=0
IPRN(1)=-1
IPRN(2)=-1
IPRN(3)=-1
IPRN(4)=2#NSTEP
FLAG1=0
CUMS1M=0.
KTYPE(1)=KTYPE(1)
KTYPE(2)=KTYPE(2)
PCYC(2)=PCYC(1)
IFAIL=0
CUMSUM=0.
1970 CALL PROOF(AO,CO, XLLOW,XUP,IEND,NPROOF)
1980 CONTINUE
C=C0
A=A0
DA=A0
WRITE TITLE, CYCLES/BLOCK, & FIRST DATA POINT IF PLOT WANTED

IF (IPLT.EQ.0) GO TO 2000
WRITE(7,7010) (TITL(I), T1=1,15), BCYCLE
WRITE(7,7000) A,C,CUMSUM

BEGINNING OF EACH STEP, EACH BLOCK

2000 IF (MOD(BLOCK, MLBLOK)) 2050, 2010, 2050
2010 IF (MOD(I, NSTEP)) 2050, 2020, 2050
2020 DC 2040 K=1+3
IF (IPRN(K)-IPRN(4)) 2040, 2030, 2040
2030 IPRN(K)=IPRN(K)-?
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 TCRGROW
GO TO 2100
2090 CALL PTGRW

HAS THE RUN ENDED?

2100 MORE=0
IF (ICR(1)+1) 2310, 2310, 2200
2200 CUME = 0
I=I+1

IS THIS THE LAST STEP OF THIS BLOCK?

IF (I-NSTEP) 2000, 2000, 2210
2210 BLOCK=BLOCK+1
IF (KTYPE(1), GT, 1) GO TO 2230
IF (A=DA) 2300, 2230, 2300
2230 IF (C-GC) 2300, 2240, 2300
2240 IF (DELMP-1.F-8) 2250, 2230, 2300
2250 IF (DXTMP-1.F-8) 2260, 2230, 2300
2260 IF (ITRANS-1) 2270, 2250, 2270
2270 IF (KTYPE(1), GT, 1) GO TO 2290
2280 IF (DCTMP-1.E-8) 2290, 2230, 2300
2290 WRITE(A, 6620)
ING=I
GO TO 2310
2300 CA=A
DC=C
I=1

IS THIS THE LAST BLOCK OF THIS RUN?
C  IF (BLOCK-NBLOCK) 2000, 2000, 2310
C
C  ARE THERE ITERATIONS?
C
2310 IF (ITER) 3000, 3000, 2320
C
C  ITERATION CALCULATIONS
C
2320 ITCNT=ITCNT+1
THICK(ITCNT)=TH
AI(ITCNT)=AO
CI(ITCNT)=CO
LIFE(ITCNT)=FLOAT(BLOCK-1)+FLOAT(I)/FLOAT(NSTEP)
LIFE(ITCNT)=LIFE(ITCNT)-((UNIT(I)-CUME)/UNIT(I))/FLOAT(NSTEP)
PCTLF(ITCNT)=LIFE(ITCNT)*100./BLIFE
IF (LIFE(ITCNT).EQ.0) GO TO 2435
DIF=PCTLF(ITCNT)/100.
IF (DIF-.991340,2340,2330 00005450
2330 IF (DIF/.2340,2340,2300 00005460
2340 IF (ITCNT-ITER) 2350, 2440, 2440
2350 MORE=1
IF (ITERP.GT.1) GO TO 2400
DIF=(BLIFE/LIFE(ITCNT))**((1./PIT)
TH=TH*DIF
IF (CSTRS) 2380, 2380, 2330
2360 CSTRS=1./DIF
DO 2370 K=1,ONSTEP
SMIN(K)=SMIN(K)*CSTRS
2370 SMAX(K)=SMAX(K)*CSTRS
SIGLM=SIGLM*CSTRS
OCSTRS=CSTRS
GO TO 3000
2380 CSTRS=CSTRS/DIF
DO 2390 K=1,ONSTEP
SMIN(K)=SMIN(K)/OCSTRS*CSTRS
2390 SMAX(K)=SMAX(K)/OCSTRS*CSTRS
SIGLM=SIGLM/OCSTRS*CSTRS
OCSTRS=CSTRS
GO TO 3000
2400 DIF=(LIFE(ITCNT)/BLIFE)**((2./PIT-2.))
GO TO (2350, 2410, 2420, 2430, ITERP
2410 CO=CO*DIF
GO TO 3000
2420 AO=AO*DIF
GO TO 3000
2430 AOVC0=AO/CO
CO=CO*DIF
AO=AOVC0*CO
GO TO 3000
2435 WRITE(6,6160)
MORE=0
2440 WRITE(6,6021)
DO 2450 K=1,ITCNT
2450 WRITE(6,6022) THICK(K),AI(K),CI(K),LIFE(K),PCTLF(K)
CSTRS=HCSTRS
NSTEP=HNSTEP
SIGLM=HSIGLM
DO 2455 I=1,NSTEP
SMIN(I)=HSMIN(I)
2445 SMAX(I)=HMAX(I)
TH=OTH
CO=CCO
AO=0A0
IF (ING-1) 3000,2460,3000
2460 WRITE(6,8013)
C
WRITE FINAL DATA FOR PLOT IF ANY
C
2000 IF (IPLOT.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(7,7046) FL(IFAIL,1),FL(IFAIL,2),BLOCK,1,CUMF,CUMSUM
GO TO 3020
3015 WRITE(7,7070) (FL(IFAIL,II),II=1,3),BLOCK,1,CUMF,CUMSUM
3020 IF (ITER.EQ.0) GO TO 3030
WRITE(7,7050) THICK(ITCNT),AI(ITCNT),CI(ITCNT)
GO TO 3040
3030 WRITE(7,7060)
C
IS THIS THE LAST RUN?
C
3040 IF (MORE.EQ.1) GO TO 1625
IF (NR-MRINGS) 3050,3990,3990
3050 IF (ICR(N)+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) ITERTP
STOP
4030 WRITE(6,6130) KTYPEO(1)
STOP
4040 WRITE(6,6150)
STOP
4050 WRITE(6,6601)
STOP
4060 WRITE(6,6130) KTYPEO(2)
STOP
4070 WRITE(6,6140)
STOP
5001 FORMAT(20A4)
5002 FORMAT(I4,I6,I14)
5003 FORMAT(E10.0,E14.2,E10.0,E14.2,E10.0)
5004 FORMAT(3I4,E10.0)
5005 FORMAT(3E10.0,E14)
5006 FORMAT(6E10.0)
5007 FORMAT(F10.0,F14.2,F10.0)
5008 FORMAT(6E10.0)
5009 FORMAT(F10.0,F6X,A4)
5010 FORMAT(6F10.0,I4)
6001 FORMAT(34H1INCOMPLETE INPUT SET, JOB ABENDED)
SUBROUTINE PROOF (AO, CO, XLow, XUP, IEND, NPROOF)

COMMON X(12, 25), Y(12, 25), TABLE(12, 25, 25), FIXED, KCPRF, KAPRF,
1 PROOFX, NMTX, NCOX(12), NOY(12), NTAB(10), IPLOT, IFAIL, CUMSUM, PCM12(2)

REAL KAPRF, KCPRF
EXTERNAL FCT1, FCT2, FCT3, FCT4, FCT5, FCT6, FCT7
IF (IEND .NE. 0) GO TO 10
IEND = 100
10 GO TO (100, 200, 300, 400, NPROOF)

C
100 CONTINUE
CALL RTMI (A1, ZERO, FCT1, XLOW, XUP, 001, IEND, IER)
CALL MESS1 (IER, A1, XUP)
IERC = IER
CALL RTMI (A2, ZERO, FCT2, 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, FCT3, 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, FCT4, XLOW, XUP, 001, IEND, IER)
CALL MESS1 (IER, A1, XUP)
IERC = IER
CALL RTMI (A2, ZERO, FCT5, 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, FCT6, XLOW, XUP, 001, IEND, IER)
CALL MESS1 (IER, C1, XUP)
IERC = IER
CALL RTMI (C2, ZERO, FCT7, XLOW, XUP, 001, IEND, IER)
CALL MESS2 (IER, C2, XUP)
IERC = IERC * IER
IF (IERC .NE. 0) GO TO 2000
AO = AMINI (C1, C2)
AO = 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(1H0,4SHPROOF LOAD CALCULATION AT DEPTH HAS NOT CONVERGED)
6020 FORMAT(1H0,39HBOUNDS ON VARIABLE ARE NOT APPROPRIATE.,/1H ,
1 54HEITHER CRITICAL STRESS INTENSITY AT DEPTH IS LESS THAN,
2 22H KPROOF AT LOWER BOUND,/1H ,26H OR GREATER THAN KPROOF,
3 15H AT UPPER BOUND)
END
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(IHO,51HPROOF LOAD CALCULATION AT SURFACE HAS NOT CONVERGED)
6020 FORMAT(IHO,39HBOUNDS ON VARIABLE ARE NOT APPROPRIATE./IH,
1 56HEITHER CRITICAL STRESS INTENSITY AT SURFACE IS LESS THAN,
2 22HPROOF AT LOWER BOUND./IH ,26H OR GREATER THAN KPROOF,
3 15H AT UPPER BOUND)
END
SUBROUTINE RTMI(X,F,FCT,XLI,XRI, EPS,IFND,IER)
C
C
SUBROUTINE RTMI
C
PURPOSE
TO SOLVE GENERAL NONLINEAR EQUATIONS OF THE FORM FCT(X)=0
BY MEANS OF MUELLER-S ITERATION METHOD.
C
USAGE
CALL RTMI (X,F,FCT,XLI,XRI, EPS,IFND,IER)
PARAMETER FCT REQUIRES AN EXTERNAL STATEMENT.
C
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.
EPS - INPUT VALUE WHICH SPECIFIES THE UPPER BOUND OF THE
      ERROR OF RESULT X.
IFND - MAXIMUM NUMBER OF ITERATION STEPS SPECIFIED.
IER - RESULTANT ERROR PARAMETER CODED AS FOLLOWS
       IER=0 - NO ERROR.
       IER=1 - NO CONVERGENCE AFTER IFND ITERATION STEPS.
       FOLLOWED BY IEND SUCCESSIVE STEPS OF
       BISECTION.
       IER=2 - BASIC ASSUMPTION FCT(XLI)*FCT(XRI) LESS
       THAN OR EQUAL TO ZERO IS NOT SATISFIED.
C
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, THE
PROCEDURE IS BYPASSED AND GIVES THE ERROR MESSAGE IER=2.
C
SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
THE EXTERNAL FUNCTION SUBPROGRAM FCT(X) MUST BE FURNISHED
BY THE USER.
C
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.
XLI AND XRI. CONVERGENCE IS QUADRATIC IF THE DERIVATIVE OF
FCT(X) AT ROOT X IS NOT EQUAL TO ZERO, ONE ITERATION STEP
REQUIRES TWO EVALUATIONS OF FCT(X), ECP TEST ON SATISFACTORY.
ACCURACY SEE FORMULAE (3,4) OF MATHEMATICAL DESCRIPTION.
FOR REFERENCE, SEE G. K. KRISTIANSEN, ZERO OF ARBITRARY
FUNCTION, BIT, VOL. 3 (1963), PP. 205-206.
C
ORIGINAL PAGE IS
OF POOR QUALITY
C
PREPARE ITERATION
IER=0

D-17
XL=XL1
XR=XRI
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
START ITERATION LOOP
4 I=I+1
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.,FL)+SIGN(1.,FR))7,6,7
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-FCR*(FR-FL))8,9,9
8 IF(I-IEND)17,17,9
9 XR=X
FR=F
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)-TOL)14,14,13
13 CONTINUE
C END OF BISECTION LOOP
C
NO CONVERGENCE AFTER IEND ITERATION STEPS FOLLOWED BY IEND
C SUCCESSIVE STEPS OF BISECTION OR STEADILY INCREASING FUNCTION
C VALUES AT RIGHT ROUNDS. ERROR RETURN.
IER=1
14 IF(ABS(FR)-ABS(FL)) < 1e-15
15 X=XL
16 RETURN

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)
   IF(F)18,16,19

18 TOL=EPS
   A=ABS(X)
   IF(A-1.120,20,19
   TOL=TOL*A
20 IF(ABS(DX)-TCL) < 21,21,22
21 IF(ABS(F)-TCL) < 16,16,22

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

25 IF(R=2
   RETURN
END
FUNCTION FCT1(AF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
PRMFX,NKTMX,NNOY(12),NOY(12),NTAB(10),IPLT,IFAIL,CUMSUM,PCYC(2)
COMMON A,AP(2),ALIH,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
CUMELM,CIB1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
KOA,KOC,KCRA,KCRC,KMAX,DA,OC,P1,R,RAD,RE,RYOL(2),ROL(2),
S I G,S I G L M,SI G Y,SIGYS(10),SMIN(422),SMAX(422),TH,
UNIT(422),W,DCYMP,DELTMP,DXTMP,
ALOWN,BLOCK,FLAG1,1,ICO(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
ISTEP,ITRANS,J,K TYPE(2),NC,NEQ(10),NR,NRFT(10),TYPE,TITL
INTEGER ALOWN,BLOCK,FLAG1,T YP E (422),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
FCT1=-KAPRF*FA*PRMFX
RETURN
END
FUNCTION FCT2(AF)
COMMON X(12,25), Y(12,25), TABLE(12,25,25), FIXED, KCPRF, KAPRF
INTEGER A, AP(2), ALIM, ACL(2), C, CB, CLIM, CR(12, 10, 10), CO, CI, ME,
COMMON A, AP(2), ALIM, ACL(2), C, CB, CLIM, CR(12, 10, 10), CO, CI, ME,
1 PROOFX, NKTMX, NOX(12), NOY(12), NTAB(10), IPILOT, IFAIL, CUMSUM, PCYC(2)
COMMON A, AP(2), ALIM, ACL(2), C, CB, CLIM, CR(12, 10, 10), CO, CI, ME,
2 KOA, KOC, KCRA, KCRF, 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, DELTMP, DXTMP,
5 ALOWN, BLOCK, FLAG1, I, ICD(2), ICK(2), ICR(2), IBLOCK, IFIRST, IPRN(4),
6 ISTEP, ITTRANS, J, KTYPE(2), NC, NEQ(10), NR, NRET(10), TYPE, TITL
INTEGER ALOWN, BLOCK, FLAG1, KTYPE(2), NC, NEQ(10), NR, NRET(10), TYPE, TITL
REAL KCL, KCI, KCL, KCPA(10), KCPF, KAPRF, KMAX, INC
REAL KCPF, KAPRF
A=AF
C=A/FIXED
CALL KANAL
FCT2=-KCPRF+FC*PRC*FX
RETURN
END
FUNCTION FCT3(CF)

COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,

1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLLOT,IFAIL,CUMSUM,PCYC(2)

COMMON A,AP(2),ALM,AD(2),C,CB,CLIM,CR(2,10,10),CO,CUME,

1 CUMELM,CIB1,D(2,10,10),DK,DKJ,DXDFA,FC,H,INC,KCL,KC1,KDL,

2 KOA,KOC,KCR,EMAX,OA,OC,P1,R,RAD,RE,RYOL(2),ROL(2),

3 SIG,SLG,SIY,SIGYS(10),SMIN(422),SMAX(422),TH,

4 UNIT(422),W,DCTMP,DEL,TMP,DTMP,

5 ALON,CLBL,FLAG1,ICD(2),ICR(2),IBLCK,IFIRST,IPRN(4),

6 ISTEP,TRANS,J,KTYPE(2),NC,NEQ(10),NR,NRFT(10),TYPE,TITL

INTEGER ALON,CLBL,FLAG1,TYPE(422),TITL(20)

REAL KCL,KC1,KO(10),KOC(10),KCR(10),KCR(10),KMAX,INC

REAL KCPRF,KAPRF

C=CF

CALL KANAL

FCT3=-KCPRF+FC*PROOFX

RETURN

END
FUNCTION FC4(AF)
COMMON X(12,25), Y(12,25), TABLE(12,25), FIXED, KCPRF, KAPRF,
1  PRODFX, NKTMY, NIX(12), NIV(12), NTA6(10), IFAIL, CMISUM, PCYC(2)
COMMON A, AP(2), ALIM, ACL(2), CE, CLIM, CR, C0, CLIMF,
1  CUMELM, C1BI, D(12,10,10), DK, DKE, DXDX, FA, FC, H, INC, KCL, KCL1, KCL1,
2  KOC, KOC, KCR1, KCR1, KMAX, CA, OC, PI, R, RAD, RER, RYOL(2), ROL(2),
3  SIG, SIGLM, SIGY, SIGYS(10), SMIN(22), SMAX(422), TH,
4  UNIT(422), W, DCTMP, DELTMP, DXTMP,
5  ALOWN, BLOCK, FLAGI, I, ICD(2), ICDK(2), ICR(2), IBLK, IFIR, IPRN(4),
6  ISTEP, ITRANS, J, KTYPE(2), NC, NEQ(10), NR, NRRET(10), TYPE, TITI
INTEGER ALOWN, BLOCK, FLAGI, TYPE(422), TITL(20)
REAL KCL, KCL, KCL, KOC(10), KCR(10), KCR(10), KMAX, INC
REAL KCPRF, KAPRF
A=AF
C=FIXED
CALL KANAL
FC4=-KAPRF*FA*PRCFFX
RETURN
END
FUNCTION FCTS(AF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
  PROOFX,NKTMX,NOX(12),NOY(12),NTA5(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
COMMON A,AP(2),ALIM,ADL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
  CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KCI,KOL,
  KOC,KOCT,KCRC,KMAX,OA,OC,PI,P,R,RAD,RE,RYL(2),ROL(2),
  SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
  UNIT(422),X,DCTMP,DELTMP,DXTMP,
  ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
  STEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL,
  INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20),
  REAL KCI,KOR,KOC(10),KRC(10),KRC(10),KMAX,INC
RETURN
END

A=AF
C=FIXED
CALL KANAL
FCT5=-KCPRF+FC*PROOF
RETURN
END
FUNCTION FCT6(CF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPBF,KAPRF,
1 PROOFX,NKTMX,NOX(12),NDY(12),NTAB(10),TPILOT,IFAIL,CUMSUM,PCYCL(2)
COMMON A,AP(2),ALIN,ALNL(2),C,CB,CLIM,CR(2,10,10),CO,CUMF,
1 CUMELM,C1B1,D(2,10,10),DK,DKE,DYDX,FA,PC,H,INC,KCL,KC1,KOL,
2 KOA,KGC,KCRA,KCRC,KMAX,DA,DC,PI,R,RAD,RE,RYCL(2),ROL(2),
3 SIG,SI6LM,SIGY,SIGYS(10),SMIN(422),SMAK(422),TH,
4 UNIT(422),W,DCTMP,DELTM,DXTMP,
5 ALOWN,BLOCK,FLAG1,I,ICO(2),ICK(2),ICR(2),IBLOCK,IFPST,IPRN(4),
6 ISTEP,TRANS,J,KTYPE(2),MC,MEU(10),NR,NRFT(10),TYPE,TITL
INTEGER ALOWN,BLOCK,FLAG1,TYPE(4,21),TITL(20)
REAL KCL,KC1,KCL,KOA(10),KGC(10),KCR(10),KCRC(10),KMAX,INC
REAL KCPBF,KAPRF
C=CF
A=FIXED
CALL KANAL
FCT6=-KAPRF*FA*PR1OFX
RETURN
END
FUNCTION FCT7(CF)
COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF, 00001110
1 PROOFX, NKTMX, NOX(12), NOY(12), NTAB(10), IPILOT, IFAIL, CUMSEL, PCYC(2) 00001160
COMMON A, AP(2), ALIM, AOL(2), CCB, CLIM, CR(2,10,10), CO, CLMF, 00001170
1 CUMELM, C181, D(12,10,10), DK, DKE, DXD, FA, FC, H, INC, KCL, K11, K12, 00001180
2 K0A, K1C, KCRA, KCRM, KMAX, OA, OC, PI, PRAD, RE, RYOL(2), ROL(2), 00001190
3 SIG, SIGLM, SIGY, SIGYS(10), SMING(422), SMAX(422), TH, 00001200
4 UNIT(422), W, DCTF, DEFT, DXTK, 00001210
5 ALOWN, BLOCK, F1AIL, I, ICD(2), IC1(2), IC1R(2), IBLOCK, IFIRST, IPRR(4), 00001220
6 ISTEP, ITFANS, J, KTYF(2), NC, NFQ(10), NR, NRET(10), TYPE, TITL 00001230
INTEGER ALOWN, BLOCK, F1AIL, TYPE(422), TITL(20) 00001240
REAL KCL, K11, KOB, KOA(10), KOC(10), KCRA(10), KCRM(10), KMAX, INC 00001250
REAL KCPRF, KAPRF 00001260
C=CF 00001270
A=FIXED 00001280
CALL KANAL 00001290
FCT7=-KCPRF+FC*FCO 00001300
RETURN 00001310
END 00001320
SUBROUTINE PTGCM
COMMON X(12, 25), Y(12, 25), TABLE(12, 25, 25), FIXED, KCP, KPRF, KAPRF,
1 PROEX, NKTMA, ONOX(12), NDY(12), NTAB(10), IPOINT, IFAIL, CUMSUM, PCYC(2)
COMMON A, AP(2), ALIM, AOL7, C, CB, CLIM, CR(2, 10, 10), CO, CUME,
1 CUMEM, CH1(2), D(2, 10, 10), DK, DK, DK, FA, FC, HC, INC, KCL, KCI, KOL,
2 KGA, KOC, KCR, KMAX, CA, CP, PI, KR, RAD, RE, RYOL(2), ROL(2),
3 SIG, SIGLM, SIGY, SIGYS(10), SMIN, MAX(22), MAX(422), TH,
4 UNIT(422), W, DCTMP, DELTMP, DXTMP,
5 ALOWI, BLOCK, FLAG1, 1, ICT(2), ICK(2), IC(2), I BLOCK, IFIRST, IPRN(4),
6 ISTEP, ITRANS, J, KTYPE(2), KCL, EQ(10), NR, NRET(10), TYPE, TITL
INTEGER ALOWI, BLOCK, FLAG1, TYPE(22), TITL(20)
REAL KCL, KCI, KOL, KCR(10), KOC(10), KCR(10), KMAX
PEAL INC, KA, KC, KCP, KCP
K = 1
IFIRST = 1
J = TYPE(I)
1025 DEL = INC*A
1030 IF (NR(1)) 1050, 1050, 1030
1038 IF (ABS(RYOL(2)) - OCC1) 1050, 1050, 1038
1040 DEL = 1*R YOL(2)
1050 A = A + DEL
K = KTYPE(2)
1054 TEMP = TH
20 GO TO 1058
C
1058 IF (ABS(AC - DEL - TEMP) - 1, 0 - 6) 1060, 1060, 070
1060 IF (KTYPE(2) != OR.7) GO TO 1065
KTYPE(1) = 2
CALL TRANS
RETURN
1065 WRITE(A, 61110)
ICR(1) = 1
CUMSUM = CUMSUM + CUF
RETURN
1070 IF (A - TEMP) 1090, 1090, 1070
1080 DEL = TEMP - A + DEL
A = TEMP
1090 SIG = SIGYS(J)
1090 IF (FLAG1) 1130, 1100, 1130
1100 R = O
SIG = SIGLM
CALL KANAL
50 IF (SIGLM*FA - KCR(1)) 1110, 1110, 1120
1110 IF (SIGLM*FC - KCC(1)) 1130, 1130, 1120
1120 FLAG1 = 1
ALIM = A
1130 A = A - DEL/2
RETURN

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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+CUME
ICR(J)=1
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+CUME
ICR(J)=1
RETURN
1160 IF (KOA(J)-DKA) 1180,1170,1170
1170 DADX=0
IF (KCC(J)-DKC) 1190,1172,1172
1172 K=1
DCDX=0
GO TO 1211
1180 KMAX=KA
DK=DKA
NC=2
CALL DAMAGE
IF (DXD) 1191,1192,1182
1182 CONTINUE
DADX=DXD
IF (KOC(J)-DKC) 1190,1200,1200
1190 KMAX=KC
DK=DKC
NC=1
CALL DAMAGE
IF (DXD) 1191,1192,1192
1191 ICR(J)=1
CUMSUM=CUMSUM+CUME
WRITE(6,6100)
RETURN
1192 CONTINUE
DCDX=DXD
GO TO 1210
1200 DCDX=0
1210 AVAIL=UNIT(I)-CUME
IF (A*C*DCDX*DADX,EQ,0) GO TO 1211
ADJ=5.*DADX/A/(DCDX/C)
IF (ADJ,GE,1.) GO TO 1211
DEL=ADJ*DEL
1211 IF (IPRN1)-IPRN(4)) 1201,1205,1205
1201 IF (IPRN(1)) 1202,1203,1203
1202 WRITF(6,8002) NR,TITL
WRITE(6,8003)
IPRN(1)=0
DFLTM=0.
DCTMP=0.
DXTMP=0.
1203 IF (IFIRST-1) 1205, 1204, 1205
1204 IFIRST=0
IPRN(1)=IPRN(1)+1
WHITE(6,8004) BLOCK,1,CUME,C,A,KC,KA,DCDX,DADX
IF (K) 5000, 1205, 5000
1205 CONTINUE
IF (ALOWN-1) 1230, 1220, 1230
1220 DX=1
DE=DX
DC=DCX
GC TC 1260
1230 IF (DADX) 1235, 1265, 1235
1235 IF (DEL/DADX-AVAIL) 1250, 1250, 1240
1240 DLTMP=DLTMP+AVAIL*DADX
IF (A) 1241, 1242, 1241
1241 IF (DLTMP/A-1.1-0.) 1244, 1244, 1247
1242 A=A+DLTMP
DELTMP=0.
1244 DCLMP=DCTMP+AVAIL*DADX
IF (C) 1245, 1245, 1245
1245 IF (DCLMP/C-1.1-4) 5000, 5000, 1246
1246 C=C+DCTMP
DCTMP=0.
GO TO 5000
1250 DX=DEL/DADX
DC=DX*DCX
GO TO 1260
1265 DC=INC*G
IF (FLMP/A-1.1-4) 1258, 1258, 1256
1256 IF (FLMP/A-1.1-4) 1257, 1257, 1257
1257 DC=AMINF.1*CUM(1),DC
1258 IF (DCDX) 5000, 5000, 1259
1259 DX=DC/DCX
DEL=DX*DADX
1260 IF (DX-AVAIL) 1280, 1280, 1270
1270 DLTMP=DLTMP+AVAIL*DADX
IF (A) 1271, 1272, 1271
1271 IF (DLTMP/A-1.1-4) 1274, 1274, 1272
1272 A=A+DLTMP
DELTMP=0.
1274 DCLMP=DCTMP+AVAIL*DADX
IF (C) 1275, 1276, 1275
1275 IF (DCLMP/C-1.1-4) 5000, 5000, 1276
1276 C=C+DCTMP
DCTMP=0.
GO TO 5000
1280 DLTMP=DLTMP*DE
IF (A) 1281, 1282, 1281
1281 IF (DLTMP/A-1.1-4) 1284, 1284, 1282
1282 A=A+DLTMP
DELTMP=0.
1284 DCLMP=DCTMP+DC
IF (C) 1285, 1286, 1285
1285 IF (DCLMP/C-1.1-4) 1288, 1288, 1286
1286 C=C+DCTMP
DCTMP=0.
1288 DXMP=DXTMP+DX
   IF (IPLTNE.2) GO TO 1300
   CUMMP=CUMSUM+SUME
   IF (CUMMP.LT.PYC(2)) GO TO 1300
   WRITE(7,7000) A,C,CUMMP
   PCYC(2)=PCYC(2)+PCYC(1)
1300 IF (CUME) 1269,1290,1289
1289 IF (DXTMP/CUME-1.0E-4) 1025,1025,1290
1290 CUME=CUME+DXTMP
   DXMP=0.
   GO TO 1025
5000 CONTINUE
   CUME=UNIT(I)
   CUMSUM=CUMSUM+UNIT(I)
   IF (IPLTNE.2) GO TO 5005
   IF (CUMSUM.LT.PYC(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,KA,DCDX,DADX
   IF (IPLTNE.1) GO TO 5020
   WRITE(7,7000) A,C,CUMSUM
5020 CONTINUE
   RETURN
6002 FORMAT(5H,0,45H,CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE,16,
   1 14H BLOCK AND THE,14,11H STEP AFTER,1PE12.3,7H CYCLES )
6003 FORMAT(45H,0,45H,CRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE,16,
   1 14H BLOCK AND THE,14,11H STEP AFTER,1PE12.3,7H CYCLES )
6019 FORMAT(35H,0,45H,LIMIT LOAD FRACTURE OCCURS IN THE,16,7H BLOCK ,
   1 45H,12H STEP AFTER ,1PE12.3,7H CYCLES )
6100 FORMAT(1H,0,45H,CRACK GROWTH RATE IS NEGATIVE,1/1H ,
   1 45H,ACCEPTABLE END OF LIFE IF FORMUN EQUATION USED)
6110 FORMAT(1H,0,45H,CRACK IN TRANSITION. NEED TABLES FOR ANALYSIS.)
7000 FORMAT(1H,0,45H,DATA,1PE12.3)
8002 FORMAT(5H,0,45H,HIRUN,14,5X,20A4,1H0,50X,26HCRACK IS A PART THRU CRACK,1
   1 /1H0,42X,12H,HALF SURFACE,50X,7HSURFACE,9X,5HDEPTH)
8003 FORMAT(1H,0,45H,CRACK LENGTH ,
   1 15HCRACK DEPTH KMAX-SURFACE KMAX-DEPTH GROWTH RATE,4X,1
   1 21HHGROWTH RATE,1H 4X,4H(IN),11X,4H(IN),6X,13H(KSI ROOT-IN),2X,1
   1 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), FIXED, KCPFRF, KAPRF,
1 PRODFX, NKTMX, NOX(12), NCY(12), NTAB(10), IPILOT, IFAIL, CUMSUM, PGC1(2)
COMMON A, AP(2), ALIM, AOL(2), C, CB, CLIM, CR(2, 10, 10), CO, CUME,
1 CUMELM, CB1(2), D(2, 10, 10), DK, DE, DDX, FA, FC, H, INC, KCL, KCOL,
2 KOA, KOC, KPI, KRC, KRMAX, GA, CC, P1, R, R, R, RYOL(2), ROL(2),
3 SIG, SIGLM, SIGY, SIGCY(10), SMIN(22), MAX(22), THN,
4 UNIT(422), WP, DCMP, DCTMP, DELTMP, DXTMP,
5 ALOWN, BLOCK, FLAG, I, I(2), ICK(2), ICR(2), ILOCK, IFIRST, IPRN(4),
6 STEP, ITRANS, K, KTYPE(2), NC, NEW(10), NR, PELT(10), TYPE, TITL
INTEGER ALOWN, BLOCK, FLAG, I(2), ICK(2), ICR(2), ILOCK, IFIRST, IPRN(4),
REAL KCL, KCO, KOL, KOA(10), KCPA(10), KCR(10), KMAX, INC
REAL KA, KC, KAPRF, KCPFRF
K=C
IFIRST=1
IF (TRANS-1) 10, 18, 10
10 CONTINUE
TRANS=1
KORIC=KTYPE(1)
KTYPE(1)=3
FLAG2=0
CALL KANAL
IF (FC*SMAX(I)-KRC(J)) 110, 110, 100
110 WRITE(6, 6021) BLOCK, 1, CUME
CUMSUM=CUMSUM+CF
IFAIL=3
ICR(1)=-1
RETURN
110 IF (FLAG1) 140, 120, 140
120 IF (FC*SIGLM-KRC(J)) 140, 140, 130
130 FLAG3=1
ALIM=A
CLIM=C
IBLOCK=BLOCK
ISTEP=1
CUMFLM=CUME
140 CR=CR+0.02*CR
KTYPE(1)=KORIC
SIGY=SIGCY(I)
SIG=SMAX(1)
R=SMIN(1)/SIG
140 CALL KANAL
IF (FA*KIC-KRC(J)) 180, 180, 160
160 CR=CR+0.02*CR
FLAG2=1
IF (CR-C) 150, 170, 170
170 WRITE(6, 6022) BLOCK, 1, CUME
WRITE(6, 6027) CR, C
IFAIL=4
ICR(1)=-1
CUMSUM=CUMSUM+CF
RETURN
180 DEL=INC*CB
IF (INRET(J)) 204, 209, 201
201 IF (ANS(RYOL(I))-0.001) 209, 209, 202
202 IF (DFL-1.8*RYOL(I)) 709, 709, 705
203 DEL=.1*RYOL(I)
204 CR=CB+DEL
IF (CR-.95*CR) 220, 220, 210
210 ITRANS=0

IF (KTYPE(1).NE.2) GO TO 215
KTYPE(1)=3
CALL TCGRW
RETURN
215 WRITE(6,6110)
ICR(1)=-1
CUMSUM=CUMSUM+CUME
RETURN
220 CONTINUE
SIG=SIGLM
CALL KANAL
IF (SIGLM*FA-KCRC(J)) 1110,1110,1120
1110 IF (SIGLM*FC-KCRC(J)) 1130,1130,1120
1120 FLAG1=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
CB=CB-DEL/2
KA=FA*SIG
KC=FC*SIG
DKA=(1-R)*KA
DKC=(1-R)*KC
IF (KA-KCRC(J)) 1140,1140,1150
1140 IF (KC-KCRC(J)) 1160,1160,1153
1150 IF (FLAG1) 1152,1152,1151
1151 WRITE(6,6019) IPLOCK,ISTEP,CUME
1152 WRITE (6,6002) BLOCK,I,CUME
CUMSUM=CUMSUM+CUME
IFAIL=1
ICR(1)=-1
RETURN
1153 IF (FLAG1) 1155,1155,1154
1154 WRITE(6,6019) IPLOCK,ISTEP,CUME
1155 WRITE (6,6003) BLOCK,I,CUME
CUMSUM=CUMSUM+CUME
IFAIL=2
ICR(1)=-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 (DXDX) 1192,1184,1184
1184 DADX=DXDX
IF (KOC(J)-DKC) 119C,1200,1200
1190 KMAX=KC
DK=DKC
NC=1
CALL DAMAGE
32X,13H(1 Roots-In),4X,10H(IN/CYCLE),5X,10H(IN/CYCLE),//

AC04 FORMAT(10H
	I6,3X,14,7(3X,1PE12.3))

END

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SUBROUTINE TCGROW
COMMON X(12,25),Y(12,25),TABLE(12,25),FIXED,KCPRF,KAPRF,
1 PROFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPILOT,IFAIL,CUMSUM,PCYC(2)
COMMON A,AP(2),ALIM,ANL(2),C,CR(2,10,10),CO,CUME,
1 CUMELM,CBL(2,10,10),DK,DKE,DXX,DXFA,FC,H,INC,KCL,KCI,KDL,
2 KOA,KOC,KCRA,KCRC,KMAX,DCA,OC,E,PI,F,RAD,RE,RYC(2),RUL(2),
3 SIG,SIGLM,SIGV,SIGYS(10),SMIN(422),SMAX(422),TH,
4 UNIT(422),W,DCTMP,DELMTMP,DXTMP,
5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
6 ISTEP,ITRANS,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
INTEGER ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
REAL KCL,KCI,KC,KCL,KOA(10),KCC(10),KCRC(10),KMAX
REAL INC,KC,KAPF,KCPF
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*RYC(1)) 1050,1050,1038
1040 DEL=1*RYCL(1)
10400 C=C*DEL
SIG=SIGYS(J)
IF (FLAG1) 1130,1130,1130
1100 R=0
SIG=SIGLM
CALL KANAL
IF (SIGM=FC-KCRC(J)) 1130,1130,1130
11000 C=C-DEL/2
SIG=SMIN(J)
R=SMIN(J)/SMAX(J)
CALL KANAL
C=C-DEL/2
KC=FC*SIG
DK=(1-R)*KC
IF (KC-KCRC(J)) 1160,1160,1160
1153 IF (FLAG1) 1155,1155,1155
1154 WRITE(6,6010) IBLOCK,ISTEP,CUMELM
1155 WRITE(6,6003) BLOCK,1,CUME
IFAIL=2
CUMSUM=CUMSUM+CUME
ICR(1)=1
RETURN
1160 IF (KOC(J)-DKC(J)) 1190,1170,1170
1170 DCDX=0
GO TO 1180
1190 KMAX=KC
DK=DKC
NC=1
CALL DAMAGE
DCDX=DXX
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
00000010
00000020
00000030
00000040
00000050
00000060
00000070
00000080
00000090
00000100
00000110
00000120
00000130
00000140
00000150
00000160
00000170
00000180
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00000210
00000220
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00000360
00000370
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00000390
00000400
00000410
00000420
00000430
00000440
00000450
00000460
00000470
00000480
00000490
00000500
00000510
00000520
00000530
00000540
00000550
00000560
00000570
00000580
00000590
00000600
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DELTMP=0.
DXTMP=0.
1193 IF (IFIRST-1) 1195,1194,1195
1194 IFIRST=0
IPRN(2)=IPRN(2)+1
WRITE(6,6004) BLOCK,1,CUME,C,KC,DCDX
1195 CONTINUE
IF (DCDX) 1200,5000,1210
1200 ICRI(1)=-1
WRITE(6,6100)
CUMSUM=CUMSUM+CUME
RETURN
1210 AVAL=TUNIT(I)-CUME
IF (ALOWN-1) 1230,1220,1230
1220 DX=1
DELP=DCDX
GO TO 1280
1230 DX=DEL/DCDX
IF (DX-AVAL) 1280,1280,1270
1270 DELTMP=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 DELTMP=DELTMP+DEL
IF (C) 1281,1282,1281
1281 IF (DELTMP/C-1.E-4) 1284,1284,1282
1282 C=C+DELTMP
DELTMP=0.
1284 DXMTMP=DXTMP+DX
IF (IPLONT.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 (CUM) 1285,1286,1285
1285 IF (DXTMP/CUME-1.E-4) 1025,1025,1286
1286 CUME=CUME+DXMTMP
DXTMP=0.
GO TO 1025
5000 CONTINUE
CUMSUM=CUMSUM+UNIT(I)
CUME=UNIT(I)
IF (IPLONT.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(7)-IPRN(4)) 5010,5020,5020
5010 IPRN(2)=IPRN(2)+1
WRITE(6,6005) BLOCK,1,CUME,C,KC,DCDX
IF (IPLONT.NE.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,/1H )
D-37
1 ACCEPTABLE END OF LIFE IF FORMULA EQUATION USED.

7000 FORMAT(4HDATA,1P3E12.3)  00001210
8002 FORMAT(5H1RUN,14,5X,20A4,/1H0,50X,24HCRAK IS A THROUGH CRACK, 00001230
          1/1H0,46X,4HHALF,25X,5HCRAK)          00001240
8003 FORMAT(1H,12X,4HBlocks STEP CYCLES CRACK LENGTH,
          14X,4HMAX,16X,11HGROWTH RATE,/1H,6X,4H(IN),6X,13H(KSI ROOT-IN),
          24X,10H(IN/CYCLE),/)  00001250
8004 FORMAT(10H,16,3X,14,7(3X,1PE12.3))  00001280
8005 FORMAT(10H,16,3X,14,7(3X,1PE12.3))  00001250
END  00001300
SUBROUTINE DAMAGE
COMMON X(12,25),Y(12,25),TABF(12,25,25),FIXED,KCPRF,KAPRF,
1 PROFX,NKTHX,NOCI(12),NOY(12),NTAB(10),IPLIOT,FAIL,CUSUM,PCYC(2)
COMMON A,AP(2),ALIM,ADL(2),C, CB, CLIH,CR(2,10),CC,CUME,
1 CUMELM,CIVB(12,10,10),DK,DKF,DXDX,FA,FC,H,INC,KCL,KCL,KCL,
2 KDA,KOC,KCR, KCRC, KMAX, CA, GC, PI, R, RAD, RE, RC(2), RL(2),
3 SIG,SIGM, SIGY, SIGYS(10), SMIN(422), SMAX(422), TH,
4 UNIT(422),X, DCTMP, DTLTMP,DXTMP,
5 ALWON,BLOCK,FLAG1,ICD(2), ICK(2), ICR(2), IBLOCK, IFIRST, IPRM(4),
6 ISTEP,TRANS,J,KTYPE(2),NC,NEQ(10),NR,NRFT(10), TYPE,TITL
INTEGER ALWON,BLOCK,FLAG1,TYPE(422),TITL(20)
REAL KCL,KC1,KO1,KC4(10), KCC(10), KCRA(10), KCRC(10), KMAX, INC
REAL KO,KCR,KCP,KCPF,KAPF
RF=R
DKE=(1.0-RE)*KMAX
IF (NEQ(J)) 700,700,10
10 IF (NEQ(J)-4) 20,20,700
20 J1=NEQ(J)
GO TO (30,206,300,400), J1
C
C COLLIPRIEST-EBRET EQUATION
C
30 CD=D(NC+1,J)
31 PN=D(NC+2,J)
32 KG=D(NC+4,J)
33 KCR=D(NC+3,J)
34 IF (NRFT(J)) 60,90,80
80 CALL RETARD
90 CC1=ALOG(KCC/KO)
CC2=CC1*PN/2.
CC1=PN/2.
35 CC1=(KCF*KO)**CC1
36 CC1=CD*CC1
37 T1=(1.-RE)*KCR*KO
38 T1=DKF**2/3/T1
39 T2=T1=ALOG(T1)
T2=(1.-RE)*KCR/KO
T2=ALOG(T2)
T1=T1/72
T3=(T1+T1)/(1.-T1)
T2=.5*ALOG(T3)
T1=CC2*T2
12=EXP(T1)
DXDX=CC1*T2
GO TO 600
C
C PARIS EQUATION
C
200 IF (NC-2) 220,270,220
210 CD=D(2,1,J)
220 PN=D(2,2,J)
GO TO 250
230 CD=D(1,1,J)
240 PN=D(1,2,J)
250 IF (NRFT(J)) 260,270,240
260 CALL RETARD
270 DXDX=1
IF (DKF-KCC(J)) 271,275,275
271 IF (NC-1) 275,272,275
272 DXDX=0

ORIGINAL PAGE IS POOR QUALITY.
GO TO 600
275 IF (DKE-KOA(J)) 276,278,278
276 IF (NC-2) 278,277,278
277 DXDX=0
GO TO 600
278 DXDX=CD*KKE**PN
GO TO 600
C
C FORMAN EQUATION
C
300 DXDX=-1
IF (DKE-KOC(J)) 310,330,330
310 IF (NC-1) 330,320,330
320 DXDX=0
GO TO 600
330 IF (DKE-KOA(J)) 340,360,360
340 IF (NC-2) 360,350,360
350 DXDX=0
GO TO 600
360 IF (((1.-RE)*D(NC,3,J)-DKE) 370,370,380
370 WRITE(6,6001)
GO TO 600
380 DXDX = D(NC,1,J)*DKE**D(NC,2,J)
DXDX=DXDX/(((1.-RE)*D(NC,3,J)-DKE)
GO TO 600
C
C INTERPOLATION MODEL
C
400 NT=NTAB(J)
IF (NC.EQ.1) GO TO 402
NT=NT+1
402 IF (NRET(J)) 420,420,410
410 CALL RETARD
420 IF (NT.LT.13) GO TO 430
WRITE(6,6002)
STOP
430 CALL INTP(NT,DKE,RE,2,DXDX)
RETURN
600 RETURN
700 WRITE (6,1000) NEQ(J)
STOP
1000 FORMAT (I0HONEQ(J) = ,13,13H OUT OF RANGE)
6001 FORMAT(39HOCRAK; GROWTH RATE HAS GONE TO INFINITY)
6002 FORMAT(I0H, 'NT IS GREATER THAN 12')
END
SUBROUTINE RETARD
COMMNX XX(12,25), YY(12,25), TABLE(12,25,25), FIXED, KCFPRF, KAFPRF,
1 PROFX, NKT, MX, NOX(12), NOY(12), NTAB(10), IPLT, IFAIL, CM, SUM, PCYC(2)
COMMNX A, AP(2), ALIM, ACL(2), C, CR, CLIM, CR(2, 10, 10), CO, CUMF,
1 CUMEL, M, C1B1, D12, 10, 10, DKE, DKE, DDX, DAT, FC, H, INC, KCL, KCL,
2 KOA, KOC, KCR, KCR, KMAX, CA, NC, PI, R, RAD, RE, RYQ(2), RYQ(2),
3 SIG, SIGM, SIG, SIG(10), SMIN(22), SMAX(22, 2), TH,
4 UNIT(22), W, NCTMP, DELTMP, DXTMP,
5 ALW1, BLCK, RCA, ICD(2), ICK2, ICR(2), IBLOCK, IFIRST, IPRN(4),
6 ISTEP, ITRANS, J, KTYPE(2), NC, NEW(10), NR, NRET(10), TYPE, TITL
INTEGER ALW1, BLCK, FLAG1, TYPE(22), TITL(20)
REAL KCL, KCL, KCL, KOA(10), KOC(10), KCR(10), KCR(10), KMAX, INC
REAL KAP, KMINE, KC2, KMAK, KCFPRF, KAFPRF
PZ = CRINC, I = J
IF (NRET(J)) 500, 500, 10
10 IF (NRET(J) - 3) 20, 20, 500
20 J = NRET(J)
IF (NC - 1) 22, 21, 22
21 X = C
GO TO 23
22 X = A
23 CONTINUE
GO TO (AC, 26, 33), J1
C
C WILLENBOURG MODEL
C
30 RY = (KMAX / SIG2) * 2
R1 = CR(NC, 1, J) * 2 * PI
R1 = 1 / R1
RY = RY * R1
IF (RY - AP(NC) + X) 50, 40, 40
40 AP(NC) = X + RY
RYOL(NC) = RY
50 KAP = 2 * PI * (AP(NC) - X)
KAP = AP(NC) * SIG
KMAX = 2 * KMAX - KAP
KMIN = (1 + R) * KMAX - KAP
IF (KMIN) 60, 60, 70
60 KMIN = 0
70 IF (KMAX) 30, 80, 90
60 KMAX = 0
90 DKE = KMAK - KMINE
RE = KMINE / KMAK
GO TO 430
C
C WHEELER MODEL
C
200 RY = (KMAX / SIG2) * 2
R1 = CR(NC, 1, J) * 2 * PI
R1 = 1 / R1
RY = RY * R1
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 - K) * KMAX
RE =
GO TO 430
C
D-41
GRUMMAN CLOSURE MODEL

300 ALOWN=0

P2=CR(NC,1,J)
CFM1 = CR(NC,2,J)
CFO = 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+(CFO-CFM1)*(1+R)**P
KC2=CF2*KMAX
IF (R*KMAX-ROL(NC)*KOL) 310,320,320
310 ROL(NC)=1(R*KMAX)/KOL
CF1=CFM1+(CFO-CFM1)*(1+ROL(NC))**P
KC1=CF1*KOL
ACL(NC)=X
320 IF (KMAX-KCL) 320,330,340
330 DKE=0
RE=0
GO TO 430
340 IF (KCL-KC2) 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 KCI=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)
1600 FORMAT(11HONRET(J) = ,I3,13H OUT OF RANGE)
STOP
END
SUBROUTINE INTFIT(NT, X, Y, INTQ, F)
COMMON X(12, 25), Y(12, 25), TABLE(12, 25, 25), FIXED, KCPRF, KAPRF,
1 PREDX, NKTMX, NX(12), NNY(12), NTAB(10), IPILOT, IFAIL, CUMSUM, PECYC(2)
REAL KCPRF, KAPRF
NEND=0
NUMX=NX(NT)
NUMY=NNY(NT)
IF (X(NT, 1) .GE. X(T, NT)) GO TO 5
IF (X(NT, NUMX).GE.XT) GO TO 10
5 WRITE(6, 6010) XT, NT
NEND=1
10 IF (Y(NT, 1).GT.YT) GO TO 15
IF (Y(NT, 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(NT, IJ)) GO TO 60
50 CONTINUE
60 NX=IJ
DO 70 IJ=2, NUMY
IF (YT.LT.Y(NT, IJ)) GO TO 80
70 CONTINUE
80 NY=IJ
IF (INTQ.EQ.1) GO TO 100
IF (INTQ.EQ.2) GO TO 200
WRITE(6, 6030)
STOP
C
FOUR-POINT LINEAR BIVARIATE INTERPOLATION
C
100 NXM1=NX-1
NYM1=NY-1
P=X(NT, NX)-X(NT, NXM1)
Q=Y(NT, NY)-Y(NT, NYM1)
C=(YT-Y(NT, NYM1))/Q
FOO=TABLE(NT, NXM1, NYM1)
F10=TABLE(NT, NX, NYM1)
FO1=TABLE(NT, NXM1, NY)
F11=TABLE(NT, NX, NY)
F=(1.-P)*(1.-Q)*FOO + P*(1.-Q)*F10
F=F + Q*(1.-P)*FO1 + P*Q*F11
RETURN
C
FOUR-POINT LOG-LINEAR BIVARIATE INTERPOLATION
C
200 NXM1=NX-1
NYM1=NY-1
P=ALOG(XT/X(NT, NXM1))
Q=ALOG(YT/NY)
C=(YT-Y(NT, NYM1))/Q
FOO=ALOG(TABLE(NT, NXM1, NYM1))
F10=ALOG(TABLE(NT, NX, NYM1))
FO1=ALOG(TABLE(NT, NXM1, NY))
F11=ALOG(TABLE(NT, NX, NY))
F=(1.-P)*(1.-Q)*FOO + P*(1.-Q)*F10
F=F + Q*(1.-P)*FO1 + P*Q*F11
RETURN
F=EXP(F)
RETURN

6010 FORMAT(1HO, 4HX = ,1PE12.3, 26H IS OUT OF RANGE OF TABLE ,I4)
6020 FORMAT(1HO, 4HY = ,1PE12.3, 26H IS OUT OF RANGE OF TABLE ,I4)
6030 FORMAT(1HO, Z1HERROR IN CALL TO INTP)
END
SUBROUTINE KANAL
COMMON X(12,25),Y(12,25), TABLE(12,25,25),FIXFD,KCPRF,KAPRF,
1 PROCEX,NKTMX,NDX(12),NDY(12),NTAB(10),IPLT,IFAIL,CUMSUM,PCYC(12)
COMMON A,AP(2),ALIM,ACOL(12),C,CA,C*,CLIM,CR(2,10,10),CO,CUME,
1 CUMFLM,GClB1,DF(2,10,10),DK,DKE,DXD,FA,FC,H,INC,KCL,KC1,KCL,
2 KOA,KOC,KCR,KCRA,KCRC,KMAX,GA,DC,PI,R,RAD,RE,RYCL(2),RUL(2),
3 SIG,SIGLM,SY,SYGM(10),SMIN(22),SMAX(422),TH,
4 UNIT(142),WDCMP,DELTM,DXTMP,
5 ALCWD,FLCCW,FLAG1,IC,ICD(2),ICK(2),IIC(2),IICL,BLOCK,IFIRST,IPRN(4),
6 ISTEP,ITRANS,J,KTYPE(2),K,NKFC(10),NR,NPET(10),TYPE,TITL
INTEGER ALCWD,FLCCW,FLAG1,TYPE(422),TITL(20)
REAL KCL,KC1,KCC(10),KCR(10),KMAX,INC
REAL KCPRF,KAPRF

C
C KT = KTYPE(1)
GO TO (1000,2000,3000), KT
C
C PART THROUGH CRACK
C
1000 KT = KTYPE(2)
GO TO (1020,1040,1060,1080,1100,1120,1140,1160,1200,1220,
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
1024 B = AMIN1(A,C)
B = SORT(P1*B)
ADVC = A/C
FSUR = FNSP1(ADVC,2)
FEFP = FNSP1(ADVC,1)
FC = B*FSUR/SORT(COS(P1*C/W))
W1 = A/TH
W2 = 0.6963*W1*2.333*W1**2.3972*W1**3.352*W1**4
W3 = W2 = 0.111*W1**5.233*W1**6
W4 = A/W(2.,C)
FA = 1.10*W1*4.12*W1*4.12*W1**2.86*W1**3.65*W1**4
PH1 = W2**FA/W(5.62) + 1.
PH12 = PH12*(1. + 12*(1.-W1)**2)
FA = B*FEFP*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 MFLF
C
1060 CONTINUE
B = AMIN1(A,C)
FA = SORT(P1*B)
FE = 1.2133-2.265*(C/(C+RAD))-.6451*(C/(C+RAD))**2
FH = EXP(FB)
FS1 = 1.0/COS(P1*RAD/W)
FA = FA*SORT(FE(1))*FB
ADVC = A/C
FS2 = FNSP1(ADVC,1)
FS2 = FNSP1(ADVC,5)
C
C
FA = FA * FS1
FC = PI * (C + 2.0 * RAD) / (2.0 * (W - C))
FC = SORT(1.0 / COS(FC)) * FB * SORT(PI * B) * FS2
GO TO 4000

C

C PTC 04 - DOUBLE CORNER CRACK AT HOLE

1080 CONTINUE
B = AMIN1(A, C)
S = C / (C + RAD)
FB = EXP(1.2133 - 2.086 * S + .8727 * S * S)
FA = SORT(1.0 / COS(PI * RAD / W)) * FB
AOVC = A / C
FS1 = FUNP1(AOVC, 1)
FS2 = FUNP1(AOVC, 2)
FA = FA * FS1 * SORT(PI * B)
FC = SORT(PI * B) * SORT(1.0 / COS(PI * (C + RAD) / W)) * FB * FS2
GO TO 4000

C

C PTC 05 - SINGLE INTERNAL CRACK AT HOLE

1100 CONTINUE
B = AMIN1(A, C)
FC = SORT(PI * B) / 1.122
FS6 = C / (C + RAD)
FB = EXP(1.2133 - 2.05 * S + .6451 * FS6 * S + S)
FA = SORT(1.0 / COS(PI * (C + RAD) / W)) * FB * FC
AOVC = A / C
FS6 = FUNP1(AOVC, 1)
FS5 = FUNP1(AOVC, 2)
FA = SORT(PI * B) / 1.122
FA = FB * FA * FS5 * SORT(1.0 / COS(PI * RAD / W))
GO TO 4000

C

C PTC 06 - DOUBLE INTERNAL CRACK AT HOLE

1120 CONTINUE
B = AMIN1(A, C)
FC = SORT(PI * B) / 1.122
FA = FC
S = C / (RAD + C)
FB = EXP(1.2133 - 2.086 * S + .8727 * S * S)
FA = SORT(1.0 / COS(PI * (C + RAD) / W)) * FB * FC
AOVC = A / C
FS6 = FUNP1(AOVC, 1)
FS5 = FUNP1(AOVC, 2)
FA = FC * FS6
FA = FB * FA * FS5 * SORT(1.0 / COS(PI * RAD / W))
GO TO 4000

C

C PTC 07 - INTERPOLATION MODEL - PART-THROUGH CRACK

1140 FA = SORT(PI * A)
FA = FA
NT = 0
CALL INTPT(NT, C, A, 1, FCC)
NT = NT + 1
CALL INTP(NT, C, A, 1, FAA)
FC=FC*FCC
FA=FA*FAA
IF (MT-NKTMX*2) 1142,-000,4000

C

DTC OR - PIN LOADED LUG, SINGLE CORNER CRACK

1160 Z=(C+2.*RAD)/2.
E=C/2.*
F=W/2.*
R=P-R-E
FS1=2.*Z/H
FS2=7/BP
PHCP=FUNT1(FS2)
PHCP=PHCP/SORT(1.,FS2)
PHHP=1.*-08*FS1+2.*69*FS1**2-*.99*FS1***3
PHWP=1.*-5*FS2+.97*FS2**2-*.16*FS2***3
PHHP=PHHP/SORT(1.,FS2)
PHP=PHP=PHWP/SORT(1.,FS2)
PHP=PHP=PHWP/SORT(1.,FS2)

C

DTC OR - PIN LOADED LUG, TWO CORNER CRACKS

D-47
1180 B=W/2.
    Z=RAD+C
    PHCP=FUNT1(Z/B)
    FS1=2.*Z/W
    FS2=2.*Z/H
    PHCP=PHCP/SQRT(1.-FS1)
    PHWP=1.-.5*FS1+.957*FS1**2-.16*FS1**3
    PHWP=PHWP/SQRT(1.-FS1)
    PHHP=1.-.08*FS2+2.69*FS2**2-.91*FS2**3
    PHP=(PHCP+PHWP*PHHP)/2.
    PHCS=FUNT2(Z/B)
    PHCS=PHCS/SQRT(1.-FS1)
    PHSS=FUNT3(FS2)
    PHSS=PHSS*SQRT(1./COS(PI*Z/W))
    S=C/(RAD+C)
    FB=EXP(1.2133-2.086*5+.8727*5*5)
    PHS=(PHCS+PHSS)*FB/2.
    FC=1.05*PHP/(2.*TH*SQRTPHI)
    FC=FC+PHS*SQRT(PI*C)/(2.*W*TH)
    ADV=C/A/C
    D1=AMINIII(A,C)
    FS2=FUNT1(AVC,2)
    FS4=SQRTPHI
    FC=FC*FS2*FS4
    B=W/2.
    Z=RAD+C
    FS1=RAD/B
    PHCP=FUNT1(FS1)
    FS2=2.*Z/H
    PHCP=PHCP/SQRT(1.-FS1)
    PHWP=1.-.5*FS1+.957*FS1**2-.16*FS1**3
    PHWP=PHWP/SQRT(1.-FS1)
    PHHP=1.-.08*FS2+2.69*FS2**2-.91*FS2**3
    PHP=(PHCP+PHWP*PHHP)/2.
    PHCS=FUNT2(FS1)
    PHCS=PHCS/SQRT(1.-FS1)
    PHSS=FUNT3(FS2)
    PHSS=PHSS*SQRT(1./COS(PI*RAD/W))
    S=C/(RAD+C)
    FB=EXP(1.2133-2.086*5+.8727*5*5)
    PHS=(PHCS+PHSS)*FB/2.
    FC=1.05*PHP/(2.*TH*SQRTPHI)
    FC=FC+PHS*SQRT(PI*C)/(2.*W*TH)
    FA=FUNT1(AVC,1)
    FA=FA*FA*FS4
    GO TO 4000

PTC 10 - PIN LOADED LUG, SINGLE INTERNAL CRACK

1200 Z=(C+2.*RAD)/2.
    E=C/2.
    B=W/2.
    BP=B-E
    FS1=2.*Z/H
    FS2=Z/BP
    PHCP=FUNT1(FS2)
    PHCP=PHCP/SQRT(1.-FS2)
    PHHP=1.-.08*FS1+2.69*FS1**2-.99*FS1**3

D-48
PIC II - PIN LOADED LUG, TWO INTERNAL CRACKS

1220

5=W/2.
Z=RAD+C
PMCP=FUNT1(2/R)
FS1=2.*Z/7
FS2=2.*Z/7
PMCP=PHCP/SORT(1,-FS1)
PHWP=1.08*FS1+1.69*FS1**3
PMHP1=1.08*FS2+1.69*FS2**3
PMHP2=PHHP/SORT(1,-FS2)
PMHP=(PHCP+PHHP*PHHP)/2.
PHCP=PHCS/SORT(1,-FS1)
PHCS=PHCS/SORT(1,-FS2)
PMHP=(PMHP+PMHP*PMHP)/2.
FS1=2.*Z/7
FS2=RAD/2
PMCP=FUNT1(2/R)
PMHP=1.08*FS1+1.69*FS1**3
PMHP2=PHHP/SORT(1,-FS2)
PMHP=(PHCP+PHHP*PHHP)/2.
PHCP=PHCS/SORT(1,-FS1)
PHCS=PHCS/SORT(1,-FS2)
PMHP=(PMHP+PMHP*PMHP)/2.
FS1=2.*Z/7
FS2=RAD/2
PMCP=FUNT1(2/R)
PMHP=1.08*FS1+1.69*FS1**3
PMHP2=PHHP/SORT(1,-FS2)
PMHP=(PHCP+PHHP*PHHP)/2.
PHCP=PHCS/SORT(1,-FS1)
PHCS=PHCS/SORT(1,-FS2)
PMHP=(PMHP+PMHP*PMHP)/2.

PMHP1=1.08*FS1+1.69*FS1**3
PMHP2=PHHP/SORT(1,-FS2)
PMHP=(PHCP+PHHP*PHHP)/2.
PHCP=PHCS/SORT(1,-FS1)
PHCS=PHCS/SORT(1,-FS2)
PMHP=(PMHP+PMHP*PMHP)/2.

C

PMCP=FUND1(2/R)
FS1=2.*Z/7
FS2=2.*Z/7
PMCP=PHCP/SORT(1,-FS1)
PHWP=1.08*FS1+1.69*FS1**3
PMHP1=1.08*FS1+1.69*FS1**3
PMHP2=PHHP/SORT(1,-FS2)
PMHP=(PHCP+PHHP*PHHP)/2.
PHCP=PHCS/SORT(1,-FS1)
PHCS=PHCS/SORT(1,-FS2)
PMHP=(PMHP+PMHP*PMHP)/2.

PMHP1=1.08*FS1+1.69*FS1**3
PMHP2=PHHP/SORT(1,-FS2)
PMHP=(PHCP+PHHP*PHHP)/2.
PHCP=PHCS/SORT(1,-FS1)
PHCS=PHCS/SORT(1,-FS2)
PMHP=(PMHP+PMHP*PMHP)/2.
S=C/(RAD+C)

FB=EXP(1.2133-2.086*S+.8727*S*S)

PHS=(PHCS+PHSS)*F6/2.

FC=1.05*PHP/(2.*TH*SQR(P42))

FC=FC+PHS*SQR(PI*C)/(1.*W*TH)

DI=AMIN1(A,C)

ADCVC=A/C

FS4=SORT(PI*D1)/SQR(PI*C)

FA=FUP1(AOVC,1)

FC=FC*FA/1.122*FS4

---

C

B=W/2.

Z=RAD+C

FS1=RAD/B

PHC=FUP1(FS1)

FS2=2.77/H

PHCP=PHCP/SORT(1.-FS1)

PHWP=1.-FS1+.457*FS1**2-0.16*FS1**3

PHHP=PHWP/SORT(1.-FS1)

PHHP1=1.-08*FS2+2.64*FS2**2-0.91*FS2**3

PHP=(PHCP+PHWP+PHHP)/2.

PHCS=FUP2(FS1)

PHCS=PHCS/SORT(1.-FS1)

PHSS=FUP3(FS2)

PHSS=PHSS*SORT(1./COS(PI*RAD/W))

C

FS1=4AD/B

IF (FS1.LT.0.01) GO TO 1246

S=C/(B+C)

FC=FC+PHS*SQR(PI*C)/(1.*W*TH)

FA=FUP1(AOVC,1)

FA=FA*FS1*1.122*FS4

C

PTC 12 - SINGLE CORNER CRACK AT SINGLE NOTCH

S=C/(B+C)

FB=EXP(1.2133-2.086*S+.8727*S*S)

PHS=(PHCS+PHSS)*F6/2.

FC=1.05*PHP/(2.*TH*SQR(P42))

FC=FC+PHS*SQR(PI*C)/(1.*W*TH)

DI=AMIN1(A,C)

ADCVC=A/C

FS4=SORT(PI*D1)/SQR(PI*C)

FA=FUP1(AOVC,1)

FC=FC*FA/1.122*FS4

C

B=W/2.

Z=RAD+C

FS1=RAD/B

PHC=FUP1(FS1)

FS2=2.77/H

PHCP=PHCP/SORT(1.-FS1)

PHWP=1.-FS1+.457*FS1**2-0.16*FS1**3

PHHP=PHWP/SORT(1.-FS1)

PHHP1=1.-08*FS2+2.64*FS2**2-0.91*FS2**3

PHP=(PHCP+PHWP+PHHP)/2.

PHCS=FUP2(FS1)

PHCS=PHCS/SORT(1.-FS1)

PHSS=FUP3(FS2)

PHSS=PHSS*SORT(1./COS(PI*RAD/W))

S=C/(B+C)

FB=EXP(1.2133-2.086*S+.8727*S*S)

PHS=(PHCS+PHSS)*F6/2.

FC=1.05*PHP/(2.*TH*SQR(P42))

FC=FC+PHS*SQR(PI*C)/(1.*W*TH)

DI=AMIN1(A,C)

ADCVC=A/C

FS1=4AD/B

IF (FS1.LT.0.01) GO TO 1246

S=C/B

FA=FUP1(FS1)

FA=FA*FS1*1.122*FS4

GO TO 1248
1246 F0=1.127*SORT(B)*FW
1248 F0=FO*SORT(PI*D1)/SORT(PI*C)*FU(PI*AVC+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=1.127*SORT(B+C)*FW
1264 AVC=A/C
D1=AMIN1(A,C)
FW=(1.+1.127*(COS(PI*(B+C)/W))**4)*COS(PI*(B+C)/W)
FC=FC*FW/FS2
FC=FC*SORT(PI*D1)/SORT(PI*C)*FUNPI(1,AVC+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/F/TAN(PI*(B+C)/W))
FS1=RAD/B
IF (FS1.LT. .01) GO TO 1266
S=C/(B+C)
FC=FUNT4(S,FS1)
FC=FC*FW*SORT(PI*C)
GO TO 1266
1266 FC=1.127*SORT(B+C)*FW
1268 CONTINUE
FW=(1.+1.127*(COS(PI*(B+C)/W))**4)*COS(PI*(B+C)/W)
FC=FC*FW/FS2
FA=FC*SORT(PI*D1)/SORT(PI*C)*FUNPI(1,AVC+1)
GO TO 4000
C
C
PTC 14 - SINGLE INTERIOR 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/2.)/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 1282
S=C/(B+C)
FC=FUNT4(S,FS1)
FC=FC*FW*SORT(PI*C)
GO TO 1284
1282 FC=1.127*SORT(B+C)*FW
1284 AVC=A/C
D1=AMIN1(A,C)
FC=FC*SORT(PI*D1)/SORT(PI*C)*FUNPI(1,AVC+1)/1.122
FS2=.752+2.02*(B+C)/(W/2.)+.37*(1-SIN(PI*(B+C)/W/2.))**3
FW=FS2/COS(PI*(B+C)/W/2.)/1.122
FW=FW*SORT(W/2./PI/TAN(PI*(B+C)/W/2.))
FS1=RAD/B
IF (FS1.LT. .01) GO TO 1286
D-51
S=C/B
FQ =FUNT4(S,FS1)
F0=FO*FW*SQRT(PI*C)
GO TO 1288

1286 FO=1.122*SQRT(B)*FW
1288 FA=FO*SQRT(PI*D1)/SQRT(PI*C)*FNP1(ADVVC,2)/1.122
GO TO 4000

C
PTC 15 - DOUBLE INTERNAL CRACK AT DOUBLE NOTCH

1300 B=H
FS2=0.752+2.02*((B+C)/(W/2.))+.37*(1.-SIN(PI*(B+C)/W))**3
FW=FS2/COS(PI*(B+C)/W)/1.122
FS1=RAD/B
IF (F51.LT. .01) GO TO 1302
S=C/(B+C)
FC =FUNT4(S,FS1)
FC=FC*FW*SQRT(PI*C)
GO TO 1304

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

1304 ADVVC=A/C
D1=AMIN1(A,C)
FW=(1.+1.122*(COS(PI*(R+C)/W))**4)*COS(PI*(B+C)/W)
FC=FC*FW/FS2
FC=FC*SQRT(PI*D1)/SQRT(PI*C)*FNP1(ADVVC,1)/1.122
FS2=.752+2.02*((B)/(W/2.))+.37*(1.-SIN(PI*B/W))**3
FW=FS2/COS(PI*B/W)/1.122
FS1=RAD/B
IF (F51.LT. .01) GO TO 1306
S=C/B
FQ =FUNT4(S,FS1)
FQ=FQ*FW*SQRT(PI*C)
GO TO 1308

1306 FO=1.122*SQRT(B)*FW

1308 CONTINUE
FW=(1.+1.122*(COS(PI*B/W))**4)*COS(PI*B/W)
FO=FO*FW/FS2
FA=FO*SQRT(PI*D1)/SQRT(PI*C)*FNP1(ADVVC,2)/1.122
GO TO 4000

C
PTC 16 - CORNER CRACK OUT OF SHOULDER

1320 B1=(W-H)/2.
S1=C/(C+B1)
FC=W/PI/(C+B1)*TAN(PI*(C+B1)/W)
FC=SQRT(FC)
FC=FC*(1.+1.122*(COS(PI*(C+B1)/W))**4)/1.122
FC=FC*SQRT(PI*C)*FUNT4(S1,C1B1)
ADVVC=A/C
D1=AMIN1(A,C)
FC=FC*SQRT(PI*D1)/SQRT(PI*C)*FNP1(ADVVC,2)
B1=(W-H)/2.
S1=C/B1
FQ=W/PI/B1*TAN(PI*B1/W)
F0=FO*(1.+1.122*(COS(PI*B1/W))**4)
F0=FO*SQRT(PI*C)*FNP1(S1,C1B1)
FA=FO*SQRT(PI*D1)/SQRT(PI*C)*FNP1(ADVVC,1)
GO TO 4000

D-52
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.+1.122*(CCS(1.+(C+B1)/W))**-1)/1.122
FC = FC*SORT(PI*C)*FUNP/(S1,C1B1)
ACVC = A/C
D1 = AMIN1(A,C)
FC = FC*SORT(P1*D1)/SORT(PI*C)*FUNP1(ACVC,1)
B1 = (W-H)/2.
S1 = C/B1
FC = w/PI/B1*TAN(PI*B1/W)
FC = FC*(1.+1.122*(CCS(PI*B1/W))**-1)
FA = FC*SORT(PI*C)*FUNP1(S1,C1B1)
FA = FC*SORT(P1*D1)/SORT(PI*C)*FUNP1(ACVC,2)
GO TO 4000

TRANSITION CRACK

2000 CHOLD=C
C = (C+C1)/2.

KT = KTYPE(2)
GO TO (3020,3040,3060,3080,3100,3120,3140,3160,3180,3190,3180,3160,3120,3100,3080,3060,3040,3020,3020,3020), KT

THROUGH CRACK EQUATIONS

3000 KT = KTYPE(2)
GO TO (3020,3040,3060,3080,3100,3120,3140,3160,3180,3190,3180,3160,3120,3100,3080,3060,3040,3020,3020,3020), KT

TC 01 - CENTER CRACKED PANEL

3020 Z = PI*C
G = SORT(1)
Z = COS(2/W)
Z = 1/Z
Z = SORT(1)
FC = C/Z
FA = G
IF (KTYPE(1).EQ.2) GO TO 2100
GO TO 4000

TC 02 - COMPACT SPECIMEN

3040 W1 = C/W
W2 = SORT(W1)
FC = 29.1*W2 - 155.5*W1*W2
W2 = W2*W1*W1
FC = FC + 655.7*W2 - 1017.9*W2*W1

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\[ W_2 = W_2 \times W_1 \times W_1 \]
\[ F_2 = F_2 + 638.9 \times W_2 \]
\[ F_C = F_C / T \]
\[ F_C = F_C / \text{SORT} (W) \]
\[ F_A = 0 \]
\[ W_1 \times N_1 \]
\[ F_C = F_C + 618.4 \times w_2 \]
\[ F_A = 0.000545 \]
\[ \text{IF} (KTYPE(1) \neq 2) \text{ GO TO 2100} \]
\[ \text{GO TO 4000} \]

TC 03, 05 - SINGLE THROUGH CRACK AT HOLE

3060
\[ S = C / (\text{RAD} + C) \]
\[ F_B = \text{EXP} (1.2133 - 2.205 \times S + 0.6451 \times S \times S) \]
\[ F_C = \text{COS} (C + 2.0 \times \text{RAD}) \times \text{PI} / (2.0 \times (W - C)) \]
\[ F_C = \text{SORT} (1.0 / F_C) \]
\[ F_C = F_C / \text{SORT} (\text{PI} \times C) \]
\[ F_A = 0.000546 \]
\[ \text{IF} (KTYPE(1) \neq 2) \text{ GO TO 2100} \]
\[ \text{GO TO 4000} \]

TC 04, 06 - DOUBLE THROUGH CRACK AT HOLE

3080
\[ S = C / (\text{RAD} + C) \]
\[ F_B = \text{EXP} (1.2133 - 2.086 \times S + 0.8727 \times S \times S) \]
\[ F_C = \text{COS} (C + 2.0 \times \text{RAD}) \times \text{W} \]
\[ F_C = \text{SORT} (1.0 / F_C) \]
\[ F_C = F_C / \text{SORT} (\text{PI} \times C) \]
\[ F_A = 0.000547 \]
\[ \text{IF} (KTYPE(1) \neq 2) \text{ GO TO 2100} \]
\[ \text{GO TO 4000} \]

TC 07 - INTERPOLATION MODFL - THROUGH CRACK

3140
\[ F_C = \text{SORT} (\text{PI} \times C) \]
\[ \text{CALL} \text{ INTP} (1.0, C, A, 1, F_C) \]
\[ F_C = F_C / F_C \]
\[ F_A = 0.000548 \]
\[ \text{IF} (KTYPE(1) \neq 2) \text{ GO TO 2100} \]
\[ \text{GO TO 4000} \]

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

3160
\[ Z = (C + 2.0 \times \text{RAD}) / 2. \]
\[ F = C / 2. \]
\[ B = W / 2. \]
\[ F_P = B - F \]
\[ F_S1 = Z \times F / 2. \]
\[ F_S2 = Z / F_P \]
\[ F_C = \text{FUNT} (F_S2) \]
\[ F_P = \text{FHC} / \text{SORT} (1.0 - F_S2) \]
\[ F_P = F_P + 0.08 \times F_S1 + 2.60 \times F_S1 ** 2 - 0.99 \times F_S1 ** 3 \]
\[ F_P = F_P + 1.0 \times F_S2 + 0.957 \times F_S2 ** 2 - 2.16 \times F_S2 ** 3 \]
\[ F_P = F_P / \text{SORT} (1.0 - F_S2) \]
\[ F_P = F_P + 0.5 \times (Z + E) / (Z - F) / 0. \]
\[ F_C = \text{FUNT} (F_S2) \]
\[ F_C = \text{FHC} / \text{SORT} (1.0 - F_S2) \]
\[ F_P = \text{FHC} / \text{SORT} (1.0 - F_S2) \]
\[ F_P = \text{FHC} / \text{SORT} (1.0 - F_S2) \]
\[ F_P = \text{FHC} / \text{SORT} (1.0 - F_S2) \]
\[ F_P = \text{FHC} / \text{SORT} (1.0 - F_S2) \]
\[ F_C = S / (C + \text{RAD}) \]
\[ F_B = \text{EXP} (1.2133 - 2.205 \times S + 0.6451 \times S \times S) \]
\[ F_

D-54
FCP = PHS*SORT((PI*C)/(2.*W*TH))
FC = FCP + PHP*SORT((Z-E)/(Z+E))/SORT(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 B=W/2.
Z=RAD+C
PHCP=FUNT1(Z/B)
FS1=2.*Z/W
FS2=2.*Z/H
PHCP=PHCP/SORT(1.0-FS1)
PHWP=1.0-FS1+0.57*S1**2.0*FS1**3
PHWP=PHWP/SORT(1.0-FS1)
PHWP=PHWP/SORT(1.0-FS1)

PHCP = PHCP + PHP*PHWP/2.
PHCS=FUNT2(Z/B)

IF (KTYPE(1).EQ.2) GO TO 2100
GO TO 4000

TC 12, 14 - SINGLE CRACK AT SINGLE NOTCH

3240 R=H
FS2=.752+2.02*(E+C)/W+37*(1.0-SIN(PI*(R+C)/W/2.0))**3
FW=FS2/COS(P1*(R+C)/W/2.0)*1.0/1.122
FW=FW*SORT(W/PI/(B+C)*TAN(PI*(B+C)/W/2.0))

S1=RAD/B
IF (S1.LT.0.01) GO TO 3242
S=C/(R+C)
FC = FUNT1(S,FS1)
FC = FC + FW*SORT(P1*C)
GO TO 3244

3242 FC=1.122*SORT(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+2.02*(E+C)/W/2.0)+37*(1.0-SIN(PI*(B+C)/W))**3
FW=FS2/COS(P1*(B+C)/W/2.0)*1.0/1.122
FW=FW*SORT(W/PI/(B+C)*TAN(PI*(B+C)/W))
FS1=RAD/B
IF (FS1.LT.0.01) GO TO 3262
S=C/(B+C)
FC = FUNT1(S,FS1)
FC = FC + FW*SORT(P1*C)
GO TO 3264

D-55
3262 FC=1.122*SORT(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 (KTYPE(1),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=SORT(FC)
FC=FC*(1.+122*(COS(PI*(C+B1)/W))**4)/1.122
FC= FC*SORT(PI*C)*FUNT4(S1,C1B1)
FA=0.
IF (KTYPE(1),EQ.2) GO TO 2100
GO TO 4000
C
4000 RETURN
6002 FORMAT(1HC,'NO COMPACT CRACK FOR PART-THROUGH')
END
FUNCTION FUNK1(X,IX)
DIMENSION ADVC(25),FUNS(25,2)
C.
DATA ADVC /0.,.04,.07,.12,.15,.21,.34,.58,.72,.775,.86,1.,1.25,
1 1.49,1.785,2.375,3.45,5.5,6.66,10.,25.,50.,100.,1000.,10000./
DATA FUNS /0.122,1.11,1.,1.08,1.07,1.04,97.,84.,77.,75.,71.,
1 65.,63.,61.,57.,5.,43.,35.,31.,17.,1.,0.5,0.,0.,
2 0.,17.,27.,37.,42.,5.,6.,71.,74.,75.,76.,775.,81.,86.
3 .9.,96.,975.,99.,998.,1.,1.1.,1.1.,1.1./
C.
IF (ADVC(I).GT.X) GO TO 5
IF (ADVC(25).GE.X) GO TO 10
5 WRITE (/6000) X
STOP
10 DO 20 I=2,24
20 CONTINUE
IF (X.LT.ADVC(I)) GO TO 30
I=2
30 J=I-1
T=ADVC(I)-ADVC(J)
T=(X-ADVC(J))/T
FUNK1=FUNS(J,IX)+T*(FUNS(I,IX)-FUNS(J,IX))
RETURN
C.
6000 FORMAT(1H0,'FUNK1: X= ',1DF12.2,' IS OUT OF RANGE')
END
FUNCTION FUNCT1(X)

DIMENSION VALUE(14),FUNS(14)

DATA VALUE /0.,12.,19.,34.,48.,54.,6.,7.,8.,9.,96.,1./
DATA FUNS /1.,1.06,1.24,1.3,1.36,1.38,1.395,1.395,1.38,
1.36,1.32,1.297/

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

6000 FORMAT(1HO,'FUNTI: X = ',1PE12.3,' IS OUT OF RANGE')
END
FUNCTION FUNT2(X)
C
DIMENSION VALUE(16),FUNS(16)
C
DATA VALUE /0.,-0.,13.,-18.,2.,26.,32.,62.,7.,-76.,-8.,-86.,9.,94.,
1 .67,1.7/
DATA FUNS /1.,.54,.96,.955,.95,.95,.955,1.,.01,1.,01,1.,.98,
1 .96,.97,.88,.826/
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(I)-VALUE(J)
 T=(X-VALUE(J))/T
 FUNT2=FUNS(J)+T*(FUNS(I)-FUNS(J))
 RETURN
C
6000 FORMAT(1HO,'FUNT2: X = ',1PE12.3,' IS OUT OF RANGE')
END

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FUNCTION FUNT3(X)
C
DIMENSION VALUE(16), FUNS(16)
C
DATA VALUE /0.1666, 2., .25, .3333, 5., .5714, .6315, .8, .8889, 1
  1.0909, 1.2632, 1.6, 2.1819, 2.6666, 4.8, 7.000
DATA FUNS /1., 1.05, 1.0666, 1.075, 1.0916, 1.25, 1.3333, 1.4166, 1
  1.625, 1.75, 2., 2.24, 2.72, 3.64, 4.4166, 8.4
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
  IF (X.LE.VALUE(I)) GO TO 30
20 CONTINUE
I=16
30 J=I-1
T=VALUE(I)-VALUE(J)
T=(X-VALUE(J))/T
FUNT3=FUNS(J)+T*(FUNS(I)-FUNS(J))
RETURN
C
6000 FORMAT(1HO,'FUNT3: X = ',1PE12.3,' IS OUT OF RANGE')
END
FUNCTION FINT4(S,R)

DIMENSION SVAL(9),RVAL(8),TABEL(R,C)

DATA SVAL / .01,.05,1,2,3,4,6,8,1/. 
DATA RVAL / 0,1,25,333,1,2,4,6,9/. 
DATA TABEL / 11,22,6,5,8,4,5,2,2,3,1,5,1,122/. 

2 5.02,5.02,5.02,1.3,2.2,1.45,1.122/. 
3 3.55,3.55,3.55,3.5,2.9,2.7,1.4,1.122/. 
4 2.51,2.51,2.51,2.51,2.4,2.1,3.5,1.122/. 
5 2.05,2.05,2.05,2.05,2.05,1.8,1.3,1.122/. 
6 1.77,1.77,1.77,1.77,1.77,1.77,1.71,1.122/. 
7 1.45,1.45,1.45,1.45,1.45,1.35,1.2,1.122/. 
8 1.25,1.25,1.25,1.25,1.25,1.18,1.122/. 
9 1.122,1.122,1.122,1.122,1.122,1.122,1.122/.

IF (S.LT.SVAL(1)) GO TO 1000 
IF (S.GT.SVAL(9)) GO TO 1000 
IF (R.LT.RVAL(1)) GO TO 2000 
IF (R.GT.RVAL(8)) GO TO 2000 

10 CONTINUE 
IS=0 
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) 
PR=SVAL(ISM1)/PS 
PR=1.0/RVAL(IRM1)/PR 
FINT4=(1-PS)*(1-PR)*TABEL(ISM1,ISM1)+PS*(1-PR)*TABEL(IRM1,IS) 
FINT4=FINT4+PR*(1-PS)*TABEL(IR,ISM1)+PS*PR*TABEL(IS,IR) 
RETURN

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

6000 FORMAT(1HC,'FINT4: S = '1PF12.3, ' IS OUT OF RANGE') 
6005 FORMAT(1HC,'FINT4: R/B = '1PF12.3, ' IS OUT OF RANGE') 

END
FUNCTION FUNT5(R,S)

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

DATA SVAL /1.01,1.02,1.05,1.07,1.1,1.15,1.2,1.3,1.5,2.,3./
DATA RVAL /0.02,0.04,0.06,0.08,1.12,1.14,1.18,2.22,2.26,3./
DATA TABL /1.75,3.,4.,5.,6.,7.,8.,9.,10.,11./

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

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(ISM1, IR)
FUNT5 = FUNT5 + PR*(1 - PS)*TABL(IR, ISM1) + PS*PR*TABL(IS, IR)
RETURN

1000 WRITE(6,6000) S
  STOP

2000 WRITE(6,6005) R
  STOP

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

PROGRAM SCPLCT (INPUT,OUTPUT,TAPER=INPUT,TAPER5=INPUT,
             TAPE6=OUTPUT,PLOT)

C     ROUTING GENERATE PLOTS ON AN SC4020 FROM A PREVIOUSLY

C     GENERATED DATA FILE

C     CONSTANTS AND DATA DECLARATIONS

C     INTEGER CDTIIL,DDATA,CDDEMD,CDHDR1,CDHDR2,CDHDR3,CDHDR4
INTEGER CDHDR5,CDHDR6,Y1SYMBY2SYM
INTEGER TITLE(6),FHDRS(4,6)
C     INTEGER TITLE(9),FHDRS(13,6)
C     INTEGER GDTYPE,NPLMTS,NPLMTS,NLABLES,MXDPTS,NVAMAS,XADARY(4)
C     INTEGER NPLMTS, PPLGXR,RX1,RX2,RX3,RY4,RY5,RY6,RY7,RY8
C     INTEGER XINS,YINS
C     INTEGER MAX OF 270 DATA POINTS

C     REAL XVAL(2,1),Y1VAL(201),Y2VAL(201)
REAL XMAX,YAXMIN,YMIN
REAL XMAXIN,YMAXIN,XMININ,YMININ
REAL XINCIN,YINCIN,XINCIN,YINCIN
REAL CYPHLK,X1,X2,Y1,Y2
REAL XH1,AXH
REAL YMATST(4)
C     CAT A CDTIIL/4HTITL/
C     CAT A CDDATA/4HDATA/
C     CAT A CDDEMD/4HHDEMD/
C     CAT A CDHDR1/4HHHDR1/
C     CAT A CDHDR2/4HHHDR2/
C     CAT A CDHDR3/4HHHDR3/
C     CAT A CDHDR4/4HHHDR4/
C     CAT A CDHDR5/4HHHDR5/
C     CAT A CDHDR6/4HHHDR6/
C     CAT A X1SYM/1X1/
C     CAT A Y2SYM/1Y2/
C     CAT A MXDPTS/200/
C     CAT A YMATST/1,.5,.1,.5/

C     INITIALIZE

C     XMIN = 0.
C     YMIN = 0.
C     NPLMTS = 1

C     READ PARAMETER CARD

REAL (5,100) XAXMIN,YMAXIN,XINCIN,YINCIN,CAMRAS,
C     XADARY
1000 FOR AT (4F1,4,4,4A6)
C     PRINT INPUT SPECIFICATIONS

C     WHILE (5,20,0)
PROGRAM SCPL0T

2000 FORAT (# INPUT SPECIFICATIONS#/)
  WHITE (6.20) XMAXIN, YMAXIN, XINCIN, YINCIN, CAMRAS,
  ADARY

2010 FORAT (# MAXIMUM X    = *, 1PE10.3/
  # MAXIMUM Y    = *, 1PE10.3/
  # INCREMENT X  = *, 1PE10.3/
  # INCREMENT Y  = *, 1PE10.3/
  # CAMRAS       = *, 13/
  # SPECIAL INSTRUCTIONS = *, 4A6///))

65 C DEFAULT SETTINGs IF NOT INPUT

70 C START PLOT

CALL IDENT (CAMRAS, ADARY)

75 C INITIAL READ

READ (R*101*, END=999) CTYPE, TITLE, CYPPLK
READ (R*101*) CTYPE, TITLE, CYPPLK
IF (EOF(8)) 999*35

80 C MA11: PGM LOGIC

CALL PRINTV (-20*20HAAAAAAAAAAAAAAAAAAAAAAAAAAAAA*300*100)
CALL PRINTV (-20*20RRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRRR
PROGRAM SCPLCT

YMAX = 0.

MAIN DATA READ LOOP

50 CONTINUE

NDPTS = NDPTS + 1
READ (H*103:) CTYPE,Y1VAL(NDPTS),Y2VAL(NDPTS),XVAL(NDPTS)
1020 FOR AT (A4*3E12.3)

CHECK FOR END OF DATA VALUES

IF (CTYPE .EQ. CEND) GO TO 100

ERROR IF NOT DATA CARD

IF (CTYPE .NE. CDCDATA) GO TO 980

ERROR IF MAX DATA POINTS EXCEEDED

IF (NDPTS .GT. VXNDPTS) GO TO 975

ACCUMULATE MAX DATA VALUES

XMAX = AMAX1(XMAX,XVAL(NDPTS))
YMAX = AMAX1(YMAX,Y1VAL(NDPTS),Y2VAL(NDPTS))
GO TO 50

CONTINUE

ADJUST NUMBER OF DATA POINTS COUNTER

NDPTS = NDPTS - 1

READ HEADER CARDS

READ (H*103:) CTYPE,(FHDRS(I,1)),I = 1,*M)
1030 FOR AT (A4*7A10:A6)
C1030 FOR AT (A4*12A6:A2)

IF (CTYPE .AE. CDHDR1) GO TO 985
READ (H*103:) CTYPE,(FHDRS(I,2)),I = 1,*M)
150 IF (CTYPE .AE. CDHDR2) GO TO 985
READ (H*103:) CTYPE,(FHDRS(I,3)),I = 1,*M)
150 IF (CTYPE .AE. CDHDR3) GO TO 985
READ (H*103:) CTYPE,(FHDRS(I,4)),I = 1,*M)
150 IF (CTYPE .AE. CDHDR4) GO TO 985
READ (H*103:) CTYPE,(FHDRS(I,5)),I = 1,*M)
150 IF (CTYPE .AE. CDHDR5) GO TO 985
READ (H*103:) CTYPE,(FHDRS(I,6)),I = 1,*M)
150 IF (CTYPE .AE. CDHDR6) GO TO 985

SET UP PARM; FOR THIS GRAPH

IF INPUT MAXS LI! CALCULATED MAXS - INPUTS ARE OVERRIDEN

150 CONTINUE

IF (XMAXIN .GE. XMAX) GO TO 158
PROGRAM SCPLCT

I = 0

ADJUST XMAX

152 CONTINUE
I = 1 + 1
IF (I .GT. 100) GO TO 965
IF (10**I .LT. XMAX) GO TO 152
XMAX = 10**I
GO TO 150

158 CONTINUE
YMAX = XMAX

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

164 CONTINUE
I = 1 + 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

COMPUTE INCREMENTS

CALCULATE X INCREMENT IF NOT SPECIFIED

205 CONTINUE
XINC = XMAX / 10.
GO TO 180

IF SPECIFIED INCREMENT WOULD ALLOW MORE THAN 10 TIC MARKS

OVERRIDE

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

CALCULATE Y INCREMENT IF NOT SPECIFIED

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

182 CONTINUE
YINC = YMAX / 10.
GO TO 190

IF SPECIFIED INCREMENT WOULD ALLOW MORE THAN 10 TIC MARKS
OVER-RIDE

185 CONTINUE
IF (YMAX/YINC GT. 10.) GO TO 182

230 CONTINUE
OUTPUT CALCULATED SPECIFICATIONS

190 CONTINUE
WHITE (6*2020) UPLOTS*NDPTS*XMAX*YMAX*XINC*YINC*CYRBLK
2020 FORMAT ("# SPECIFICATIONS FOR PLOT #, 13/
235  # NUMBER OF DATA PTS = #, 13/
236  # MAXIMUM X = #* 1PE10.3/
237  # MAXIMUM Y = #* 1PE10.3/
238  # INCREMENT X = #* 1PE10.3/
239  # INCREMENT Y = #* 1PE10.3/
240  # CYCLES PER BLOCK = #* 1PE10.3/

DEFINE AND SET SCALING FACTORS FOR PLOTTING AREA

200 CONTINUE
CALL XSCALE (XMIN*XMAX*150.50)
CALL YSCALE (YMIN*YMAX*150.50)

DRAW SQUARE SURROUNDING PLOT AREA

220 CONTINUE

GET RASTER COORDS OF ENDPOINTS

250 CALL XSCALE (XMIN*RX1*ERRFLG)
251 CALL XSCALE (XMAX*RX2*ERRFLG)
252 CALL YSCALE (YMIN*RY1*ERRFLG)
253 CALL YSCALE (YMAX*RY2*ERRFLG)
RX1 = IXV(XMIN)
RX2 = IXV(XMAX)
RY1 = IYV(YMIN)
RY2 = IYV(YMAX)

DRAW SQUARE

260 CALL XAXSTP (RX1*RY1*RX2)
261 CALL YAXSTP (RX2*RY1*RY2)
262 CALL XAXSTP (RX1*RY2*RX1)
263 CALL YAXSTP (RX2*RY2*RY1)
264 CALL XAXISV (RX1*HY1*RX2)
265 CALL YAXISV (RX2*HY1*RY2)
266 CALL XAXISV (RX1*HY2*RX1)
267 CALL YAXISV (RX2*HY2*RY1)

DRAW TITLE (ASSUME CENTERED ON INPUT)
CALL RITE2V (56+13,1023*90,1,54,1,TITLE,ERRFLG)

DRAW AXIS TITLES

280 CALL PRINTV (-6,6HCYCLES,RX1+390,RY1-40)
CALL PRINTV (-6,6HBOCKS,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

290 RY3 = 950
IF ( (Y2VAL(1) + Y1VAL(1)) / 2.0 .GT. YMAX / 2.0 ) RY3 = 29
DO 260 I = 1,6
CALL PRINTV (76,FHCRS(I),RX1,16,PY3)
RY3 = RY3 - 15

295 260 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)

310 CALL LINE2V (RX1-4,RY1+8,0)
CALL LINE2V (RX1,RY1-4,0,8)
CALL PRINTV (-1,1H0,RX1,RY1-16)
CALL PRINTV (-1,1H0,RX1-16,RY1)

315 DRAW X AXIS LABELS

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

GET NEXT TIC MARK VALUE

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

DRAW TIC MARK

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

CALL LAHLV (X1+X3-35*RY1-1A*-2*1+1)

CALL LABEL (X1 / CYPBLK)
B1 = H1 + 1
XH1 = B1 * CYPBLK
XH2 = B2 * CYPBLK

GET VALUE CLOSEST TO CYCLE TIC MARK

IF (ABS(XH2-X1) * GT * ABS(X1-XH1) ) GO TO 320
XH1 = XH2
B1 = B2

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 COORDS

CALL XSLCLV1 (XH1, RB1, ERRFLG)
RX1 = IXV(X1+1)

DRAW TIC MARK

CALL LINE2V (RB1, RY2-4*0.8)

LABEL TIC MARK

XH1 = B1
CALL LAHLV (XH1+RB1-35*RY2+12*-2*1+1)

CONTINUE

LAST TIC MARK AT XMAX (UNLESS UNUSUAL USER INCREMENT SPECIFIED)

CALL XSLCLV1 (X1*XINC,RX3,ERRFLG)
RX3 = IXV(X1+XINC)
IF (IABS(RX3-RX2) * GF * 5 ) GO TO 360
CALL LINE2V (RX2*RY1-4*0.8)
CALL LAHLV (XMAX*RX2-35*RY1-18*-2*1+1)

DRAW LAST BLOCK LABEL IF IN PLOT AREA

CALL LABEL (XH1 / CYPBLK)

CONTINUE

COMPUTE BLOCK LABEL VALUE

B1 = XMAX / CYPBLK
XH1 = B1 * CYPBLK

D-69
IF MORE THAN ONE HALF A CYCLE TIC MARK AWAY DON'T DRAW

IF (XBL.LT. XMAX - XINC/2.) GO TO 360

GET RASTER COORDS

CALL XSLCLV1 (XBL, RBL, ERRFLG)
RBL = IXV(XBL)
CALL LINE2V (RBL, RY2-4, 0, 8)
XBL = BL
CALL LAHLV (XBL, RBL-35, RY2+12, -2, 1, 1)

DRAW Y AXIS LABELS

CONTINUE

Y1 = YMIN
NLABS = YMAX / YINC - .99
DO 380 1 = 1, NLABS
Y1 = Y1 + YINC

CALL YSLCLV1 (Y1, RY3, ERRFLG)
RY3 = IYV(Y1)

DRAW TIC MARK

CALL LINE2V (RX1-4, RY3, 8, 0)

LABEL TIC MARK

CALL LAHLV (Y1, RX1-92, RY3-3, 1, 1)

LAST TIC MARK AT YMAX (UNLESS UNUSUAL USER INCREMENT SPECIFIED

CALL YSLCLV1 (Y1+YINC, RY3, ERRFLG)
RY3 = IYV(Y1+YINC)
IF (IAHS(RY3-RY2) .GE. 5) GO TO 400
CALL LINE2V (RX1-4, RY2+8, 0)
CALL LAHLV (YMAX, RX1-92, RY2+3, 1, 1)

PLOT DATA

CONTINUE

CALL XSLCLV1 (XVAL(1), RX3, ERRFLG)
CALL YSLCLV1 (Y1VAL(1), RY3, ERRFLG)
CALL YSLCLV1 (Y2VAL(1), RY4, ERRFLG)
RX3 = IXV(XVAL(1))
RY3 = IYV(Y1VAL(1))
RY4 = IYV(Y2VAL(1))

PLOT SYMBOL AT FIRST DATA POINT (BOTH Y VALUES)

CALL PLOTV (RX3+RY3+Y1SYM)
CALL PLOTV (RX3+RY4+Y2SYM)

CALL PLOTV (RX3+RY3, 20)
C CALI PLOTV (RX3•RY4,24)
IF (NDPTS •LE. 1) GO TO 431
C
C LOOK FOR REST OF DATA POINTS
445 C
C GO 430 I = 2•NDPTS
C
C GET COORDS OF NEXT POINT
450 C
C CALI XSCLV1 (XVAL(I),RX1•ERRFLG)
C CALI YSCLV1 (Y1VAL(I),RY1•ERRFLG)
C CALI XSCLV1 (Y2VAL(I),RY2•ERRFLG)
RX1 = IXV(XVAL(I))
RY1 = IYV(Y1VAL(I))
RY2 = IYV(Y2VAL(I))
C
C PLOT SYMBOL AT DATA POINT (FOR BOTH Y VALUES)
460 C
C CALI PLOTV (RX1•RY1•Y1SYM8)
C CALI PLOTV (RX1•RY2•Y2SYM8)
C CALI PLOTV (RX1•RY1,20)
C CALI PLOTV (RX1•RY2,29)
C
C DRAW LINE FROM PREVIOUS POINT TO THIS POINT
465 C
C CALI LINEV(RX3•RY3•RX1•RY1)
C CALI LINEV (RX3•RY4•RX1•RY2)
C
C SET UP FOR NEXT POINT
470 C
RX3 = RX1
RY3 = RY1
RY4 = RY2
C
C CONTINUE
430 CONTINUE
C
C GO TO NEXT PLOT
431 CONTINUE
C
C GO .0 30
480 C
C MAX OF 10**100 EXCEEDED
C
C 965 CONTINUE
C WRITE (.L2990)
C
C 2990 FORMAT (12# MAX VALUE OF 10**100 EXCEEDED#)
GO TO 995
C
C FIRST CARD IN DATA GROUP NOT A TITLE CARD
C
C 490 970 CONTINUE
C WRITE (.L3000)
C
C 3000 FORMAT (12# MISSING TITLE CARD - DATA SEQUENCE ERROR#)
GO TO 995
C
C MAX DATA POINTS EXCEEDED
C
D-71
PROGRAM SCPL0T

C 975 CONTINUE
   WRITE (6,3010) NDPTS
3010 FORM AT (/1X,I4,'DATA POINT MAXIMUM EXCEEDED')
   GO TO 995
.C.
C DATA CARD EXPECTED BUT NOT READ
C 980 CONTINUE
   WRITE (6,3020)
3020 FORM AT (/1X,'MISSING EXPECTED DATA CARD - DATA SEQUENCE ERROR')
   GO TO 995
.C.
C HDR CARD MISSING
C 985 CONTINUE
   WRITE (6,3040)
3040 FORM AT (/1X,'MISSING HDR CARD - DATA SEQUENCE ERROR')
   GO TO 995
.C.
C GENERAL ERROR TERMINATION
C 995 CONTINUE
   WRITE (6,3060)
3060 FORM AT (/1X,'*** RUN TERMINATED ***')
   CALL ENDJOB
   STOP 777
   999 CONTINUE
C CALL ENDJOB
   STOP
   525 

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