

AD-A171 209

**ASSESSMENT OF DAMAGE TOLERANCE
REQUIREMENTS AND ANALYSES:**

**A user's manual for crack growth
and crack initiation analysis: "DAMGRO"**

**M. LEVY
A. KUO**

**Fairchild Industries
Fairchild Republic Company
Farmingdale, N.Y. 11735**

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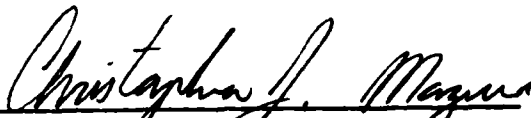
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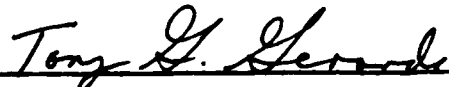
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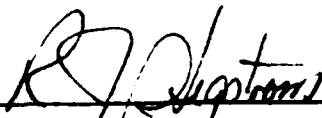


Christopher J. Mazur, 1 Lt, USAF
Project Engineer



TONY G. GERARDI, Chief
Structural Integrity Branch
Structures and Dynamics Division

FOR THE COMMANDER



ROGER J. HEGSTROM, Colonel, USAF
Chief, Structures and Dynamics Division

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A structural test program of typical aircraft structural configurations was conducted to assess the current Air Force damage tolerance design requirements defined in MIL-A-83444. The specimens, made of 2024-T3XX and 7075-T6XX, were subjected to randomized flight-by-flight spectra, representative of fighter/trainer and bomber/cargo type loading spectra, respectively, and to a constant amplitude loading spectrum. A total of two-hundred fifty-six specimens were tested. The test results were correlated with analytical predictions using crack growth and crack initiation methods. As a result of this study, recommendation is provided to the validity of MIL-A-83444, to develop guidelines for selection of critical crack locations, and to assess the state-of-the-art analytical capabilities in predicting crack growth and crack initiation time. This report presents the user's manual of the computer program "DAMGRO". This program has been developed in conjunction with this contract, and used to predict the crack growth and crack initiation of the structural test specimens.					
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FOREWORD

This report presents the User's Manual for Crack Growth and Crack Initiation Computer Program "DAMGRO" developed as part of the "Assessment of Damage Tolerance Requirements and Analyses", contract No. F33615-82-C-3215. This program has been administrated by the Flight Dynamics Laboratory, Air Force Wright Aeronautical Laboratories, Air Force Systems Command, Wright Patterson Air Force Base, Ohio. James L. Rudd (AFWAL/FIBEC) was the Air Force Project Engineer through December 1985. Subsequently, Mr Rudd was replaced by Lt Christopher Mazur. A. Kuo was the Program Manager and Principal Investigator through March 1985. Subsequently, Mr Kuo was replaced by Meir Levy for the completion of the program. The structural test program has been performed at the University of Dayton Research Lab under the supervision of George Roth.

The eight major tasks listed below have been planned to achieve the program objectives. Namely, (a) assessing the validity of, and recommending improvements to the current MIL-A-83444, (b) developing guidelines for identifying the most critical initial primary damage locations for typical aircraft structures, and (c) assessing and improving the state-of-the-art analytical methods to satisfy the requirements of MIL-A-83444.

- Task I: Analytical Methods
- Task II: Basic Tests
- Task III: Analytical Predictions
- Task IV: Structural Tests
- Task V: Analytical/Experimental Correlations
- Task VI: Assessment of and Recommended Improvements to MIL-A-83444
- Task VII: Guidelines for Selecting Most Critical Initial Primary Damage Location
- Task VIII: Assessment of and Improvements to Damage Tolerance Analyses

The material presented in this report was developed during Phase I of the contract. Additional five reports were issued including:

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Volume I: Executive Summary
Volume II: Analytical Methods
Volume III: Analytical Predictions and Correlations
Volume IV: Raw Test Data
Volume V: Assessment and Recommendations

Volume I report contains an Executive Summary of the entire program including the Basic Test Program for material allowables, test results of the Structural Test Program and Analytical Predictions. It also contains a summary of the Analytical Formulation derived during Task I.

Volume II report contains the Analytical Methodology derived during Task I of the Program, including crack growth and crack initiation techniques, and results of Finite Element Modeling of stress intensity factors.

Volume III report contains Analytical to Experimental Correlation of seventy-two (72) Structural Test Specimens performed during Task IV of the Program.

Volume IV report contains the Raw Test Data obtained during the Basic Test, and the Structural Test Programs.

Volume V report contains an assessment of the Damage Tolerance Design Requirements defined in MIL-A-83444, Analytical methods evaluation and a Guideline for Identifying Critical Locations for Damage Tolerance Analysis. It also contains recommendations and follow-on work.

This program began in September 1982 and was completed in May 1986.

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1.0 INTRODUCTION

This report presents a description of the crack growth and crack initiation computer program "DAMGRO". The computer program has the capabilities of simultaneously analyzing crack growth and crack initiation. The three options available are:

- (i) Crack Growth Only "Method 1"
- (ii) Crack Growth and Crack Initiation "Method 2"
- (iii) Crack Initiation Only.

The program is coded in Fortran Computer Language and consists of a total of 22 routines. Various geometrical configurations can be analyzed including plate or stringer sections, subjected to a constant amplitude loading or a randomized spectrum loading. The generalized Willenborg Retardation Model was adopted to be used when a variable amplitude loading spectrum was applied. The crack growth rates ' da/dN ' are presented in terms of the modified Walker's equation.

A majority of typical aircraft structural configurations may be accurately modeled using one or more of the available routines. However, some important configurations are not presently available with a prediction accuracy deemed necessary. In particular, growth of two cracks at adjacent holes consistent with the MIL-A-83444 specification. In this case the growth of the primary crack may influence the growth of the secondary one. In performing the prediction, such a configuration was treated independently which may have resulted in unconservative predictions.

In performing crack growth or crack initiation predictions, some structural geometrics are not, explicitly, included in the program. However, modeling techniques may be applied to use available routines to obtain reasonable representations. For example for subroutine K1020, if the two adjacent holes were eliminated, the result will be a crack at the edge of a hole approaching a free edge. Similarly, initiation may be applied to one location when only one hole is present.

The program is constructed in such a way, that additional stress intensity routines may be added. A flow chart of the program is presented in Appendix A. Three examples are presented in Section 3.0.

2.0 DAMGRO COMPUTER PROGRAM

"DAMGRO" Computer Program was developed to have the capability of simultaneously analyzing crack growth and crack initiation at the edge of a hole. Various geometrical configurations may be analyzed using one or more of the routines shown in Figures 2.1-1 through 2.1-10. The program contains ten crack growth and six crack initiation routines. The crack growth is governed by the stress intensity factor at the edge of the crack. The crack initiation is governed by the stress severity factor, which itself is a function of strain energy density at the edge of a hole. The analytical formulation for both crack growth and crack initiation are presented in Volume II of the report.

2.1 CRACK GROWTH "METHOD 1"

Various geometrical configurations may be analyzed using the 'DAMGRO' computer program "Method 1" of the program includes the following configurations:

1. Corner crack emanating from a circular hole, and approaching an adjacent hole (subroutine K1010 Ref. Figure 2.1-1).
2. Corner crack emanating from a circular hole with an additional crack through the thickness extending from the hole to the edge of the part (subroutine K1020 Ref. Figure 2.1-2).
3. Corner crack emanating from a circular hole with an additional crack, through the thickness extending from the hole to the edge of an adjacent hole (subroutine K1030 Ref. Figure 2.1-3).
4. Two equal or unequal size corner cracks at the edge of a circular hole and approaching adjacent holes (subroutine K1040 Ref. Figure 2.1-4).

5. Two equal or unequal size corner cracks at the opposite edges of two adjacent holes, with an additional crack through the thickness extended between the two holes (subroutine K1050 Ref. Figure 2.1-5).
6. Corner crack emanating from a circular hole of a stringer section horizontal leg. The crack may approach the free edge or the stringer upstanding leg, (subroutine K2010 Ref. Figure 2.1-6).
7. Corner crack emanating from a circular hole of a stringer section. An additional crack extending from the hole to the free edge, (subroutine K2020 Ref. Figure 2.1-7).
8. Two corner cracks emanating from a circular hole of a stringer horizontal leg. One crack approaches the stringer upstanding leg, and the second one approaching the free edge of the horizontal leg, (subroutine K2040 Ref. Figure 2.1-8).
9. A crack emanating from a circular hole of a stringer tee section, and propagating into the upstanding leg, (subroutine K2050 Ref. Figure 2.1-9).
10. A crack emanating from a circular hole of a stringer 'L' section, and propagating into the upstanding leg, (subroutine K2060 Ref. Figure 2.1-10).

2.2 COMBINED CRACK GROWTH AND CRACK INITIATION "METHOD 2"

The combined method routines (Method 2) are capable of predicting crack initiation for the following geometrical configurations:

1. Crack initiation at the edge of two adjacent holes with one crack present at one of the holes, (subroutines S1010 and S1020 Ref. Figures 2.2-1 and 2.2-2).

2. Crack initiation at the edge of two holes in an array of three holes with two cracks present at the mid hole, (subroutine S1030 Ref. Figure 2.2-3).
3. Crack initiation at the edge of two adjacent holes with a through the thickness crack between them, (subroutine S1040 Ref. Figure 2.2-4).
4. Crack initiation at the edge of two holes in an array of three holes with the presence of one crack at the edge of one hole and a second through the thickness crack between two holes, (subroutine S1050 Ref. Figure 2.2-5).
5. Crack initiation at the edge of two adjacent holes with a crack extending from one hole to the edge of the part, (subroutine S1060 Ref. Figure 2.2-6).

2.2.1 Input Data Description of "Method 2"

The input parameters needed to perform the crack initiation (0.050 inch corner crack) are defined in Volume II of the report and summarized below:

- (i) Damage index 'di' for the initiation of a 0.050 inch quarter-circular corner crack was derived during Phase I of the program. The index for 2024-T3 and 7075-T651 is given by the following equation:

- (i) For Group A (no interference, clamp-up or sealant)

$$d_i = 1.0 - 0.629 S_{\max} \quad \text{for 2024-T3}$$

$$d_i = 0.873 - 0.795 S_{\max} \quad \text{for 7075-T651}$$

- (ii) For Group B, C and D (with interference, clamp-up or sealant)

$$d_i = 1.0 - 0.580 S_{\max} \quad \text{for 2024-T3}$$

$$d_i = 0.958 - 0.619 S_{\max} \quad \text{for 7075-T651}$$

where $S_{\max} = 0.5 (\sigma K)^2 / E$, $K = 1 + (K_t - 1) / (1 + \sqrt{\rho/R})$. The equations above represent the damage index for crack initiation of specimens subjected to a constant amplitude loading spectrum. For specimens subjected to a randomized loading spectrum, the damage index ' D_f ' to initiate a 0.05 inch quarter-circular corner crack, was determined using weighted average.

(ii) Crack Initiation Constants

1. Strain energy density $S = S_f(N)^m$

$$S = 10.4261 N^{-0.366} \quad \text{for 2024-T3}$$

$$S = 20.4257 N^{-0.4515} \quad \text{for 7075-T651}$$

where N is the number of cycles to failure.

(iii) Geometry parameters α, β, γ

(i) Group A

$$\alpha\beta\gamma = 1.0$$

(ii) Group B

$$\alpha\beta\gamma = 0.8503 \quad \text{for 2024-T3}$$

$$= 0.8126 \quad \text{for 7075-T651}$$

(iv) Other parameters which were found to improve fatigue initiation life are:

(i) Stress due to faying surface, FAYSUR.

(ii) Stress level due to Hi-Lok clamp-up, FRICT.

As a conservative assumption, the faying surface stress and the Hi-Lok clamp-up stress may be set to zero.

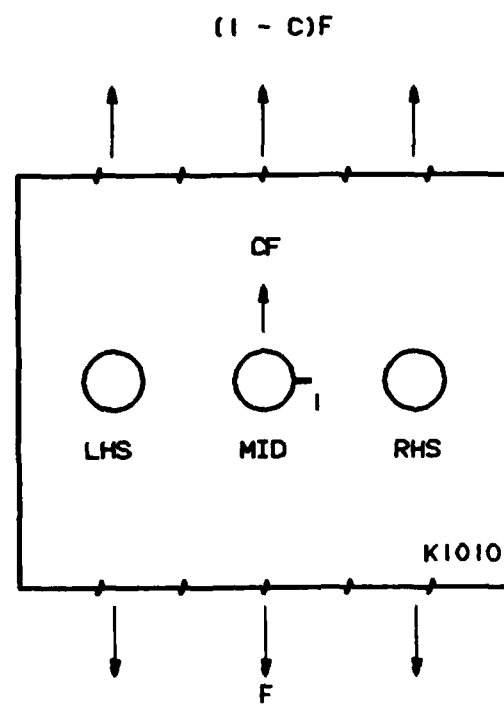


Figure 2.1-1. Geometrical Configuration of Crack Growth Routine K1010

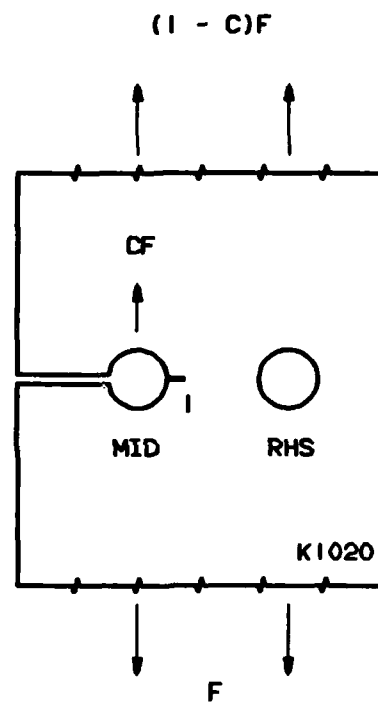


Figure 2.1-2. Geometrical Configuration of Crack Growth Routine K1020

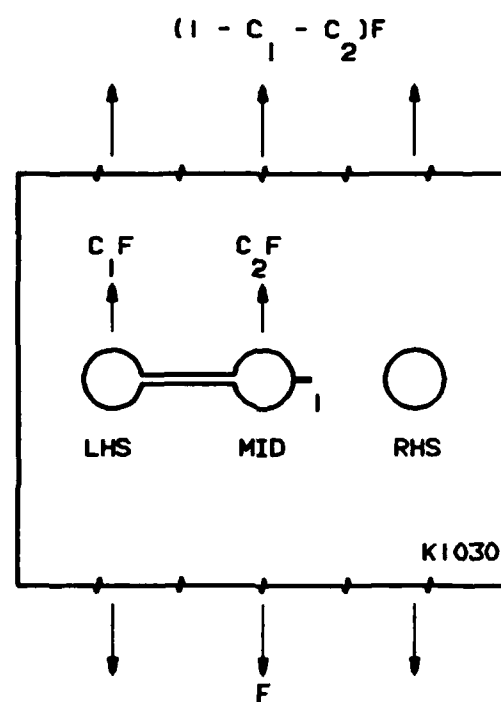


Figure 2.1-3. Geometrical Configuration of Crack Growth Routine K1030

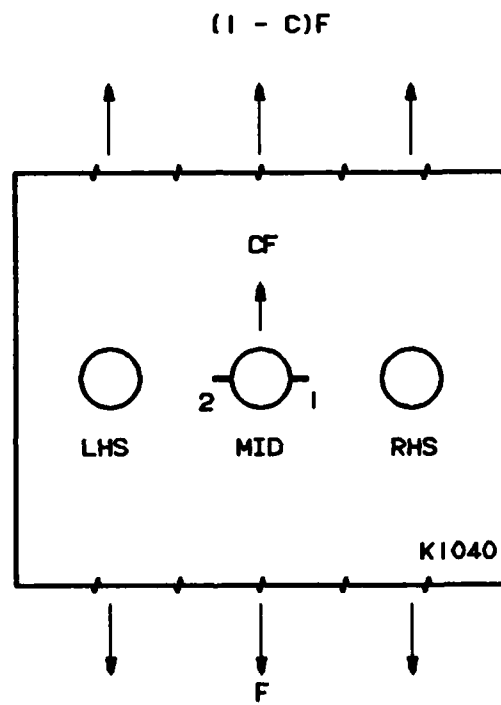


Figure 2.1-4. Geometrical Configuration of Crack Growth Routine K1040

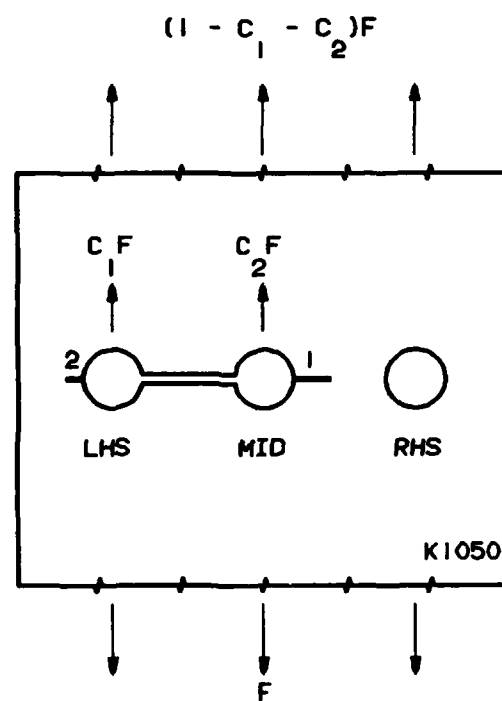
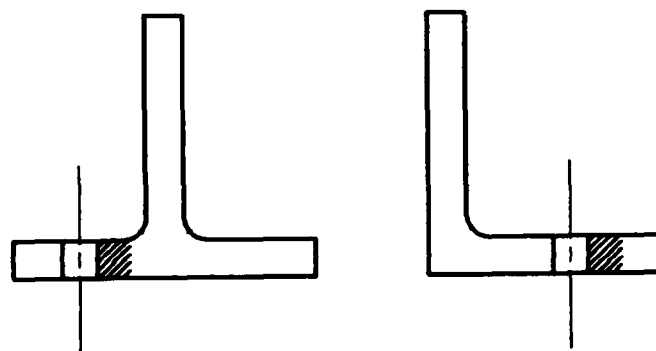


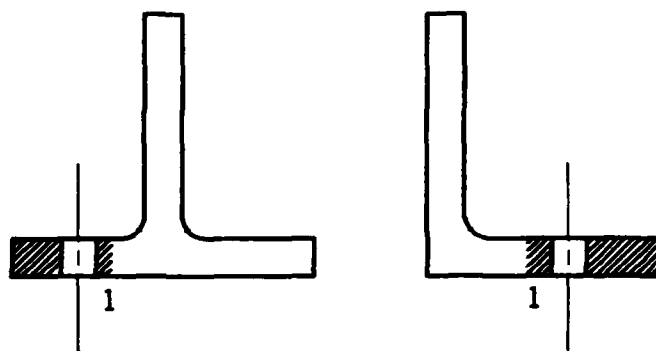
Figure 2.1-5. Geometrical Configuration of Crack Growth Routine K1050

CRACK CAN BE ON
EITHER SIDE OF
THE HOLE.



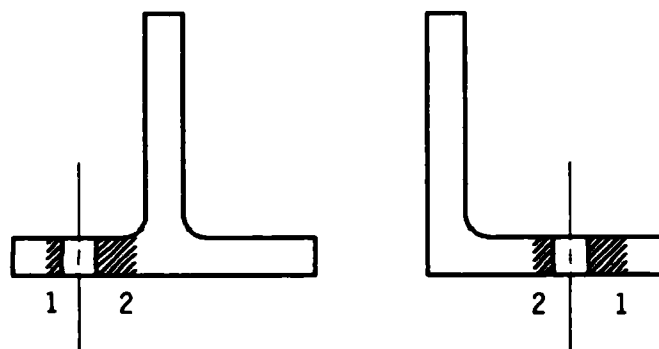
K2010

Figure 2.1-6. Geometrical Configuration of Crack Growth Routine K2010



K2020

Figure 2.1-7. Geometrical Configuration of Crack Growth Routine K2020



K2040

Figure 2.1-8. Geometrical Configuration of Crack Growth Routine K2040

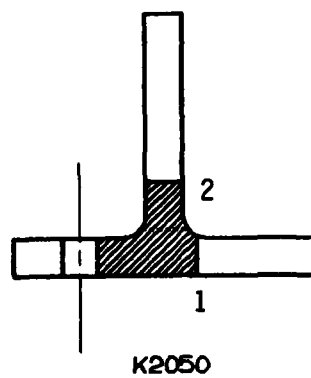


Figure 2.1-9. Geometrical Configuration of Crack Growth Routine K2050

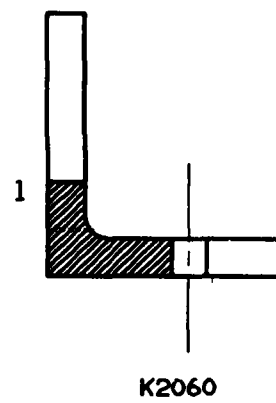


Figure 2.1-10. Geometrical Configuration of Crack Growth Routine K2060

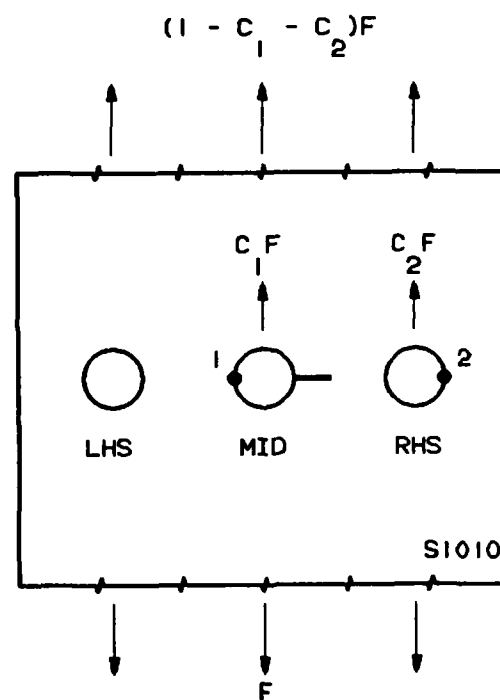


Figure 2.2-1. Geometrical Configuration of Crack Initiation Routine S1010

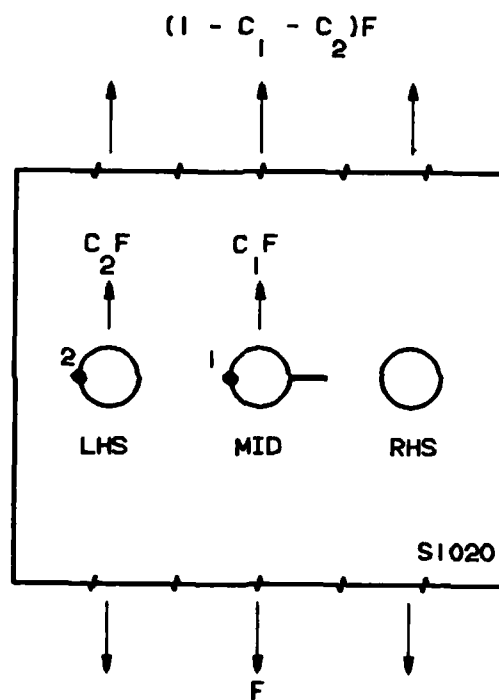


Figure 2.2-2. Geometrical Configuration of Crack Initiation Routine S1020

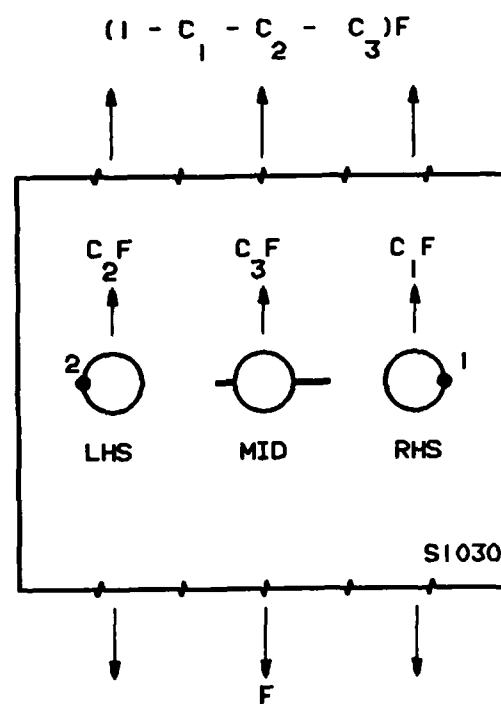


Figure 2.2-3. Geometrical Configuration of Crack Initiation Routine S1030

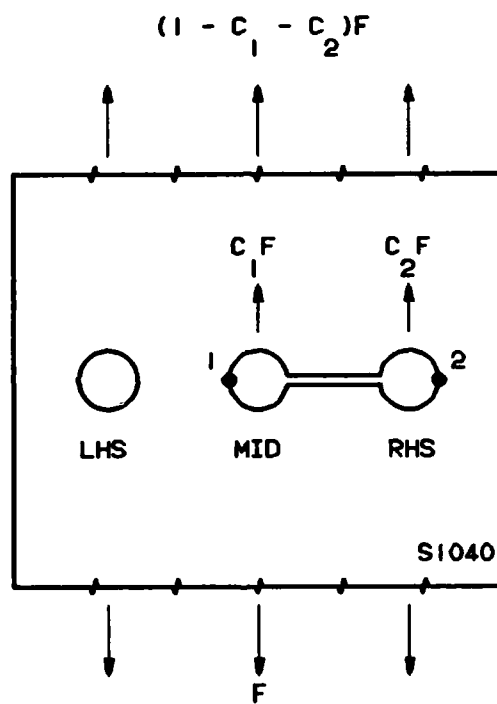


Figure 2.2-4. Geometrical Configuration of Crack Initiation Routine S1040

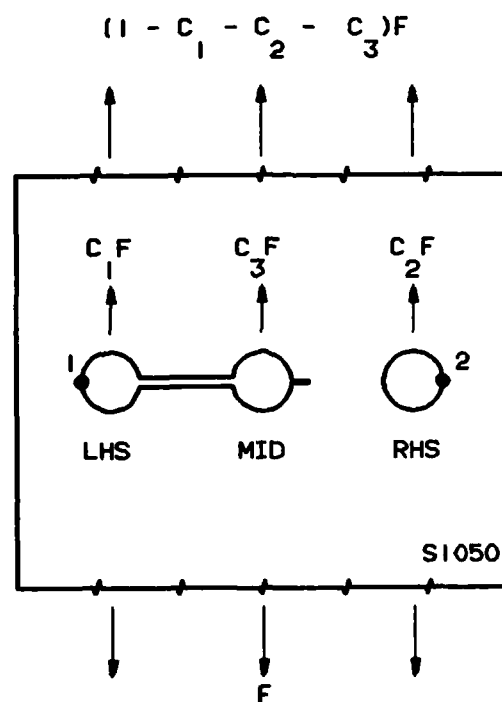


Figure 2.2-5. Geometrical Configuration of Crack Initiation Routine S1050

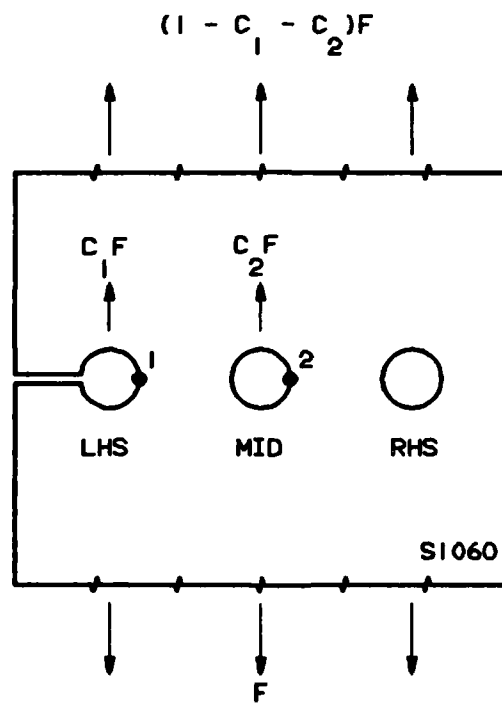


Figure 2.2-6. Geometrical Configuration of Crack Initiation Routine S1060

2.3 DAMGRO INPUT FORMAT

The following pages describe the input format for the DAMGRO Computer Program. Two files are needed to run the program. "File 1" contains geometrical configurations and material allowables (Ref. Table 2.3-1 and pages 25 through 39) and "File 2" contains the spectrum loading considered (Ref. page 40)

TABLE 2.3-1. 'DAMGRO' INPUT FILE FORMAT

INPUT										FORMAT
TITLE										(20A4)
RMATID										(20A4)
WALKC	WALKM	WALKN	WALKMC	WALKMM	WALKMN					(6E10.3)
CKC	AKIC	SIGMAY	CKMXTH	SHUTOF	RCUT	RCUTN				(7F10.4)
SF	RM	DMG	ELAMOD	ZOU	ALPHA	BETA	GAMMA			(8F10.4)
CI1	CF1	AI1	AF1	CI2	CF2	AI2	AF2			(8F10.5)
APAOL1	APCOL1	RYAOL1	RYCOL1	AKOL1	CKOL1	AOL1	COL1			(8E10.4)
APAOL2	APCOL2	RYAOL2	RYCOL2	AKOL2	CKOL2	AOL2	COL2			(8E10.4)
DMG1	DMGOL1	DELOG1	DMG2	DMGOL2	DELOG2					(6E10.4)
THK	RADIUS	B1	B2	BOLTM1	BOLTM2	EOD	CSK	PINDEF		(7F10.4, F5.1, F5.2)
RAD1	RAD2	HODIS1	HODIS2	BOLTR1	BOLTR2	BOLTL1	BOLTL2			(8F10.4)
FRICT	FAYSUR									(2F10.4)
IRESTA	NSOLD	NCRKS	NINITS	IRETAD	NBLKS	KID	LID			(8I5)
VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8			(8F10.4)
FLTBK	BLKLIF	FLTHR	ISTRESS							(3F10.4, I10)

FILE 1: INPUT DATA CARD NO. 1

DESCRIPTION: TITLE

FORMAT: 20A4

FIELD	1 - 80
VARIABLE	TITLE (I)
EXAMPLE	SPECIMEN NO. ABC-1 SUBJECTED TO A-10A LOADING SPECTRUM

<u>VARIABLE</u>	<u>DESCRIPTION</u>
-----------------	--------------------

TITLE (I) I = 1, 20	Any alphanumeric data for problem information, fields 1 through 80.
------------------------	---

REMARKS (1) One title card printed on the first page of the output file.

FILE 1: INPUT DATA CARD NO. 2

DESCRIPTION: MATERIAL OR ID INFORMATION

FORMAT: 20A4

FIELD	1 - 80
VARIABLE	RMATID (I)
EXAMPLE	2024-T351 EXT. (REF. DAMAGE TOLERANCE HANDBOOK)

<u>VARIABLE</u>	<u>DESCRIPTION</u>
-----------------	--------------------

RMATID (I) I = 1, 20	Any alphanumeric data for material information, fields 1 through 80.
-------------------------	--

REMARKS (1) One title card printed on the first page of the output file.
Non executable data.

FILE 1: INPUT DATA CARD NO. 3

DESCRIPTION: CRACK GROWTH RATE CONSTANTS

FORMAT: 6E10.3

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	
VARIABLE	WALKC	WALKM	WALKN	WALKMC	WALKMM	WALKMN	
EXAMPLE	0.160E-09	0.650	4.554	0.230E-08	1.00	3.115	

VARIABLE

DESCRIPTION

WALKC 'C' coefficient in Walker's equation for $R \geq 0$
WALKM 'm' coefficient in Walker's equation for $R \geq 0$
WALKN 'n' coefficient in Walker's equation for $R \geq 0$
WALKMC 'C' coefficient in Walker's equation for $R < 0$
WALKMM 'm' coefficient in Walker's equation for $R < 0$
WALKMN 'n' coefficient in Walker's equation for $R < 0$

REMARKS (1) To represent the modified Walker's equation:

$$\frac{da}{dN} = C ((1-R)^m K_{max})^n$$

FILE 1: INPUT DATA CARD NO. 4

DESCRIPTION: MATERIAL PROPERTIES FOR CRACK GROWTH

FORMAT: 7F10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	
VARIABLE	CKC	K _{IC}	SIGMAY	CKMXTH	SHUTOF	RCUT	RCUTN	
EXAMPLE	58.0	36.0	53.30	2.0	2.3	0.99	-0.99	

<u>VARIABLE</u>	<u>DESCRIPTION</u>
-----------------	--------------------

CKC	Plane stress fracture toughness, K_C
KIC	Plane strain fracture toughness, K_{Ic}
SIGMAY	Tensile yield stress, F_{ty}
CKMXTH	K_{max} for threshold da/dn
SHUTOF	Retardation shut-off ratio
RCUT	Positive stress ratio 'R' cut-off
RCUTN	Negative stress ratio 'R' cut-off

REMARKS (1) Executable data when Method 1 is used.

FILE 1: INPUT DATA CARD NO. 5

DESCRIPTION: MATERIAL PROPERTIES FOR CRACK INITIATION

FORMAT: 8F10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	SF	RM	DMG	ELAMOD	ZOU	ALPHA	BETA	GAMMA
EXAMPLE	10.426	-0.366	0.872	0.107E5	0.022	0.875	1.0	1.0

<u>VARIABLE</u>	<u>DESCRIPTION</u>
SF	Crack initiation eqn. constant, SF
RM	Crack initiation eqn. constant, m
DMG	Damage index for crack initiation, d_i
ELAMOD	Elastic modulus, E
ZOU	Nueber material constant, ρ
ALPHA	Stress severity factor parameter, α
BETA	Stress severity factor parameter, β
GAMMA	Stress severity factor parameter, γ

REMARKS (1) Executable when Method 2 is used.

FILE 1: INPUT DATA CARD NO. 6

DESCRIPTION: CRACK SIZE DATA

FORMAT: 8F10.5

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	CTI	CFI	AI1	AF1	CI2	CF2	CI2	CF2
EXAMPLE	0.050	0.75	0.050	0.188	0.0	0.0	0.0	0.0

VARIABLE

DESCRIPTION

CI1 Initial crack length of crack No. 1
CF1 Final crack length of crack No. 1
AI1 Initial crack depth of crack No. 1
AF1 Final crack depth of crack No. 1
CI2 Initial crack length of crack No. 2
CF2 Final crack length of crack No. 2
CI2 Initial crack depth of crack No. 2
CF2 Final crack depth of crack No. 2

REMARKS

(1) Initial flaw configuration consistent with the subroutines for growth and initiation.

FILE 1: INPUT DATA CARD NO. 7

DESCRIPTION: RETARDATION PARAMETERS AT THE EDGE OF CRACK NO. 1

FORMAT: 8E10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	APAOL1	APCOL1	RYAOL1	RYCOL1	AKOL1	CKOL1	AOL1	COL1
EXAMPLE	0.192E0	.889E0	.386E-2	.241E-1	.144E2	.208E2	.188E0	.865E0

VARIABLE

DESCRIPTION

APAOL1 Depth of crack No. 1 plus plastic zone size at overload
 APCOL1 Length of crack No. 1 plus plastic zone size at overload
 RYAOL1 Plane strain plastic zone for crack No. 1 at overload
 RYCOL1 Plane stress plastic zone for crack No. 1 at overload
 AKOL1 Depth direction K_{max} for crack No. 1 at overload
 CKOL1 Surface direction K_{max} for crack No. 1 at overload
 AOL1 Depth of crack No. 1 at overload
 COL1 Length of crack No. 1 at overload

REMARKS

- (1) Executable when Method 1 is used.
- (2) Initial values are equal to 0.0.

FILE 1: INPUT DATA CARD NO. 8

DESCRIPTION: RETARDATION PARAMETERS AT THE EDGE OF CRACK NO. 2

FORMAT: 8E10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	APAOL2	APCOL2	RYAOL2	RYCOL2	AKOL2	CKOL2	AOL2	COL2
EXAMPLE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

<u>VARIABLE</u>	<u>DESCRIPTION</u>
-----------------	--------------------

APAOL2	Depth of crack No. 2 plus plastic zone size at overload
APCOL2	Length of crack No. 2 plus plastic zone size at overload
RYAOL2	Plane strain plastic zone for crack No. 2 at overload
RYCOL2	Plane stress plastic zone for crack No. 2 at overload
AKOL2	Depth direction K_{max} for crack No. 2 at overload
CKOL2	Surface direction K_{max} for crack No. 2 at overload
AOL2	Depth of crack No. 2 at overload
COL2	Length of crack No. 2 at overload

REMARKS (1) Executable when Method 1 is used.

(2) Initial values are equal to 0.0.

FILE 1: INPUT DATA CARD NO. 9

DESCRIPTION: FATIGUE DAMAGE PARAMETERS

FORMAT: 6E10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	
VARIABLE	DMG1	DMGOL1	DELOG1	DMG2	DMGOL2	DELOC2	
EXAMPLE	.333E0	.685E-04	0.0	.430E-01	.179E-05	0.0	

VARIABLE

DESCRIPTION

DMG1	Accumulated damage for site No. 1
DMGOL1	Damage at overload for site No. 1
DELOG1	Accumulated damage for site No. 1 since last overload
DMG2	Accumulated damage for site No. 2
DMGOL2	Damage at overload for site No. 2
DELOG2	Accumulated damage for site No. 2 since last overload

REMARKS

- (1) Executable when Method 2 is used.
- (2) Initial values are equal to 0.0.

FILE 1: INPUT DATA CARD NO. 10

DESCRIPTION: MODEL GEOMETRY AND LOADING CONFIGURATION

FORMAT: 7F10.4, F5.1, F5.2

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71-75	76-80
VARIABLE	THK	RADIUS	B1	B2	BOLTM1	BOLTM2	EOD	CBK	PINDEF
EXAMPLE	0.188	0.125	2.14	0.5	0.0825	-0.0026	5.0	20.0	1.06

<u>VARIABLE</u>	<u>DESCRIPTION</u>
THK	Thickness of specimen
RADIUS	Radius of middle hole
B1	R.H.S. edge distance to mid hole
B2	L.H.S. edge distance to mid hole
BOLTM1	Fraction of load transfer by mid bolt - C ₁
BOLTM2	Fraction of Load transfer by mid bolt - C ₂
EOD	E/D ratio
CBK	% countersunk height
PINDEF	Pin deflection

REMARKS (1) Executable for both Methods.

FILE 1: INPUT DATA CARD NO. 11

DESCRIPTION: MODEL GEOMETRY AND LOADING CONFIGURATION

FORMAT: 8F10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	RAD1	RAD2	HODIS1	HODIS2	BOLTR1	BOLTR2	BOLTL1	BOLTL2
EXAMPLE	0.125	0.0	1.64	0.0	0.0825	0.0100	0.0	0.0

VARIABLE

DESCRIPTION

RAD1	Radius of R.H.S. hole
RAD2	Radius of L.H.S. hole
HODIS1	Distance between mid and R.H.S. holes
HODIS2	Distance between mid and L.H.S. holes
BOLTR1	Fraction of load transfer in R.H.S. bolt - C_1
BOLTR2	Fraction of Load transfer in R.H.S. bolt - C_2
BOLTL1	Fraction of load transfer in L.H.S. bolt - C_1
BOLTL2	Fraction of Load transfer in L.H.S. bolt - C_2

REMARKS (1) Executable for both Methods.

FILE 1: INPUT DATA CARD NO. 12

DESCRIPTION: SURFACE STRESSES

FORMAT: 2F10.4

FIELD	1 - 10	11 - 20	
VARIABLE	FRICT	FAYSUR	
EXAMPLE	3.00	2.00	

VARIABLE

DESCRIPTION

FRICT
FAYSUR

Friction stress due to fastener pre-load
Faying surface friction stress

REMARKS

(1) Executable for both Method 1 and Method 2

FILE 1: INPUT DATA CARD NO. 13

DESCRIPTION: SPECTRUM AND ROUTINE SELECTION

FORMAT: 8I5 (RIGHT JUSTIFIED)

FIELD	1 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40
VARIABLE	IRESTA	NSOLD	NCRKS	NINITS	IRETAD	NBLKS	KID	LID
EXAMPLE	0	0	1	2	1	100	1010	1010

VARIABLE

DESCRIPTION

IRESTA	1 a re-start problem, otherwise 0
NSOLD	Old step number from spectrum at stop
NCRKS	Number of crack tips
NINITS	Number of crack initiation sites
IRETAD	Code to include retardation 1, otherwise 0
NBLKS	Maximum number of blocks for analysis
KID	Stress intensity factor code KXXXX subroutine
LID	Stress concentration factor code SXXXX subroutine

REMARKS (1) Routines selection (Ref. Figures 2.1-1 through 2.2-6).

FILE 1: INPUT DATA CARD NO. 14

DESCRIPTION: STRINGER'S VARIABLES

FORMAT: 8F10.4

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
VARIABLE	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8
EXAMPLE	1.226	1.414	0.462	1.0	0.2658	0.0	0.0	0.0

SUBROUTINE

<u>VARIABLE</u>	<u>K2010</u>	<u>K2020</u>	<u>K2040</u>	<u>K2050</u>	<u>K2060</u>
VAR1	W1	W1	W1	HTG	D
VAR2	W2	W2	W2	XBAR	XBAR
VAR3	T2	T2	T2	YBAR	YBAR
VAR4	SFJ	SFJ	SFJ	Ixx	Ixx
VAR5	CLTD	CLTD	CLTD	Iyy	Iyy
VAR6				Ixy	Ixy
VAR7				T2	TU
VAR8					

REMARKS (1) User defined variables used only with subroutines K2010, K2020, K2040, K2050 and K2060.

(2) Definition of variable reference pages 41 and 42.

FILE 1: INPUT DATA CARD NO. 15

DESCRIPTION: SPECTRUM DESCRIPTION

FORMAT: 3F10.4, I10

FIELD	1 - 10	11 - 20	21 - 30	31 - 40	
VARIABLE	FLTBLK	BLKLIF	FLTHR	ISTRES	
EXAMPLE	120.0	25.0	6000.0	1	

VARIABLE

DESCRIPTION

FLTBLK	Total number of flights in one block
BLKLIF	Total number of blocks in one design lifetime
FLTHR	Total number of flight hours in one design lifetime
ISTRES	Flag for output of stress spectrum (=1 if desired)

REMARKS (1) Non executable variables.

FILE 2: INPUT DATA CARD NO. 1

DESCRIPTION: LOADING SPECTRUM

FORMAT: 3F10.3

FIELD	0 - 10	11 - 20	21 - 30	
VARIABLE	SIGMAX(I)	SIGMIN(I)	CYC(I)	
EXAMPLE	21.7	- 5.0	135.0	
	35.0	21.0	3.0	

VARIABLE

DESCRIPTION

SIGMAX(I) Maximum stress level
SIGMIN(I) Minimum stress level
CYC(I) Number of cycles in the layer

REMARKS (1) Maximum 3000 stress layers.

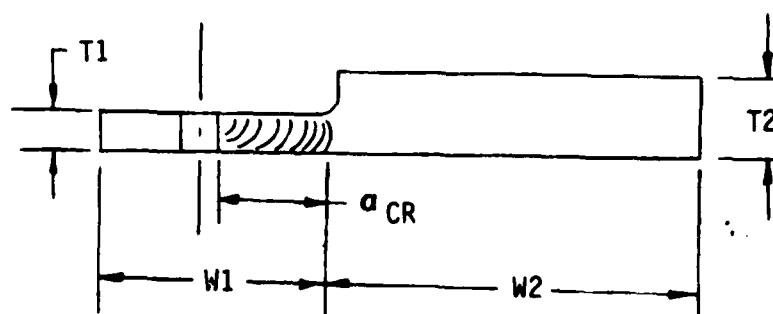
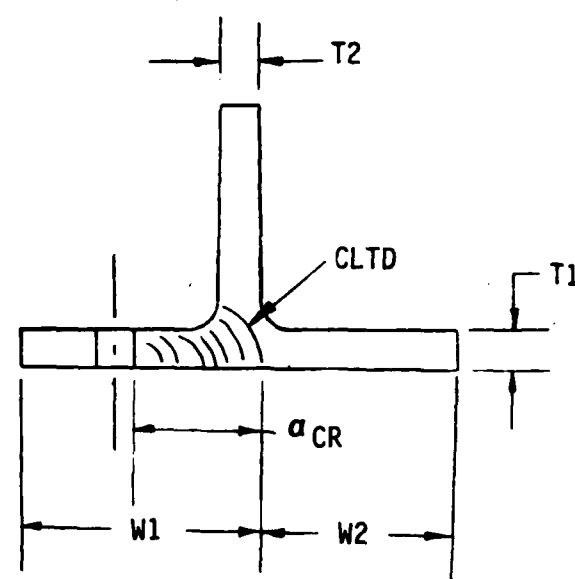
TABLE 2.3-2. VARIABLES DEFINITION OF SUBROUTINES K2010, K2020 AND K2040

(a) 'TEE' SECTION

$$CLTD = (T1^2 + T2^2)^{1/2}$$

SFJ = 0 Crack grows toward upstanding leg

= 1 Crack growth away from upstanding leg



(b) 'L' SECTION

$$CLTD = W2 \quad \text{if } W2 \geq T1$$

$$CLTD = T1 \quad \text{if } T1 > W2$$

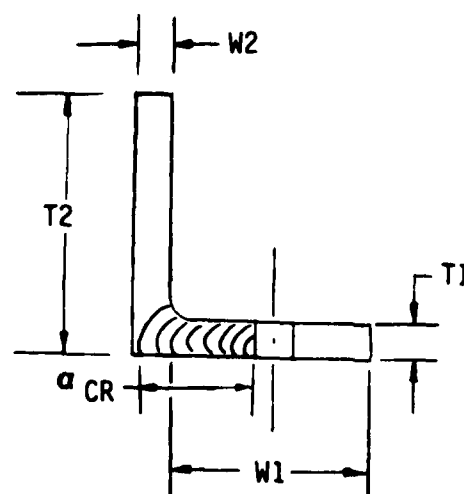


TABLE 2.3-3. VARIABLE DEFINITIONS OF SUBROUTINE K2050

HGT = Stringer Height
 XBAR = $\bar{x}$
 YBAR = $\bar{y}$
 I_{xx} = moment of inertia x - x
 I_{yy} = moment of inertia y - y
 I_{xy} = product of inertia x - y
 TU = Thickness of upstanding leg

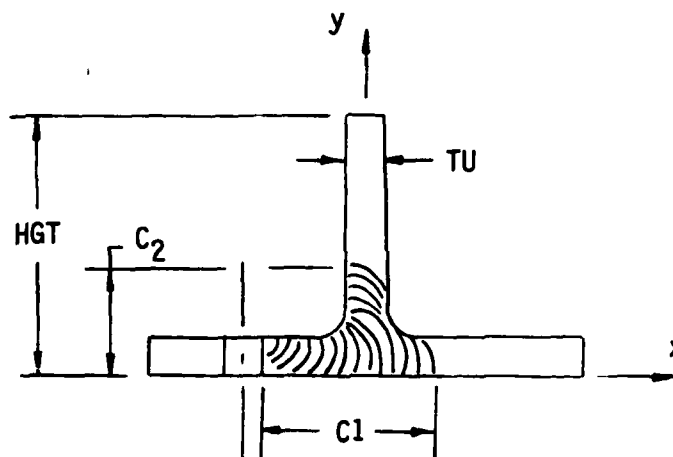
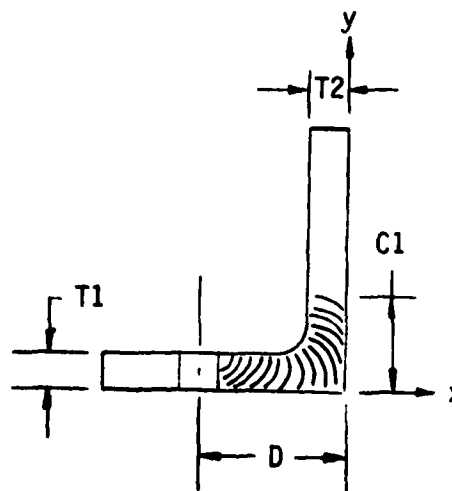


TABLE 2.3-4. VARIABLE DEFINITION OF SUBROUTINE K2060

D = Distance from $\bar{C}$ of hole to outer surface of upstanding leg
 XBAR = $\bar{x}$
 YBAR = $\bar{y}$
 I_{xx} = moment of inertia x - x
 I_{yy} = moment of inertia y - y
 I_{xy} = product of inertia x - y
 T2 = Thickness of upstanding leg



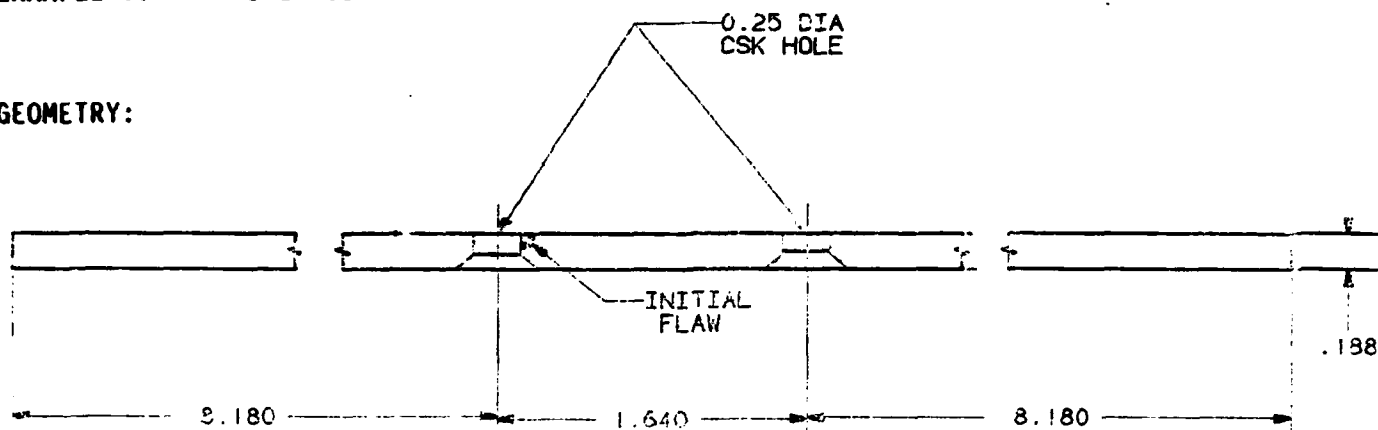
3.0 EXAMPLE RUNS

This section presents three (3) examples to illustrate the usage of DAMGRO Computer Program. They include the following:

- (1) Skin section subjected to a constant amplitude loading, with maximum gross stress of 17.0 KSI, $R = 0.10$ (Ref. pages 44 through 65).
- (2) Skin section subjected to a randomized loading spectrum. The modified Willenborg model was applied (Ref. pages 66 through 90).
- (3) Stringer section subjected to a constant amplitude loading spectrum, with maximum gross stress of 17.0 KSI, $R = 0.10$ (Ref. pages 91 through 107).

EXAMPLE 1: SKIN SECTION SUBJECTED TO CONSTANT AMPLITUDE LOADING

GEOMETRY:



MATERIAL:

2024-T3 SHEET

LOADING SPECTRUM:

CONSTANT AMPLITUDE

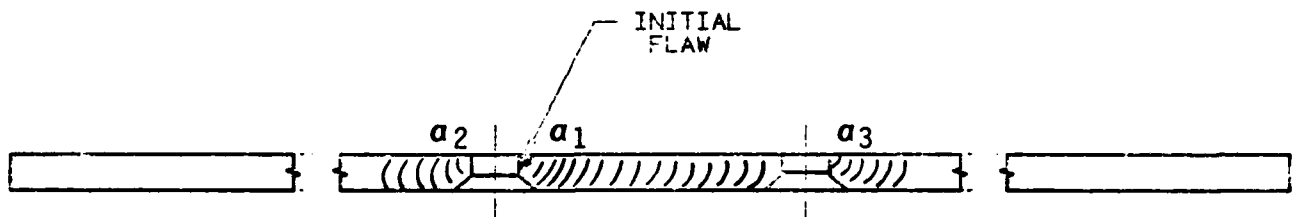
$$\sigma_{\max} = 17.0 \text{ KSI}$$

$$\sigma_{\min} = 1.7 \text{ KSI}$$

REF. PAGES 45 THROUGH 65

TABLE 3.1.1. EXAMPLE 1, METHOD 1 SUMMARY TABLE

REF. PAGES 46 THROUGH 51



a_1 (IN)	a_2 (IN)	a_3 (IN)	LIFE (CYCLES)	ROUTINE GROWTH	RUN NO.
.050	0	.005	0	K1010	1
.102	0		10,000	K1010	1
.220	0		20,000	K1010	1
.419	0		30,000	K1010	1
.788	0		40,000	K1010	1
1.39	0		46,625	K1010	1
	0	.380	48,025	K1030	2
	0	1.034	50,025	K1030	2
	0	1.955	52,625	K1030	2
	0	3.484	54,625	K1030	2
	0	7.303	56,198	K1030	2

 NO. OF CYCLES TO FAILURE = 56,198 CYCLES

TABLE 3.1.1-1. EXAMPLE 1, METHOD 1, RUN 1 INPUT FILE

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM
 2024-T3 SHEET
 2.2374E-09 0.70 3.3386 6.2126E-9 0.00 2.9783
 116.00 36.0 53.0 2.0 2.3 0.99 -0.99
 10.426 -0.366 0.887 10700.0 0.022 1.000 1.0 1.0
 0.050 1.390 0.050 0.188 .0000 0.000 0.000 0.000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.188 0.1250 8.18 9.82 0.00000 .00000 99.900 50. 1.00
 0.0000 0.1250 0.00 1.64 0.00000 .00000 0.00000 .00000
 0.000 0.0000
 0 00 1 0 1 100 1010 0000
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 120.0 25.0 6000. 1

TABLE 3.1.1-2. EXAMPLE 1, METHOD 1, RUN 1 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

* THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1; CRACK INITIATION = 0
 CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1010; CRACK INITIATION = 0

LOAD INTERACTION : NONE

MATERIAL : 2024-T3 SHEET

WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339

WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.978

MAX. K FOR DC/DN THRESHOLD = 2.000

RETARDATION SHUT-OFF RATIO = 2.300

+R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900

YIELD STRENGTH : 53.000

ELASTIC MODULUS = 0.1070E+05

PL. STRESS FRACT. TOUGHNESS = 116.00

PL. STRAIN FRACT. TOUGHNESS = 36.00

DAMAGE INDEX FOR CRACK INITIATION = 0.892

NEUBER MATERIAL CONST. = 0.022

CRACK INITIATION EQ. CONST. : SF = 10.426, M = -0.366

STRESS SEVERITY FACTOR PARAMETERS :

ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.05000

FINAL CRACK LENGTH OF CRACK NO. 1 : 1.39000

INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.05000

FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800

INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000

FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000

INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000

FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :

APCOL1 = .000E+00, APCOL1 = .000E+00, RYCOL1 = .000E+00, RYCOL1 = .000E+00

AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00

APCOL2 = .000E+00, APCOL2 = .000E+00, RYCOL2 = .000E+00, RYCOL2 = .000E+00

AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :

DMG1 = .000E+00, DMGOL1 = .000E+00, DEL DMG1 = .000E+00

DMG2 = .000E+00, DMGOL2 = .000E+00, DEL DMG2 = .000E+00

TABLE 3.1.1-2. EXAMPLE 1, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	9.82000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	8.18000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	20.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	10000.000
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	17.000
NO. OF STRESS LAYERS IN ONE BLOCK	10

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	17.000	1.700	1000.000	2	17.000	1.700	1000.000
3	17.000	1.700	1000.000	4	17.000	1.700	1000.000
5	17.000	1.700	1000.000	6	17.000	1.700	1000.000
7	17.000	1.700	1000.000	8	17.000	1.700	1000.000
9	17.000	1.700	1000.000	10	17.000	1.700	1000.000

TABLE 3.1.1-2. EXAMPLE 1, METHOD 1, RUN 1 OUTPUT FILE (CONCLUDED)

***** DAMAGE GROWTH HISTORY *****								
BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	9.054	0.000	.000E+00	.000E+00	.000E+00	.000E+00
	0.05000	0.00000	11.348	0.000	.000E+00	.000E+00	.000E+00	.000E+00
1.0	0.10203	0.00000	12.570	0.000	.434E-03	.000E+00	.000E+00	.000E+00
	0.13103	0.00000	13.606	0.000	.675E-03	.000E+00	.000E+00	.000E+00

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :

CYC= 135.0, STEP = 6, BLOCK = 2, CRACK DEPTH = 0.18805
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

2.0	0.22022	0.00000	15.227	0.000	.985E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.475E-03	.000E+00	.000E+00	.000E+00
3.0	0.41962	0.00000	17.733	0.000	.166E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
4.0	0.78810	0.00000	22.009	0.000	.307E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00

CRACK NO. 1 HAS REACHED THE SPECIFIED LENGTH 1.3900 INCHES AT :

CYC = 625.0, STEP = 7, BLOCK = 5, CKMAXS= 63.24, C1= 1.39096
TERMINATE DAMAGE COMPUTATION

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :

C1 = 1.39096, A1 = 0.18800, C2 = 0.00000, A2 = 0.00000

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :

APADL1 = .000E+00, APCOL1 = .000E+00, RYADL1 = .000E+00, RYCOL1 = .000E+00
AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
APADL2 = .000E+00, APCOL2 = .000E+00, RYADL2 = .000E+00, RYCOL2 = .000E+00
AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :

DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.1.1-3. EXAMPLE 1, METHOD 1, RUN 2 INPUT FILE

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM
 2024-T3 SHEET
 2.2374E-09 0.70 3.3386 6.2126E-9 0.00 2.9783
 116.00 36.0 53.0 2.0 2.3 0.99 -0.99
 10.426 -0.366 0.887 10700.0 0.022 1.000 1.0 1.0
 0.055 8.180 0.072 0.188 0.000 0.000 0.000 0.000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.188 0.1250 8.18 9.82 0.00000 0.0000 99.900 50.1.00
 0.0000 0.1250 0.00 1.64 0.00000 0.0000 0.00000 0.00000
 0.000 0.0000
 0 00 1 0 1 100 1030 0000
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 120.0 25.0 6000. 1

TABLE 3.1.1-4. EXAMPLE 1, METHOD 1, RUN 2 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****
 EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM
 * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *
 NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1; CRACK INITIATION = 0
 CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1030; CRACK INITIATION = 0
 LOAD INTERACTION : NONE
 MATERIAL : 2024-T3 SHEET
 WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339
 WALKER EQ. CONST. (-R) : C = 0.421E-08, M = 0.000, N = 2.978
 MAX. K FOR DC/DN THRESHOLD = 2.000
 RETARDATION SHUT-OFF RATIO = 2.300
 +R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
 YIELD STRENGTH : 53.000
 ELASTIC MODULUS = 0.1070E+05
 PL. STRESS FRACT. TOUGHNESS = 116.00
 PL. STRAIN FRACT. TOUGHNESS = 36.00
 DAMAGE INDEX FOR CRACK INITIATION = 0.892
 NEUBER MATERIAL CONST. = 0.022
 CRACK INITIATION EQ. CONST. SF = 10.426, M = -0.366
 STRESS SEVERITY FACTOR PARAMETERS :
 ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000
 SPECIFIED DAMAGE CONDITIONS :
 INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.05500
 FINAL CRACK LENGTH OF CRACK NO. 1 : 0.18000
 INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.07200
 FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
 INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
 APAOL1 = 0.000E+00, APCOL1 = 0.000E+00, RYAO1 = 0.000E+00, RYCOL1 = 0.000E+00
 AKOL1 = 0.000E+00, CKOL1 = 0.000E+00, ADL1 = 0.000E+00, COL1 = 0.000E+00
 APAOL2 = 0.000E+00, APCOL2 = 0.000E+00, RYAO2 = 0.000E+00, RYCOL2 = 0.000E+00
 AKOL2 = 0.000E+00, CKOL2 = 0.000E+00, ADL2 = 0.000E+00, COL2 = 0.000E+00
 PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
 DMG1 = 0.000E+00, DMGOL1 = 0.000E+00, DELDEL1 = 0.000E+00
 DMG2 = 0.000E+00, DMGOL2 = 0.000E+00, DELDEL2 = 0.000E+00

TABLE 3.1.1-4. EXAMPLE 1, METHOD 1, RUN 2 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	8.18000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	9.82000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	20.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	2000.000
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	17.000
NO. OF STRESS LAYERS IN ONE BLOCK :	2

TABLE 3.1.1-4. EXAMPLE 1, METHOD 1, RUN 2 OUTPUT FILE (CONCLUDED)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	17.000	1.700	1000.000	2	17.000	1.700	1000.000

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :

CYC = 946.0, STEP = 1, BLOCK = 1, CRACK DEPTH = 0.18893
 CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

0.0	0.05500	0.00000	23.358	0.000	.000E+00	.000E+00	.000E+00	.000E+00
	0.07200	0.00000	25.781	0.000	.000E+00	.000E+00	.000E+00	.000E+00
1.0	0.38048	0.00000	35.380	0.000	.271E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.967E-03	.000E+00	.000E+00	.000E+00
2.0	1.03462	0.00000	39.558	0.000	.545E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
3.0	1.95571	0.00000	44.499	0.000	.768E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
4.0	3.48375	0.00000	54.072	0.000	.127E-01	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:

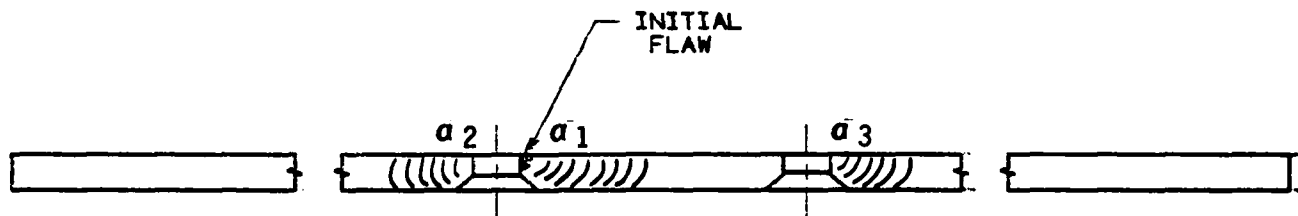
CYC = 573.0, STEP = 2, BLOCK = 5, CRACK LENGTH = 7.30257, CKHXS=116.4
 THE OTHER CRACK LENGTH = 0.00000
 TERMINATE DAMAGE COMPUTATION

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :

AFAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
 AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
 AFAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00
 RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
 DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.1.2. EXAMPLE 1, METHOD 2 SUMMARY TABLE

REF. PAGES 53 THROUGH 65



a_1 (IN)	a_2 (IN)	a_3 (IN)	LIFE (CYCLES)	ROUTINES GROWTH	ROUTINES INITIATION	RUN NO.
.050	0	0	0	K1010	S1010	1
.102	0	0	10,000	K1010	S1010	1
.220	0	0	20,000	K1010	S1010	1
.419	0	0	30,000	K1010	S1010	1
.788	0	0	40,000	K1010	S1010	1
.904	0	0	42,000	K1010	S1010	1
1.048	0	0	44,000	K1010	S1010	1
1.246	0	0	46,000	K1010	S1010	1
1.39	0	0	46,625	K1010	S1010	1
	.050	0	51,625	-	S1040	2
	.330	0	53,625	K1030	S1050	3
	.961	0	55,625	K1030	S1050	3
	1.364	0.050	56,625	K1030	S1050	3
	2.618	1.233	58,625	K1050	-	4
	3.254	4.572	59,625	K1050	-	4

NO. OF CYCLES TO SECONDARY CRACK INITIATION = 51,625 CYCLES
 NO. OF CYCLES TO FAILURE = 59,625 CYCLES

TABLE 3.1.2-1. EXAMPLE 1, METHOD 2, RUN 1 INPUT FILE

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM
2024-T3 SHEET

2.2374E-09	0.70	3.3386	6.2126E-9	0.00	2.9783			
116.00	36.0	53.0	2.0	2.3	0.99	-0.99		
10.426	-1.366	0.892	10700.0	0.022	1.000	1.0	1.0	
0.050	1.390	0.050	0.188	0.000	0.000	0.000	0.000	
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.188	0.1250	8.18	9.82	0.00000	0.00000	99.900	50.100	
0.0000	0.1250	0.00	1.64	0.00000	0.00000	0.00000	0.00000	
0.000	0.0000							
0.00	1.2	1.100	1010	1010				
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
120.0	25.0	6000.	1					

TABLE 3.1.2-2. EXAMPLE 1, METHOD 2, RUN 1 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

* THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1; CRACK INITIATION = 2
CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1010; CRACK INITIATION = 1010

LOAD INTERACTION : NONE

MATERIAL : 2024-T3 SHEET

WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339
WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.978
MAX. K FOR DC/DN THRESHOLD = 2.000
RETARDATION SHUT-OFF RATIO = 2.300
+R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
YIELD STRENGTH : 53.000
ELASTIC MODULUS = 0.1070E+05
PL. STRESS FRACT. TOUGHNESS = 116.00
PL. STRAIN FRACT. TOUGHNESS = 36.00
DAMAGE INDEX FOR CRACK INITIATION = 0.892
NEUBER MATERIAL CONST. = 0.022
CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366
STRESS SEVERITY FACTOR PARAMETERS :
ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.05000
FINAL CRACK LENGTH OF CRACK NO. 1 : 1.39000
INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.05000
FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY

APCOL1 = 1.000E+00, APCOL1 = 1.000E+00, RYCOL1 = 1.000E+00, RYCOL1 = 1.000E+00
AKOL1 = 1.000E+00, CKOL1 = 1.000E+00, COL1 = 1.000E+00, COL1 = 1.000E+00
APCOL2 = 1.000E+00, APCOL2 = 1.000E+00, RYCOL2 = 1.000E+00, RYCOL2 = 1.000E+00
AKOL2 = 1.000E+00, CKOL2 = 1.000E+00, COL2 = 1.000E+00, COL2 = 1.000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY

DMG1 = 1.000E+00, DMGOL1 = 0.00E+00, DELDGI = 0.00E+00
DMG2 = 1.000E+00, DMGOL2 = 0.00E+00, DELDGI = 0.00E+00

TABLE 3.1.2-2. EXAMPLE 1, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY

THICKNESS OF PLATE	0.18800	
RADIUS OF MID. HOLE	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE	9.82000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE	8.18000	
FRACTION OF LOAD TRANSFER BY MID. BOLT	0.00000	0.00000
RADIUS OF THE R.H.S. HOLE	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT	0.00000	0.00000
RADIUS OF THE L.H.S. HOLE	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT	0.00000	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS	20.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS	0.0000	
FAYING SURFACE FRICTION STRESS	0.0000	

STRESS SPECTRUM

NO. OF BLOCKS SPECIFIED FOR ANALYSIS	100
TOTAL NO. OF CYCLES IN ONE BLOCK	2000.000
TOTAL NO. OF FLIGHTS IN ONE BLOCK	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM	17.000
NO. OF STRESS LAYERS IN ONE BLOCK	2

STRESS LAYERS IN ONE BLOCK

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	17.000	1.700	1000.000	2	17.000	1.700	1000.000

TABLE 3.1.2-2. EXAMPLE 1, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

***** DAMAGE GROWTH HISTORY *****								
BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	9.054	0.000	.000E+00	.000E+00	.252E-02	.037E-02
	0.05000	0.00000	11.348	0.000	.000E+00	.000E+00	.264E+01	.250E+01
1.0	0.05630	0.00000	9.860	0.000	.515E-04	.000E+00	.269E-02	.260E-02
	0.06240	0.00000	11.820	0.000	.103E-03	.000E+00	.266E+01	.250E+01
2.0	0.06449	0.00000	10.579	0.000	.682E-04	.000E+00	.131E-01	.933E-02
	0.07658	0.00000	12.290	0.000	.113E-03	.000E+00	.268E+01	.250E+01
3.0	0.07468	0.00000	11.249	0.000	.850E-04	.000E+00	.188E-01	.131E-01
	0.09268	0.00000	12.751	0.000	.134E-03	.000E+00	.270E+01	.250E+01
4.0	0.08709	0.00000	11.902	0.000	.103E-03	.000E+00	.248E-01	.168E-01
	0.11082	0.00000	13.192	0.000	.151E-03	.000E+00	.274E+01	.250E+01
5.0	0.10203	0.00000	12.570	0.000	.124E-03	.000E+00	.313E-01	.205E-01
	0.13103	0.00000	13.606	0.000	.168E-03	.000E+00	.278E+01	.250E+01
6.0	0.11997	0.00000	13.282	0.000	.149E-03	.000E+00	.384E-01	.243E-01
	0.15333	0.00000	13.987	0.000	.186E-03	.000E+00	.282E+01	.250E+01
7.0	0.13949	0.00000	13.429	0.000	.163E-03	.000E+00	.448E-01	.280E-01
	0.17540	0.00000	13.725	0.000	.184E-03	.000E+00	.276E+01	.250E+01

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :
 CYC= 135.0, STEP = 2, BLOCK = 8, CRACK DEPTH = 0.18805
 CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

8.0	0.16290	0.00000	14.511	0.000	.195E-03	.000E+00	.518E-01	.317E-01
	0.18800	0.00000	0.000	0.000	.105E-03	.000E+00	.282E+01	.250E+01
9.0	0.19041	0.00000	14.852	0.000	.229E-03	.000E+00	.597E-01	.355E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.288E+01	.250E+01
10.0	0.22022	0.00000	15.227	0.000	.248E-03	.000E+00	.684E-01	.392E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.295E+01	.250E+01
11.0	0.25265	0.00000	15.637	0.000	.270E-03	.000E+00	.787E-01	.429E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.302E+01	.250E+01
12.0	0.28822	0.00000	16.088	0.000	.296E-03	.000E+00	.903E-01	.467E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.309E+01	.250E+01
13.0	0.32744	0.00000	16.584	0.000	.327E-03	.000E+00	.104E+00	.504E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.317E+01	.250E+01
14.0	0.37097	0.00000	17.130	0.000	.363E-03	.000E+00	.119E+00	.541E-01

TABLE 3.1.2-2. EXAMPLE 1, METHOD 2, RUN 1 OUTPUT FILE (CONCLUDED)

	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.326E+01	.250E+01
15.0	0.41962	0.00000	17.733	0.000	.405E-03	.000E+00	.137E+00	.579E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.335E+01	.250E+01
16.0	0.47447	0.00000	18.410	0.000	.457E-03	.000E+00	.158E+00	.616E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.345E+01	.250E+01
17.0	0.53670	0.00000	19.143	0.000	.519E-03	.000E+00	.183E+00	.758E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.354E+01	.250E+01
18.0	0.60812	0.00000	19.974	0.000	.595E-03	.000E+00	.210E+00	.891E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.364E+01	.250E+01
19.0	0.69090	0.00000	20.920	0.000	.690E-03	.000E+00	.249E+00	.1.028E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.382E+01	.250E+01
20.0	0.78810	0.00000	22.009	0.000	.810E-03	.000E+00	.294E+00	.1.265E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.398E+01	.250E+01
21.0	0.90453	0.00000	23.313	0.000	.970E-03	.000E+00	.350E+00	.1.503E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.416E+01	.250E+01
22.0	1.04848	0.00000	25.039	0.000	.120E-02	.000E+00	.424E+00	.1.840E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.436E+01	.250E+01

CRACK NO. 1 HAS REACHED THE SPECIFIED LENGTH 1.3900 INCHES AT

CYC = 625.0, STEP = 1, BLOCK = 24, CKMAXS = 63.24, C1 = 1.39096

TERMINATE DAMAGE COMPUTATION

23.0	1.24675	0.00000	29.167	0.000	.165E-02	.000E+00	.525E+00	.1.877E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.464E+01	.250E+01

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION

C1 = 1.39096, A1 = 0.18800, C2 = 0.00000, A2 = 0.00000

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION

APCOL1 = .000E+00, APCOL1 = .000E+00, RYCOL1 = .000E+00, RYCOL1 = .000E+00
 AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
 APCOL2 = .000E+00, APCOL2 = .000E+00, RYCOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION

DMG1 = .525E+00, DMGOL1 = .000E+00, DELD1 = .000E+00
 DMG2 = .1877E-01, DMGOL2 = .000E+00, DELD2 = .000E+00

TABLE 3.1.2-3. EXAMPLE 1, METHOD 2, RUN 2 INPUT FILE

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM
 2024-T3 SHEET
 2.2374E-09 0.70 3.3386 6.2126E-9 0.00 2.9783
 116.00 36.0 53.0 2.0 2.3 0.99 -0.99
 10.426 -1.366 0.892 10700.0 0.022 1.000 1.0 1.0
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.5250E+000.0000E+000.0000E+000.8770E-010.0000E+000.0000E+000
 0.188 0.1250 8.18 9.82 0.00000 0.00000 99.900 50.100
 0.0000 0.1250 0.00 1.64 0.00000 0.00000 0.00000 0.00000
 0.000 0.0000
 0 00 0 2 0 100 0000 1040
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 120.0 25.0 6000. 1

TABLE 3.1.2-4. EXAMPLE 1, METHOD 2, RUN 2 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

* THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 0; CRACK INITIATION = 2
 CORRESPONDING DAMAGE CODES : CRACK GROWTH = 0; CRACK INITIATION = 1040

LOAD INTERACTION : NONE

MATERIAL : 2024-T3 SHEET

WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339

WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 0.978

MAX. K FOR DC/DN THRESHOLD = 2.000

RETARDATION SHUT-OFF RATIO = 2.300

+R CUT-OFF = 0.9900, -R CUT OFF = -0.9900

YIELD STRENGTH = 53.000

ELASTIC MODULUS = 0.1070E+05

PL. STRESS FRACT. TOUGHNESS = 116.00

PL. STRAIN FRACT. TOUGHNESS = 36.00

DAMAGE INDEX FOR CRACK INITIATION = 0.892

NEUBER MATERIAL CONST. = 0.022

CRACK INITIATION EQ. CONST. : SE = 10.426, M = -1.366

STRESS SEVERITY FACTOR PARAMETERS :

ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.00000

FINAL CRACK LENGTH OF CRACK NO. 1 : 0.00000

INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.00000

FINAL CRACK DEPTH OF CRACK NO. 1 : 0.00000

INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000

FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000

INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000

FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :

APCOL1 = 1.000E+00, APCOL1 = 1.000E+00, PYCOL1 = 0.000E+00, RYCOL1 = 0.000E+00

AKOL1 = 1.000E+00, CKOL1 = 1.000E+00, APL1 = 0.000E+00, COL1 = 0.000E+00

APCOL2 = 1.000E+00, APCOL2 = 1.000E+00, PYCOL2 = 0.000E+00, RYCOL2 = 1.000E+00

AKOL2 = 1.000E+00, CKOL2 = 1.000E+00, APL2 = 0.000E+00, COL2 = 1.000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :

DMC1 = 1.525E+00, DMCOL1 = 1.000E+00, DELDGL = 0.000E+00

DMG2 = 1.877E-01, DMCOL2 = 0.000E+00, DELDGL = 0.000E+00

TABLE 3.1.2-4. EXAMPLE 1, METHOD 2, RUN 2 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :		
THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, L/D	92.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE	9.82000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE	8.18000	
FRACTION OF LOAD TRANSFER BY MID. BOLT	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS	20.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS	0.0000	
FAYING SURFACE FRICTION STRESS	0.0000	
STRESS SPECTRUM :		
NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100	
TOTAL NO. OF CYCLES IN ONE BLOCK	2000.000	
TOTAL NO. OF FLIGHTS IN ONE BLOCK	120.000	
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000	
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000	
MAXIMUM PEAK STRESS OF THE SPECTRUM	17.000	
NO. OF STRESS LAYERS IN ONE BLOCK	2	

TABLE 3.1.2-4. EXAMPLE 1, METHOD 2, RUN 2 OUTPUT FILE (CONCLUDED)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	17.000	1.700	1000.000

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
2	17.000	1.700	1000.000

***** DAMAGE GROWTH HISTORY *****

BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.00000	0.00000	0.000	0.000	1.000E+00	1.000E+00	1.600E+00	1.63E+00
	0.00000	0.00000	0.000	0.000	1.000E+00	1.000E+00	1.492E+01	1.492E+01
1.0	0.00000	0.00000	0.000	0.000	1.000E+00	1.000E+00	1.752E+00	1.74E+00
	0.00000	0.00000	0.000	0.000	1.000E+00	1.000E+00	1.492E+01	1.492E+01

CRACK INITIATION FOR LOCATION 1 OCCURS AT :

CYC = 1000.000, STEP = 1, BLOCK = 3

2.0	0.00000	0.00000	0.000	0.000	1.000E+00	1.000E+00	1.827E+00	1.466E+00
	0.00000	0.00000	0.000	0.000	1.000E+00	1.000E+00	1.492E+01	1.492E+01

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :

C1 = 0.00000, A1 = 0.00000, C2 = 0.00000, A2 = 0.00000

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION

APCOL1 = 1.000E+00, APCOL1 = 1.000E+00, RYACOL1 = 1.000E+00, RYCOL1 = 1.000E+00
 AKOL1 = 1.000E+00, CKOL1 = 1.000E+00, AOL1 = 1.000E+00, COL1 = 1.000E+00
 APCOL2 = 1.000E+00, APCOL2 = 1.000E+00, RYACOL2 = 1.000E+00, RYCOL2 = 1.000E+00
 AKOL2 = 1.000E+00, CKOL2 = 1.000E+00, AOL2 = 1.000E+00, COL2 = 1.000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION

DMG1 = 1.827E+00, DMGOL1 = 1.000E+00, DEDMG1 = 0.000E+00
 DMG2 = 1.466E+00, DMGOL2 = 1.000E+00, DEDMG2 = 0.000E+00

TABLE 3.1.2-5. EXAMPLE 1, METHOD 2, RUN 3 INPUT FILE

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM
 2024-T3 SHEET
 2.2374E-09 0.70 3.3386 6.2126E-9 0.00 2.9783
 116.00 36.0 53.0 2.0 2.3 0.99 -0.99
 10.426 -1.366 0.892 10700.0 0.022 1.000 1.0 1.0
 0.050 8.180 0.050 0.188 .0000 0.000 0.000 0.000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.4660E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.188 0.1250 8.18 9.82 0.00000 .00000 99.900 50.1.00
 0.0000 0.1250 0.00 1.64 0.00000 .00000 0.00000 .00000
 0.000 0.0000
 0.00 1. 1 0.100 1030 1050
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 120.0 25.0 6000. 1

TABLE 3.1.2-6. EXAMPLE 1, METHOD 2, RUN 3 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R D *****
 EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM
 * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *
 NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1; CRACK INITIATION = 1
 CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1030; CRACK INITIATION = 1050
 LOAD INTERACTION : NONE
 MATERIAL : 2024-T3 SHEET
 WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339
 WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.978
 MAX. K FOR DC/DN THRESHOLD = 2.000
 RETARDATION SHUT-OFF RATIO = 2.300
 +R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
 YIELD STRENGTH : 53.000
 ELASTIC MODULUS = 0.1070E+05
 PL. STRESS FRACT. TOUGHNESS = 116.00
 PL. STRAIN FRACT. TOUGHNESS = 36.00
 DAMAGE INDEX FOR CRACK INITIATION = 0.892
 NEUBER MATERIAL CONST. = 0.022
 CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366
 STRESS SEVERITY FACTOR PARAMETERS :
 ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000
 SPECIFIED DAMAGE CONDITIONS :
 INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.05000
 FINAL CRACK LENGTH OF CRACK NO. 1 : 8.18000
 INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.05000
 FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
 INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
 APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
 AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
 APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00
 PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
 DMG1 = .466E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.1.2-6. EXAMPLE 1, METHOD 2, RUN 3 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :		
THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.99999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	0.18000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	9.82000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	20.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	
STRESS SPECTRUM :		
NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100	
TOTAL NO. OF CYCLES IN ONE BLOCK :	2000.000	
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000	
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000	
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000	
MAXIMUM PEAK STRESS OF THE SPECTRUM :	17.000	
NO. OF STRESS LAYERS IN ONE BLOCK :	2	

TABLE 3.1.2-6. EXAMPLE 1, METHOD 2, RUN 3 OUTPUT FILE (CONCLUDED)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	17.000	1.700	1000.000	2	17.000	1.700	1000.000

***** DAMAGE GROWTH HISTORY *****

BLOCK	C1	C2	KMAX-C1	KMAX-C2	DC1/DF	DC2/DF	INITIA1	INITIA2
	A1	A2	KMAX-A1	KMAX-A2	DA1/DF	DA2/DF	KN1	KN2
0.0	0.05000	0.00000	19.898	0.000	.000E+00	.000E+00	.546E+00	.000E+00
	0.05000	0.00000	24.939	0.000	.000E+00	.000E+00	.497E+01	.000E+00

STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :

CYC = 157.0, STEP = 2, BLOCK = 1, CRACK DEPTH = 0.18954
 CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES

1.0	0.33032	0.00000	34.706	0.000	.234E-02	.000E+00	.744E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.115E-02	.000E+00	.526E+01	.000E+00

CRACK INITIATION FOR LOCATION 1 OCCURS AT :

CYC = 1000.000, STEP = 1, BLOCK = 3

2.0	0.96141	0.00000	39.187	0.000	.526E-02	.000E+00	.890E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.567E+01	.000E+00

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :

C1 = 1.36451, A1 = 0.18800, C2 = 0.00000, A2 = 0.00000

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :

APCOL1 = .000E+00, APCOL1 = .000E+00, RYCOL1 = .000E+00, RYCOL1 = .000E+00
 AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
 APCOL2 = .000E+00, APCOL2 = .000E+00, RYCOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :

DMG1 = .890E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.1.2-7. EXAMPLE 1, METHOD 2, RUN 4 INPUT FILE

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM
 2024-T3 SHEET
 2.2374E-09 0.70 3.3386 6.2126E-9 0.00 2.9783
 116.00 36.0 53.0 2.0 2.3 0.99 -0.99
 10.426 -1.366 0.892 10700.0 0.022 1.000 1.0 1.0
 1.364 8.180 0.188 0.188 .0500 8.180 0.050 0.188
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.188 0.1250 8.18 9.82 0.00000 .00000 99.900 50.1.00
 0.0000 0.1250 0.00 1.64 0.00000 .00000 0.00000 .00000
 0.000 0.0000
 0 00 2 0 0 100 1050 0000
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 120.0 25.0 6000. 1

TABLE 3.1.2-8. EXAMPLE 1, METHOD 2, RUN 4 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R D *****

EXAMPLE RUN NO. 1 SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING SPECTRUM

* THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 2; CRACK INITIATION = 0
 CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1050; CRACK INITIATION = 0

LOAD INTERACTION : NONE

MATERIAL : 2024-T3 SHEET

WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339

WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.978

MAX. K FOR DC/DN THRESHOLD = 2.000

RETARDATION SHUT-OFF RATIO = 2.300

+R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900

YIELD STRENGTH : 53.000

ELASTIC MODULUS = 0.1070E+05

PL. STRESS FRACT. TOUGHNESS = 116.00

PL. STRAIN FRACT. TOUGHNESS = 36.00

DAMAGE INDEX FOR CRACK INITIATION = 0.892

NEUBER MATERIAL CONST. = 0.022

CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366

STRESS SEVERITY FACTOR PARAMETERS :

ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 : 1.36400

FINAL CRACK LENGTH OF CRACK NO. 1 : 8.18000

INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.18800

FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800

INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.05000

FINAL CRACK LENGTH OF CRACK NO. 2 : 8.18000

INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.05000

FINAL CRACK DEPTH OF CRACK NO. 2 : 0.18800

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :

APCOL1 = .000E+00, APCOL1 = .000E+00, RYCOL1 = .000E+00, RYCOL1 = .000E+00

AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00

APCOL2 = .000E+00, APCOL2 = .000E+00, RYCOL2 = .000E+00, RYCOL2 = .000E+00

AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY

DMG1 = .000E+00, DMGOL1 = .000E+00, DEL DMG1 = .000E+00

DMG2 = .000E+00, DMGOL2 = .000E+00, DEL DMG2 = .000E+00

TABLE 3.1.2-8. EXAMPLE 1, METHOD 2, RUN 4 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	8.18000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	9.82000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	20.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	2000.000
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	17.000
NO. OF STRESS LAYERS IN ONE BLOCK :	2

TABLE 3.1.2-8. EXAMPLE 1, METHOD 2, RUN 4 OUTPUT FILE (CONCLUDED)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	17.000	1.700	1000.000	2	17.000	1.700	1000.000

UNSTABLE BREAK-THROUGH OF CRACK NO. 2 OCCURS AT :

CYC = 0.0, STEP = 1, BLOCK = 1, DEPTH = 0.05000, AKMAXS= 37.79

***** DAMAGE GROWTH HISTORY *****

BLOCK	C1	C2	KMAX-C1	KMAX-C2	DC1/DF	DC2/DF	INITIA1	INITIA2
	A1	A2	KMAX-A1	KMAX-A2	DA1/DF	DA2/DF	KN1	KN2
0.0	1.36400	0.05000	41.432	30.154	.000E+00	.000E+00	.000E+00	.000E+00
	0.18800	0.05000	0.000	37.792	.000E+00	.000E+00	.000E+00	.000E+00
1.0	2.61890	1.23327	56.095	56.847	.105E-01	.984E-02	.000E+00	.000E+00
	0.18800	0.18800	0.000	0.000	.000E+00	.115E-02	.000E+00	.000E+00

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:

CYC = 15.0, STEP = 2, BLOCK = 2, CRACK LENGTH = 4.57208, CKMAXS=116.06
 THE OTHER CRACK LENGTH = 3.18957
 TERMINATE DAMAGE COMPUTATION

UNSTABLE GROWTH OF CRACK NO. 2 OCCURS AT:

CYC = 4.0, STEP = 2, BLOCK = 2, CRACK LENGTH = 3.25368, CKMAXS=117.03
 THE OTHER CRACK LENGTH = 4.57208
 TERMINATE DAMAGE COMPUTATION

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :

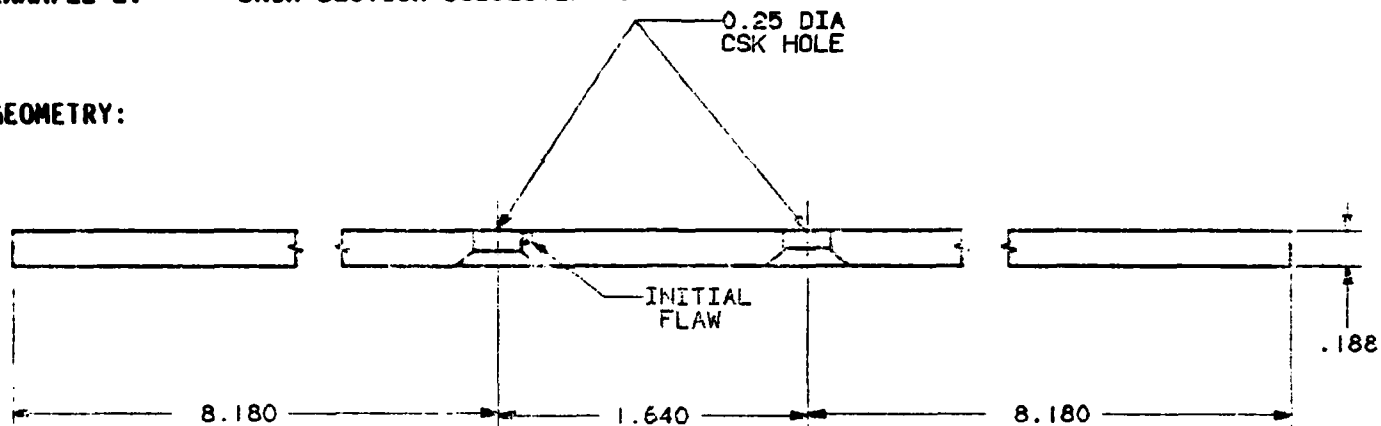
APADL1 = .000E+00, APCOL1 = .000E+00, RYADL1 = .000E+00, RYCOL1 = .000E+00
 AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
 APADL2 = .000E+00, APCOL2 = .000E+00, RYADL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :

DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

EXAMPLE 2: SKIN SECTION SUBJECTED TO RANDOMIZED LOADING SPECTRUM

GEOMETRY:



MATERIAL:

2024-T3 SHEET

LOADING SPECTRUM:

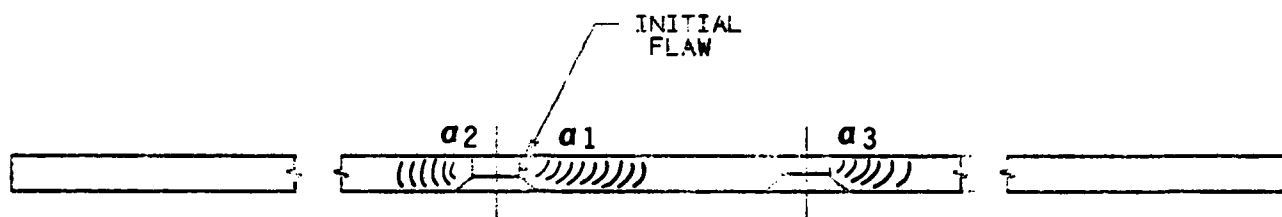
RANDOMIZED BLOCK LOADING

$$\sigma_{\max} = 35.75 \text{ KSI}$$

REF. PAGES 67 THROUGH 90

TABLE 3.2.1. EXAMPLE 2, METHOD 1 SUMMARY TABLE

REF. PAGES 68 THROUGH 76



a_1 (IN)	a_2 (IN)	a_3 (IN)	LIFE (BLOCK, LAYER, CYCLES)	ROUTINE GROWTH	RUN NO.
.050	0	.005	0	K1010	1
.065	0	.005	1, 0, 0	K1010	1
.091	0	.005	2, 0, 0	K1010	1
.126	0	.005	3, 0, 0	K1010	1
.164	0	.005	4, 0, 0	K1010	1
.208	0	.005	5, 0, 0	K1010	1
.258	0	.005	6, 0, 0	K1010	1
.316	0	.005	7, 0, 0	K1010	1
.384	0	.005	8, 0, 0	K1010	1
.466	0	.005	9, 0, 0	K1010	1
.566	0	.005	10, 0, 0	K1010	1
.693	0	.005	11, 0, 0	K1010	1
.859	0	.005	12, 0, 0	K1010	1
1.094	0	.005	13, 0, 0	K1010	1
1.39	0	.023	13, 119, 32	K1010	1
	0	.622	14, 0, 32	K1030	2
	0	2.16	15, 0, 32	K1030	2
	0	3.6507	15, 98, 38	K1030	2

NO. OF CYCLES TO FAILURE = 111,955 CYCLES

TABLE 3.2.1-1. EXAMPLE 2, METHOD 1, RUN 1 INPUT FILE

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
 2024-T3 SHEET
 2.2374E-09 0.70 3.3386 6.2126E-9 0.00 2.9783
 116.00 36.0 53.0 2.0 2.3 0.99 -0.99
 10.426 -1.366 0.887 10700.0 0.022 1.000 1.0 1.0
 0.050 1.390 0.050 0.188 .0000 0.000 0.000 0.000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.188 0.1250 9.82 8.18 0.00000 .00000 99.900 50. 1.00
 0.1250 0.0000 1.64 0.00 0.00000 .00000 0.00000 .00000
 0.000 0.0000
 0 .00 1 0 1 100 1010 0000
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 120.0 25.0 6000. 1

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****
 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
 * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *
 NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1; CRACK INITIATION = 0
 CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1010; CRACK INITIATION = 0
 LOAD INTERACTION : GENERALIZED WILLENBORG ET AL--CHANG MODEL
 MATERIAL : 2024-T3 SHEET
 WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339
 WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.978
 MAX. K FOR DC/DN THRESHOLD = 2.000
 RETARDATION SHUT-OFF RATIO = 2.300
 +R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
 YIELD STRENGTH : 53.000
 ELASTIC MODULUS = 0.1070E+05
 PL. STRESS FRACT. TOUGHNESS = 116.00
 PL. STRAIN FRACT. TOUGHNESS = 36.00
 DAMAGE INDEX FOR CRACK INITIATION = 0.887
 NEUBER MATERIAL CONST. = 0.022
 CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366
 STRESS SEVERITY FACTOR PARAMETERS :
 ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000
 SPECIFIED DAMAGE CONDITIONS :
 INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.05000
 FINAL CRACK LENGTH OF CRACK NO. 1 : 1.39000
 INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.05000
 FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
 INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
 APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
 AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
 APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00
 PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
 DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	9.82000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	8.18000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	50.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	7416.500
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	35.750
NO. OF STRESS LAYERS IN ONE BLOCK	204

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	33.609	-23.523	1.000	2	35.750	-23.244	4.000
3	16.447	-2.462	1.000	4	32.181	-3.217	1.000
5	35.750	-3.579	1.000	6	23.595	-1.179	1.000
7	27.888	-1.396	1.000	8	30.030	-1.500	1.000
9	33.609	-1.676	4.000	10	35.750	-1.790	2.000
11	28.602	0.000	4.000	12	29.316	0.000	1.000
13	30.030	0.000	3.000	14	32.181	0.000	12.000
15	33.609	0.000	9.000	16	35.750	0.000	1.500
17	16.447	0.817	2.500	18	17.161	0.859	2.000
19	17.875	0.889	5.000	20	18.589	0.931	3.000
21	19.313	0.962	1.000	22	20.027	1.004	1.000
23	20.740	1.035	1.000	24	21.454	1.076	6.000
25	22.168	1.107	2.000	26	22.882	1.148	1.000
27	23.595	1.179	11.000	28	25.747	1.283	6.000
29	26.461	1.324	6.000	30	27.175	1.355	2.000
31	28.602	1.427	4.000	32	29.316	1.469	3.000
33	30.030	1.500	2.000	34	31.467	1.572	1.000
35	32.181	1.614	18.000	36	33.609	1.676	11.000
37	35.750	1.790	0.500	38	10.727	1.076	1.000
39	13.582	1.355	2.000	40	14.306	1.427	1.000
41	21.454	2.141	12.000	42	22.168	2.214	4.000
43	22.882	2.286	9.000	44	23.595	2.358	21.000
45	24.309	2.431	4.000	46	25.033	2.503	1.000
47	25.747	2.576	18.000	48	26.461	2.648	7.000
49	27.175	2.721	4.000	50	27.888	2.793	1.000
51	28.602	2.865	24.500	52	29.316	2.928	6.000
53	30.030	3.000	32.000	54	31.467	3.145	2.000
55	32.181	3.217	3.000	56	33.609	3.362	1.000
57	14.306	2.141	1.000	58	16.447	2.462	10.000
59	17.161	2.576	4.000	60	17.875	2.679	7.000
61	19.313	2.896	4.000	62	20.027	3.000	14.000
63	20.740	3.113	5.000	64	21.454	3.217	3.000
65	22.168	3.320	4.000	66	22.882	3.434	4.000
67	23.595	3.538	18.000	68	24.309	3.652	1.000
69	25.033	3.755	2.000	70	25.747	3.858	11.000
71	26.461	3.972	10.000	72	27.175	4.075	8.000
73	27.888	4.179	1.000	74	28.602	4.293	11.500
75	29.316	4.396	1.000	76	30.030	4.510	7.000
77	33.609	5.038	1.000	78	5.720	1.148	5.000
79	7.148	1.427	1.000	80	12.868	2.576	1.000
81	13.582	2.721	2.000	82	14.306	2.865	4.000
83	15.020	3.000	2.000	84	17.875	3.579	12.000
85	18.589	3.714	8.000	86	19.313	3.858	6.000
87	20.027	4.003	22.000	88	20.740	4.148	17.000
89	21.454	4.293	58.000	90	22.168	4.438	24.000
91	22.882	4.572	11.000	92	23.595	4.717	38.000
93	24.309	4.862	6.000	94	25.033	5.007	5.000
95	25.747	5.152	28.000	96	28.602	5.720	28.000
97	29.316	5.865	4.000	98	30.030	6.010	9.000
99	32.181	6.434	10.000	100	33.609	6.724	1.000
101	10.727	2.679	2.000	102	12.155	3.041	2.000
103	12.868	3.217	2.000	104	13.582	3.393	1.000
105	14.306	3.579	2.000	106	15.020	3.755	3.000
107	16.447	4.107	8.500	108	17.161	4.293	27.000
109	17.875	4.469	134.000	110	18.589	4.645	6.000
111	19.313	4.831	13.000	112	20.027	5.007	111.000
113	21.454	5.358	1.000	114	22.168	5.544	3.000
115	22.882	5.720	1.000	116	23.595	5.896	89.000

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
117	24.309	6.083	20.000	118	25.033	6.258	3.000
119	25.747	6.434	61.000	120	26.461	6.610	17.000
121	27.175	6.796	13.000	122	28.602	7.148	5.000
123	30.030	7.510	3.000	124	4.293	1.283	1.000
125	5.007	1.500	2.000	126	12.155	3.612	1.000
127	12.868	3.858	5.000	128	13.582	4.075	32.000
129	15.020	4.510	23.000	130	15.734	4.717	17.000
131	16.447	4.934	111.000	132	17.161	5.152	4.000
133	17.875	5.358	1.000	134	18.589	5.576	6.000
135	19.313	5.793	1.000	136	20.027	6.010	209.000
137	20.740	6.217	43.000	138	21.454	6.434	134.000
139	22.168	6.651	13.000	140	22.882	6.869	32.000
141	24.309	7.293	5.000	142	11.441	4.003	7.000
143	12.155	4.251	49.000	144	12.868	4.510	6.000
145	13.582	4.758	10.000	146	14.306	5.007	258.000
147	15.020	5.255	3.000	148	16.447	5.751	14.000
149	17.161	6.010	8.000	150	17.875	6.258	402.000
151	18.589	6.506	1.000	152	19.313	6.755	65.000
153	20.740	7.262	11.000	154	7.862	3.145	1.000
155	10.727	4.293	94.000	156	12.155	4.862	19.000
157	12.868	5.152	434.000	158	13.582	5.431	19.000
159	14.306	5.720	1.000	160	15.020	6.010	19.000
161	15.734	6.289	2.000	162	16.447	6.579	494.000
163	17.161	6.869	92.000	164	18.589	7.437	4.000
165	19.313	7.727	19.000	166	6.434	2.896	2.000
167	7.148	3.217	19.000	168	9.300	4.179	230.000
169	10.727	4.831	534.000	170	12.155	5.472	1.000
171	12.868	5.793	54.000	172	13.582	6.114	5.000
173	14.306	6.434	716.000	174	15.020	6.755	130.000
175	16.447	7.396	11.000	176	17.161	7.727	36.000
177	7.862	3.931	8.000	178	11.441	5.720	5.000
179	12.155	6.083	31.000	180	12.868	6.434	363.000
181	13.582	6.796	93.000	182	15.020	7.510	63.000
183	7.862	4.324	3.000	184	10.727	5.896	37.000
185	12.155	6.682	278.000	186	12.868	7.076	126.000
187	13.582	7.469	38.000	188	7.148	4.293	3.000
189	11.441	6.869	1.000	190	7.148	4.645	7.000
191	7.862	5.110	67.000	192	6.434	4.510	12.000
193	7.148	5.007	212.500	194	5.720	4.293	2.000
195	7.862	5.896	1.000	196	5.007	4.251	1.000
197	5.720	4.862	1.000	198	7.148	6.083	17.000
199	7.862	6.682	293.000	200	7.148	6.434	7.000
201	5.007	4.758	22.000	202	6.434	6.114	4.000
203	7.148	6.796	52.000	204	7.862	7.469	2.000

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

***** DAMAGE GROWTH HISTORY *****								
BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	20.192	0.000	.000E+00	.000E+00	.000E+00	.000E+00
	0.05000	0.00000	25.306	0.000	.000E+00	.000E+00	.000E+00	.000E+00
1.0	0.06587	0.00000	24.246	0.000	.132E-03	.000E+00	.000E+00	.000E+00
	0.08191	0.00000	27.526	0.000	.266E-03	.000E+00	.000E+00	.000E+00
2.0	0.09110	0.00000	27.624	0.000	.210E-03	.000E+00	.000E+00	.000E+00
	0.12312	0.00000	29.527	0.000	.343E-03	.000E+00	.000E+00	.000E+00
3.0	0.12659	0.00000	28.050	0.000	.296E-03	.000E+00	.000E+00	.000E+00
	0.17173	0.00000	28.167	0.000	.405E-03	.000E+00	.000E+00	.000E+00
STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :								
CYC= 1.0, STEP = 77, BLOCK = 4, CRACK DEPTH = 0.18808								
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES								
4.0	0.16422	0.00000	30.549	0.000	.314E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.136E-03	.000E+00	.000E+00	.000E+00
5.0	0.20819	0.00000	31.702	0.000	.366E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
6.0	0.25813	0.00000	33.030	0.000	.416E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
7.0	0.31610	0.00000	34.575	0.000	.483E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
8.0	0.38452	0.00000	36.379	0.000	.570E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
9.0	0.46651	0.00000	38.493	0.000	.683E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
10.0	0.56608	0.00000	40.982	0.000	.830E-03	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
11.0	0.69343	0.00000	44.054	0.000	.106E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
12.0	0.85973	0.00000	47.965	0.000	.139E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
13.0	1.09410	0.00000	53.984	0.000	.195E-02	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00

TABLE 3.2.1-2. EXAMPLE 2, METHOD 1, RUN 1 OUTPUT FILE (CONCLUDED)

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:

CYC = 32.0, STEP = 119, BLOCK = 14, CRACK LENGTH = 1.38295, CKMAXS=117.96
THE OTHER CRACK LENGTH = 0.00000
TERMINATE DAMAGE COMPUTATION

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :

APADL1 = .202E+00, APCOL1 = .166E+01, RYADL1 = .137E-01, RYCOL1 = .295E+00

AKOL1 = .269E+02, CKOL1 = .722E+02, AOL1 = .183E+00, COL1 = .137E+01

APADL2 = .000E+00, APCOL2 = .000E+00, RYADL2 = .000E+00, RYCOL2 = .000E+00

AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :

DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00

DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.2.1-3. EXAMPLE 2, METHOD 1, RUN 2 INPUT FILE

```

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3 SHEET
2.2374E-09      0.70      3.3386  0.2126E-9      0.00      2.9783
116.00          36.0          53.0          2.0          2.3          0.99      -0.99
10.426         -1.366         0.887         10700.0        0.022         1.000         1.0          1.0
0.230          8.180          0.188          0.188          .0000         0.000         0.000         0.000
0.1980E+000.2870E+000.1080E-010.5260E-010.2390E+020.3050E+020.1880E+000.2340E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
0.188          0.1250         8.18          9.82          0.00000        .00000        99.900        50.100
0.0000         0.1250         0.00          1.64          0.00000        .00000        0.00000        .00000
0.000          0.0000
1.119          1.0          1.100  1030  0000
0.000          0.000          0.000          0.000          0.000          0.000          0.000          0.000
120.0          25.0          6000.          1

```

TABLE 3.2.1-4. EXAMPLE 2, METHOD 1, RUN 2 OUTPUT FILE

```

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM   D A M G R O *****

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM

* THIS ANALYSIS RESTARTS WITH THE STRESS SPECTRUM AT STEP 119 *

NO. OF SITES TO BE ANALYZED :   CRACK GROWTH =      1;   CRACK INITIATION =      0
CORRESPONDING DAMAGE CODES :   CRACK GROWTH = 1030;   CRACK INITIATION =      0

LOAD INTERACTION :   GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL :   2024-T3 SHEET
WALKER EQ. CONST. (+R) :   C = 0.224E-08,   M =0.700,   N =3.339
WALKER EQ. CONST. (-R) :   C = 0.621E-08,   M =0.000,   N =2.978
MAX. K FOR DC/DN THRESHOLD = 2.000
RETARDATION SHUT-OFF RATIO = 2.300
+R CUT-OFF = 0.9900,   -R CUT-OFF = -0.9900
YIELD STRENGTH :   53.000
ELASTIC MODULUS = 0.1070E+05
PL. STRESS FRACT. TOUGHNESS = 116.00
PL. STRAIN FRACT. TOUGHNESS = 36.00
DAMAGE INDEX FOR CRACK INITIATION = 0.887
NEUBER MATERIAL CONST. = 0.022
CRACK INITIATION EQ. CONST. :   SF = 10.426,   M =-1.366
STRESS SEVERITY FACTOR PARAMETERS :
    ALPHA = 1.0000,   BETA = 1.0000,   GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :
INITIAL CRACK LENGTH OF CRACK NO. 1 :   0.23000
FINAL CRACK LENGTH OF CRACK NO. 1 :   8.18000
INITIAL CRACK DEPTH OF CRACK NO. 1 :   0.18800
FINAL CRACK DEPTH OF CRACK NO. 1 :   0.18800
INITIAL CRACK LENGTH OF CRACK NO. 2 :   0.00000
FINAL CRACK LENGTH OF CRACK NO. 2 :   0.00000
INITIAL CRACK DEPTH OF CRACK NO. 2 :   0.00000
FINAL CRACK DEPTH OF CRACK NO. 2 :   0.00000
PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
    APAOL1 = .198E+00,   APCOL1 = .287E+00,   RYAOL1 = .108E-01,   RYCOL1 = .526E-01
    AKOL1 = .239E+02,   CKOL1 = .305E+02,   AOL1 = .188E+00,   COL1 = .234E+00
    APAOL2 = .000E+00,   APCOL2 = .000E+00,   RYAOL2 = .000E+00,   RYCOL2 = .000E+00
    AKOL2 = .000E+00,   CKOL2 = .000E+00,   AOL2 = .000E+00,   COL2 = .000E+00
PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
    DMG1 = .000E+00,   DMGOL1 = .000E+00,   DELDG1 = .000E+00
    DMG2 = .000E+00,   DMGOL2 = .000E+00,   DELDG2 = .000E+00

```

TABLE 3.2.1-4. EXAMPLE 2, METHOD 1, RUN 2 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	8.18000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	9.82000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	50.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	7416.500
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	35.750
NO. OF STRESS LAYERS IN ONE BLOCK	204

TABLE 3.2.1-4. EXAMPLE 2, METHOD 1, RUN 2 OUTPUT FILE (CONCLUDED)

```

*****  D A M A G E   G R O W T H   H I S T O R Y  *****
BLOCK      C1      C2      KMAX-C1  KMAX-C2  DC1/DF  DC2/DF  INITIA1  INITIA2
           A1      A2      KMAX-A1  KMAX-A2  DA1/DF  DA2/DF      KN1      KN2
0.0  0.23000  0.00000  68.666  0.000  .000E+00 .000E+00 .000E+00 .000E+00
      0.18800  0.00000  0.000  0.000  .000E+00 .000E+00 .000E+00 .000E+00
1.0  0.62217  0.00000  78.573  0.000  .327E-02 .000E+00 .000E+00 .000E+00
      0.18800  0.00000  0.000  0.000  .000E+00 .000E+00 .000E+00 .000E+00
2.0  2.16138  0.00000  96.070  0.000  .128E-01 .000E+00 .000E+00 .000E+00
      0.18800  0.00000  0.000  0.000  .000E+00 .000E+00 .000E+00 .000E+00

```

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:

CYC = 6.0, STEP = 98, BLOCK = 3, CRACK LENGTH = 3.65077, CKMAXS=116.20
 THE OTHER CRACK LENGTH = 0.00000
 TERMINATE DAMAGE COMPUTATION

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :

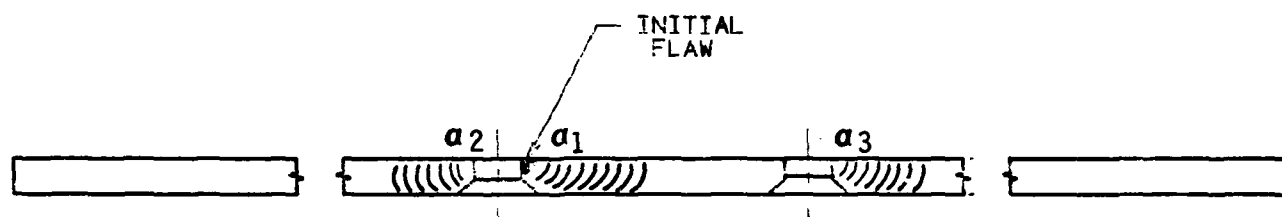
APADL1 = .198E+00, APCOL1 = .415E+01, RYAOL1 = .108E-01, RYCOL1 = .535E+00
 AKOL1 = .239E+02, CKOL1 = .972E+02, AOL1 = .188E+00, COL1 = .361E+01
 APADL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION

DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.2.2. EXAMPLE 2, METHOD 2 SUMMARY TABLE

REF. PAGES 78 THROUGH 90



a_1 (IN)	a_2 (IN)	a_3 (IN)	LIFE (BLOCK, LAYER, CYCLES)	GROWTH	ROUTINES INITIATION	RUN NO.
.050	0	0	0	K1010	S1010	1
.065	0	0	1, 0, 0	K1010	S1010	1
.091	0	0	2, 0, 0	K1010	S1010	1
.126	0	0	3, 0, 0	K1010	S1010	1
.164	0	0	4, 0, 0	K1010	S1010	1
.208	0	0	5, 0, 0	K1010	S1010	1
.258	0	0	6, 0, 0	K1010	S1010	1
.316	0	0	7, 0, 0	K1010	S1010	1
.384	0	0	8, 0, 0	K1010	S1010	1
.466	0	0	9, 0, 0	K1010	S1010	1
.566	0	0	10, 0, 0	K1010	S1010	1
.693	0	0	11, 0, 0	K1010	S1010	1
.859	0	0	12, 0, 0	K1010	S1010	1
.901	.050	0	12, 36, 11	K1010	S1010	1
1.218	.45	0	13, 0, 22	K1040	S1030	2
1.39	.532	0	13, 34, 23	K1040	S1030	2
	1.044	.050	13, 96, 40	K1030	S1050	3
	2.205	1.229	14, 0, 40	K1050	-	4

NO. OF CYCLES TO SECONDARY CRACK INITIATION = 89,134 CYCLES
 NO. OF CYCLES TO FAILURE = 103,871 CYCLES

TABLE 3.2.2-1. EXAMPLE 2, METHOD 2, RUN 1 INPUT FILE

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3 SHEET

2.2374E 09	0.70	3.3386	6.2126E 9	0.00	2.9783		
116.00	36.0	53.0	2.0	2.3	0.99	-0.99	
10.426	-1.366	0.887	10700.0	0.022	1.000	1.0	1.0
0.050	1.390	0.050	0.188	.0000	0.000	0.000	0.000
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.188	0.1250	9.82	8.18	0.00000	.00000	99.900	50. 1.00
0.1250	0.0000	1.64	0.00	0.00000	.00000	0.00000	.00000
0.000	0.0000						
0 00	1 2	1 100	1010 1010				
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
120.0	25.0	6000.	1				

TABLE 3.2.2-2. EXAMPLE 2, METHOD 2, RUN 1 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM

* THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1; CRACK INITIATION = 2
CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1010; CRACK INITIATION = 1010

LOAD INTERACTION : GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL : 2024-T3 SHEET

WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339

WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.978

MAX. K FOR DC/DN THRESHOLD = 2.000

RETARDATION SHUT-OFF RATIO = 2.300

+R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900

YIELD STRENGTH : 53.000

ELASTIC MODULUS = 0.1070E+05

PL. STRESS FRACT. TOUGHNESS = 116.00

PL. STRAIN FRACT. TOUGHNESS = 36.00

DAMAGE INDEX FOR CRACK INITIATION = 0.887

NEUBER MATERIAL CONST. = 0.022

CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366

STRESS SEVERITY FACTOR PARAMETERS :

ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.05000

FINAL CRACK LENGTH OF CRACK NO. 1 : 1.39000

INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.05000

FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800

INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000

FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000

INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000

FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :

APCOL1 = .000E+00, APCOL1 = .000E+00, RYCOL1 = .000E+00, RYCOL1 = .000E+00

AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00

APCOL2 = .000E+00, APCOL2 = .000E+00, RYCOL2 = .000E+00, RYCOL2 = .000E+00

AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :

DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00

DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.2.2-2. EXAMPLE 2, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89799	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	9.82000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	8.18000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	50.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	7416.500
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	35.750
NO. OF STRESS LAYERS IN ONE BLOCK :	204

TABLE 3.2.2-2. EXAMPLE 2, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

***** DAMAGE GROWTH HISTORY *****								
BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	20.192	0.000	.000E+00	.000E+00	.143E-03	.106E-03
	0.05000	0.00000	25.306	0.000	.000E+00	.000E+00	.278E+01	.263E+01
1.0	0.06587	0.00000	24.246	0.000	.132E-03	.000E+00	.293E-01	.209E-01
	0.08191	0.00000	27.526	0.000	.266E-03	.000E+00	.283E+01	.263E+01
2.0	0.09110	0.00000	27.624	0.000	.210E-03	.000E+00	.618E-01	.418E-01
	0.12312	0.00000	29.527	0.000	.343E-03	.000E+00	.290E+01	.263E+01
3.0	0.12659	0.00000	28.050	0.000	.296E-03	.000E+00	.980E-01	.626E-01
	0.17173	0.00000	28.167	0.000	.405E-03	.000E+00	.273E+01	.263E+01
STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :								
CYC= 1.0, STEP = 77, BLOCK = 4, CRACK DEPTH = 0.18808								
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES								
4.0	0.16422	0.00000	30.549	0.000	.314E-03	.000E+00	.126E+00	.835E-01
	0.18800	0.00000	0.000	0.000	.136E-03	.000E+00	.282E+01	.263E+01
5.0	0.20819	0.00000	31.702	0.000	.366E-03	.000E+00	.159E+00	.104E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.292E+01	.263E+01
6.0	0.25813	0.00000	33.030	0.000	.416E-03	.000E+00	.199E+00	.125E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.303E+01	.263E+01
7.0	0.31610	0.00000	34.575	0.000	.483E-03	.000E+00	.248E+00	.146E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.315E+01	.263E+01
8.0	0.38452	0.00000	36.379	0.000	.570E-03	.000E+00	.309E+00	.167E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.328E+01	.263E+01
9.0	0.46651	0.00000	38.493	0.000	.683E-03	.000E+00	.387E+00	.188E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.344E+01	.263E+01
10.0	0.56608	0.00000	40.982	0.000	.830E-03	.000E+00	.488E+00	.202E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.361E+01	.263E+01
11.0	0.69343	0.00000	44.054	0.000	.106E-02	.000E+00	.622E+00	.222E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.383E+01	.263E+01
12.0	0.85973	0.00000	47.965	0.000	.139E-02	.000E+00	.809E+00	.250E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.409E+01	.263E+01

TABLE 3.2.2-2. EXAMPLE 2, METHOD 2, RUN 1 OUTPUT FILE (CONCLUDED)

CRACK INITIATION FOR LOCATION 1 OCCURS AT :
CYC = 11.000, STEP = 36, BLOCK = 13

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
C1 = 0.90143, A1 = 0.18800, C2 = 0.00000, A2 = 0.00000

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
APCOL1 = .202E+00, APCOL1 = .101E+01, RYADL1 = .137E-01, RYCOL1 = .133E+00
AKOL1 = .269E+02, CKOL1 = .485E+02, ADL1 = .188E+00, COL1 = .0880E+00
APCOL2 = .000E+00, APCOL2 = .000E+00, RYADL2 = .000E+00, RYCOL2 = .000E+00
AKOL2 = .000E+00, CKOL2 = .000E+00, ADL2 = .000E+00, COL2 = .000E+00
RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
DMG1 = .879E+00, DMGOL1 = .970E-03, DELDG1 = .000E+00
DMG2 = .257E+00, DMGOL2 = .105E-03, DELDG2 = .000E+00

TABLE 3.2.2-3. EXAMPLE 2, METHOD 2, RUN 2 INPUT FILE

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3 SHEET

2.2574E-09	0.70	3.3386	6.2126E-9	0.00	2.9783		
116.00	36.0	53.0	2.0	2.3	0.99	-0.99	
10.426	-0.366	0.887	10700.0	0.022	1.000	1.0	1.0
0.900	1.390	0.188	0.188	0.0500	0.180	0.050	0.188
0.2020E+000	0.1010E+010	0.1370E-010	0.1330E+000	0.2690E+020	0.4840E+020	0.1880E+000	0.8800E+00
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+00
0.2570E+000	0.1050E-030	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+00
0.188	0.1250	9.82	8.18	0.00000	0.00000	99.900	50.1.00
0.1250	0.0000	1.64	0.00	0.00000	0.00000	0.00000	0.00000
0.000	0.0000						
1 36	2 1	1 100	1040 1030				
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
120.0	25.0	6000.	1				

TABLE 3.2.2-4. EXAMPLE 2, METHOD 2, RUN 2 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM

* THIS ANALYSIS RESTARTS WITH THE STRESS SPECTRUM AT STEP 36 *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 2; CRACK INITIATION = 1
CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1040; CRACK INITIATION = 1030

LOAD INTERACTION : GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL : 2024-T3 SHEET

WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339
WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.978
MAX. K FOR DC/DN THRESHOLD = 2.000
RETARDATION SHUT-OFF RATIO = 2.300
+R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
YIELD STRENGTH : 53.000
ELASTIC MODULUS = 0.1070E+05
PL. STRESS FRACT. TOUGHNESS = 116.00
PL. STRAIN FRACT. TOUGHNESS = 36.00
DAMAGE INDEX FOR CRACK INITIATION = 0.887
NEUBER MATERIAL CONST. = 0.022
CRACK INITIATION EQ. CONST. : SF = 10.426, M = -0.366
STRESS SEVERITY FACTOR PARAMETERS :
ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.90100
FINAL CRACK LENGTH OF CRACK NO. 1 : 1.39000
INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.05000
FINAL CRACK LENGTH OF CRACK NO. 2 : 0.18000
INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.05000
FINAL CRACK DEPTH OF CRACK NO. 2 : 0.18000

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY

APCOL1 = .202E+00, APCOL1 = .101E+01, RYCOL1 = .137E-01, RYCOL1 = .133E+00
AKOL1 = .269E+02, CKOL1 = .484E+02, AOL1 = .188E+00, COL1 = .880E+00
APCOL2 = .000E+00, APCOL2 = .000E+00, RYCOL2 = .000E+00, RYCOL2 = .000E+00
AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY

DMG1 = .257E+00, DMGOL1 = .105E-03, DELDOL1 = .000E+00
DMG2 = .000E+00, DMGOL2 = .000E+00, DELDOL2 = .000E+00

TABLE 3.2.2-4. EXAMPLE 2, METHOD 2, RUN 2 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	9.82000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	8.18000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	50.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	7416.500
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	35.750
NO. OF STRESS LAYERS IN ONE BLOCK :	204

UNSTABLE BREAK-THROUGH OF CRACK NO. 2 OCCURS AT :

CYC = 0.0, STEP = 36, BLOCK = 1, DEPTH = 0.05000, AKMAXS= 52.24

TABLE 3.2.2-4. EXAMPLE 2, METHOD 2, RUN 2 OUTPUT FILE (CONCLUDED)

```

*****  D A M A G E   G R O W T H   H I S T O R Y   *****
BLOCK      C1      C2      KMAX-C1  KMAX-C2      DC1/DF      DC2/DF      INITIA1  INITIA2
           A1      A2      KMAX-A1  KMAX-A2      DA1/DF      DA2/DF      KN1      KN2
0.0  0.90100  0.05000  49.490  41.685  .000E+00  .000E+00  .259E+00  .000E+00
           0.18800  0.05000  0.000  52.244  .000E+00  .000E+00  .263E+01  .000E+00
1.0  1.21853  0.45006  67.869  63.073  .265E-02  .333E-02  .272E+00  .000E+00
           0.18800  0.18800  0.000  0.000  .000E+00  .115E-02  .263E+01  .000E+00

```

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
 CYC = 1.0, STEP = 34, BLOCK = 2, CRACK LENGTH = 1.37721, CKMAXS=126.59
 THE OTHER CRACK LENGTH = 0.53209
 TERMINATE DAMAGE COMPUTATION

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :

```

AFAOL1 = .202E+00, APCOL1 = .189E+01, RYAOL1 = .137E-01, RYCOL1 = .529E+00
AKOL1 = .269E+02, CKOL1 = .966E+02, AOL1 = .188E+00, COL1 = .136E+01
AFAOL2 = .000E+00, APCOL2 = .763E+00, RYAOL2 = .000E+00, RYCOL2 = .243E+00
AKOL2 = .000E+00, CKOL2 = .655E+02, AOL2 = .000E+00, COL2 = .520E+00

```

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :

```

DMG1 = .277E+00, DMGOL1 = .732E-04, DELDG1 = .000E+00
DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

```

TABLE 3.2.2-5. EXAMPLE 2, METHOD 2, RUN 3 INPUT FILE

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
 2024-T3 SHEET
 2.2374E-02 0.70 3.3386 6.2126E-9 0.00 2.9783
 116.00 36.0 53.0 2.0 2.3 0.99 -0.99
 10.426 -1.366 0.887 10700.0 0.022 1.000 1.0 1.0
 0.532 8.180 0.188 0.188 0.000 0.000 0.000 0.000
 0.000E+000.7630E+000.0000E+000.2430E+000.0000E+000.6550E+020.0000E+000.5200E+00
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
 0.2770E+000.7320E-040.0000E+000.0000E+000.0000E+000.0000E+000.0000E+00
 0.188 0.1250 8.18 9.82 0.0000 0.0000 99.900 50.1.00
 0.0000 0.1250 0.00 1.64 0.0000 0.0000 0.0000 0.0000
 0.000 0.0000
 1 34 1 1 100 1030 1050
 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 120.0 25.0 6000. 1

TABLE 3.2.2-6. EXAMPLE 2, METHOD 2, RUN 3 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****
 EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
 * THIS ANALYSIS RESTARTS WITH THE STRESS SPECTRUM AT STEP 34 *
 NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1; CRACK INITIATION = 1
 CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1030; CRACK INITIATION = 1050
 LOAD INTERACTION : GENERALIZED WILLENBORG ET AL--CHANG MODEL
 MATERIAL : 2024-T3 SHEET
 WALKER EQ. CONST. (+R) : C = 0.224E-08, M = 0.700, N = 3.339
 WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.978
 MAX. K FOR DC/DN THRESHOLD = 2.000
 RETARDATION SHUT-OFF RATIO = 2.300
 +R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
 YIELD STRENGTH : 53.000
 ELASTIC MODULUS = 0.1070E+05
 PL. STRESS FRACT. TOUGHNESS = 116.00
 PL. STRAIN FRACT. TOUGHNESS = 36.00
 DAMAGE INDEX FOR CRACK INITIATION = 0.887
 NEUBER MATERIAL CONST. = 0.022
 CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366
 STRESS SEVERITY FACTOR PARAMETERS :
 ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000
 SPECIFIED DAMAGE CONDITIONS :
 INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.53200
 FINAL CRACK LENGTH OF CRACK NO. 1 : 8.18000
 INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
 FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
 INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :
 APAOL1 = .122E-77, APCOL1 = .763E+00, RYAOL1 = .000E+00, RYCOL1 = .243E+00
 AKOL1 = .000E+00, CKOL1 = .655E+02, AOL1 = .000E+00, COL1 = .520E+00
 APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00
 PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :
 DMG1 = .277E+00, DMGOL1 = .732E-04, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.2.2-6. EXAMPLE 2, METHOD 2, RUN 3 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	8.18000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	9.82000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	50.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	7416.500
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	8000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	35.750
NO. OF STRESS LAYERS IN ONE BLOCK :	204

TABLE 3.2.2-6. EXAMPLE 2, METHOD 2, RUN 3 OUTPUT FILE (CONCLUDED)

```

*****  D A M A G E   G R O W T H   H I S T O R Y  *****
BLOCK      C1      C2      KMAX-C1  KMAX-C2  DC1/DF  DC2/DF  INITIA1  INITIA2
           A1      A2      KMAX-A1  KMAX-A2  DA1/DF  DA2/DF      KN1      KN2
0.0  0.53200  0.00000  77.318  0.000  .000E+00  .000E+00  .281E+00  .000E+00
      0.18800  0.00000  0.000  0.000  .000E+00  .000E+00  .546E+01  .000E+00

```

CRACK INITIATION FOR LOCATION 1 OCCURS AT :
CYC = 28.000, STEP = 96, BLOCK = 1

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
C1 = 1.04419, A1 = 0.18800, C2 = 0.00000, A2 = 0.00000

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
 APAOL1 = .122E-77, APCOL1 = .129E+01, RYAOL1 = .000E+00, RYCOL1 = .251E+00
 AKOL1 = .000E+00, CKOL1 = .666E+02, AOL1 = .000E+00, COL1 = .104E+01
 APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00
 RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
 DMG1 = .379E+00, DMGOL1 = .780E-02, DELDG1 = .574E-02
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.2.2-7. EXAMPLE 2, METHOD 2, RUN 4 INPUT FILE

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM
2024-T3 SHEET

2.2374E-09	0.70	5.3386	6.2126E-9	0.00	2.9783		
116.00	36.0	53.0	2.0	2.3	0.99	-0.99	
10.426	-1.366	0.887	10700.0	0.022	1.000	1.0	1.0
1.044	8.180	0.188	0.188	0.0500	8.180	0.050	0.188
0.0000E+000	0.1290E+010	0.0000E+000	0.2510E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.8790E+000	0.7800E-020	0.5740E-020	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.188	0.1250	8.18	9.82	0.00000	0.00000	99.900	50.100
0.0000	0.1250	0.00	1.64	0.00000	0.00000	0.00000	0.00000
0.000	0.0000						
1 96	2 0	1 100	1050 0000				
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
120.0	25.0	6000.	1				

TABLE 3.2.2-8. EXAMPLE 2, METHOD 2, RUN 4 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE RUN NO. 2 SPECIMEN SUBJECTED TO RANDOMIZED LOADING SPECTRUM

* THIS ANALYSIS RESTARTS WITH THE STRESS SPECTRUM AT STEP 96 *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 2; CRACK INITIATION = 0
CORRESPONDING DAMAGE CODES : CRACK GROWTH = 1050; CRACK INITIATION = 0

LOAD INTERACTION : GENERALIZED WILLENBORG ET AL--CHANG MODEL

MATERIAL : 2024-T3 SHEET

WALKER EQ. CONST. (+R) C = 0.224E-08, M = 0.700, N = 3.339
WALKER EQ. CONST. (-R) : C = 0.621E-08, M = 0.000, N = 2.078
MAX. K FOR DC/DN THRESHOLD = 2.000
RETARDATION SHUT-OFF RATIO = 2.300
+R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
YIELD STRENGTH : 53.000
ELASTIC MODULUS = 0.1070E+05
PL. STRESS FRACT. TOUGHNESS = 116.00
PL. STRAIN FRACT. TOUGHNESS = 36.00
DAMAGE INDEX FOR CRACK INITIATION = 0.887
NEUBER MATERIAL CONST. = 0.022
CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366
STRESS SEVERITY FACTOR PARAMETERS :
ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 : 1.04400
FINAL CRACK LENGTH OF CRACK NO. 1 : 8.18000
INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.05000
FINAL CRACK LENGTH OF CRACK NO. 2 : 8.18000
INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.05000
FINAL CRACK DEPTH OF CRACK NO. 2 : 0.18800

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :

APCOL1 = .122E-77, APCOL1 = .122E+01, RYCOL1 = .000E+00, RYCOL1 = .251E+00
APOL1 = .000E+00, CKOL1 = .568E+02, APL1 = .000E+00, COL1 = .104E+01
APCOL2 = .000E+00, APCOL2 = .000E+00, RYCOL2 = .000E+00, RYCOL2 = .000E+00
AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY

DMG1 = .879E+00, DMGOL1 = .780E-02, DELTA1 = .574E-02
DMG2 = .000E+00, DMGOL2 = .000E+00, DELTA2 = .000E+00

TABLE 3.2.2-8. EXAMPLE 2, METHOD 2, RUN 4 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.89999	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	8.18000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	9.82000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	50.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	7416.500
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	120.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	25.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	6000.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	35.750
NO. OF STRESS LAYERS IN ONE BLOCK :	204

UNSTABLE BREAK-THROUGH OF CRACK NO. 2 OCCURS AT :

CYC = 0.0, STEP = 96, BLOCK = 1, DEPTH = 0.05000, AKMAX= 75.65

TABLE 3.2.2-8. EXAMPLE 2, METHOD 2, RUN 4 OUTPUT FILE (CONCLUDED)

```

*****  D A M A G E   G R O W T H   H I S T O R Y  *****

BLOCK      C1      C2      KMAX-C1  KMAX-C2  DC1/DF  DC2/DF  INITIA1  INITIA2
          A1      A2      KMAX-A1  KMAX-A2  DA1/DF  DA2/DF      KN1      KN2
0.0  1.04400  0.05000   83.509  60.363  .000E+00 .000E+00 .879E+00 .000E+00
      0.10800  0.05000    0.000  75.652  .000E+00 .000E+00 .000E+00 .000E+00

UNSTABLE GROWTH OF CRACK NO. 2 OCCURS AT:
CYC = 1.0, STEP = 1, BLOCK = 2, CRACK LENGTH = 1.42785, CKMAX3=116.00
THE OTHER CRACK LENGTH = 2.22758
TERMINATE DAMAGE COMPUTATION
1.0  2.20552  1.22989  112.207  113.402  .968E-02 .983E-02 .879E+00 .000E+00
      0.18800  0.18800    0.000    0.000  .000E+00 .115E-02 .000E+00 .000E+00

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
APCOL1 = .127E-77, APCOL1 = .286E+01, RYCOL1 = .000E+00, RYCOL1 = .634E+00
AKOL1 = .000E+00, CKOL1 = .106E+03, AOL1 = .000E+00, COL1 = .223E+01
APCOL2 = .000E+00, APCOL2 = .209E+01, RYCOL2 = .000E+00, RYCOL2 = .672E+00
AKOL2 = .000E+00, CKOL2 = .100E+03, AOL2 = .000E+00, COL2 = .141E+01
RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
DMG1 = .879E+00, DMGOL1 = .780E-02, DELDG1 = .574E-02
DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

```

EXAMPLE 3: STRINGER SECTION SUBJECTED TO CONSTANT AMPLITUDE LOADING

GEOMETRY:

MATERIAL:

2024-T351 EXTRUSION

LOADING SPECTRUM:

CONSTANT AMPLITUDE

$$\begin{aligned}\sigma_{\max} &= 17.0 \text{ KSI} \\ \sigma_{\min} &= 1.70 \text{ KSI}\end{aligned}$$

REF. PAGES 92 THROUGH 107

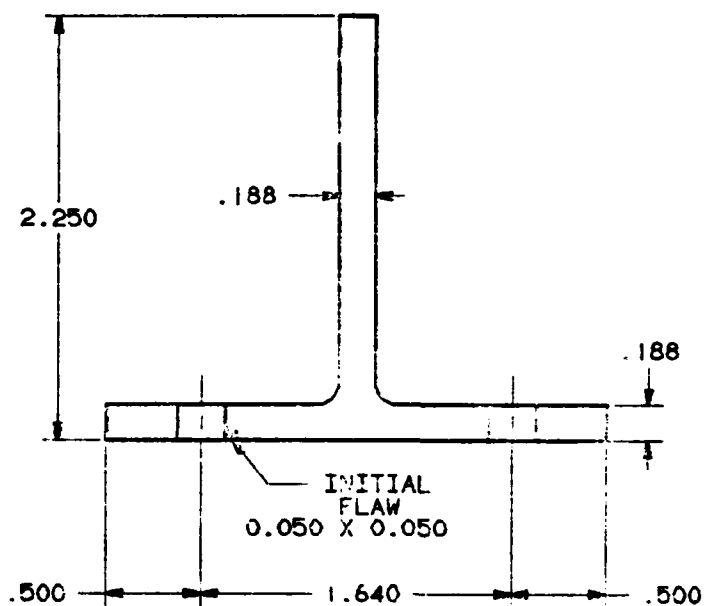
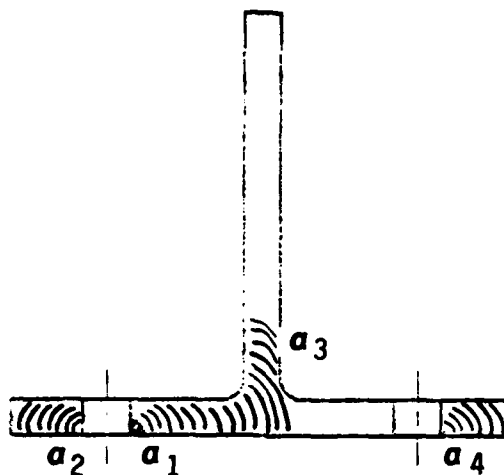


TABLE 3.3.1. EXAMPLE 3, METHOD 1 SUMMARY TABLE

REF. PAGES 93 THROUGH 99



a_1 (IN)	a_2 (IN)	a_3 (IN)	a_4 (IN)	LIFE (CYCLES)	ROUTINE GROWTH	RUN NO.
.050	0	0	0	0	2020	1
.056	0	0	0	2020	2020	1
.066	0	0	0	4000	2020	1
.080	0	0	0	6000	2020	1
.101	0	0	0	8000	2020	1
.131	0	0	0	10000	2020	1
.181	0	0	0	12000	2020	1
.248	0	0	0	14000	2020	1
.336	0	0	0	16000	2020	1
.447	0	0	0	18000	2020	1
.567	0	0	0	20000	2020	1
.700	0	0	0	22000	2020	1
.873	0	.265	0	23878	2050	2
1.089	0		0	25878	2050	2
1.396	0	.304	0	26739	2050	2

 NO. OF CYCLES TO FAILURE = 26,739 CYCLES

TABLE 3.3.1-1. EXAMPLE 3, METHOD 1, RUN 1 INPUT FILE

EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING
 2024-T351 EXTRUSION
 0.1600E-09 0.65 4.554 0.230E-08 1.00 3.115
 58.00 36.0 53.3 2.0 2.3 0.99 -0.99
 10.4260 -1.3660 0.872 10700.0 0.022 1.0 1.0 1.0
 .050 1.390 0.050 0.188 0.000 0.000 0.000 0.000
 0.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E-000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000.0000E+000
 0.0000E+000.0000E+000.0000E+000.0000E-000.0000E+000.0000E+000
 0.188 0.1250 2.14 0.500 0.00000 0.00000 99.9999 0.0 1.00
 0.1250 0.0000 -1.640 0.000 0.000 0.000 0.000 0.00000
 0.000 0.0000
 0 00 1 0 0 100 2010 0000
 1.226 1.414 0.462 1.000 0.2658 .0000 0.0000 0.000
 000.0 00.0 00000. 1

TABLE 3.3.1-2. EXAMPLE 3, METHOD 1, RUN 1 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****
 EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING
 * THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *
 NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1; CRACK INITIATION = 0
 CORRESPONDING DAMAGE CODES : CRACK GROWTH = 2010; CRACK INITIATION = 0
 LOAD INTERACTION : NONE
 MATERIAL : 2024-T351 EXTRUSION
 WALKER EQ. CONST. (+R) : C = 0.160E-09, M = 0.650, N = 4.554
 WALKER EQ. CONST. (-R) : C = 0.230E-08, M = 1.000, N = 3.115
 MAX. K FOR DC/DN THRESHOLD = 2.000
 RETARDATION SHUT-OFF RATIO = 2.300
 +R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
 YIELD STRENGTH : 53.300
 ELASTIC MODULUS = 0.1070E+05
 PL. STRESS FRACT. TOUGHNESS = 58.00
 PL. STRAIN FRACT. TOUGHNESS = 36.00
 DAMAGE INDEX FOR CRACK INITIATION = 0.872
 NEUBER MATERIAL CONST. = 0.022
 CRACK INITIATION EQ. CONST. : SE = 10.426, M = -1.366
 STRESS SEVERITY FACTOR PARAMETERS
 ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000
 SPECIFIED DAMAGE CONDITIONS
 INITIAL CRACK LENGTH OF CRACK NO. 1 : 0.05000
 FINAL CRACK LENGTH OF CRACK NO. 1 : 1.39000
 INITIAL CRACK DEPTH OF CRACK NO. 1 : 0.05000
 FINAL CRACK DEPTH OF CRACK NO. 1 : 0.18800
 INITIAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK LENGTH OF CRACK NO. 2 : 0.00000
 INITIAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 FINAL CRACK DEPTH OF CRACK NO. 2 : 0.00000
 PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY
 APAC1 = .000E+00, APCOL1 = .000E+00, RYAC1 = .000E+00, RYCOL1 = .000E+00
 AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
 APAC2 = .000E+00, APCOL2 = .000E+00, RYAC2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00
 PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY
 DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.3.1-2. EXAMPLE 3, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.97989	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	2.14000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	0.50000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	0.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

USER DEFINED VARIABLES :

VARIABLE 1 :	1.2260
VARIABLE 2 :	1.4140
VARIABLE 3 :	0.4620
VARIABLE 4 :	1.0000
VARIABLE 5 :	0.2658
VARIABLE 6 :	0.0000
VARIABLE 7 :	0.0000
VARIABLE 8 :	0.0000

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	2000.000
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	0.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	0.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	0.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	17.000
NO. OF STRESS LAYERS IN ONE BLOCK :	2

STRESS LAYERS IN ONE BLOCK :

STEP	SIGMA-MAX	SIGMA-MIN	CYCLES	STEP	SIGMA-MAX	SIGMA-MIN	CYCLES
1	17.000	1.700	1000.000	2	17.000	1.700	1000.000

TABLE 3.3.1-2. EXAMPLE 3, METHOD 1, RUN 1 OUTPUT FILE (CON'T.)

***** DAMAGE GROWTH HISTORY *****								
BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIA1 KN1	INITIA2 KN2
0.0	0.05000	0.00000	8.892	0.000	.000E+00	.000E+00	.000E+00	.000E+00
	0.05000	0.00000	11.144	0.000	.000E+00	.000E+00	.000E+00	.000E+00
1.0	0.05629	0.00000	9.900	0.000	.315E-05	.000E+00	.000E+00	.000E+00
	0.06504	0.00000	11.627	0.000	.752E-05	.000E+00	.000E+00	.000E+00
2.0	0.06611	0.00000	10.802	0.000	.491E-05	.000E+00	.000E+00	.000E+00
	0.08344	0.00000	12.171	0.000	.920E-05	.000E+00	.000E+00	.000E+00
3.0	0.08041	0.00000	11.684	0.000	.715E-05	.000E+00	.000E+00	.000E+00
	0.10629	0.00000	12.774	0.000	.114E-04	.000E+00	.000E+00	.000E+00
4.0	0.10084	0.00000	12.647	0.000	.102E-04	.000E+00	.000E+00	.000E+00
	0.13484	0.00000	13.415	0.000	.143E-04	.000E+00	.000E+00	.000E+00
STABLE BREAK-THROUGH OF CRACK NO. 1 OCCURS AT :								
CYC= 887.0, STEP = 1, BLOCK = 6, CRACK DEPTH = 0.18911								
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES								
5.0	0.13082	0.00000	13.827	0.000	.150E-04	.000E+00	.000E+00	.000E+00
	0.17055	0.00000	14.088	0.000	.179E-04	.000E+00	.000E+00	.000E+00
6.0	0.18029	0.00000	15.384	0.000	.247E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.873E-05	.000E+00	.000E+00	.000E+00
7.0	0.24819	0.00000	16.248	0.000	.340E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
8.0	0.33618	0.00000	17.216	0.000	.440E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
9.0	0.44788	0.00000	17.947	0.000	.558E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
10.0	0.56758	0.00000	17.771	0.000	.599E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00
11.0	0.70011	0.00000	18.917	0.000	.663E-04	.000E+00	.000E+00	.000E+00
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.000E+00	.000E+00

TABLE 3.3.1-2. EXAMPLE 3, METHOD 1, RUN 1 OUTPUT FILE (CONCLUDED)

CRACK NO. 1 EXCEEDS APPLICABLE RANGE OF SUBROUTINE K2010 AT :
 CYC = 878.0, STEP = 2, BLOCK = 12
 CHANGE TO K2050 OR K2060. TERMINATE COMPUTATION

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
 C1 = 0.87354, A1 = 0.18800, C2 = 0.00000, A2 = 0.00000

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION

APCOL1 = .000E+00, APCOL1 = .000E+00, RYCOL1 = .000E+00, RYCOL1 = .000E+00
 AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
 APAOL2 = .000E+00, APCOL2 = .000E+00, RYCOL2 = .000E+00, RYCOL2 = .000E+00
 AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION

DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
 DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.3.1-3. EXAMPLE 3, METHOD 1, RUN 2 INPUT FILE

EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING
2024-T351 EXTRUSION

0.1600E-09	0.65	4.554	0.230E-08	1.00	3.115			
58.00	36.0	53.3	2.0	2.3	0.99	-0.99		
10.4260	-1.3660	0.872	10700.0	0.022	1.0	1.0	1.0	
.866	1.390	0.188	0.188	0.265	2.250	0.188	0.188	
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000
0.188	0.1250	2.14	0.500	0.00000	0.00000	99.9999	0.0	1.00
0.1250	0.0000	1.640	0.000	0.000	0.000	0.000	0.0000	
0.000	0.0000							
0	00	2	0	0	100	2050	0000	
2.256	0.000	0.581	0.416	0.289	.0000	0.1880	0.000	
000.0	00.0	00000.	1					

TABLE 3.3.1-4. EXAMPLE 3, METHOD 1, RUN 2 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING

* THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 2; CRACK INITIATION = 0
CORRESPONDING DAMAGE CODES : CRACK GROWTH = 2050; CRACK INITIATION = 0

LOAD INTERACTION : NONE

MATERIAL : 2024-T351 EXTRUSION

WALKER EQ. CONST. (+R) : C = 0.160E-09, M = 0.650, N = 4.554
WALKER EQ. CONST. (-R) : C = 0.230E-08, M = 1.000, N = 3.115
MAX. K FOR DC/DN THRESHOLD 2.000
RETARDATION SHUT-OFF RATIO = 2.300
+R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
YIELD STRENGTH : 53.300
ELASTIC MODULUS = 0.1070E+05
PL. STRESS FRACT. TOUGHNESS = 58.00
PL. STRAIN FRACT. TOUGHNESS = 36.00
DAMAGE INDEX FOR CRACK INITIATION = 0.872
NEUBER MATERIAL CONST. = 0.022
CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366
STRESS SEVERITY FACTOR PARAMETERS
ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1	0.86600
FINAL CRACK LENGTH OF CRACK NO. 1	1.39000
INITIAL CRACK DEPTH OF CRACK NO. 1	0.18800
FINAL CRACK DEPTH OF CRACK NO. 1	0.18800
INITIAL CRACK LENGTH OF CRACK NO. 2	0.26500
FINAL CRACK LENGTH OF CRACK NO. 2	2.25000
INITIAL CRACK DEPTH OF CRACK NO. 2	0.18800
FINAL CRACK DEPTH OF CRACK NO. 2	0.18800

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY

APAOL1	= .000E+00	APCOL1	= .000E+00	RYAOL1	= .000E+00	RYCOL1	= .000E+00
AKOL1	= .000E+00	CKOL1	= .000E+00	AOL1	= .000E+00	COL1	= .000E+00
APAOL2	= .000E+00	APCOL2	= .000E+00	RYAOL2	= .000E+00	RYCOL2	= .000E+00
AKOL2	= .000E+00	CKOL2	= .000E+00	AOL2	= .000E+00	COL2	= .000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :

DMG1	= .000E+00	DMGOL1	= .000E+00	DEL DGI	= .000E+00
DMG2	= .000E+00	DMGOL2	= .000E+00	DEL DGI	= .000E+00

TABLE 3.3.1-4. EXAMPLE 3, METHOD 1, RUN 2 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.99989	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	2.14000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	0.50000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	0.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS :	0.0000	
FLYING SURFACE FRICTION STRESS :	0.0000	

USER DEFINED VARIABLES :

VARIABLE 1 :	2.2500
VARIABLE 2 :	0.0000
VARIABLE 3 :	0.5010
VARIABLE 4 :	0.4160
VARIABLE 5 :	0.2890
VARIABLE 6 :	0.0000
VARIABLE 7 :	0.1800
VARIABLE 8 :	0.0000

SINUS SPECTRUM

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	2000.000
TAL NO. OF FLIGHTS IN ONE BLOCK :	0.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	0.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	0.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	17.000
NO. OF STRESS LAYERS IN ONE BLOCK :	2

TABLE 3.3.1-4. EXAMPLE 3, METHOD 1, RUN 2 OUTPUT FILE (CONCLUDED)

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*****  DAMAGE  GROWTH  HISTORY  *****

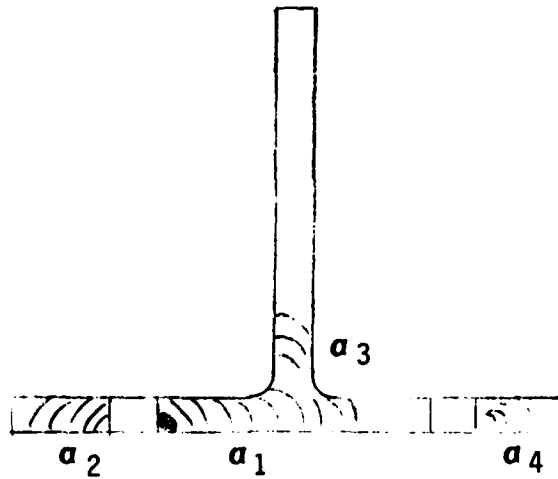
BLOCK      C1      C2      KMAX-C1  KMAX-C2  DC1/DF  DC2/DF  INITIA1  INITIA2
          A1      A2      KMAX-A1  KMAX-A2  DA1/DF  DA2/DF      KN1      KN2
0.0  0.86600  0.26500  19.252  13.435  .000E+00 .000E+00  .000E+00  .000E+00
      0.18800  0.18800   0.000   0.000  .000E+00 .000E+00  .000E+00  .000E+00

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
  CYC = 861.0, STEP = 1, BLOCK = 2, CRACK LENGTH = 1.39664, CKMAXS= 20.35
THE OTHER CRACK LENGTH = 0.30423
TERMINATE DAMAGE COMPUTATION
1.0  1.03907  0.30423  22.419  14.870  .112E-03 .196E-04  .000E+00  .000E+00
      0.18800  0.18800   0.000   0.000  .000E+00 .000E+00  .000E+00  .000E+00

RETARDATION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION
APADL1 = .000E+00, APCOL1 = .000E+00, RYADL1 = .000E+00, RYCOL1 = .000E+00
AKOL1 = .000E+00, CKOL1 = .000E+00, ADL1 = .000E+00, COL1 = .000E+00
APADL2 = .000E+00, APCOL2 = .000E+00, RYADL2 = .000E+00, RYCOL2 = .000E+00
AKOL2 = .000E+00, CKOL2 = .000E+00, ADL2 = .000E+00, COL2 = .000E+00
RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION
DMG1 = .000E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
DMG2 = .000E+00, DMGOL2 = .000E+00, DELDG2 = .000E+00

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TABLE 3.3.2. EXAMPLE 3, METHOD 2 SUMMARY TABLE
(REF. PAGES 101 THROUGH 107)



a_1 (IN)	a_2 (IN)	a_3 (IN)	a_4 (IN)	LIFE (CYCLES)	GROWTH	ROUTINES INITIATION	RUN NO.
.050	0	0	0	0	2020	1010	1
.056	0	0	0	2020	2020	1010	1
.066	0	0	0	4000	2020	1010	1
.080	0	0	0	6000	2020	1010	1
.101	0	0	0	8000	2020	1010	1
.131	0	0	0	10000	2020	1010	1
.181	0	0	0	12000	2020	1010	1
.248	0	0	0	14000	2020	1010	1
.336	0	0	0	16000	2020	1010	1
.447	0	0	0	18000	2020	1010	1
.567	0	0	0	20000	2020	1010	1
.700	0	0	0	22000	2020	1010	1
.873	0	.265	0	23878	2050	1010	2
1.089	0		0	25878	2050	1010	2
1.396	0	.304	0	26739	2050	1010	2

NO. OF CYCLES TO FAILURE = 26,739 CYCLES

TABLE 3.3.2-1. EXAMPLE 3, METHOD 2, RUN 1 INPUT FILE

EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING
2024-T351 EXTRUSION

0.1600E-09	0.65	4.554	0.230E-08	1.00	3.115			
58.00	36.0	53.3	2.0	2.3	0.99	-0.99		
10.4260	-1.3660	0.872	10700.0	0.022	1.0	1.0	1.0	
.050	1.390	0.050	0.138	0.000	0.000	0.000	0.000	
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	
0.188	0.1250	2.14	0.500	0.00000	0.00000	99.9999	0.0	1.00
0.1250	0.0000	1.640	0.000	0.000	0.000	0.000	0.00000	
0.000	0.0000							
0 00	1 2	0 100	2010 1010					
1.226	1.414	0.462	1.000	0.2658	.0000	0.000	0.000	
000.0	00.0	00000.	1					

TABLE 3.3.2-2. EXAMPLE 3, METHOD 2, RUN 1 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING

* THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 1, CRACK INITIATION = 2
CORRESPONDING DAMAGE CODES : CRACK GROWTH = 2010, CRACK INITIATION = 1010

LOAD INTERACTION : NONE

MATERIAL : 2024-T351 EXTRUSION
WALKER EQ. CONST. (+R) : C = 0.160E-09, M = 0.650, N = 4.554
WALKER EQ. CONST. (-R) : C = 0.230E-08, M = 1.000, N = 3.115
MAX. K FOR DC/DN THRESHOLD = 2.000
RETARDATION SHUT-OFF RATIO = 2.300
+R CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
YIELD STRENGTH : 53.300
ELASTIC MODULUS = 0.1070E+05
FL. STRESS FRACT. TOUGHNESS = 58.00
FL. STRAIN FRACT. TOUGHNESS = 36.00
DAMAGE INDEX FOR CRACK INITIATION = 0.872
NEUBER MATERIAL CONST. = 0.022
CRACK INITIATION EQ. CONST. SE = 10.426, M = 1.364
STRESS SEVERITY FACTOR PARAMETERS :
ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 :	0.05000
FINAL CRACK LENGTH OF CRACK NO. 1 :	1.39000
INITIAL CRACK DEPTH OF CRACK NO. 1 :	0.05000
FINAL CRACK DEPTH OF CRACK NO. 1 :	0.18800
INITIAL CRACK LENGTH OF CRACK NO. 2 :	0.00000
FINAL CRACK LENGTH OF CRACK NO. 2 :	0.00000
INITIAL CRACK DEPTH OF CRACK NO. 2 :	0.00000
FINAL CRACK DEPTH OF CRACK NO. 2 :	0.00000

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY

AP001 =	.000E+00,	AP001 =	.000E+00,	RYA001 =	.000E+00,	RYC001 =	.000E+00
AK001 =	.000E+00,	CK001 =	.000E+00,	AQ001 =	.000E+00,	COL001 =	.000E+00
AP002 =	.000E+00,	AP002 =	.000E+00,	RYA002 =	.000E+00,	RYC002 =	.000E+00
AK002 =	.000E+00,	CK002 =	.000E+00,	AQ002 =	.000E+00,	COL002 =	.000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY

DMG01 =	.000E+00,	DMG01 =	.000E+00,	DEF001 =	.000E+00
DMG02 =	.000E+00,	DMG02 =	.000E+00,	DEF002 =	.000E+00

TABLE 3.3.2-2. EXAMPLE 3, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, B/D :	99.99982	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	2.14000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	0.50000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	0.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.60	
FASTENER HEAD OR COLLAR FRICTION STRESS	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

USER DEFINED VARIABLES :

VARIABLE 1 :	1.2260
VARIABLE 2 :	1.4140
VARIABLE 3 :	0.4620
VARIABLE 4 :	1.0000
VARIABLE 5 :	0.2658
VARIABLE 6 :	0.0000
VARIABLE 7 :	0.0000
VARIABLE 8 :	0.0000

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS :	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	2000.000
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	0.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	0.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	0.000
MAXIMUM PEAK STRESS OF THE SPECTRUM	17.000
NO. OF STRESS LEVELS IN ONE BLOCK	2

TABLE 3.3.2-2. EXAMPLE 3, METHOD 2, RUN 1 OUTPUT FILE (CON'T.)

***** DAMAGE GROWTH HISTORY *****								
BLOCK	C1 A1	C2 A2	KMAX-C1 KMAX-A1	KMAX-C2 KMAX-A2	DC1/DF DA1/DF	DC2/DF DA2/DF	INITIAL KN1	INITIAL KN2
0.0	0.05000	0.00000	8.892	0.000	.000E+00	.000E+00	.254E-02	.179E-02
	0.05000	0.00000	11.144	0.000	.000E+00	.000E+00	.264E+01	.248E+01
1.0	0.05629	0.00000	9.900	0.000	.315E-05	.000E+00	.778E-02	.537E-02
	0.06504	0.00000	11.627	0.000	.752E-05	.000E+00	.266E+01	.248E+01
2.0	0.06611	0.00000	10.802	0.000	.491E-05	.000E+00	.133E-01	.895E-02
	0.08344	0.00000	12.171	0.000	.920E-05	.000E+00	.269E+01	.248E+01
3.0	0.08041	0.00000	11.684	0.000	.715E-05	.000E+00	.194E-01	.127E-01
	0.10629	0.00000	12.774	0.000	.114E-04	.000E+00	.274E+01	.248E+01
4.0	0.10084	0.00000	12.647	0.000	.102E-04	.000E+00	.262E-01	.161E-01
	0.13484	0.00000	13.415	0.000	.143E-04	.000E+00	.280E+01	.248E+01
STABLE BREAK THROUGH OF CRACK NO. 1 OCCURS AT :								
CYC = 887.0, STEP = 1, BLOCK = 6, CRACK DEPTH = 0.18911								
CRACK DEPTH IS SET EQUAL TO PLATE THICKNESS 0.1880 INCHES								
5.0	0.13082	0.00000	13.827	0.000	.150E-04	.000E+00	.342E-01	.197E-01
	0.17055	0.00000	14.088	0.000	.179E-04	.000E+00	.290E+01	.248E+01
6.0	0.18029	0.00000	15.384	0.000	.247E-04	.000E+00	.445E-01	.237E-01
	0.18800	0.00000	0.000	0.000	.873E-05	.000E+00	.305E+01	.248E+01
7.0	0.24819	0.00000	16.248	0.000	.340E-04	.000E+00	.590E-01	.269E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.325E+01	.248E+01
8.0	0.33618	0.00000	17.216	0.000	.440E-04	.000E+00	.808E-01	.304E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.352E+01	.248E+01
9.0	0.44788	0.00000	17.947	0.000	.558E-04	.000E+00	.116E+00	.340E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.385E+01	.248E+01
10.0	0.56758	0.00000	17.771	0.000	.599E-04	.000E+00	.173E+00	.376E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.420E+01	.248E+01
11.0	0.70911	0.00000	18.917	0.000	.663E-04	.000E+00	.265E+00	.412E-01
	0.18800	0.00000	0.000	0.000	.000E+00	.000E+00	.459E+01	.248E+01

TABLE 3.3.2-2. EXAMPLE 3, METHOD 2, RUN 1 OUTPUT FILE (CONCLUDED)

CRACK NO. 1 EXCEEDS APPLICABLE RANGE OF SUBROUTINE K2010 AT :
CYC = 878.0, STEP = 2, BLOCK = 12
CHANGE TO K2050 OR K2060. TERMINATE COMPUTATION

CRACK LENGTHS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
C1 = 0.87354, A1 = 0.18800, C2 = 0.00000, A2 = 0.00000

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
APAOL1 = .000E+00, APCOL1 = .000E+00, RYAOL1 = .000E+00, RYCOL1 = .000E+00
AKOL1 = .000E+00, CKOL1 = .000E+00, AOL1 = .000E+00, COL1 = .000E+00
APAOL2 = .000E+00, APCOL2 = .000E+00, RYAOL2 = .000E+00, RYCOL2 = .000E+00
AKOL2 = .000E+00, CKOL2 = .000E+00, AOL2 = .000E+00, COL2 = .000E+00
RETARDATION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
DMG1 = .333E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
DMG2 = .430E-01, DMGOL2 = .000E+00, DELDG2 = .000E+00

TABLE 3.3.2-3. EXAMPLE 3, METHOD 2, RUN 2 INPUT FILE

EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING
2024-T351 EXTRUSION

0.1600E-09	0.65	4.554	0.230E-08	1.00	3.115			
58.00	36.0	53.3	2.0	2.3	0.99	-0.99		
10.4260	-1.3660	0.872	10700.0	0.022	1.0	1.0	1.0	
.060	1.390	0.188	0.188	0.265	2.250	0.188	0.188	
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	
0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	0.0000E+000	
0.108	0.1250	2.14	0.500	0.00000	0.00000	99.9999	0.0	1.00
0.1250	0.0000	1.640	0.000	0.000	0.000	0.000	0.0000	
0.000	0.0000							
0	00	2	2	0	100	2050	1010	
2.250	0.000	0.581	0.414	0.2890	.0000	0.188	0.000	
000.0	00.0	00000.	1					

TABLE 3.3.2-4. EXAMPLE 3, METHOD 2, RUN 2 OUTPUT FILE

***** DETAILED DAMAGE GROWTH ANALYSIS PROGRAM D A M G R O *****

EXAMPLE NO. 3 STRINGER SPECIMEN SUBJECTED TO CONSTANT AMPLITUDE LOADING

* THIS ANALYSIS STARTS AT THE BEGINNING OF THE STRESS SPECTRUM *

NO. OF SITES TO BE ANALYZED : CRACK GROWTH = 2; CRACK INITIATION = 2
CORRESPONDING DAMAGE CODES : CRACK GROWTH = 2050; CRACK INITIATION = 1010

LOAD INTERACTION : NONE

MATERIAL : 2024-T351 EXTRUSION

WALKER EQ. CONST. (+R) : C = 0.160E-09, M = 0.650, N = 4.554
WALKER EQ. CONST. (-R) : C = 0.230E-08, M = 1.000, N = 3.115
MAX. K FOR DC/DN THRESHOLD = 2.000
RETARDATION SHUT-OFF RATIO = 2.300
IF CUT-OFF = 0.9900, -R CUT-OFF = -0.9900
YIELD STRENGTH = 53.300
ELASTIC MODULUS = 0.1070E+05
H. STRESS FRACT. TOUGHNESS = 58.00
H. STRAIN FRACT. TOUGHNESS = 36.00
DAMAGE INDEX FOR CRACK INITIATION = 0.872
NEUBER MATERIAL CONST. = 0.022
CRACK INITIATION EQ. CONST. : SF = 10.426, M = -1.366
STRESS SEVERITY FACTOR PARAMETERS :
ALPHA = 1.0000, BETA = 1.0000, GAMMA = 1.0000

SPECIFIED DAMAGE CONDITIONS :

INITIAL CRACK LENGTH OF CRACK NO. 1 :	0.86600
FINAL CRACK LENGTH OF CRACK NO. 1 :	1.39000
INITIAL CRACK DEPTH OF CRACK NO. 1 :	0.18800
FINAL CRACK DEPTH OF CRACK NO. 1 :	0.18800
INITIAL CRACK LENGTH OF CRACK NO. 2 :	0.26500
FINAL CRACK LENGTH OF CRACK NO. 2 :	2.25000
INITIAL CRACK DEPTH OF CRACK NO. 2 :	0.18800
FINAL CRACK DEPTH OF CRACK NO. 2 :	0.18800

PARAMETERS FROM PREVIOUS CRACK GROWTH HISTORY :

APCOL1 =	.000E+00	APCOL1 =	.000E+00	RYCOL1 =	.000E+00	RYCOL1 =	.000E+00
AKOL1 =	.000E+00	COL1 =	.000E+00	COL1 =	.000E+00	COL1 =	.000E+00
APCOL2 =	.000E+00	APCOL2 =	.000E+00	RYCOL2 =	.000E+00	RYCOL2 =	.000E+00
AKOL2 =	.000E+00	COL2 =	.000E+00	COL2 =	.000E+00	COL2 =	.000E+00

PARAMETERS FROM PREVIOUS CRACK INITIATION HISTORY :

DMG1 =	.333E+00	DMGOL1 =	.000E+00	DEL DGI =	.000E+00
DMG2 =	.430E+01	DMGOL2 =	.000E+00	DEL DGI2 =	.000E+00

TABLE 3.3.2-4. EXAMPLE 3, METHOD 2, RUN 2 OUTPUT FILE (CON'T.)

COMPONENT GEOMETRY :

THICKNESS OF PLATE :	0.18800	
RADIUS OF MID. HOLE :	0.12500	
RATIO OF PLATE LENGTH TO HOLE DIAMETER, E/D :	99.99787	
DISTANCE BETWEEN MID. HOLE AND R.H.S. EDGE :	2.14000	
DISTANCE BETWEEN MID. HOLE AND L.H.S. EDGE :	0.50000	
FRACTION OF LOAD TRANSFER BY MID. BOLT :	0.00000,	0.00000
RADIUS OF THE R.H.S. HOLE :	0.12500	
DISTANCE BETWEEN MID. AND R.H.S. HOLES :	1.64000	
FRACTION OF LOAD TRANSFER BY R.H.S. BOLT :	0.00000,	0.00000
RADIUS OF THE L.H.S. HOLE :	0.00000	
DISTANCE BETWEEN MID. AND L.H.S. HOLES :	0.00000	
FRACTION OF LOAD TRANSFER BY L.H.S. BOLT :	0.00000,	0.00000
PERCENTAGE OF COUNTERSINK DEPTH W.R.T THICKNESS :	0.0	
STRESS CONCENTRATION DUE TO PIN DEFLECTION :	1.00	
FASTENER HEAD OR COLLAR FRICTION STRESS	0.0000	
FAYING SURFACE FRICTION STRESS :	0.0000	

USER DEFINED VARIABLES :

VARIABLE 1 :	2.2500
VARIABLE 2 :	0.0000
VARIABLE 3 :	0.5810
VARIABLE 4 :	0.4160
VARIABLE 5 :	0.2890
VARIABLE 6 :	0.0000
VARIABLE 7 :	0.1880
VARIABLE 8 :	0.0000

STRESS SPECTRUM :

NO. OF BLOCKS SPECIFIED FOR ANALYSIS	100
TOTAL NO. OF CYCLES IN ONE BLOCK :	2000.000
TOTAL NO. OF FLIGHTS IN ONE BLOCK :	0.000
NO. OF BLOCKS IN ONE DESIGN LIFETIME :	0.000
NO. OF FLIGHT HOURS IN ONE DESIGN LIFETIME :	0.000
MAXIMUM PEAK STRESS OF THE SPECTRUM :	17.000
NO. OF STRESS LAYERS IN ONE BLOCK	2

TABLE 3.3.2-4. EXAMPLE 3, METHOD 2, RUN 2 OUTPUT FILE (CONCLUDED)

```

***** DAMAGE GROWTH HISTORY *****
BLOCK      C1      C2      KMAX-C1  KMAX-C2  DC1/DF  DC2/DF  INITIA1  INITIA2
           A1      A2      KMAX-A1  KMAX-A2  DA1/DF  DA2/DF      KN1      KN2
0.0  0.06600  0.26500  19.252  13.435  .000E+00 .000E+00  .423E+00  .448E-01
      0.18800  0.18800   0.000   0.000  .000E+00 .000E+00  .507E+01  .248E+01

UNSTABLE GROWTH OF CRACK NO. 1 OCCURS AT:
CYC = 861.0, STEP = 1, BLOCK = 2, CRACK LENGTH = 1.39664, CKMAXS= 70.35
THE OTHER CRACK LENGTH = 0.30423
TERMINATE DAMAGE COMPUTATION
1.0  1.08700  0.30423  22.419  14.870  .112E-03 .196E-04  .721E+00  .484E-01
      0.18800  0.18800   0.000   0.000  .000E+00 .000E+00  .575E+01  .248E+01

RETARDTION PARAMETERS AT THE TERMINATION OF CRACK GROWTH COMPUTATION :
APADL1 = .000E+00, APCOL1 = .000E+00, RYADL1 = .000E+00, RYCOL1 = .000E+00
AKOL1 = .000E+00, CKOL1 = .000E+00, ADL1 = .000E+00, COL1 = .000E+00
APADL2 = .000E+00, APCOL2 = .000E+00, RYADL2 = .000E+00, RYCOL2 = .000E+00
AKOL2 = .000E+00, CKOL2 = .000E+00, ADL2 = .000E+00, COL2 = .000E+00
RETARDTION PARAMETERS AT THE TERMINATION OF CRACK INITIATION COMPUTATION :
DMG1 = .721E+00, DMGOL1 = .000E+00, DELDG1 = .000E+00
DMG2 = .484E-01, DMGOL2 = .000E+00, DELDG2 = .000E+00

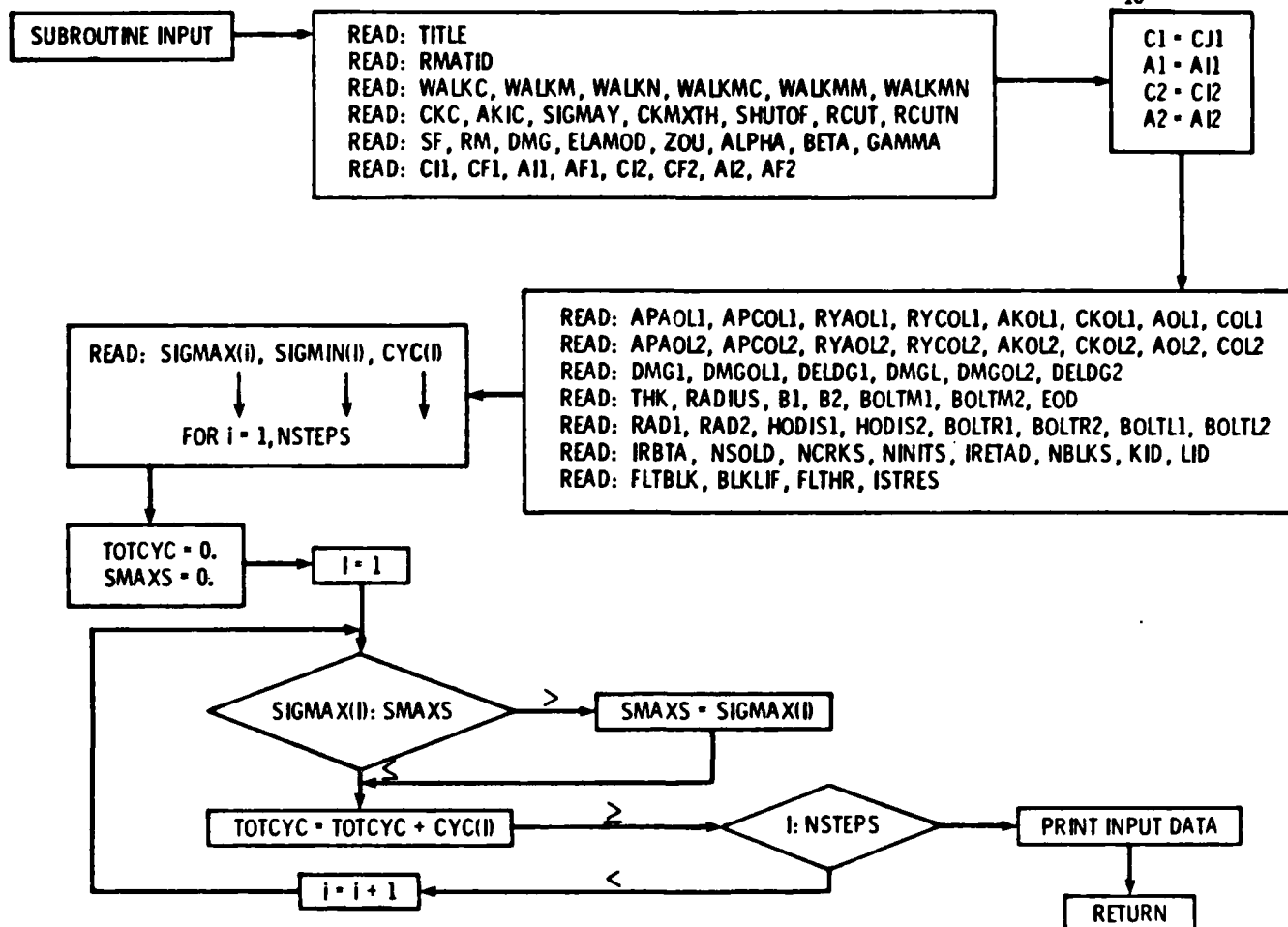
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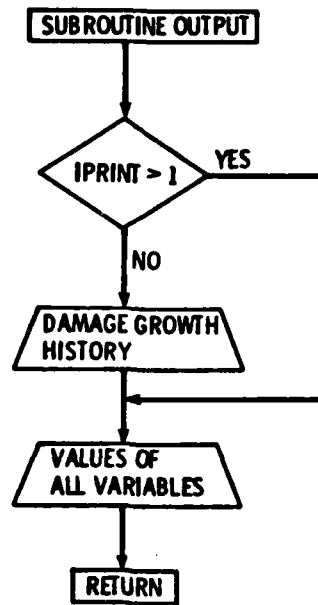
APPENDIX A

COMPUTER PROGRAM FLOW CHARTS

This section presents the flow charts of the various subroutines available in the Computer Program "DAMGRO". The analytical formulation associated with the various parameters were derived during Phase I of the program, and defined in Volume II of the Report.

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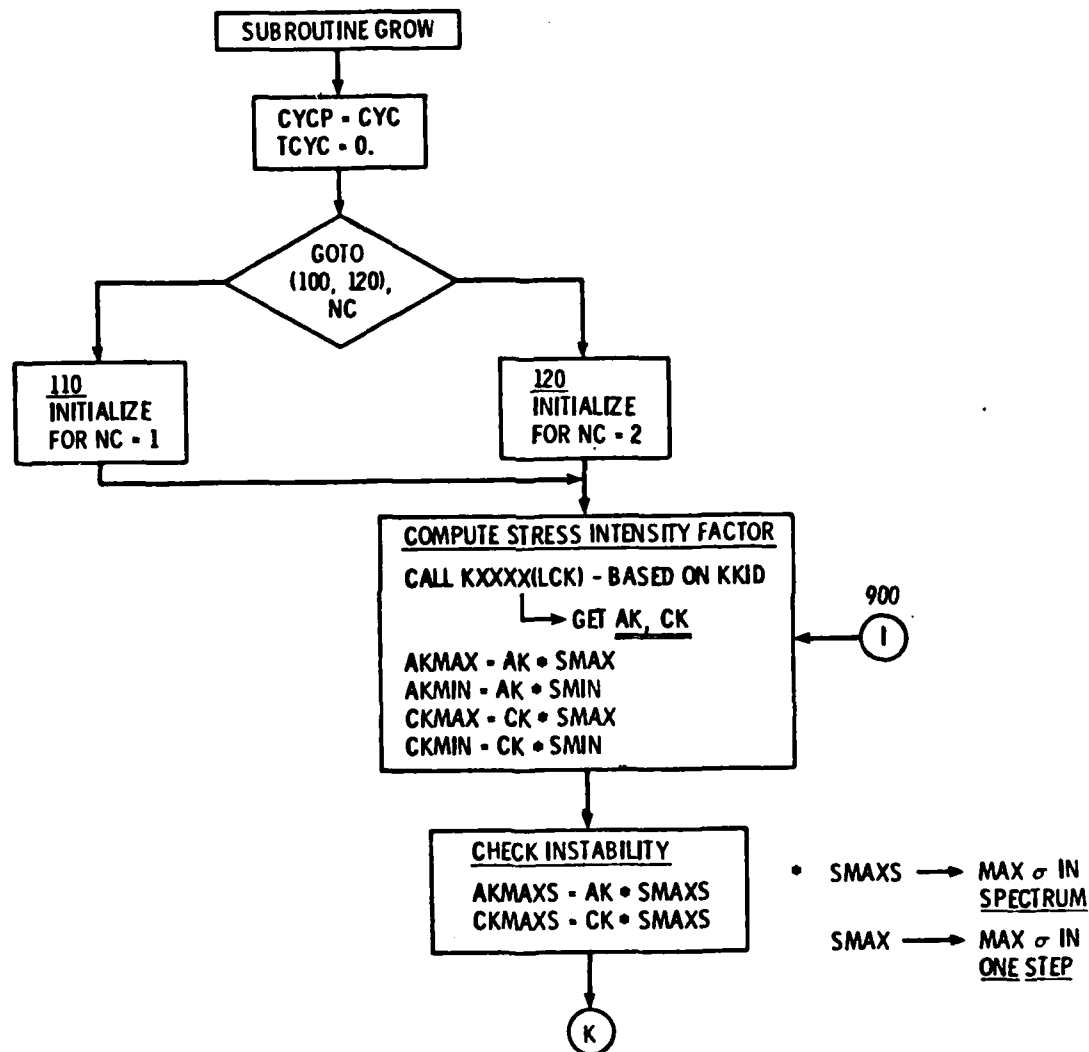


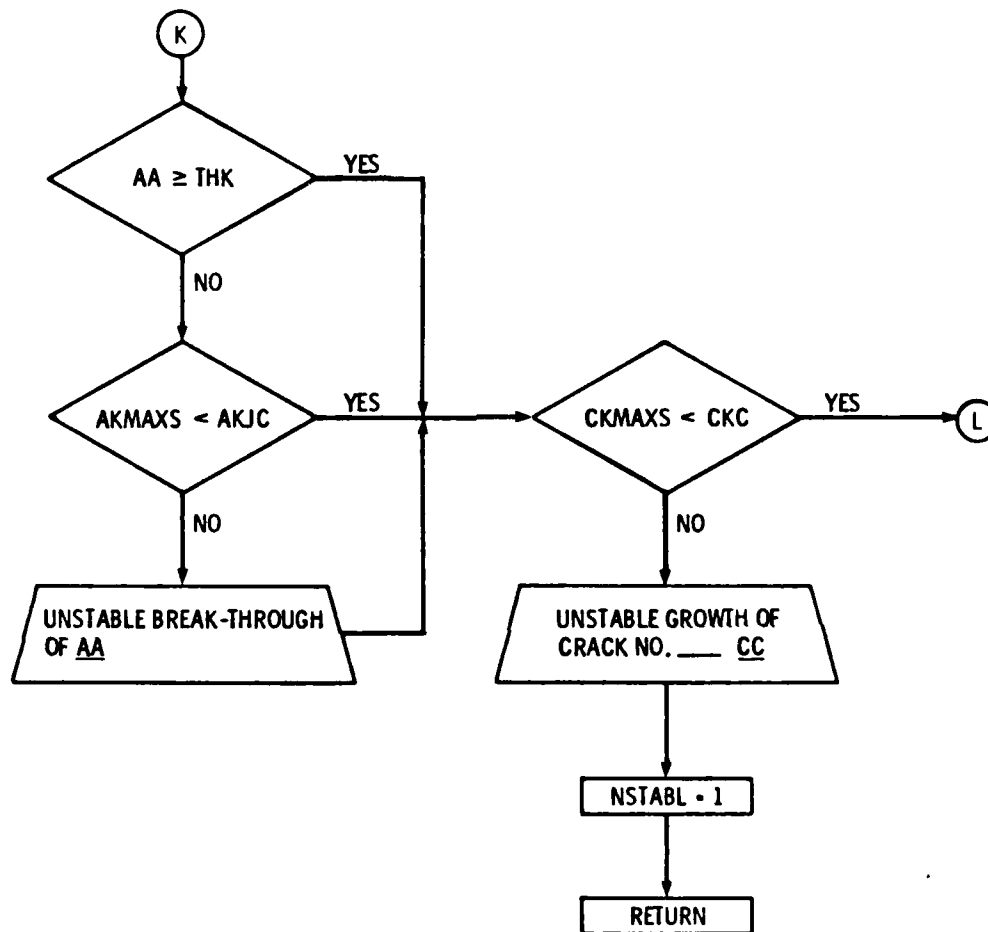


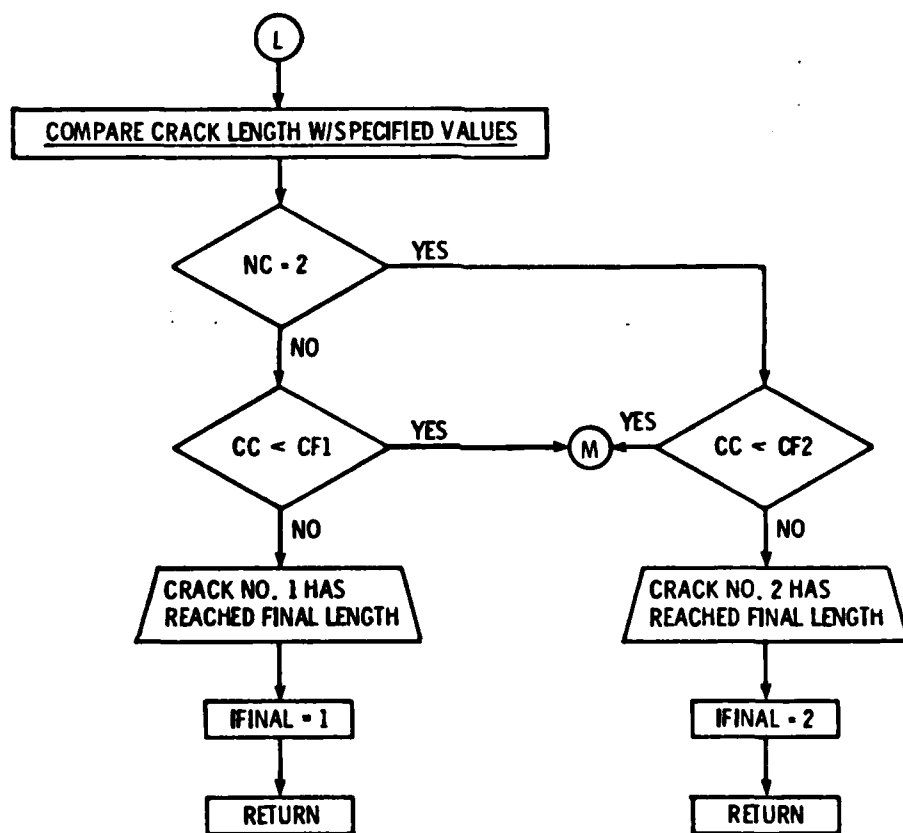
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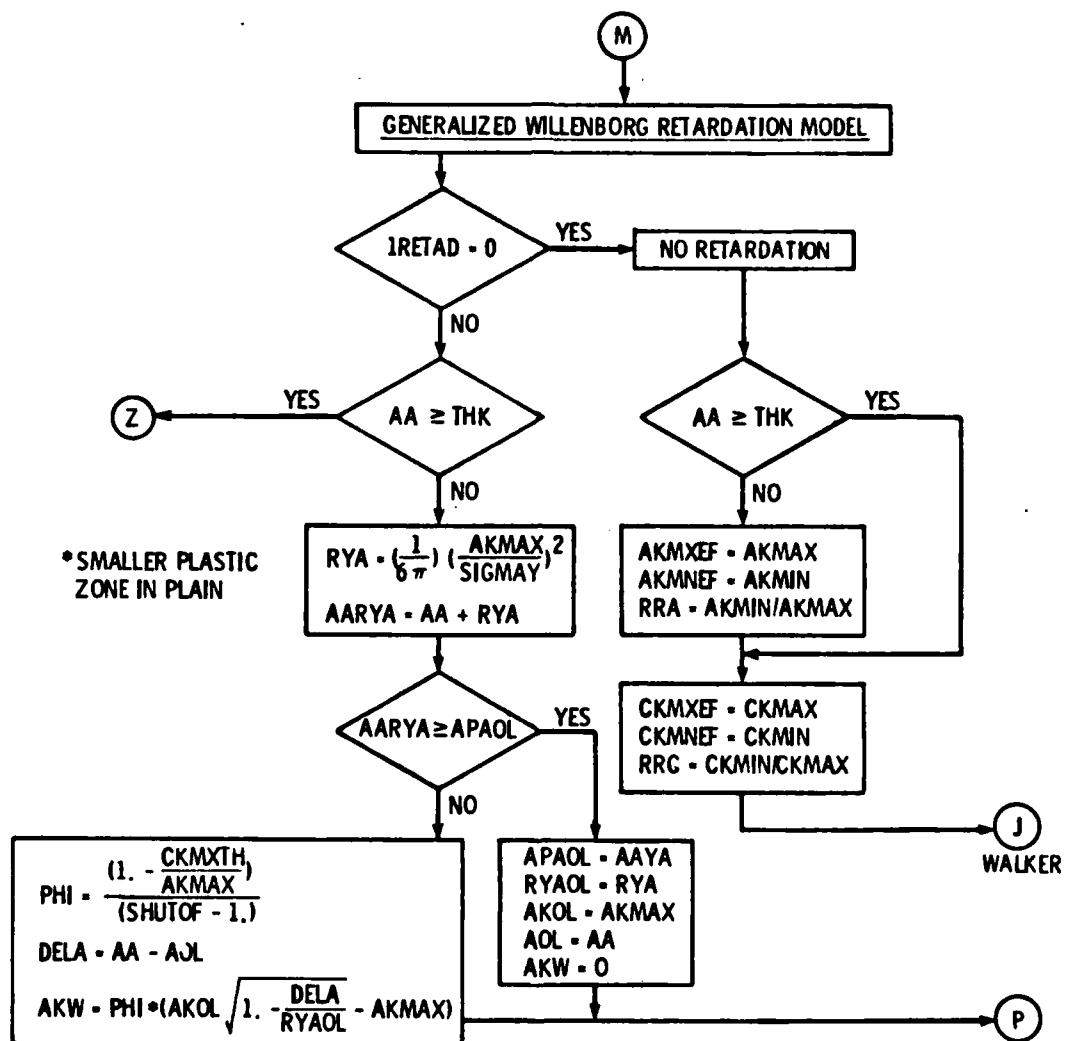
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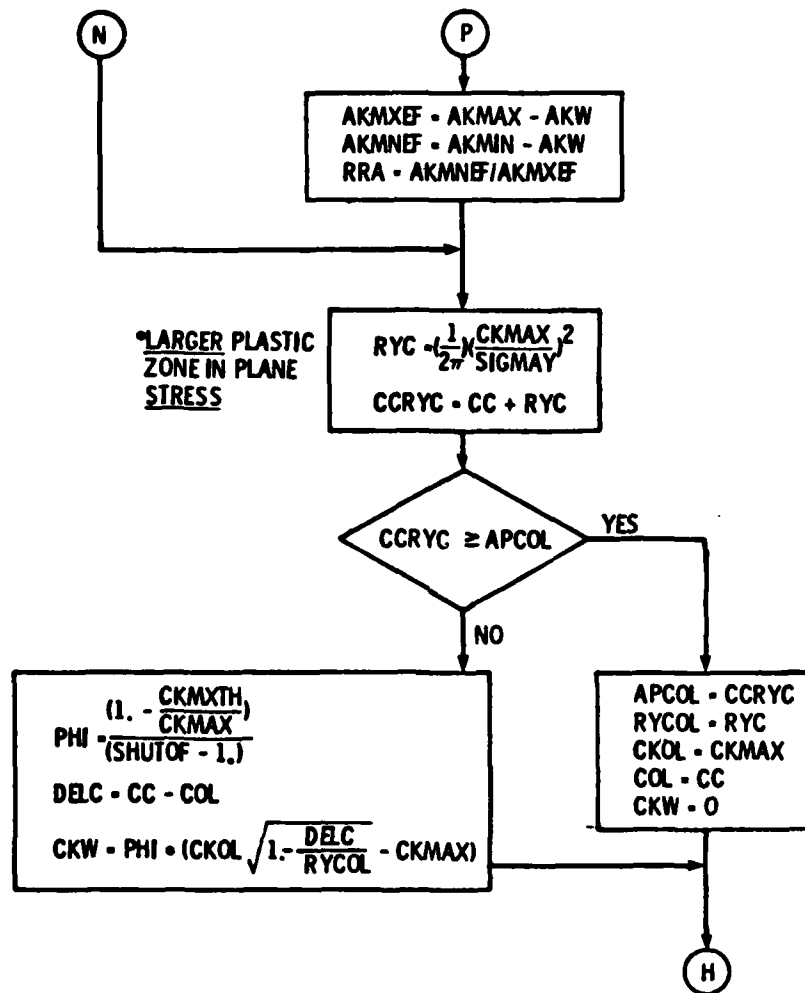
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SMXS1, SMXS2, BLOK

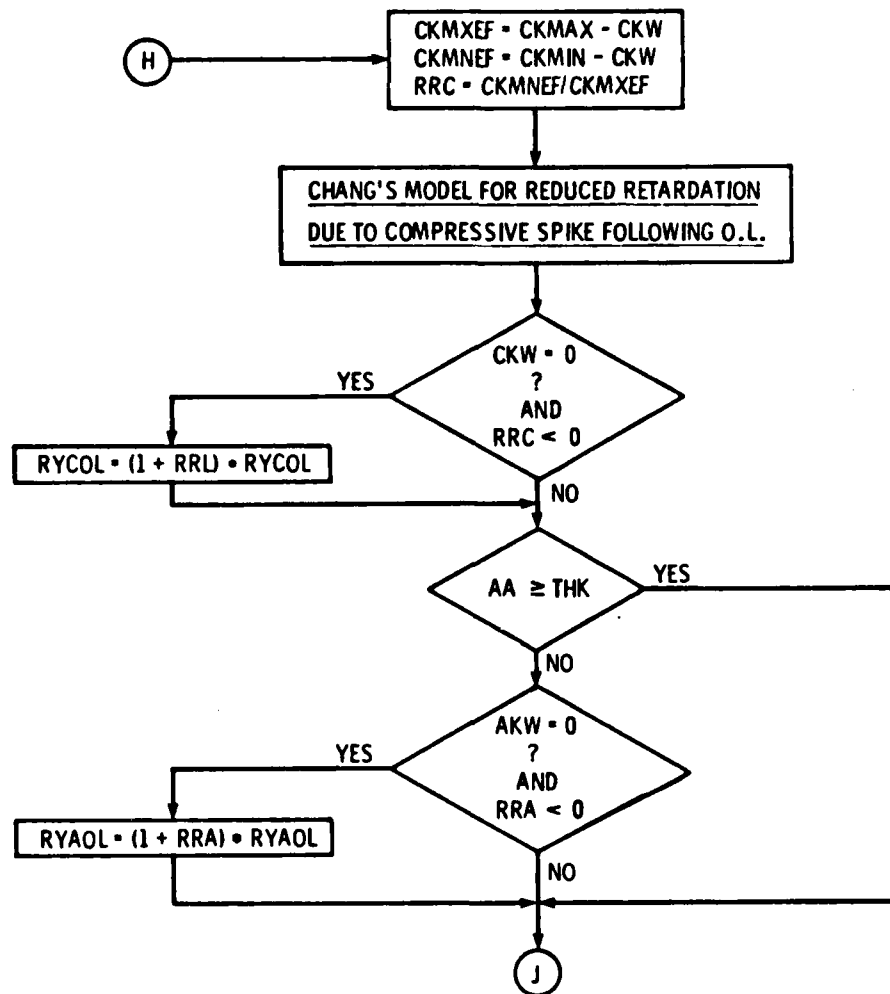


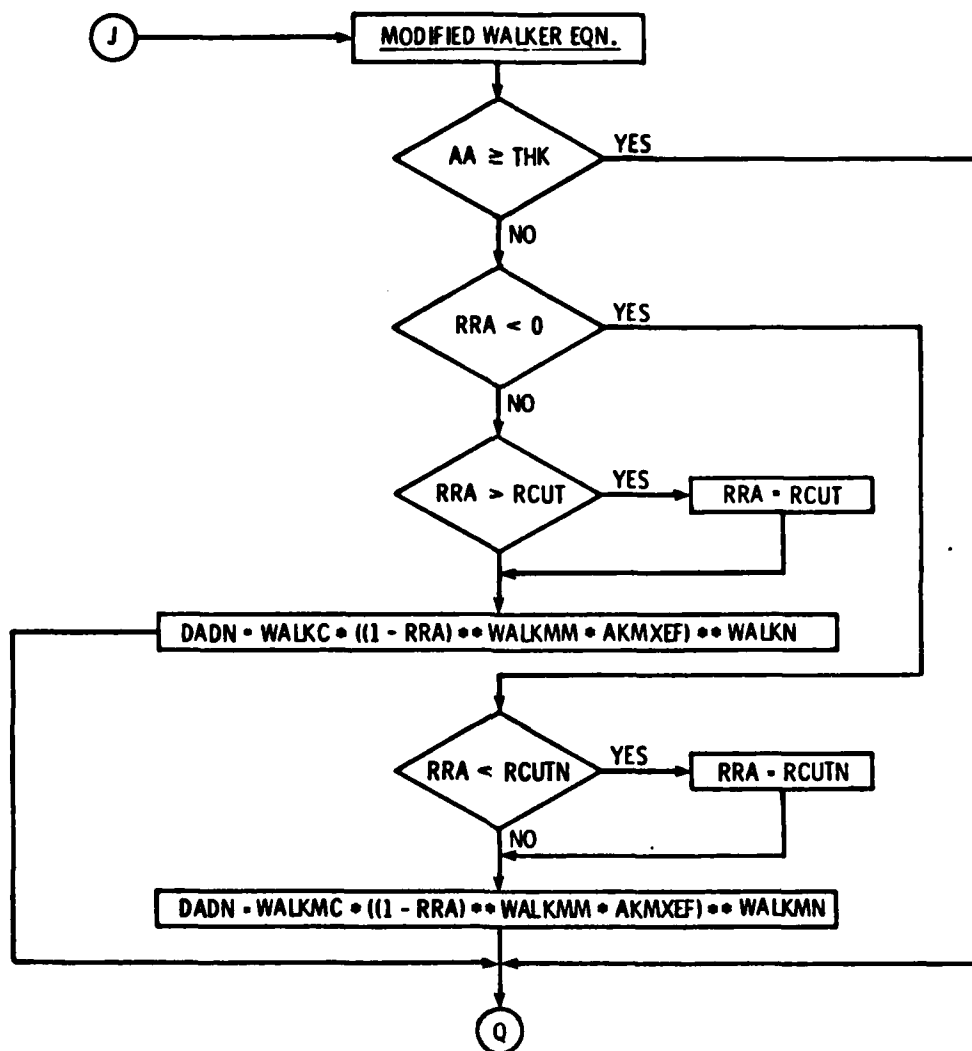


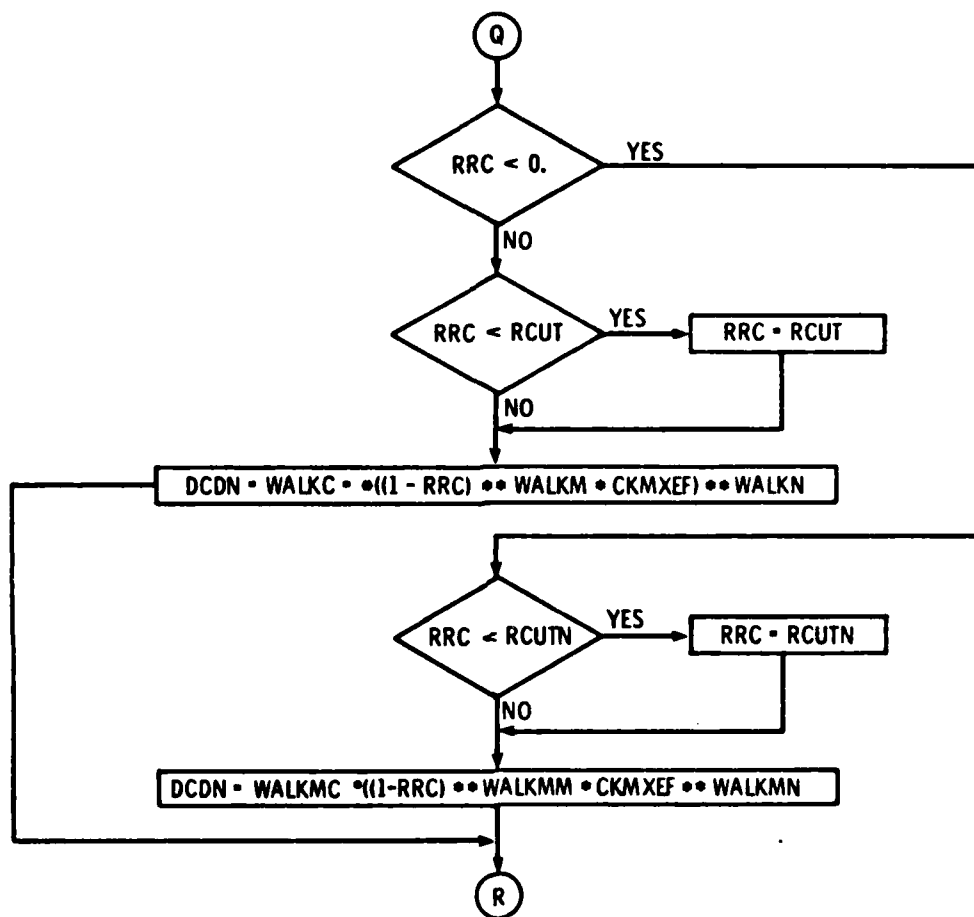


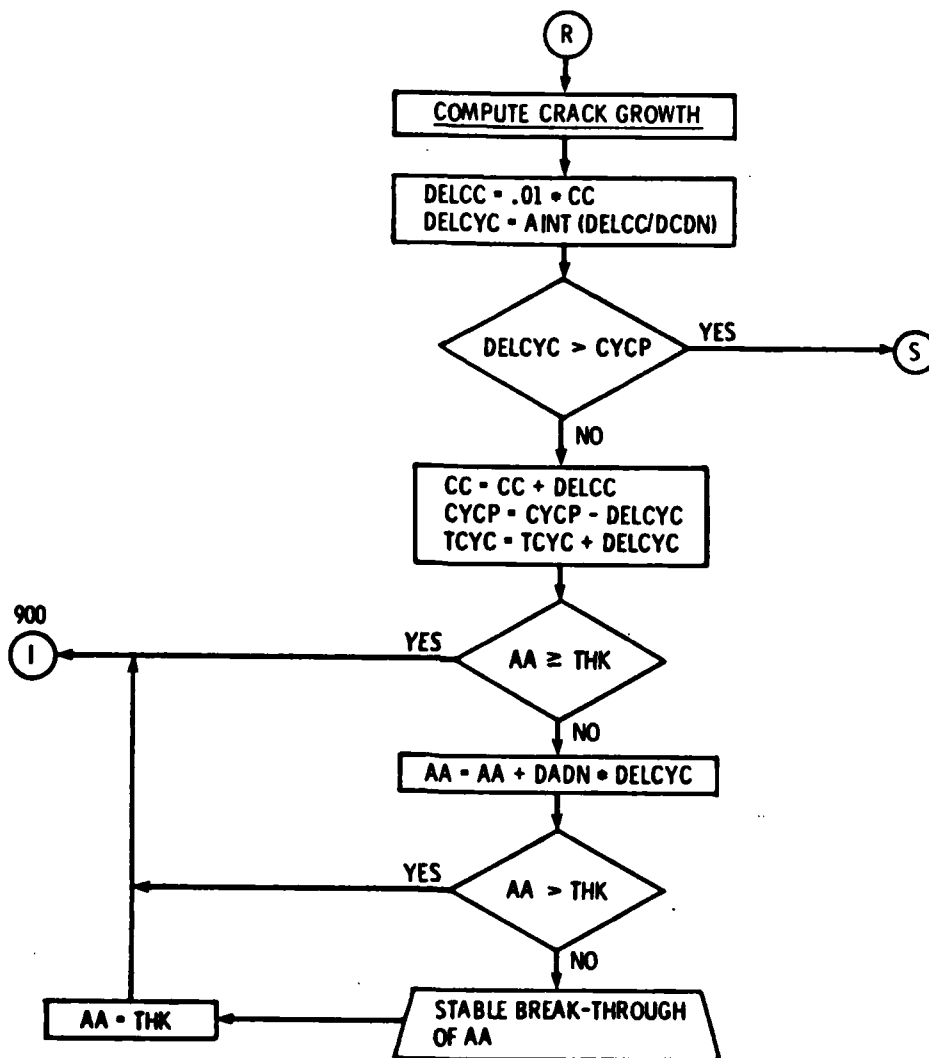


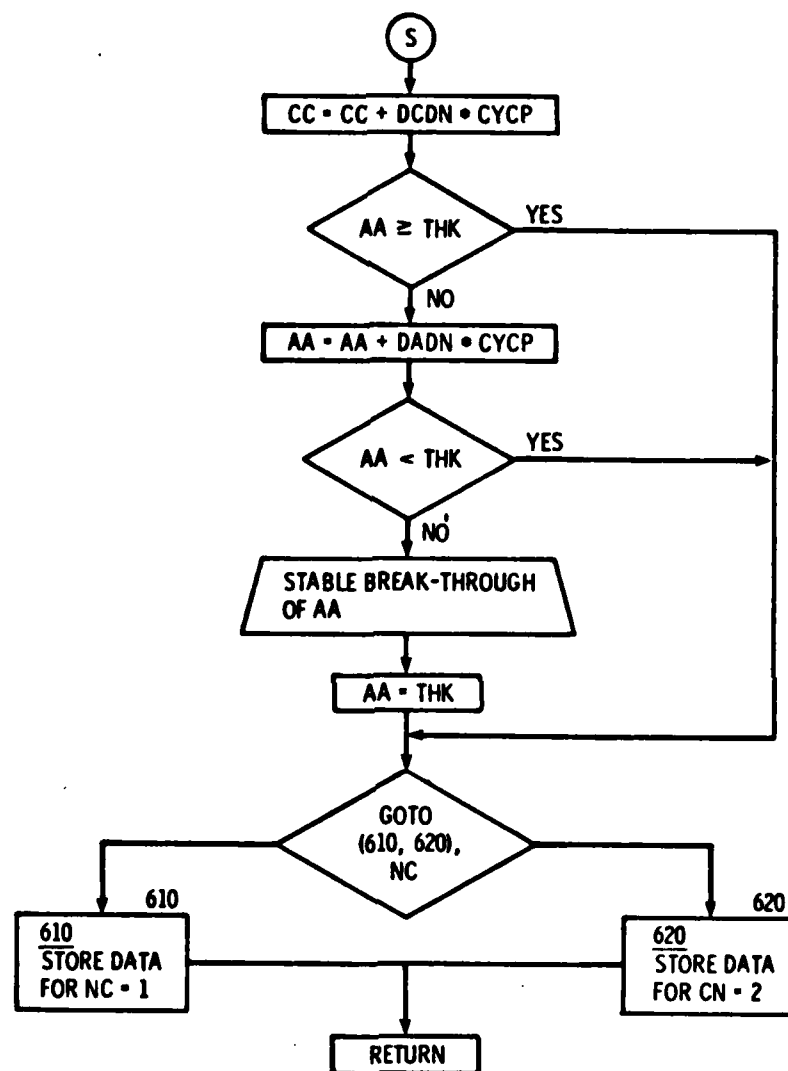


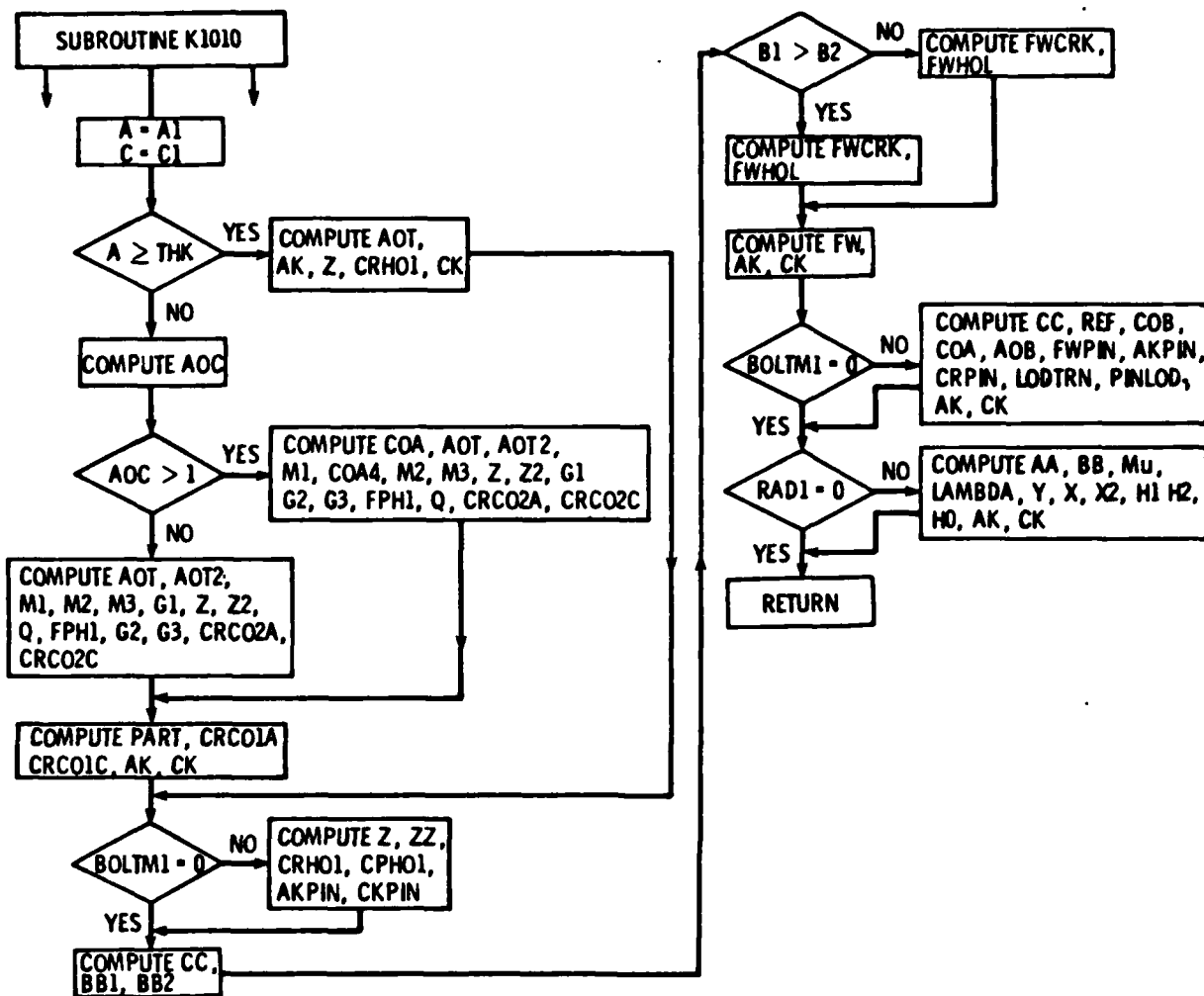


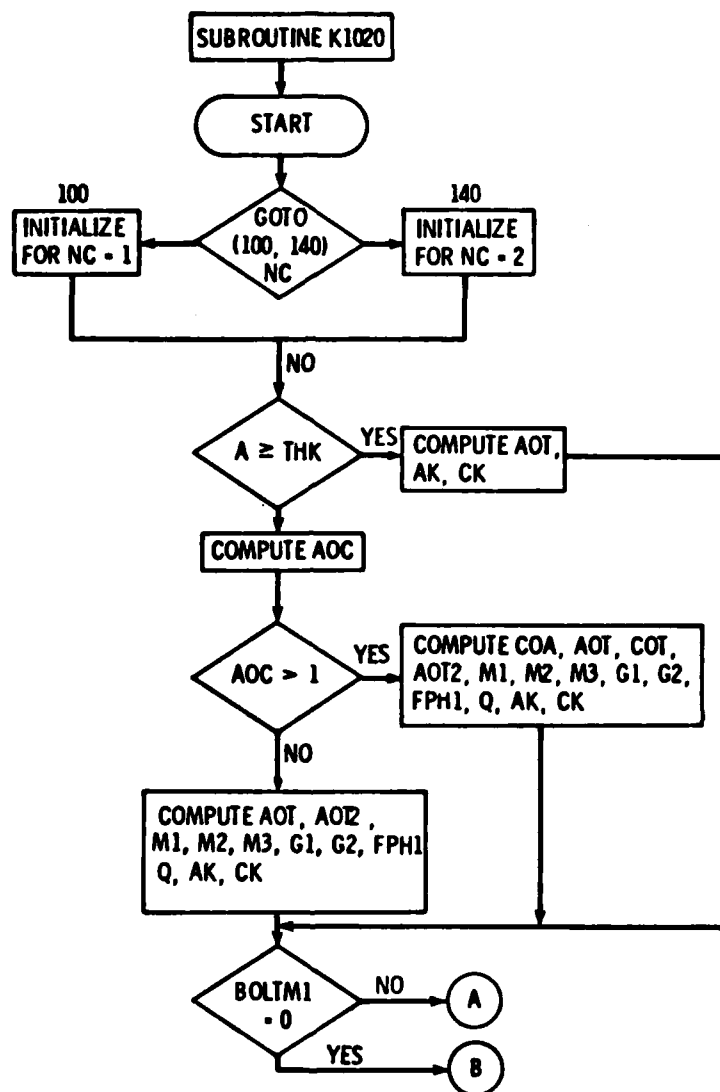


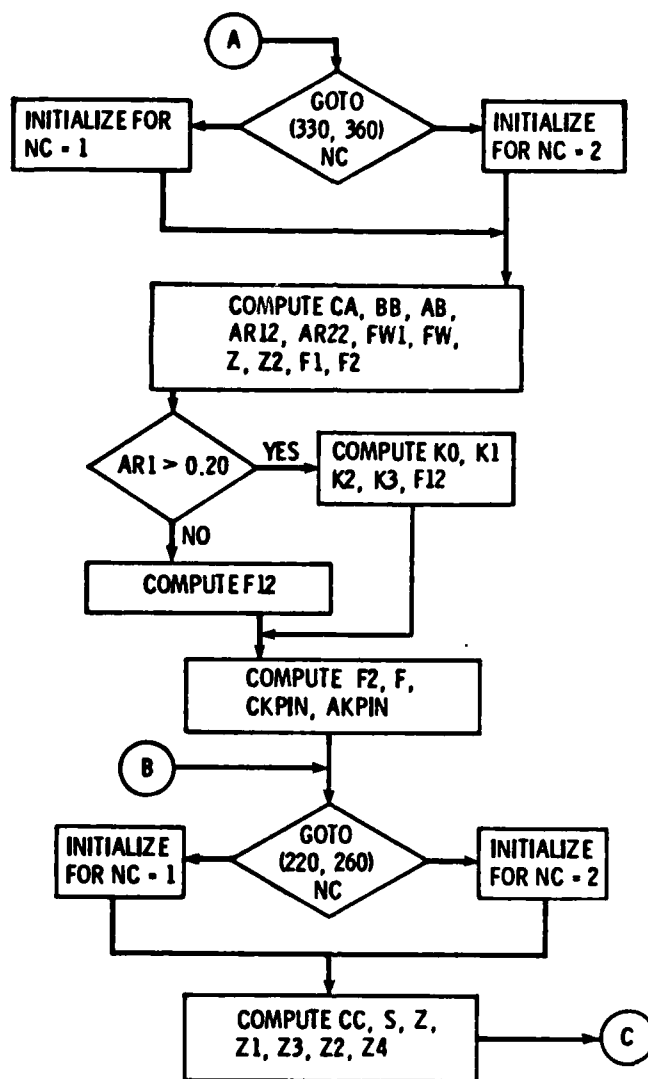


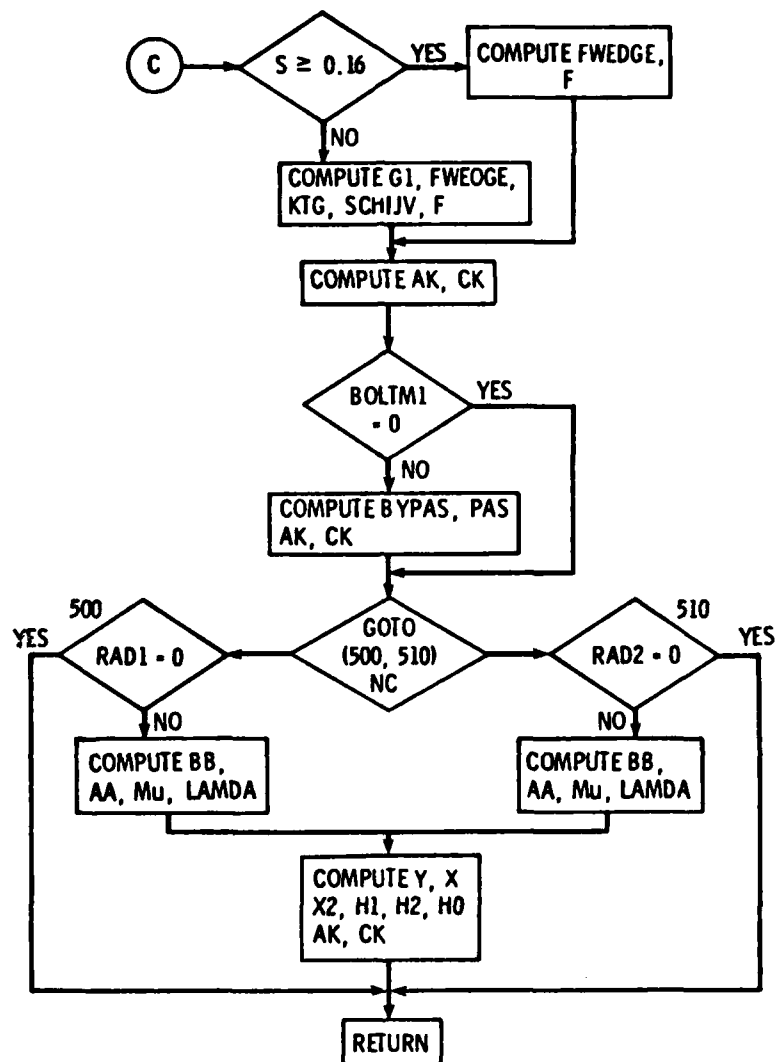


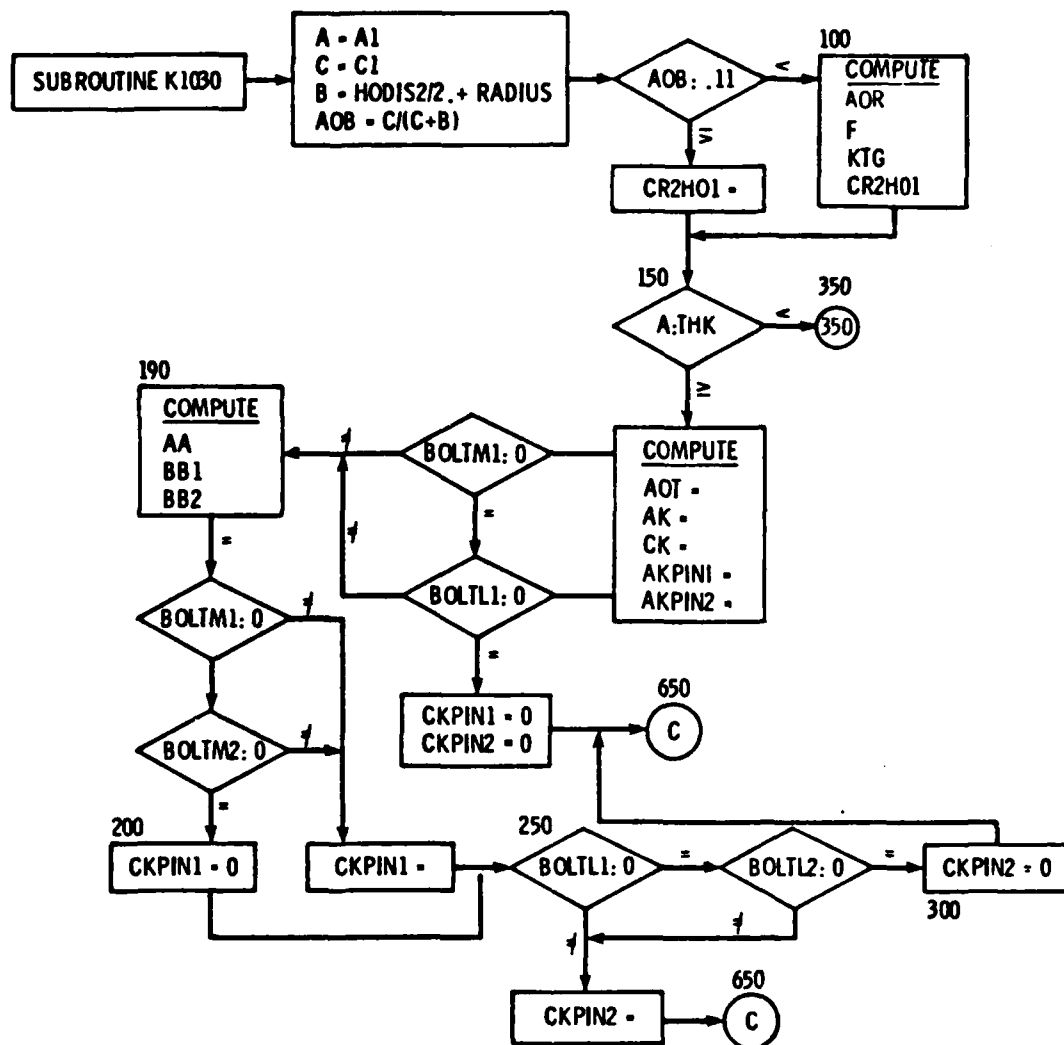


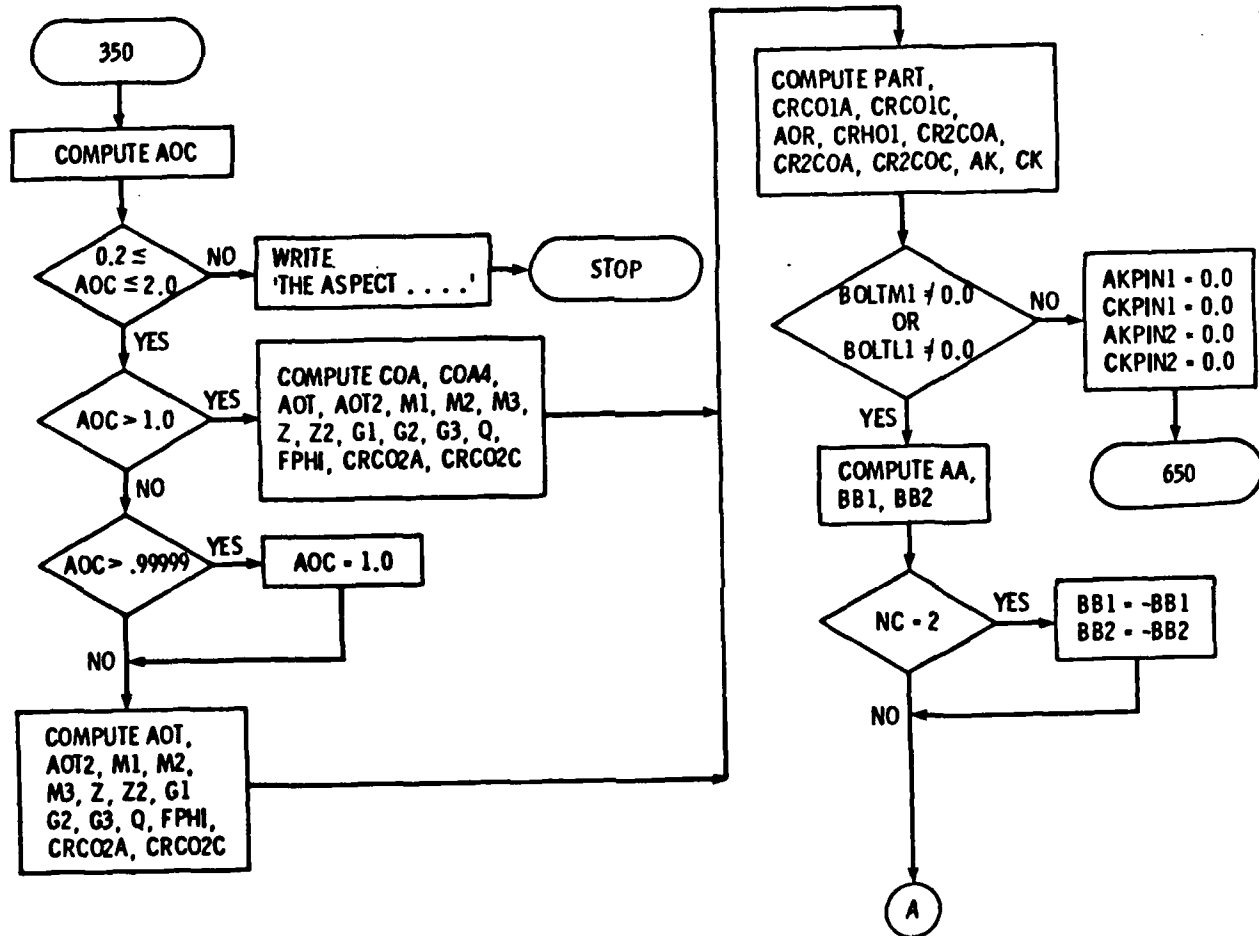


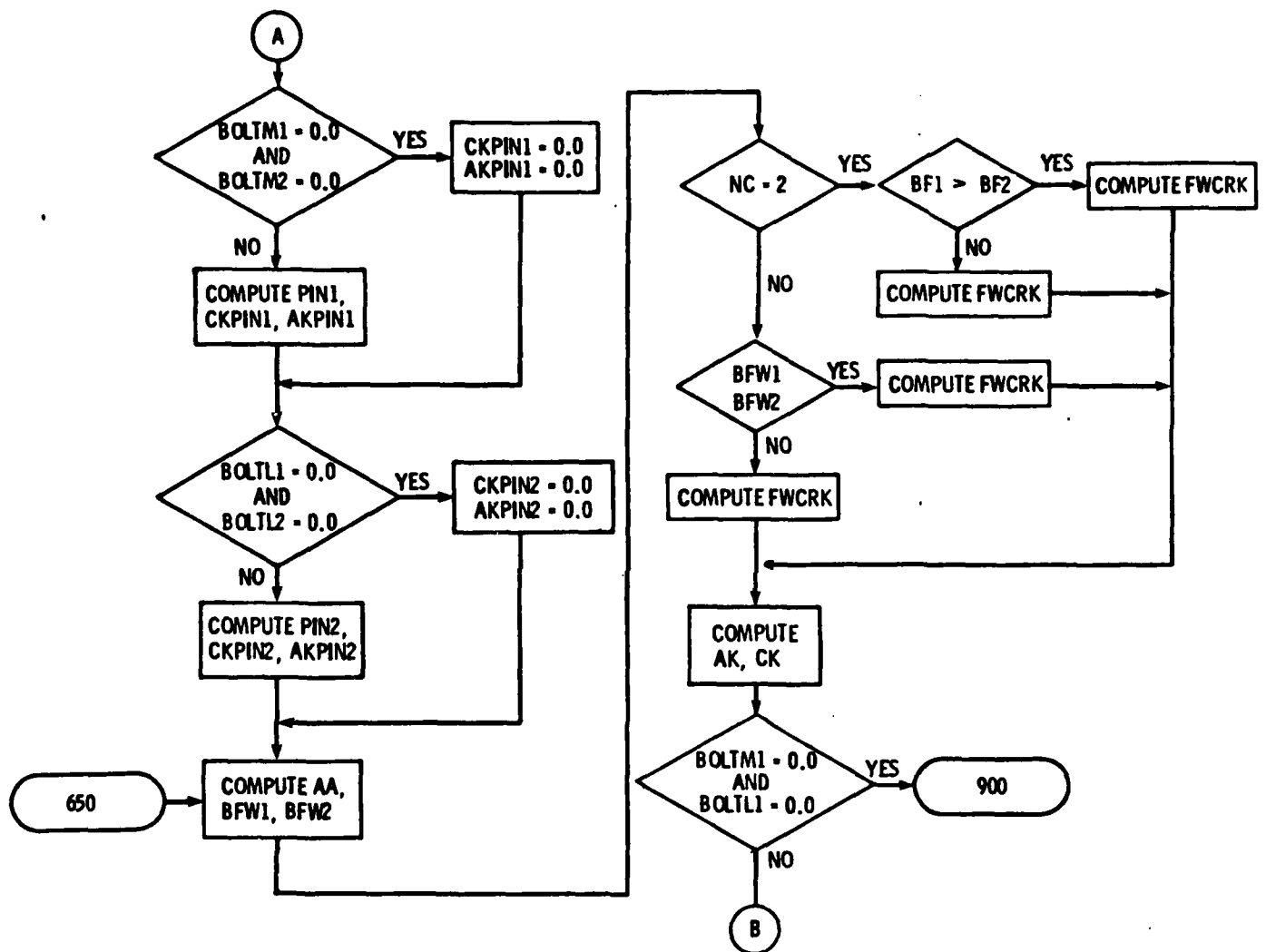


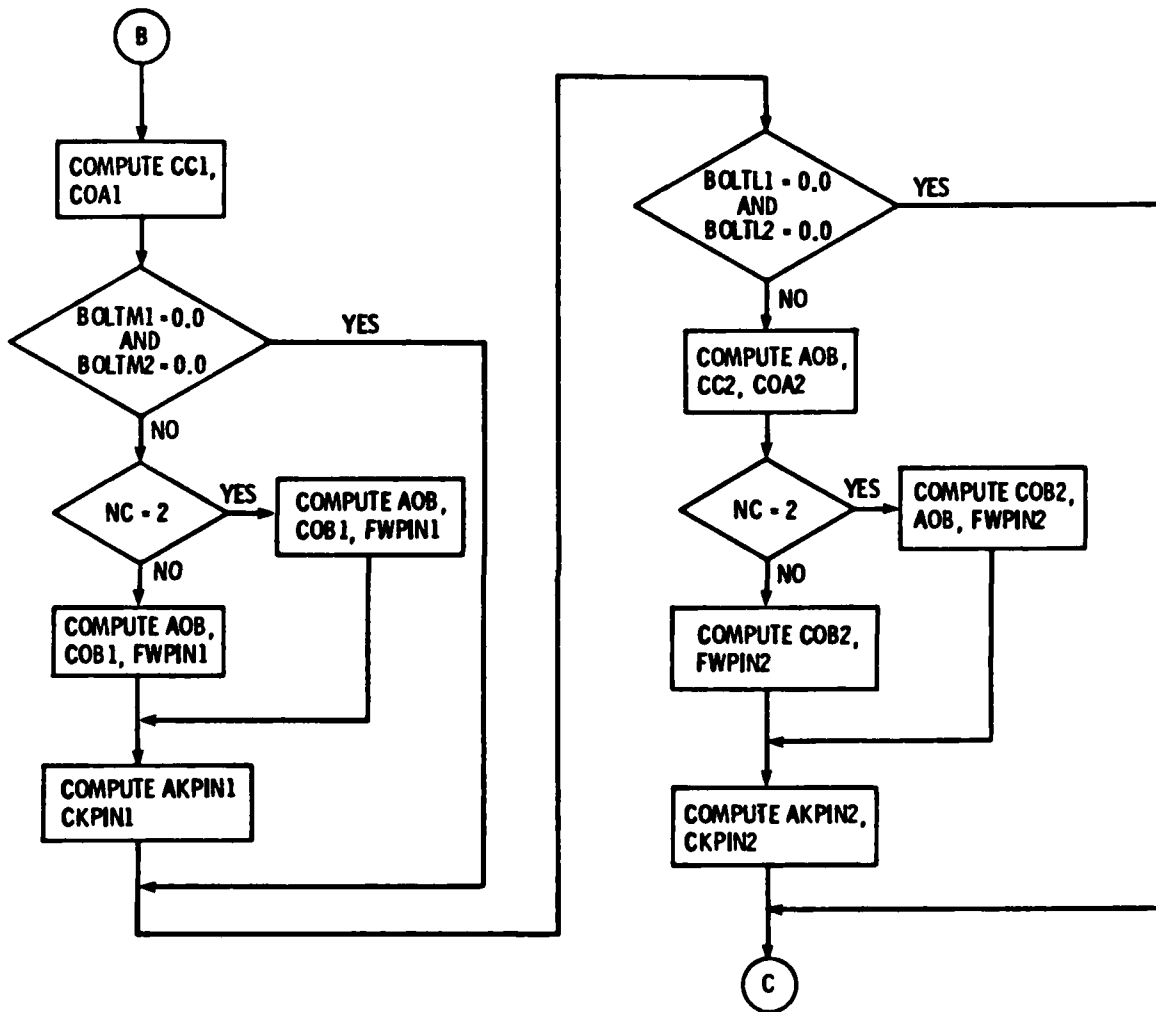


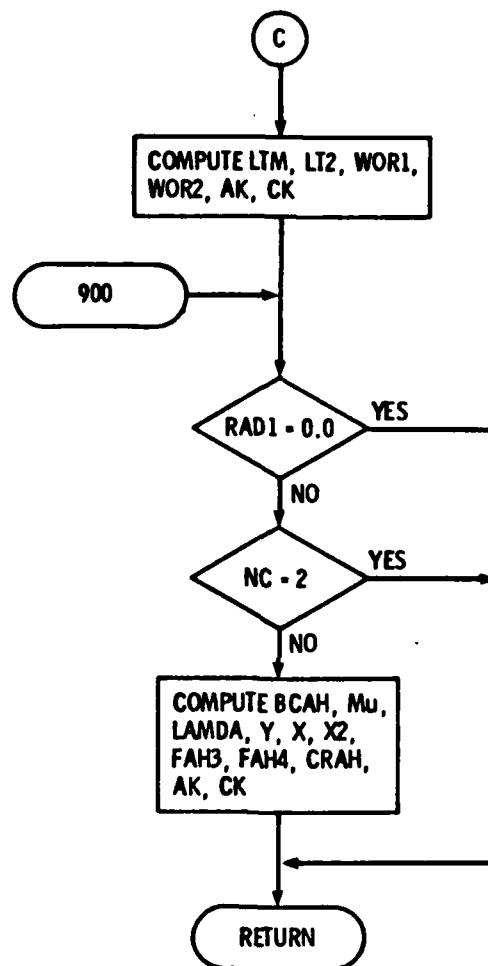


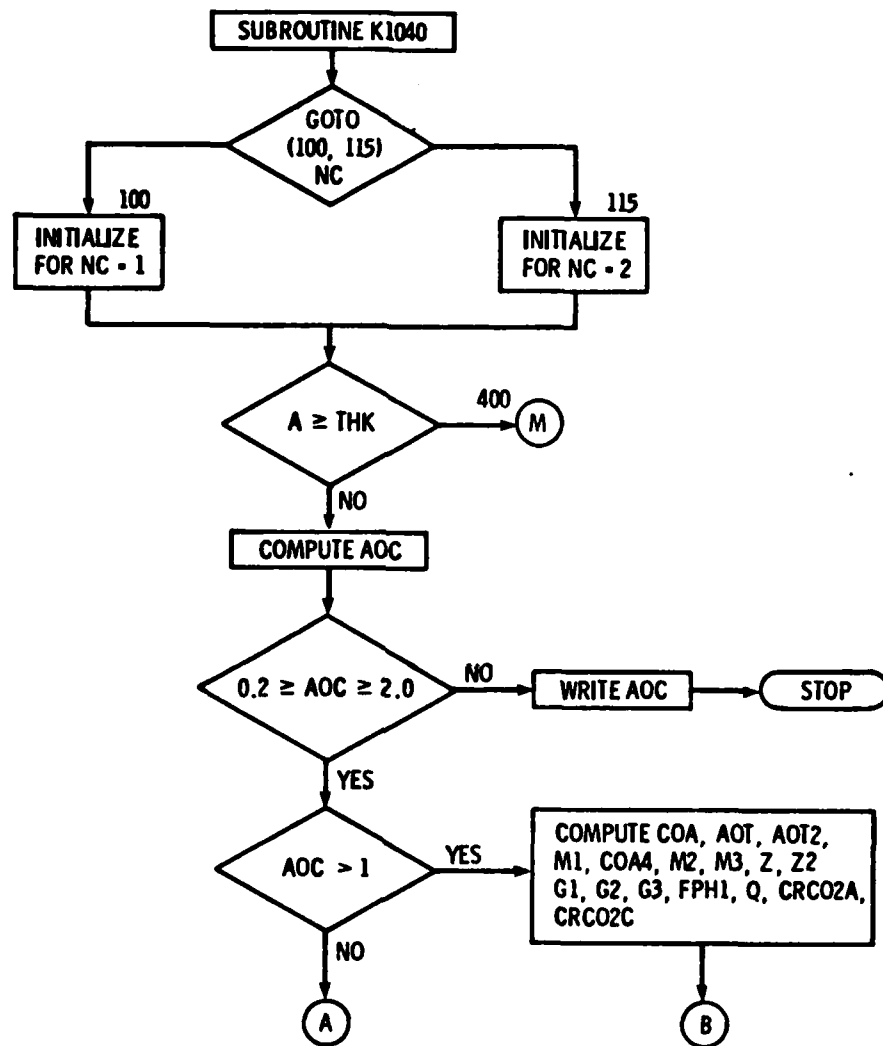


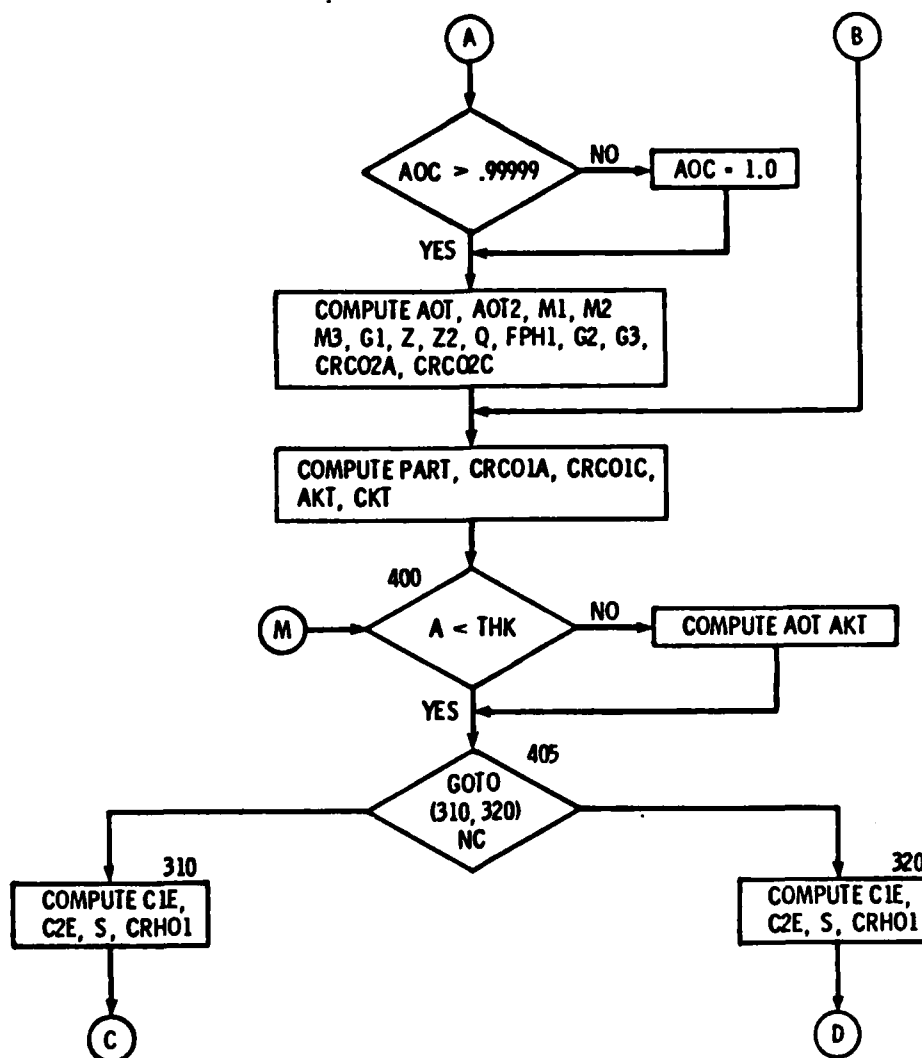


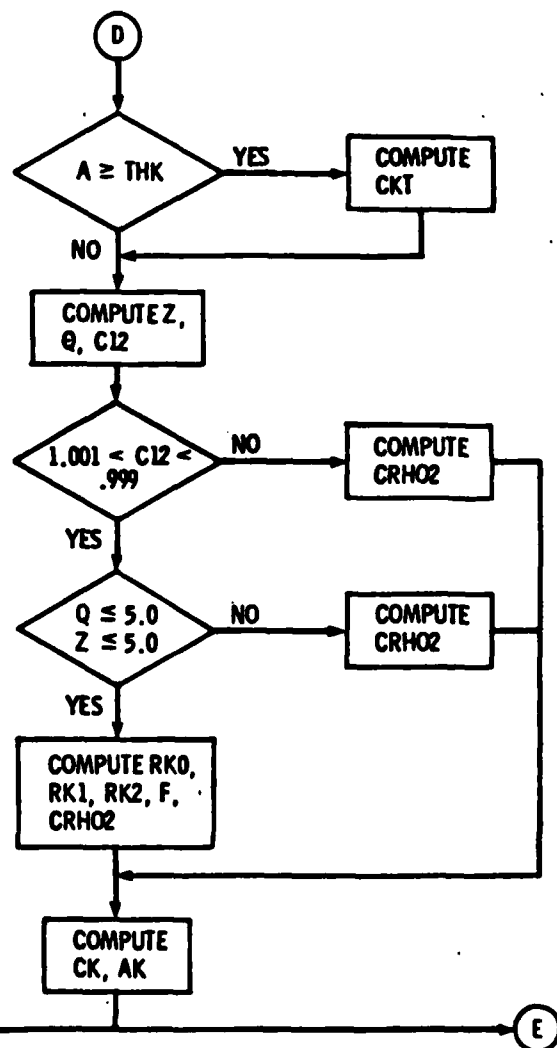
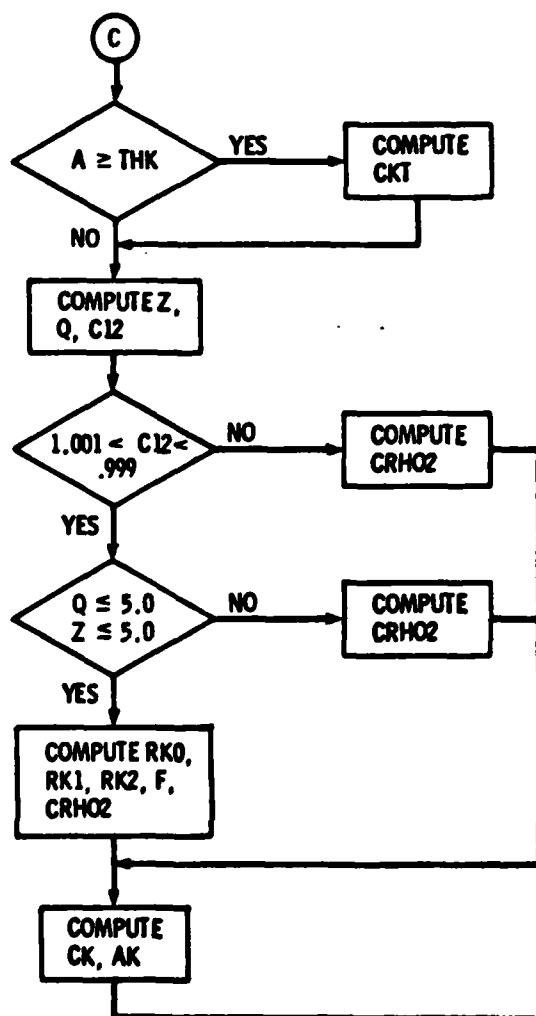


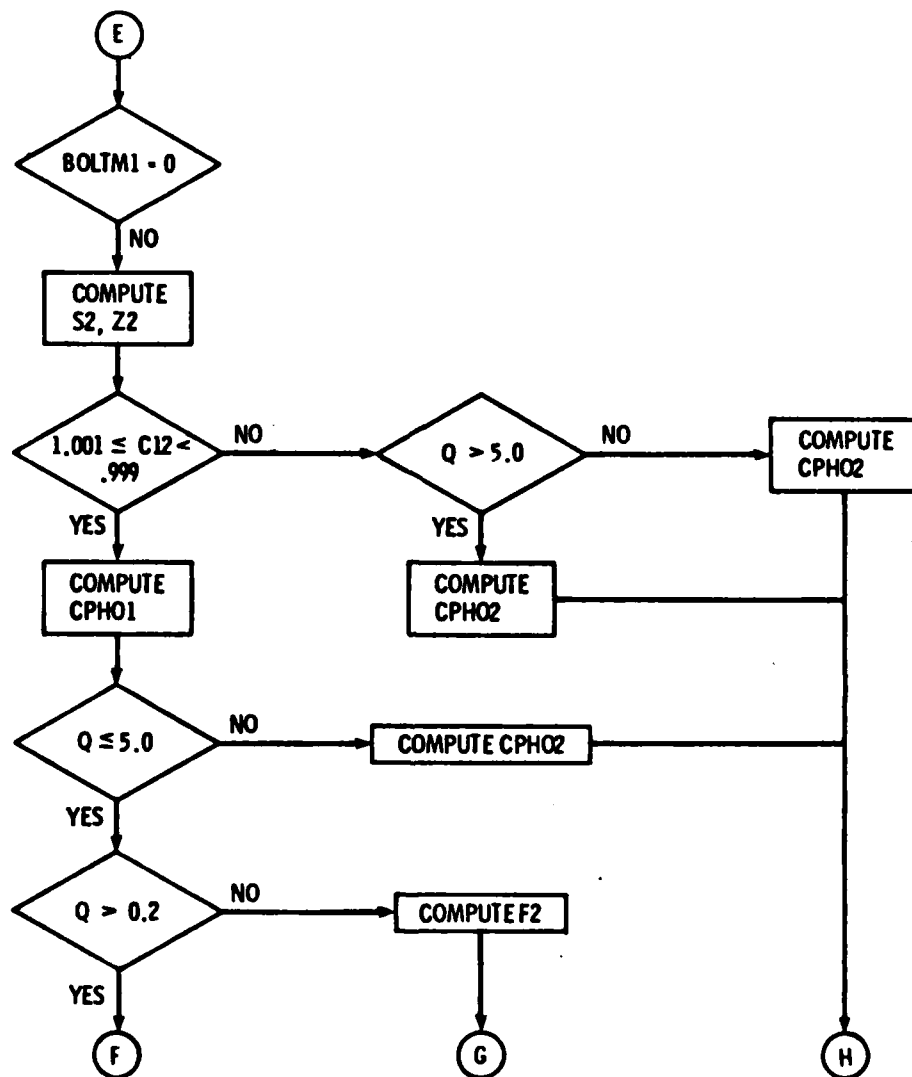


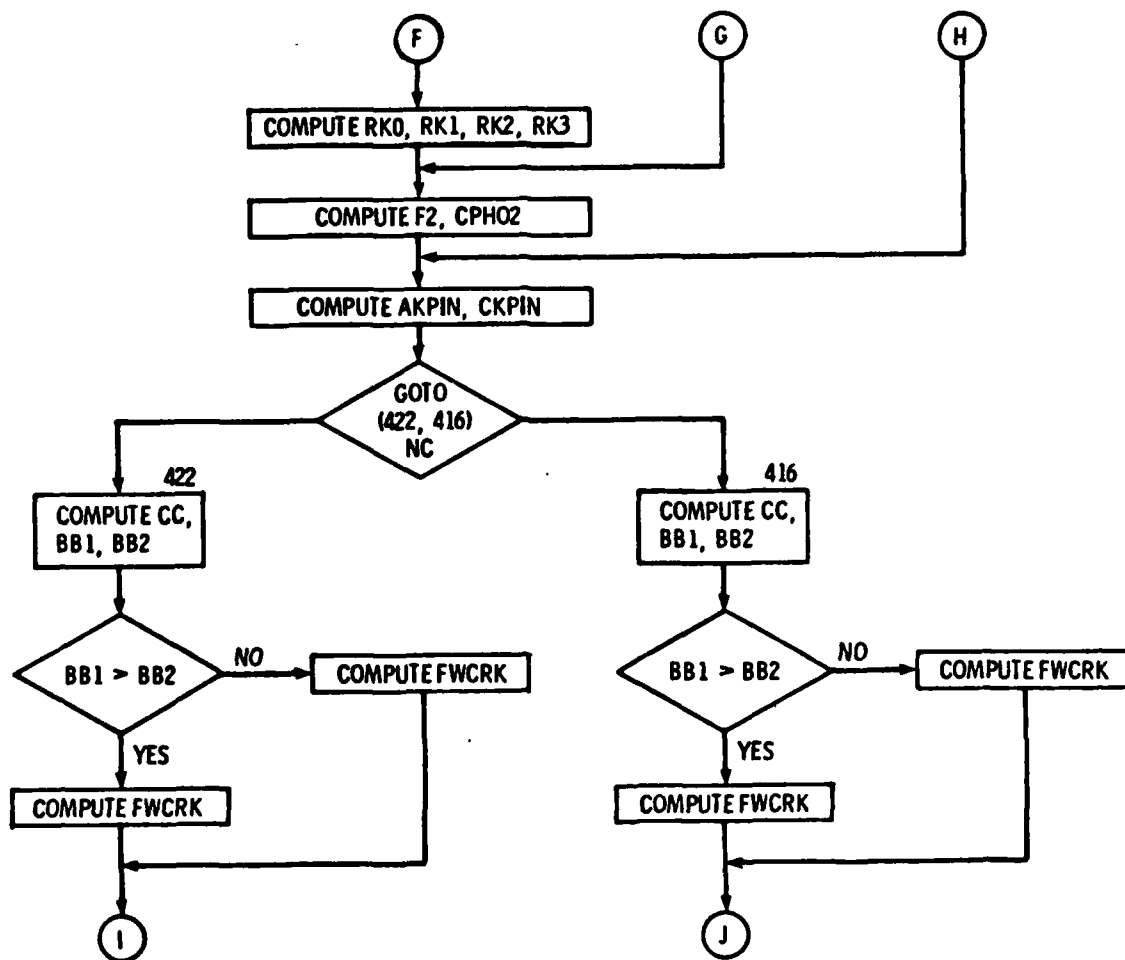


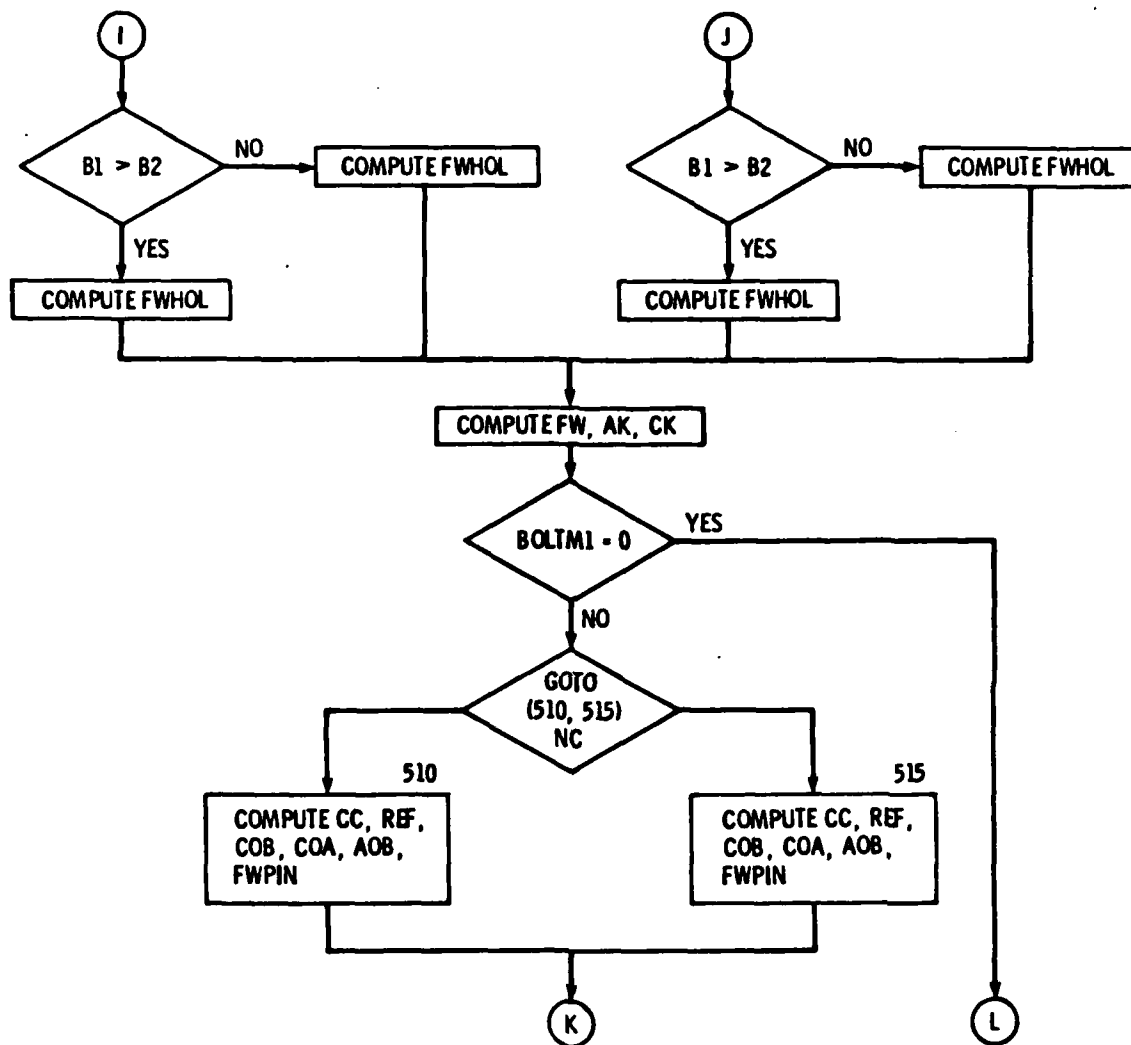


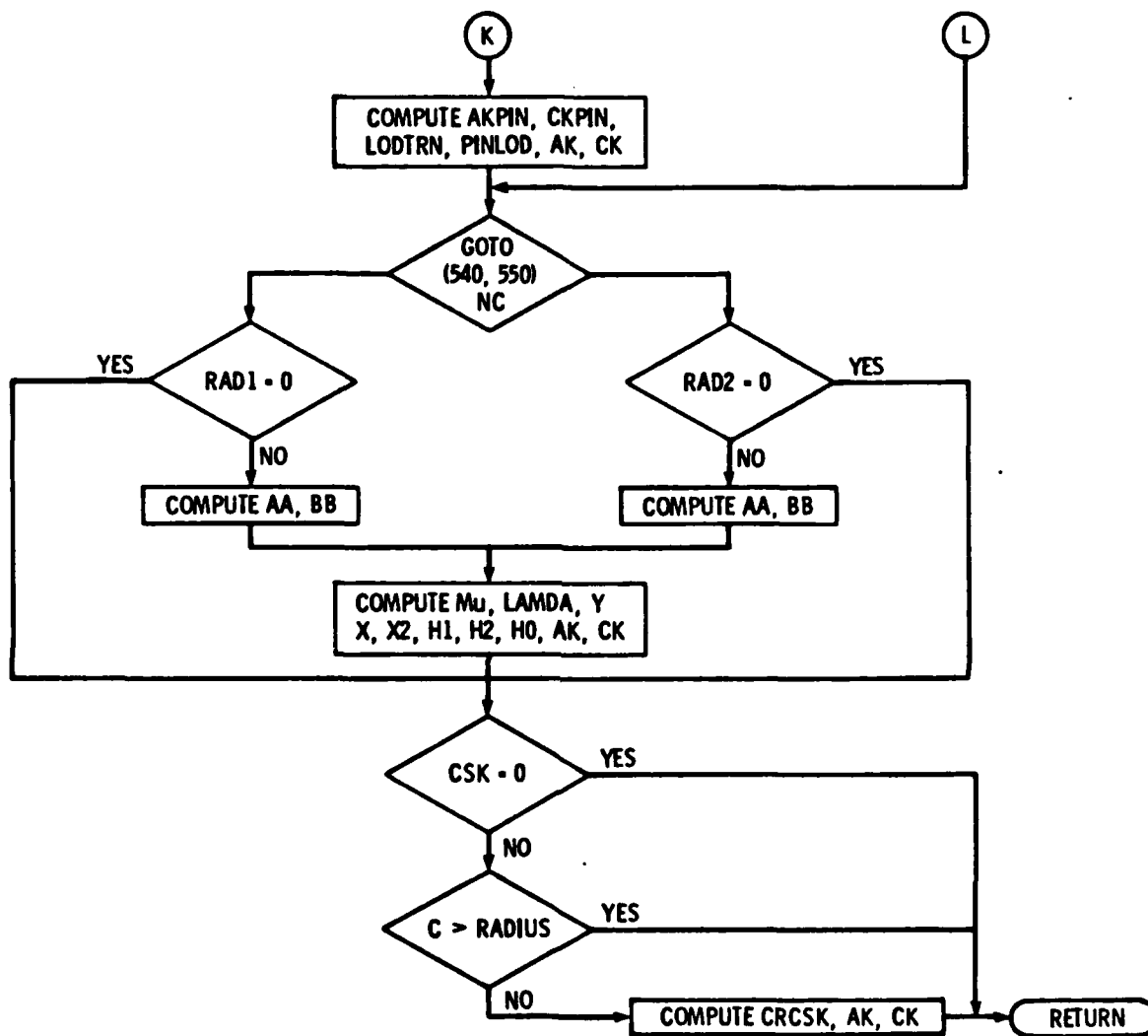


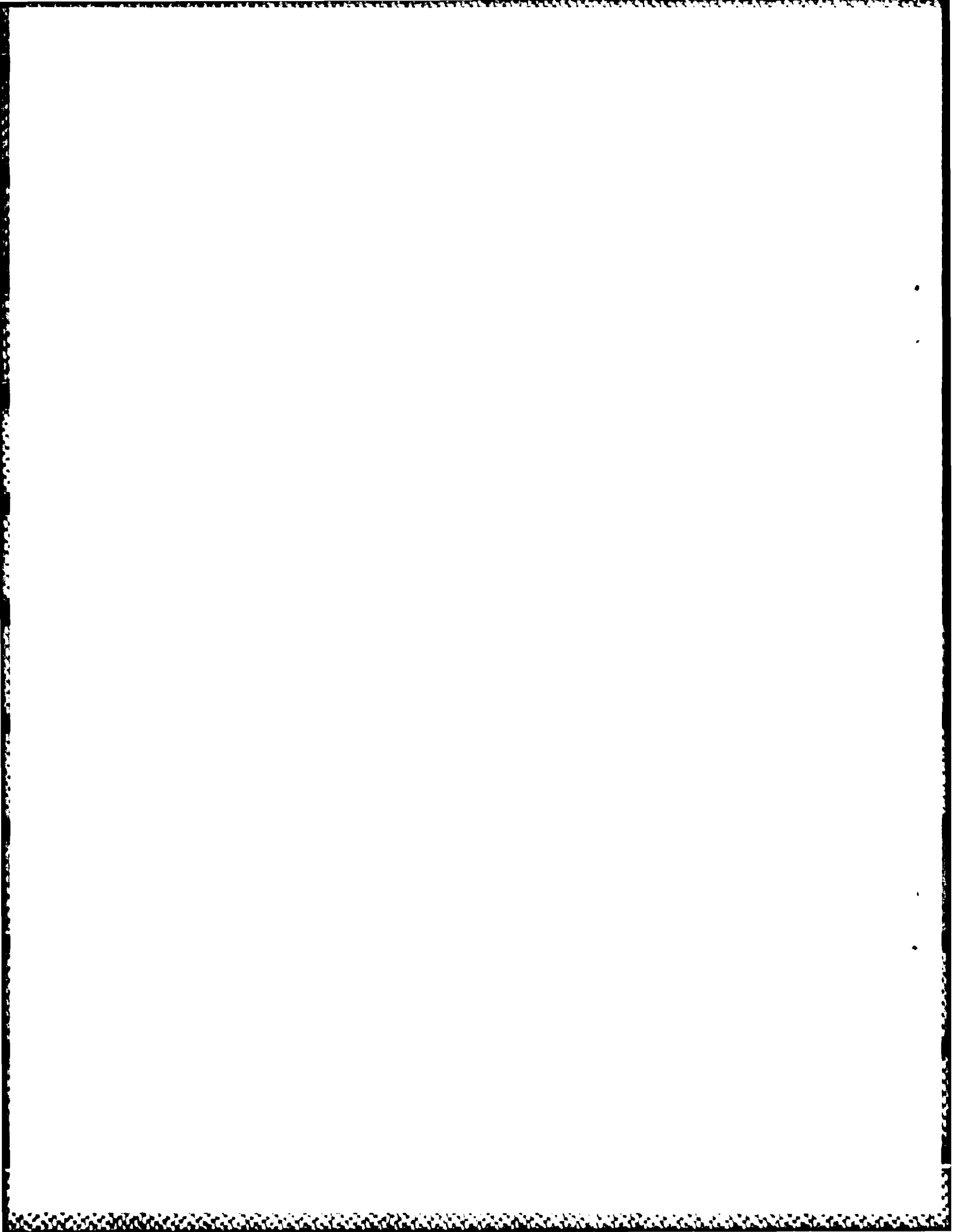


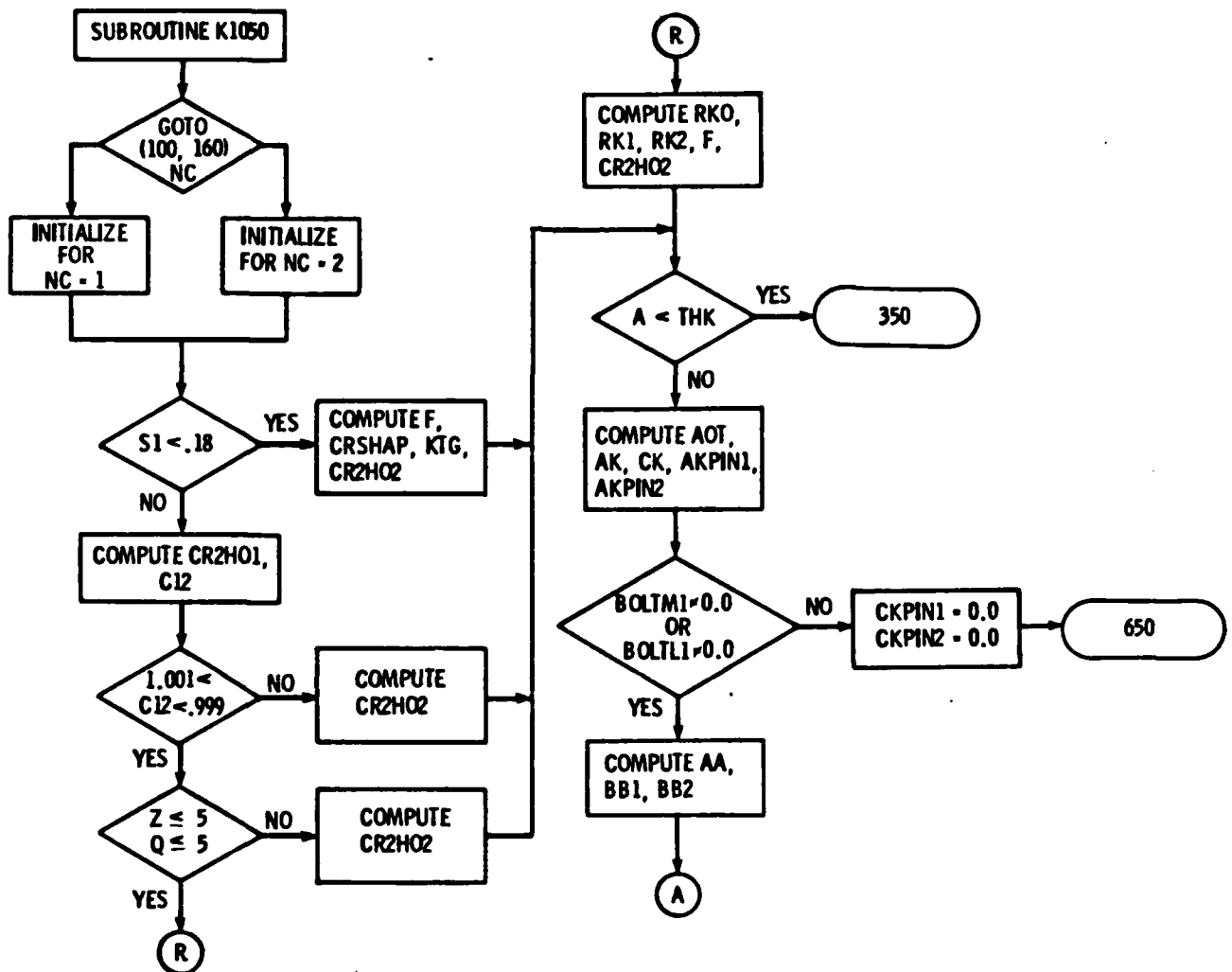


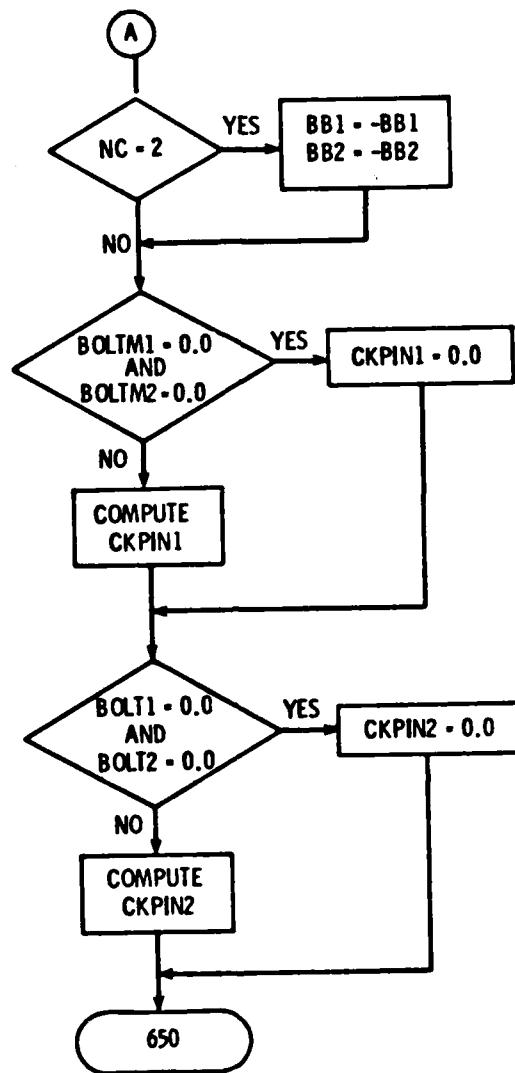


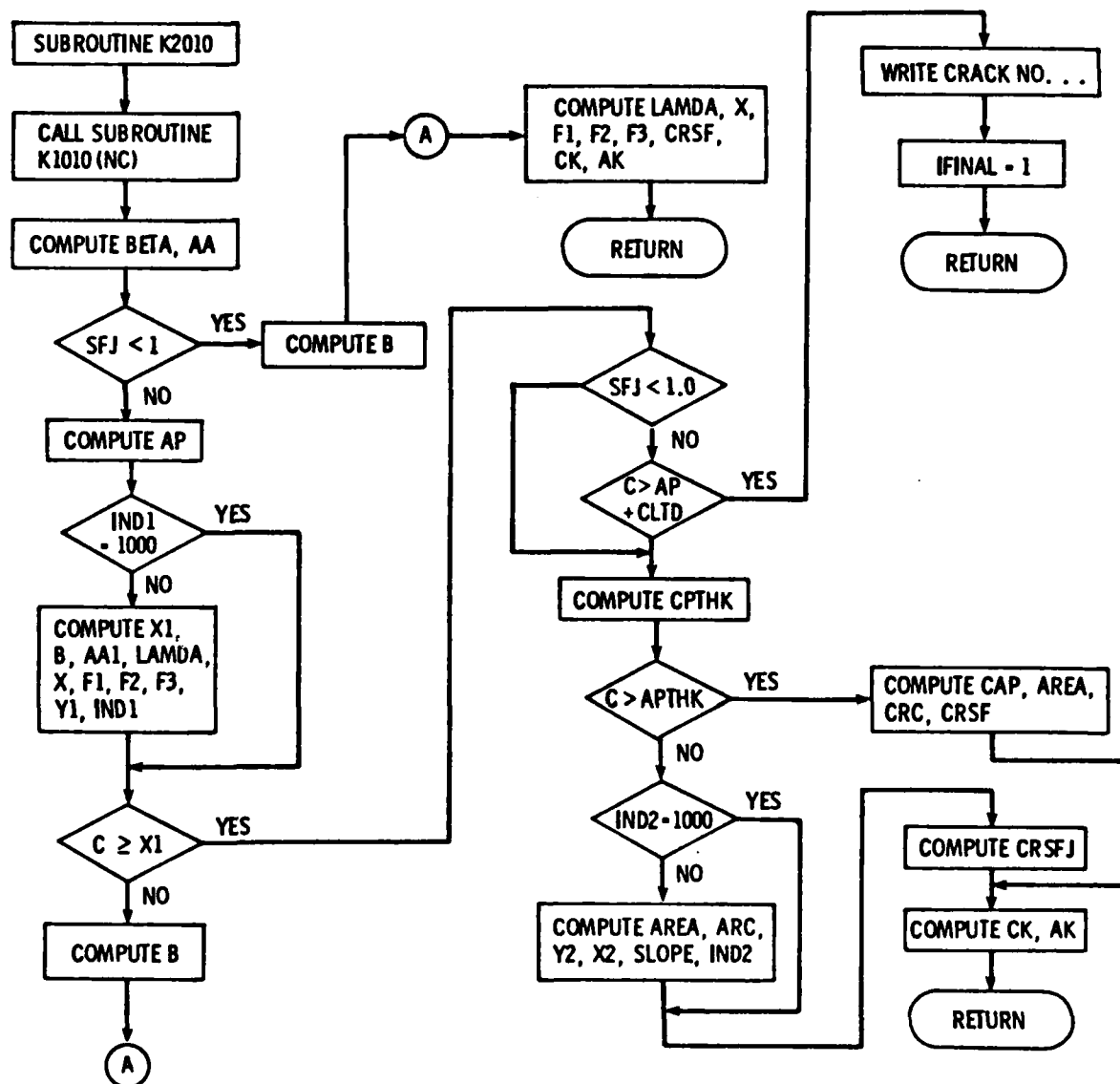


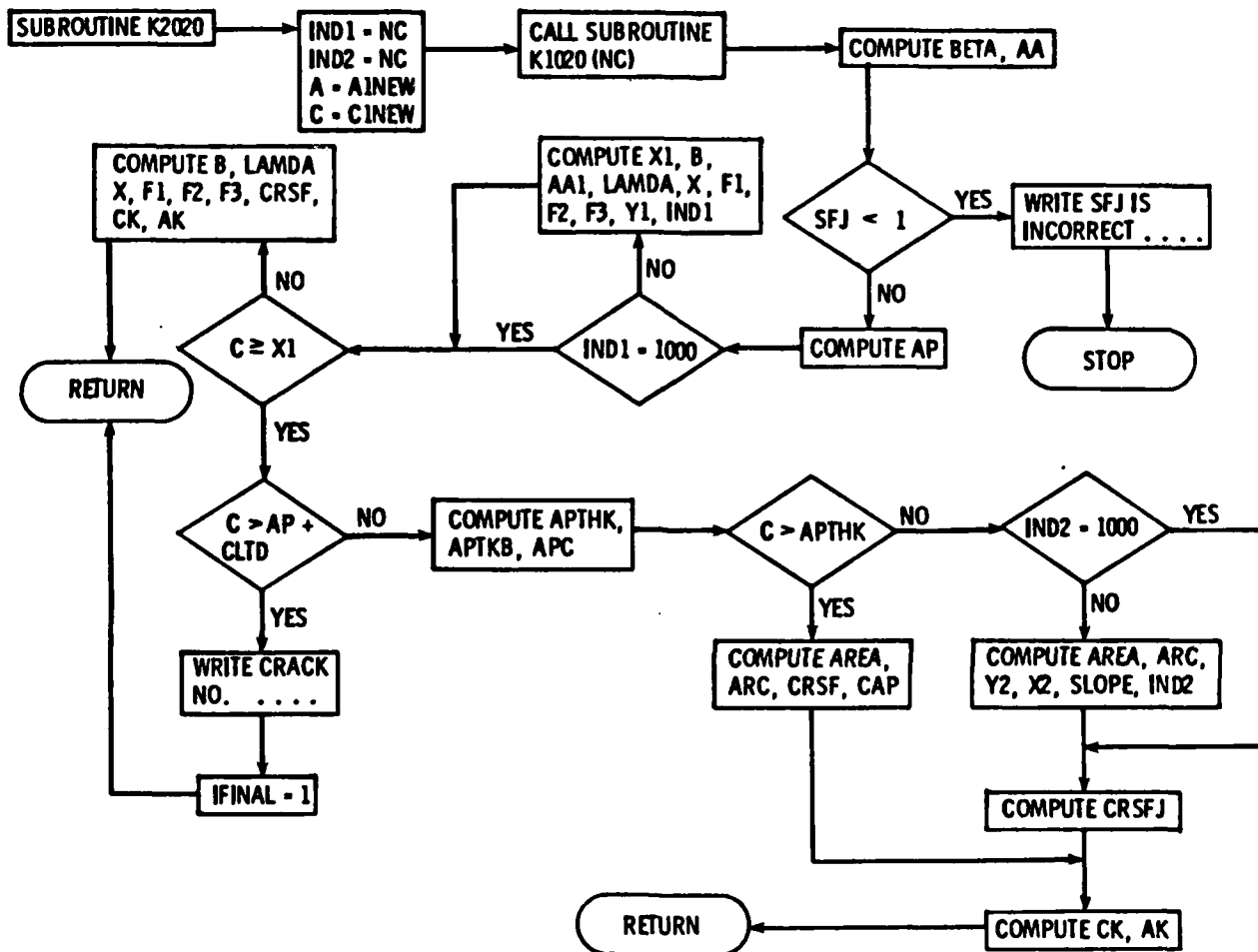


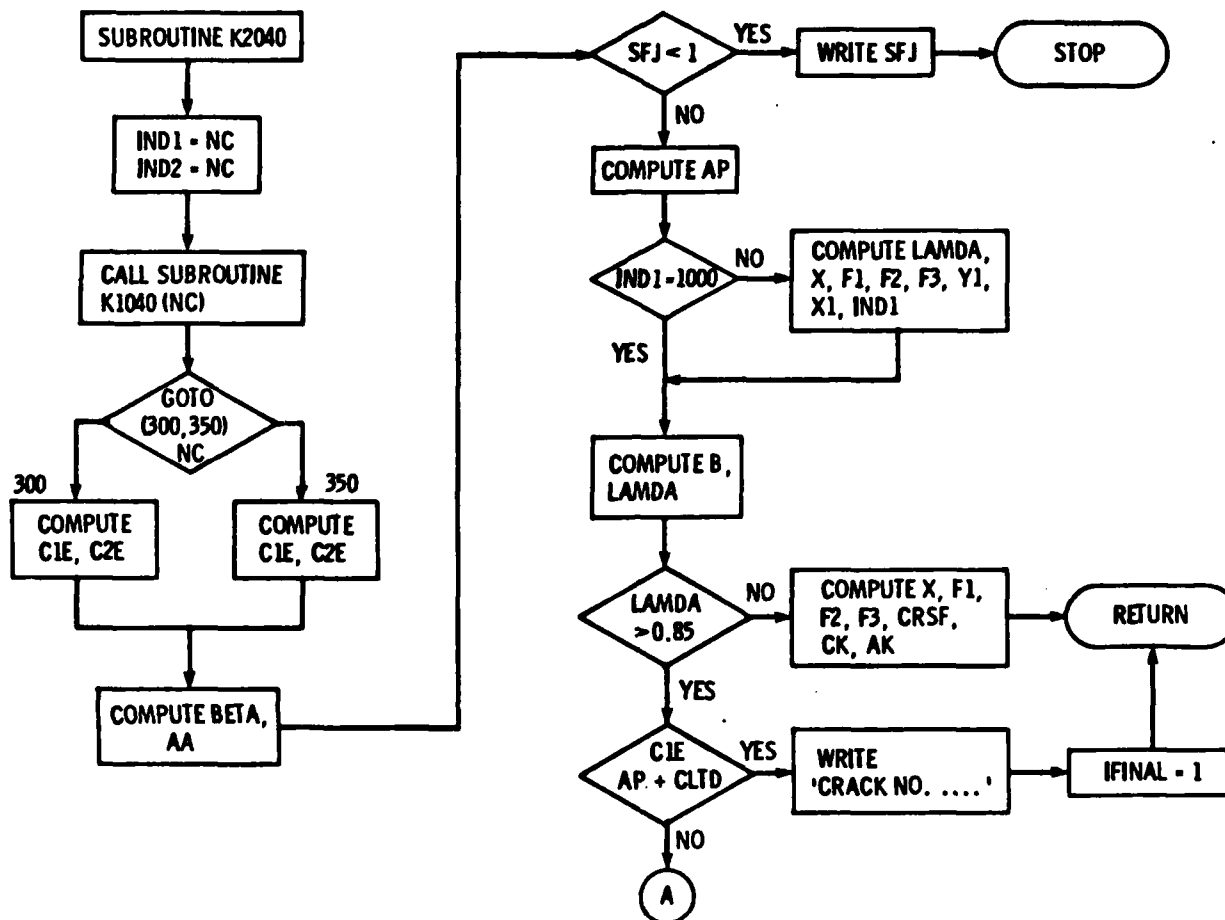


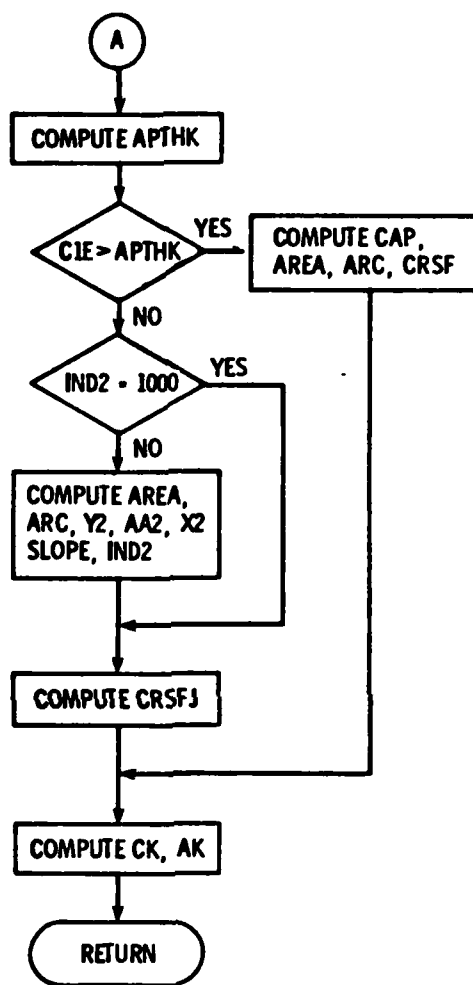


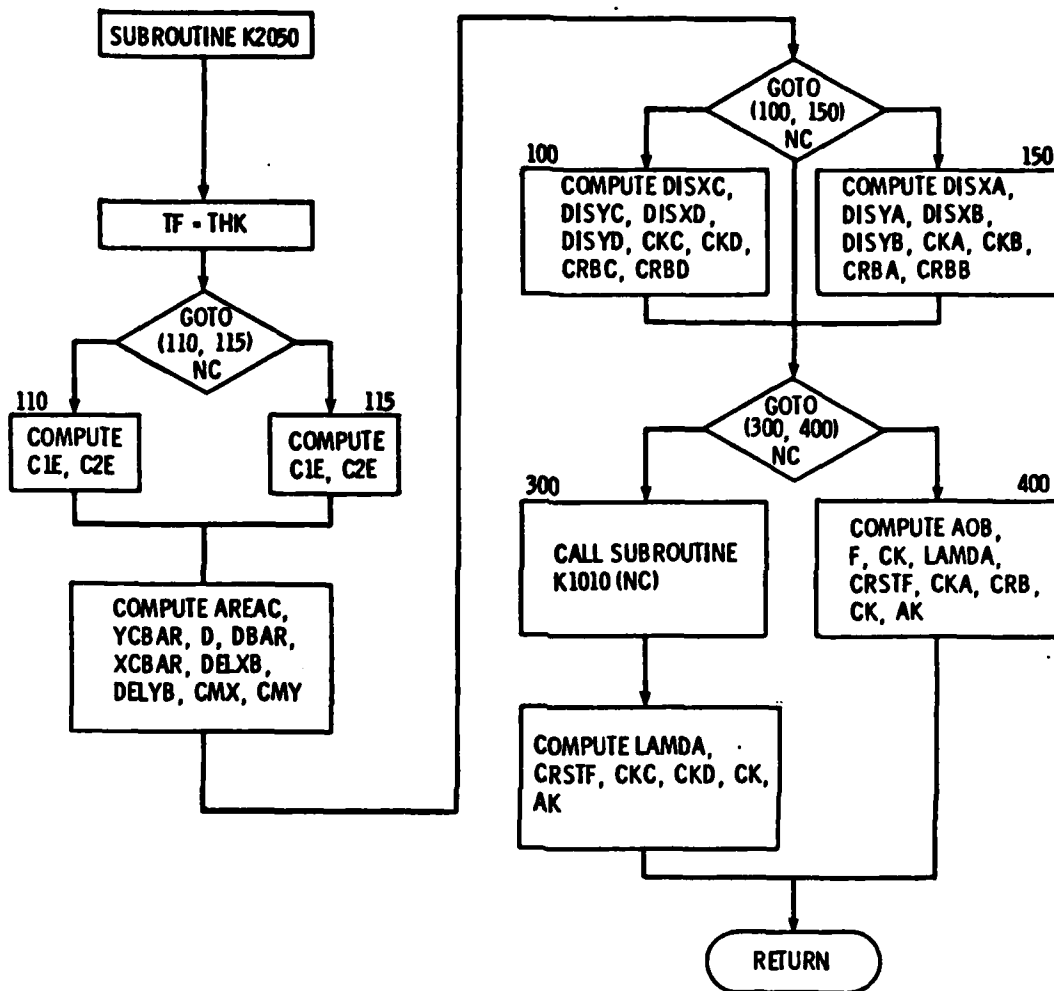


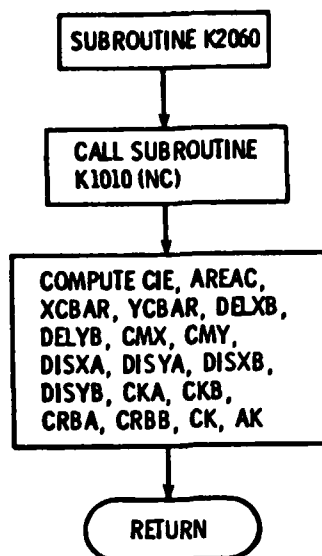




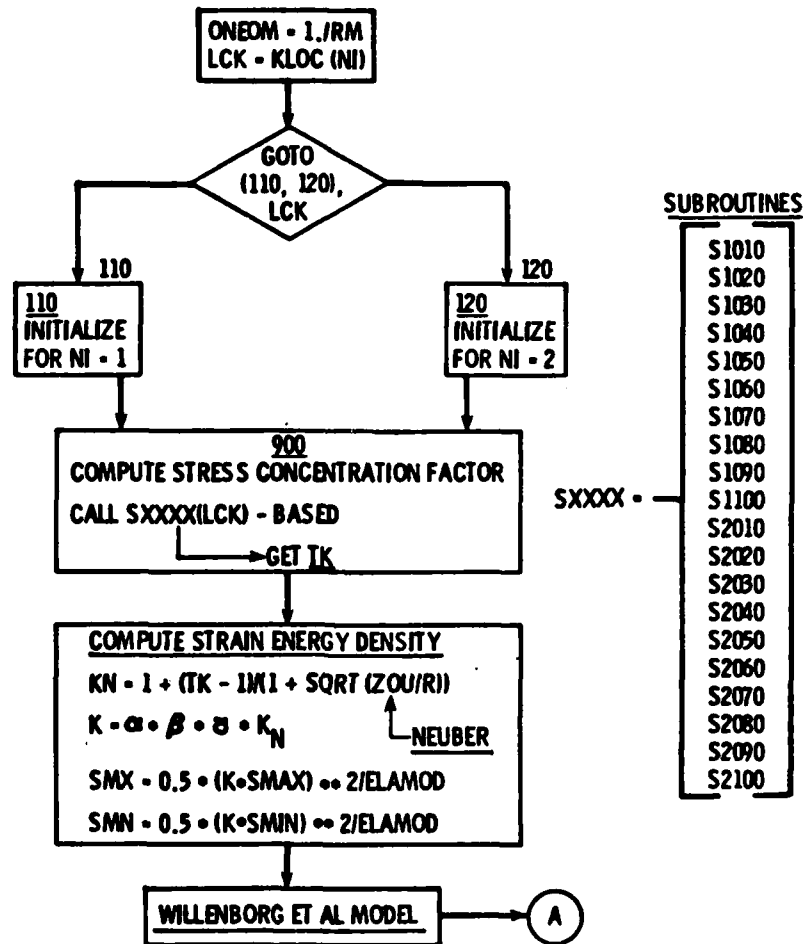


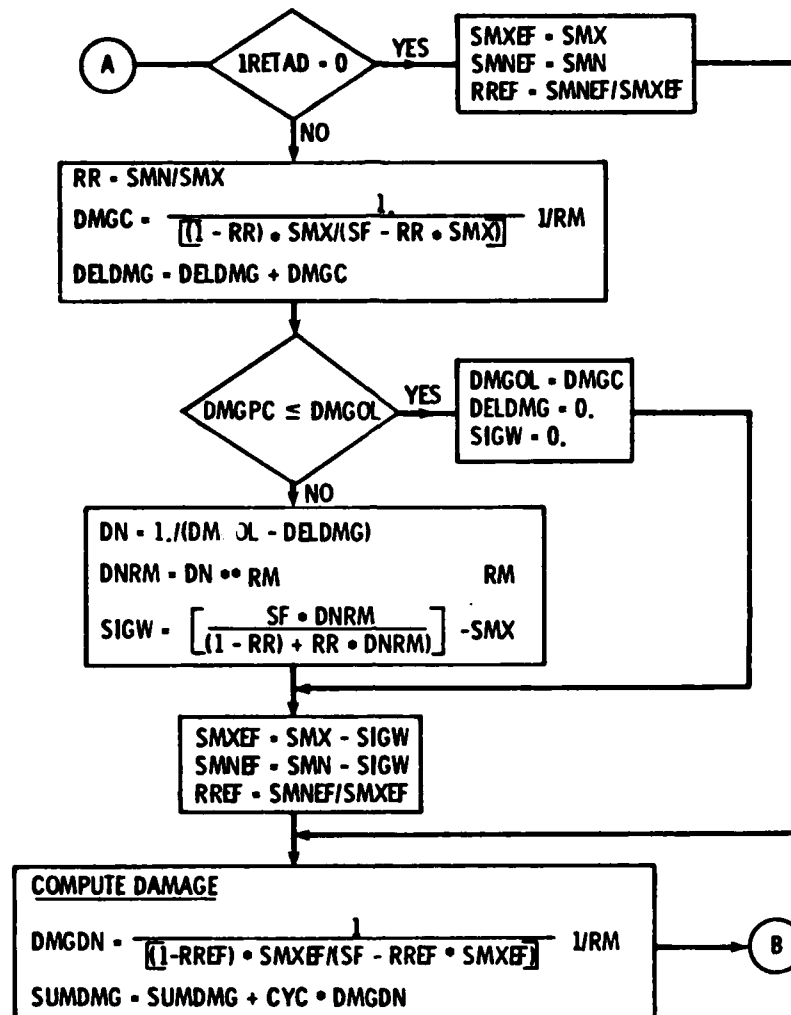


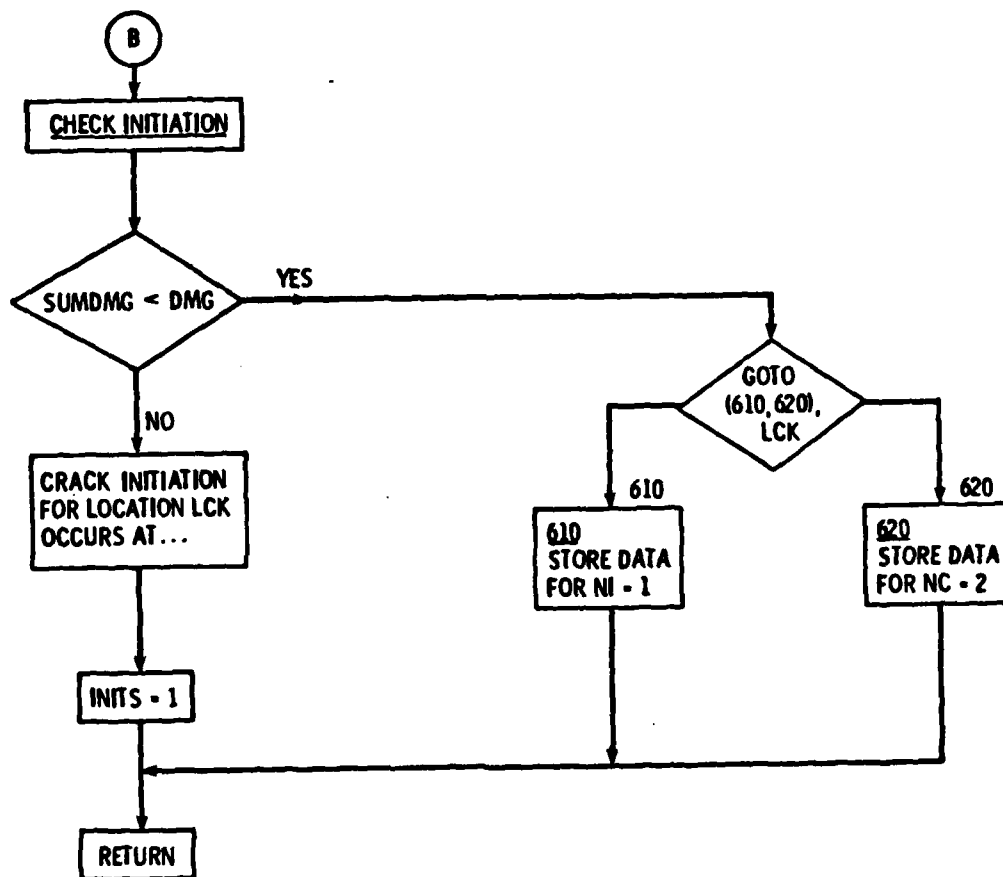


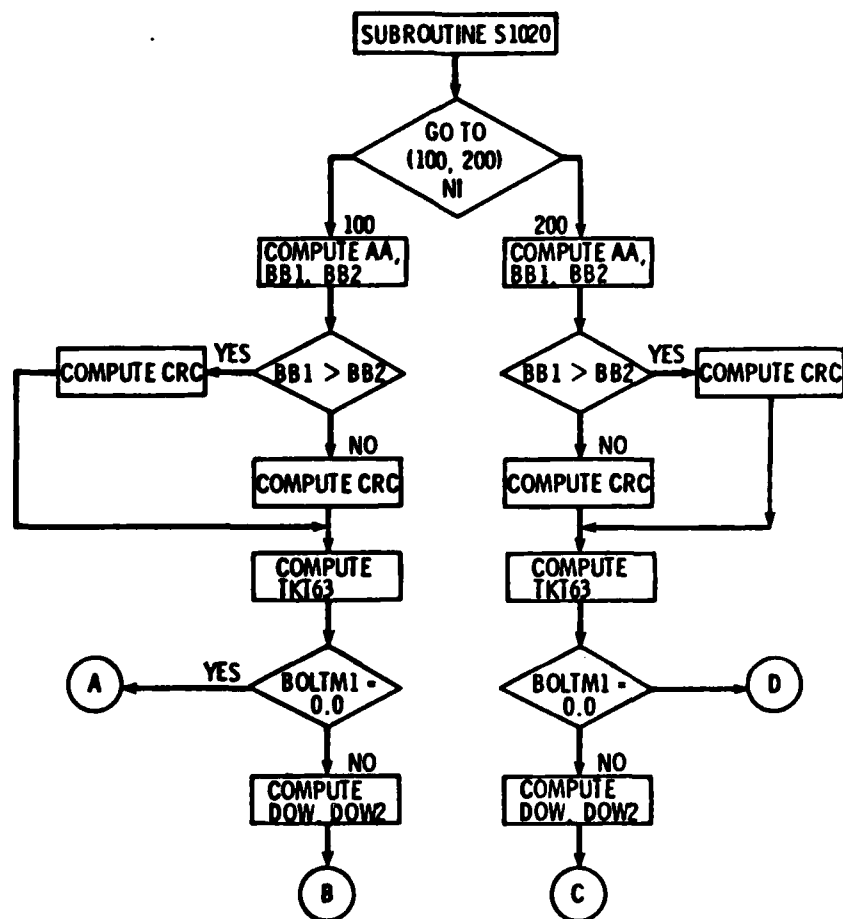


SUBROUTINE INIT (NB, NS, NC, SIGMAX, SIGMIN, CYC, INITS)









SUBROUTINE S1020

