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User's Manual for the CORTES Graphics Package GRFPAK

P. G. Fowler
J. W. Bryson

Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Under Interagency Agreements ERDA 40-551-75 and 40-552-75

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P. G. Fowler
Computer Sciences Division

J. W. Bryson

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NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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Prepared by
OAK RIDGE NATIONAL LABORATORY
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FOREWORD

The work reported here was performed at the UCC-ND Computer Sciences Division and the Oak Ridge National Laboratory (ORNL) in support of the ORNL Design Criteria for Piping and Nozzles Program being conducted for the U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research. E. K. Lynn of the Metallurgy and Materials Branch, Division of Reactor Safety Research, USNRC, is the cognizant RSR engineer, and S. E. Moore, of the Oak Ridge National Laboratory Engineering Technology Division (formerly Reactor Division), is the program manager.

The objectives of the ORNL Design Criteria Program are to conduct integrated experimental and analytical stress analysis studies of piping system components and pressure vessel nozzles in order to confirm and/or improve the adequacy of structural design criteria and analytical methods used to assure the safe design of nuclear power plants. Activities under the program are coordinated with other safety-related piping and pressure vessel research through the Design Division, Pressure Vessel Research Committee (PVRC) of the Welding Research Council, and through the ASME Boiler and Pressure Vessel Code Committee. Results from the ORNL program are used by appropriate codes and standards groups in drafting new or improved rules and criteria.

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P. G. Fowler J. W. Bryson

ABSTRACT

This report provides necessary user information to implement and use a graphics package for the CORTES finite-element computer programs. Complete input instructions are provided. Sample input and output are given in the appendices.

1. INTRODUCTION

The CORTES[1,2,3] (California, Oak Ridge TEeS) graphics package described in this report has been developed by the Computer Sciences Division in collaboration with the Oak Ridge National Laboratory Engineering Technology Division under the Design Criteria for Piping and Nozzles Program. This package is available on a nonproprietary basis and is intended to be used on the recipient's in-house computing facilities. CORTES is a series of five finite-element computer programs designed specifically for the analysis of piping tee joints and single nozzles in pipe and cylindrical vessels subjected to a variety of mechanical and thermal loadings. The five programs are CORTES-SA (Stress Analysis), -THFA (Transient Heat Flow Analysis), -SHFA (Steady State Heat Flow Analysis),-TSA (Thermal Stress Analysis), and -EP (Elastic-Plastic Analysis). These programs are available upon request from the Argonne Code Center, Argonne National Laboratory. They were originally developed for the analysis of ANSI B16.9 Standard piping tees but are also applicable to a wider range of joint geometries including reinforced and unreinforced nozzles in cylindrical pressure vessels.

The CORTES graphics package includes three plotting routines which greatly facilitate analyzing, interpreting, and presenting the results from the CORTES programs. One plotting routine displays stresses or stress indices by means of contour curves drawn within either the outside or inside surface outline of a quarter section of the tee-joint. Using this routine, one can also obtain plots of the finite-element mesh as viewed from any point in space. A second plotting routine gives a stress versus distance plot along any specified line or stringer of nodes. A third routine displays cross-sectional views of the finite-element mesh for both the undeformed (original) and deformed configuration. The deformed configurations are drawn using an exaggerated scale specified by the user.

2. PROGRAMMING DISCUSSION

2.1 Specifics

The CORTES GRAPHICS PACKAGE is written in FORTRAN for the IBM models 75, 91, and 195 and for the CALCOMP pen-and-ink plotters. Modification of the program so that other plotters may be used can be easily accomplished as discussed in detail in section 2.4.

A vector storage scheme has been used which allows the user to dimension the working storage area in a very convenient manner. This allows the user to change the amount of computer memory required by simply changing the dimension of an array in a small main program.

2.2 Core Requirements

Since the CORTES GRAPHICS PACKAGE consists of three programs which may be independent of the others, the user is able to use the overlay feature of the IBM linkage editor. This will reduce the amount of storage needed to run the program. The overlay structure is described in Appendix A.

The amount of core required for the execution of the program depends primarily on the number of nodes and elements in the finite element idealization. The amount of core used can be increased or decreased by changing the value of the program variable MTOT and dimensioning the A array by MTOT in the MAIN program. The value of MTOT should be greater than or equal to the following:

1. For contour and displacement plots

   MTOT $\geq$ 22 * NUMNPS + 4 * NUMELS,

2. For mesh plots,

   MTOT $\geq$ 19 * NUMNPS + 4 * NUMELS,

3. For node line plots,

   MTOT $\geq$ 12 * NUMNPS + 4 * NUMELS,

4. For cross section plots

MTOT > Maximum (7.5 * NUMNPS + 3 or

3 * NW + 16 * NMAX + 2),

where NUMNPS = number of nodes on a surface

NUMELS = number of elements on a surface

NMAX = maximum number of nodes along one surface of the cross sections

NLAYER = number of layers through the cross section

NW = NMAX * NLAYER * 2

The amount of core needed for the program to run on the IBM 360 model 195, excluding the A array, is estimated to be as follows:

1. For contour, mesh, and displacement plots--160K (No contour plots - 101K Bytes)

2. For node line plots--72K bytes

3. For cross section plots--67K bytes

These estimates were obtained from compilations on release 21.6 of the H-level compiler (OPT=2).

2.3 I/O Units

The CORTES GRAPHICS PACKAGE requires two data sets which are obtained by running the CORTES programs. Logical unit 12 contains the connectivity of the nodes, the coordinates at the nodes, and the stress quantities (temperature quantities for THFA). Logical unit 16 contains the displacements at the nodes for each load case. Only CORTES SA and EP output displacements; therefore, requests for plots relating to displacements are invalid for the other CORTES programs (TSA, THFA, and SHFA).

A temporary data set is required for reading and writing when requesting cross section plots. This data set is referred to as logical unit 13.

2.4 Modifying the Program for Other Plotters

All of the plotter software calls are channeled through one of the several multiple entries in subroutine PLTINT. If one wishes to modify the program to make use of another plotter, five statements need to be replaced with equivalent statements for the new plotter. These statements occur in subroutine PLTINT and are as follows:

1. CALL PLOTS(DATA,1200,1)

   This call performs initialization of the routine and is executed only once. The first argument indicates a buffer of length 1200 words (second argument).

2. CALL PLOT(X,Y,MODE)

   MODE=3 - The pen will be lifted prior to execution of the movement to the (X,Y) position.

   MODE=2 - The pen will be lowered and a straight line drawn to the (X,Y) position.

3. CALL SYMBOL (X,Y,H,ISTR,THET,NCHAR)

   If NCHAR > 0, then the character string ISTR is drawn. Spacing between the characters is accomplished automatically and is one-half the width of the characters. The arguments are as follows:

   X is the abscissa in inches of the left edge of the first character to be drawn,

   Y is the ordinate in inches of the lower edge of the first character to be drawn,

   H is the height in inches of the characters to be drawn. The width of the character is four-sevenths of the height.

   ISTR is an array containing the alphanumeric characters to be drawn.

THET is the angle in degrees, expressed in floating point, at which the characters are to be written. THETA is measured counterclockwise from the positive X axis; hence for THETA=0.0, the characters are drawn left to right parallel to the X axis. If a string of characters is to be drawn at an angle other than 0.0, the entire string is rotated with the (X,Y) given in the calling sequence as the pivot point.

NCHAR is an integer which specifies the number of characters to be drawn.

If NCHAR= - 1, then a symbol is plotted.

The arguments are as follows:

X is the abscissa in inches of the center of the character.

Y is the ordinate in inches of the center of the character.

H is the height in inches of the character.

ISTR is an integer which determines which symbol is to be plotted.

THET is the angle of rotation as described above.

4. CALL NUMBER(X,Y,H,VAL,THET,FMT)

This is a subroutine to convert a machine format number to its decimal equivalent and plot it according to a specific format.

X,Y,H and THET are described above in the call to subroutine SYMBOL.

VAL is the variable name of the machine format number to be converted and plotted. The type (integer or real) must conform to the FORMAT specified.

FMT is a BCD argument or an array of alphanumeric characters specifying the format to be used. Examples of this argument are '(E12.5)', '(F8.3)', and '(I6)'.

5. CALL PLOT(XAX+5.0,0.0,-3)

This call ends the present plot and sets the origin of the next plot five inches to the right of the last plot.

3. CONTOUR, MESH, AND DISPLACEMENT PLOTTING

3.1 General Discussion

This segment of the CORTES GRAPHICS PACKAGE will produce contour curves of stresses or temperatures stored on input unit 12. The contour curves may be drawn within the projected outline of a surface of the joint or on the projected mesh of a surface of the joint. Plots of the original and displaced geometry from SA or EP may also be obtained. The entire finite element mesh of quadrilateral elements on a surface or any continuously numbered subset of quadrilateral elements can be considered for the plots. The latter allows the user to "zero in" on a particular area of interest.

3.2 Input for Contour, Mesh, and Displacement Plots

For programs SA, TSA, THFA, and SHFA, cards 1-10 should be input. For EP, cards 1-6 and cards 7EP-11EP should be input.

CARDS 1-10

Card (1) FORMAT (A4,1X,I5)

Variable	Description
PROG	CORTES program name for which plots are to be produced. Input the characters 'SA', 'TSA', 'EP', or 'THFA'.
NLOAD	Number of load cases output on logical unit 12 for SA. (Does not apply to TSA, EP and THFA.)

Card (2) FORMAT (2A4)

Variable	Description
FNCTN	Type of plots requested. Input the following: 'GRID' - Only the original mesh will be plotted. Only cards 1-6 need to be supplied.

'DISPLACE' - The displaced mesh will be plotted. The original mesh may also be plotted as an option. Cards 1-7 and card 10 need to be supplied for SA. Cards 1-6 and Card 11EP need to be supplied for EP. ('DISPLACE' is valid only for SA and EP.)

'CONTOUR' - Contour plots, as well as displaced and original meshes, may be plotted.

Card (3) FORMAT (20A4)

Variable	Description
TITL	Title to be written on plots.

Card (4) FORMAT (4I5)

Variable	Description
NREP1	The number of the first finite element to use in the plots.
NREP2	The number of the last finite element to use in the plots.
IGRID(1)	Option to plot outer surface mesh. 0 means No 1 means Yes
IGRID(2)	Option to plot inner surface mesh. 0 means No 1 means Yes

Card (5) FORMAT (7E10.0)

Variable	Description
AX	Length in inches of the horizontal and vertical axes. (If 0.0, then the length is set to 10.0 inches.)
SCAL	Scaling factor. (If 0.0, then a scaling factor is computed.)
P1,P2,P3	The Cartesian coordinates of a point in space from which the surface is being viewed.

Card (6) FORMAT (14I5)
(Omit if FNCTN≠'CONTOUR')

Variable	Description
IOP1	IOP1=0 means that the contours are to be plotted on the surface outline. IOP1=1 means that the contours are to be plotted on the surface mesh.
ICONTR(1,1)	Option to plot contours for the outer surface of quadrant 1. 0 means No 1 means Yes
ICONTR(2,1)	Option to plot contours for the outer surface of quadrant 2. 0 means No 1 means Yes
ICONTR(3,1)	Option to plot contours for the outer surface of quadrant 3. (Applies only to SA and EP since these programs are the only two which calculate values for quadrant 3.) 0 means No 1 means Yes
ICONTR(4,1)	Option to plot contours for the outer surface of quadrant 4. (Applies only to SA and EP.) 0 means No 1 means Yes
ICONTR(1,2)	Same as ICONTR(1,1) except for the inner surface.
ICONTR(2,2)	Same as ICONTR(2,1) except for the inner surface.
ICONTR(3,2)	Same as ICONTR(3,1) except for the inner surface.
ICONTR(4,2)	Same as ICONTR(4,1) except for the inner surface.

Card (7) FORMAT (14I5)
(Omit if FNCTN = 'GRID')

Variable	Description
NT	Number of load cases (SA and EP) or time steps to be plotted.
(NTM(I),I=1,NT)	Load case numbers (SA and EP) that are written on logical units 12 and 16 or the positions on the logical unit of a particular time step (TSA and THFA).

Card (8) FORMAT(14I5)
(Omit if FNCTN≠'CONTOUR')

Variable	Description
(NC(I),I=1,N) where N=6 for SA, TSA and EP and N=1 for THFA	NC(1) - Number of contour values for T1 for SA, TSA, and EP - Temperature for THFA NC(2) - Number of contour values for T2 NC(3) - Number of contour values for T12 NC(4) - Number of contour values for TMAX NC(5) - Number of contour values for TMIN NC(6) - Number of contour values for stress indices For definitions of T1, T2, T12, etc., see Ref. 1.

Card (9) FORMAT (T73,A8,T1,(7E10.0))
(Omit if NC(J)=0)

Variable	Description
STRES(J)	Eight character description of contours that are being plotted. This can be in columns 73-80 of all cards 9.
(CV(I,J),I=1,NC(J)) J=1,6 for SA,TSA and EP J=1 for THFA	Contour values to be plotted for STRESS(J)

Card (10) FORMAT (2I5,E10.0)
(Omit if FNCTN = 'GRID')

Variable	Description
IDISP(1)	Option to plot outer surface displacement mesh. 0 means No 1 means Yes
IDISP(2)	Option to plot inner surface displacement mesh. 0 means No 1 means Yes
DISPIN	Maximum dislacement in plotter inches. (Leave blank if displacement plots are not requested.)

A card with the characters 'END' in columns 1-3 should be placed at the end of the data. One may then input data beginning with a "Card 2" as described in sections 3, 4, and 5. If no other plots are to be requested, then another card with the characters 'END' should be placed at the end of the input stream.

CARDS 7EP-11EP

These cards should be repeated for each load case that is to be plotted for EP. Cards 1-6 should not be repeated.

Card (7EP) FORMAT (4I5)

Variable	Description
LC	Current load case to be plotted.
MNOLS	Maximum number of load steps for current case.
NQDS	Maximum number of quadrants.
NSTR	Symmetry code.

Card (8EP) FORMAT (16I5)

Variable	Description
NT	Number of load steps of current load case for contour and/or displacement plots.
(NTM(I),I=1,NT)	Load steps of current load case to be plotted.

Card (9EP) FORMAT (16I5)

Variable	Description
(NC(I),I=1,6)	Number of contour values NC(1) - Number of contour values for T1 NC(2) - Number of contour values for T2 NC(3) - Number of contour values for T12 NC(4) - Number of contour values for TMAX NC(5) - Number of contour values for TMIN NC(6) - Number of contour values for stress indices For definitions of T1, T2, T12, etc., see Ref. 2.

Card (10EP) FORMAT(T73,A8,T1,(7E10.0))
(Omit if NC(J)=0)

Variable	Description
STRES(J)	Eight character description of contours that are being plotted. This can be in columns 73-80 of all cards (10EP).
(CV(I,J),I=1,NC(J))	Contour values to be plotted for STRES(J) for the load steps of the current load case.

CARD (11EP)

Variable	Description
IDISP(1)	Option to plot outer surface displaced mesh for the load steps of the current load case. 0 means No 1 means Yes
IDISP(2)	Option to plot inner surface displaced mesh for the load steps of the current load case. 0 means No 1 means Yes
DISPIN	Maximum displacement in plotter inches. This applies to the load steps of the current load case.

Cards 7EP-11EP should be repeated for as many load cases as plots are requested. To indicate that the last load case has been requested, place a blank card after the last card (11EP). If a different type of plot is needed, i.e., 'NODE','XSEC', etc., a card with the characters 'END' in columns 1-3 should be placed after the blank card to signal the program that the following card to be read is card (2).

3.3 Output for Contour, Mesh, and Displacement Plots

Printed output from this segment of the program consists of the input parameters and a message after each plot request has been completed.

The following plots can be obtained:

1. Finite element mesh for the original geometry,

2. Finite element mesh for the displaced geometry for each load case,

3. Contour plots for any surface in any quadrant for any stress (or temperature). These contours may be displayed on the mesh or on the outline of the tee.

4. NODE LINE PLOT

4.1 General Discussion

This segment of the CORTES GRAPHICS PACKAGE produces plots of the longitudinal (along the node line) stresses and transverse (normal to node line) stresses along the 0 degree node line (X-Y plane) and along the 90 degree node line (Y-Z plane) for a given surface. The global (X,Y,Z) coordinates for the nodes along the 0 degree node line (X-Y plane) are given a -45 degree rotation to a new X'-Y' coordinate system. The abscissa values in the plots represent X' along this line. (See Figure 1.) For the 90 degree node line (Y-Z plane) the abscissa values for the plots represent the Y global coordinate values. For the program THFA the temperature values along these node lines are plotted.

4.2 Input for Node Line Plot

Cards 1-11 should be input for programs SA, TSA, and THFA. Cards 1-3, 5-10, and 11EP-13EP should be input for EP.

CARDS 1-11

Card (1) FORMAT (A4,1X,I5)

Variable	Description
PROG	CORTES program name for which plots are to be produced. Input the characters 'SA', 'TSA', 'THFA', or 'EP'.
NLOAD	Number of load cases output on logical unit 12 for SA. (Does not apply to TSA ,THFA or EP.)

Card (2) FORMAT (2A4)

Variable	Description
FNCTN	To obtain Node Line Plots, the characters 'NODE' should be in columns 1-4.

Card (3) FORMAT (18A4)

Variable	Description
TITL	Title to be written on plots.

Card (4) FORMAT (14I5)
(Omit if PROG='EP'.)

Variable	Description
NT	Number of load cases for SA or time steps for TSA or THFA to be plotted.
(NTM(I),I=1,NT)	Load case numbers for SA or positions on logical unit 12 of time steps for TSA or THFA that are to be plotted.

Card (5) FORMAT (14I5)
(Omit if PROG = 'THFA')

Variable	Description
NODT(1,1)	Index on NODE(I,1) array (Card 7) to indicate the first node at which T1 is normal to the 0 degree node line.
NODT(2,1)	Index on NODE(I,1) array (Card 7) to indicate the first node at which T2 is normal to the 0 degree node line.
NODT(1,2)	Index on NODE(I,2) array (Card 8) to indicate the first node at which T1 is normal to the 90 degree node line.
NODT(2,2)	Index on NODE(I,2) array (Card 8) to indicate the first node at which T2 is normal to the 90 degree node line.

Card (6) FORMAT (14I5)

Variable	Description
INOUT(1)	Option to produce plots for the outer surface. 0 means No 1 means Yes
INOUT(2)	Option to produce plots for the inner surface. 0 means No 1 means Yes
NND(1)	Number of nodes for the 0 degree node line (X' vs T1,T2). If 0, this type of plot will be omitted.
NND(2)	Number of nodes for the 90 degree node line (Y vs T1,T2). If 0, this type of plot will be omitted.
INX	Option to input lower and upper values of abscissas for scaling purposes. 0 means No 1 means Yes

INY	Option to input lower and upper values of ordinates for scaling purposes. 0 means No 1 means Yes
INAX	Option to input lengths of horizontal and vertical axes. (The default is 8.0 inches for both axes.) 0 means No 1 means Yes
IRND	Option to round the upper and lower values on each axis. This is done so that each inch represents a number with as few significant digits as possible while at the same time filling the major portion of the plotting area. 0 means No 1 means Yes

Card (7) FORMAT (14I5)
(Omit if NND(1)=0)

Variable	Description
(NODE(I,1), I=1,NND(1))	Nodes that are along the 0 degree node line. These nodes should be input so that the value of X' will be increasing with the values for I.

Card (8) FORMAT (14I5)
(Omit if NND(2)=0)

Variable	Description
(NODE(I,2), I=1,NND(2))	Nodes that are along the 90 degree node line. These nodes should be input so that the value of Y will be increasing with the values for I.

Card (9) FORMAT (2E10.0)
(Omit if INAX=0, Card 6)

Variable	Description
XAX	Length of abscissa axis.
YAX	Length of ordinate axis.

Card (10-A) FORMAT (2E10.0)
(Omit if INX=0 or INOUT(1)=0 or NND(1)=0)

Variable	Description
XMIN(1)	Minimum value to use in the scaling of the abscissas for the 0 degree node line plots (X' vs. variable) on the outer surface.
XMAX(1)	Maximum value to use in the scaling of the abscissas for the 0 degree node line plots on the outer surface.

Card (10-B) FORMAT (2E10.0)
(Omit if INX=0 or INOUT(2)=0 or NND(1)=0)

Variable	Description
XMIN(2) XMAX(2)	Same as Card 9-A except values are for the inner surface.

Card (10-C) FORMAT (2E10.0)
(Omit if INX=0 or INOUT(1)=0 or NND(2)=0)

Variable	Description
XMIN(3)	Minimum value to use in the scaling of the abscissas for the 90 degree node line plots (Y vs. variable) on the outer surface.
XMAX(3)	Maximum value to use in the scaling of the abscissas for the 90 degree node line plots (Y vs. variable) on the outer surface.

Card(10-D) FORMAT (2E10.0)
(Omit if INX=0 or INOUT(2)=0 or NND(2)=0)

Variable	Description
XMIN(4) XMAX(4)	Same as Card 9-C except the values are for the inner surface.

Card (11) FORMAT (I5,5X,2E10.0)
(Omit if INY=0)

NOTE: A card 11 needs to be provided for each plot that is requested if INY≠0.

Variable	Description
NOPY	Option to input minimum and maximum values for scaling the ordinates. (0 means that the program will do the scaling for the ordinate on this plot. 1 means that the scaling will be done based on the minimum and maximum values that are input on this card.)
YMIN	Minimum value to use in the scaling of the ordinates.
YMAX	Maximum value to use in the scaling of the ordinates.

Card 11 should be repeated in the following manner for each plot that has been requested.

Outer Surface for Each Load Case

0 Degree Node Line (X' vs. T1, T2, or X' vs. TEMP)

90 Degree Node Line (Y vs. T1, T2 or Y vs. TEMP)

Inner Surface for Each Load Case

0 Degree Node Line

90 Degree Node Line

If more than one time step is being plotted for THFA or TSA, then all of the time steps will appear on one graph; therefore, this must be taken into account when inputting the YMIN, YMAX values.

CARDS 11EP-13EP

(These cards should be repeated for each load case that is to be plotted.)

Card (11EP) FORMAT (14I5)

Variable	Description
LC	Current load case to be plotted. If LC=0, then all load cases have been plotted.
MNOLS	Maximum number of load steps for current case.
NQDS	Maximum number of quadrants.
NSTR	Symmetry code.

Card (12EP) FORMAT (14I5)

Variable	Description
NT	Number of load steps of load case LC (card 11EP) to be plotted.
(NTM(I),I=1,NT)	Load steps to be plotted for load case LC.

CARD (13EP)
(Omit if INY=0)

Same as card (11) above.

A card with the characters 'END' in columns 1-3 should be placed at the end of the data. One may then input data beginning with a "Card 2" as described in sections 3, 4, and 5. If no other plots are to be requested, then another card with the characters 'END' should be placed at the end of the input stream.

4.3 Output from Node Line Plot

Printed output from this section of the program consists of parameter input to the program and a table listing the nodes and coordinates for each curve. A message is printed when each plot has been completed.

Plots can be produced that will consist of values for the T1 and T2 stresses or temperatures (THFA) along the 0 degree and 90 degree node lines for the inner and outer surfaces. Two curves are drawn for each node line when T1 and T2 are plotted. One curve represents the transverse stress and the other represents the longitudinal stress.

5. CROSS SECTION PLOT

5.1 General Discussion

The cross section segment of the Graphics Package produces plots of the X=0 and the Z=0 planes of the tee for programs SA and EP. These cross sections may represent the entire cross section or only a specified number of nodes along the axes from the control node. The cross sections of the original mesh and the displaced mesh may be obtained.

5.2 Input for Cross Section Plot

For the program SA cards 1-8 should be input. For the program EP cards 1-7 and cards 8EP-9EP should be input.

CARDS 1-8

Card (1) FORMAT (A4,1X,I5)

Variable	Description
PROG	Program for which plots are to be produced. Input the characters 'SA' or 'EP'.
NLOAD	Number of load cases output on logical unit 16.

Card (2) FORMAT (2A4)

Variable	Description
FNCTN	The characters 'XSEC' should be in columns 1-4.

Card (3) FORMAT (20A4)

Variable	Description
TITL	The title to be written on each plot.

Card (4) FORMAT (14I5)

Variable	Description
IOPT15	Option to plot Z=0 plane 0 means No 1 means Yes
IOPT23	Option to plot the X=0 plane 0 means No 1 means Yes
IORIG	Option to plot the original coordinates through the thickness 0 means No 1 means Yes
IDISP	Option to plot the displaced coordinates through the thickness. 0 means No 1 means Yes

Card (5) FORMAT (14I5)

Variable	Description
IA2	Number of divisions along axis 2 to be plotted.
IA4	Number of divisions along axis 4 to be plotted.
IA5	Number of divisions along axis 5 to be plotted.

Card (6) FORMAT (7E10.0)

Variable	Description
XAXI	Length in inches of the horizontal axis. If 0.0 or blank, the axis length is set to 9.0 inches.
YAXI	Length in inches of the vertical axis. If 0.0 or blank, the axis length is set to 9.0 inches.
SCAL	Scale factor to be used for plotting cross section points. If 0.0 or blank, the scale factor will be computed.
DISPIN	Exaggerated value of the maximum displacement in inches scaled relative to the dimensions of the tee joint.

Card (7) FORMAT(3I5)

Variable	Description
NLAYER	Number of layers for the cross section.
NCB	Number of circumferential divisions along the branch.

Card (8) FORMAT (14I5)
(Omit if IDISP=0)

Variable	Description
MLOAD	Number of load cases for displaced cross section plots.
(LOAD(I),I=1,MLOAD)	Load case numbers for displaced cross section plots.

CARDS 8EP-9EP

Cards (8EP-9EP) should be repeated for each load case.

Card (8EP) FORMAT (14I5)
(Omit if IDISP=0)

Variable	Description
LC	Current load cases to be plotted. If LC=0, then all load cases have been completed.
MNOLS	Maximum number of load steps for current load cases.
NQDS	Number of quadrants.

Card (9EP) FORMAT (14I5)
(Omit if IDISP=0)

Variable	Description
NS	Number of load steps to be plotted for load case LC (card 8EP).
(NOLS(I),I=1,NS)	Load steps to be plotted for load case LC.

A card with the characters 'END' in columns 1-3 should be placed at the end of the data. One may then input data beginning with a "Card 2" as described in sections 3, 4, and 5. If no other plots are to be requested, then another card with the characters 'END' should be placed at the end of the input stream.

5.3 Output from Cross Section Plot

The Cross Section Plotting subroutines print the parameter input, tables of the values for each plane that is plotted, and a message after each plot has been completed. Plots can be obtained for the X=0 plane and the Z=0 plane for the original geometry and for selected load cases for the displaced geometry.

REFERENCES

1. A. N. Gantayat and G. H. Powell, Stress Analysis of Tee Joints by the Finite Element Method, (ORNL/Sub/3193-1) Report No. UCSESM 76-6, University of California, Berkeley (February 1973).

2. G. H. Powell, Finite Element Analysis of Elastic-Plastic Tee Joints, (ORNL/Sub/3193-2) Report No. UCSESM 73-14, University of California, Berkeley (February 1973).

3. R. E. Textor, User's Guide for SHFA: Steady-State Heat Flow Analysis for Tee Joints by the Finite Element Method, Report No. UCCND/CSD/INF-60, Oak Ridge Gaseous Diffusion Plant (January 1976).

APPENDIX A

OVERLAY STRUCTURE

Segment 1

MAIN
MAAN
PLTINT
COMMON BLOCKS
System Subroutines
Plotting Subroutines

Segment 2

PROG1
PROGEP
PRSPEP
PRSPLT
LABEL
SCALE
NODERR
ERRSUB
PLOTOT
CONSEG
CONDRW
FINDOT
SQUEEZ
ANGLE
ROTATE

Segment 3

CNTUR1

Segment 4

PROG2
NODEEP
IPLT
IPLTEP
LAB1D
GRAPH
ROUND
SCALID
ORDER

Segment 5

CRSSEC
EPXSEC
REDISP
SAVDEP
SAVEXS
PLTXCS
MIDCOR
PLTGRD
LABELX
SAVDSP
PLTDSP

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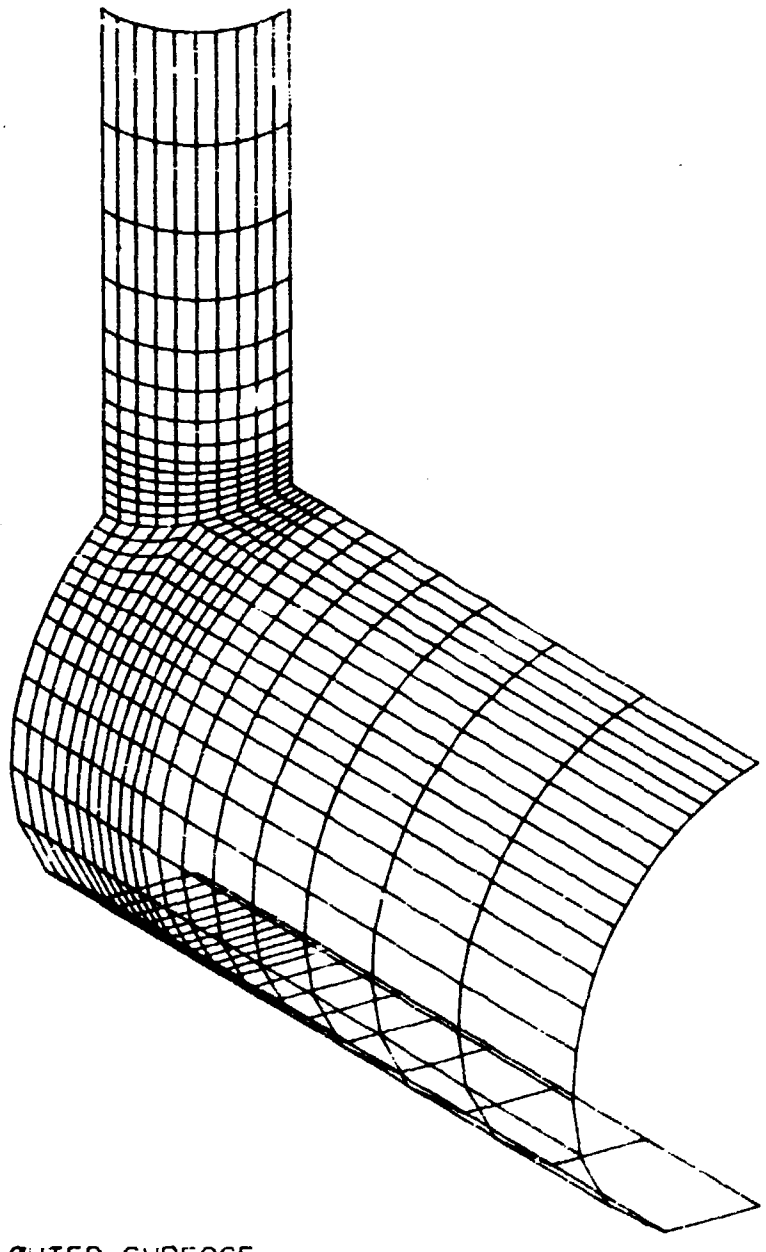
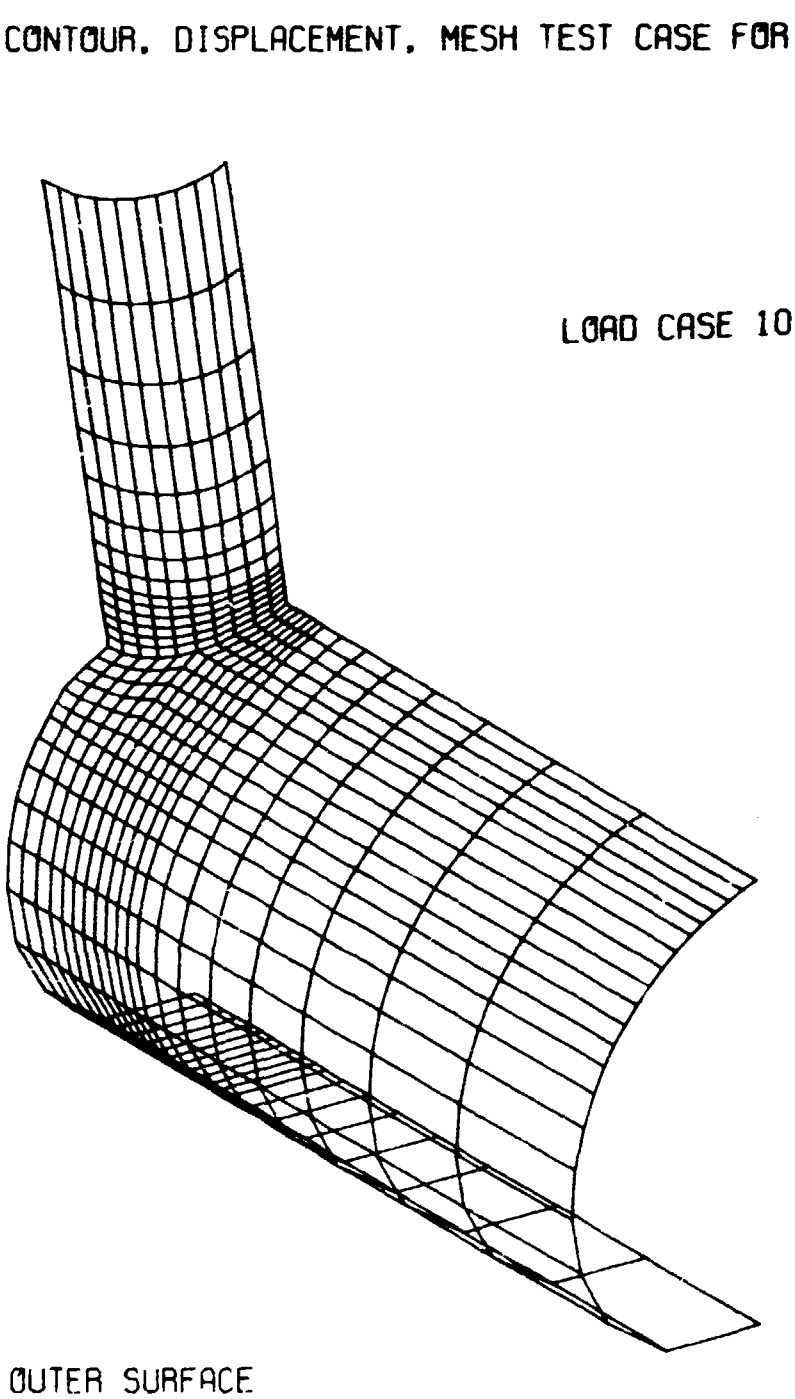
APPENDIX B

SAMPLE DATA AND PLOTS

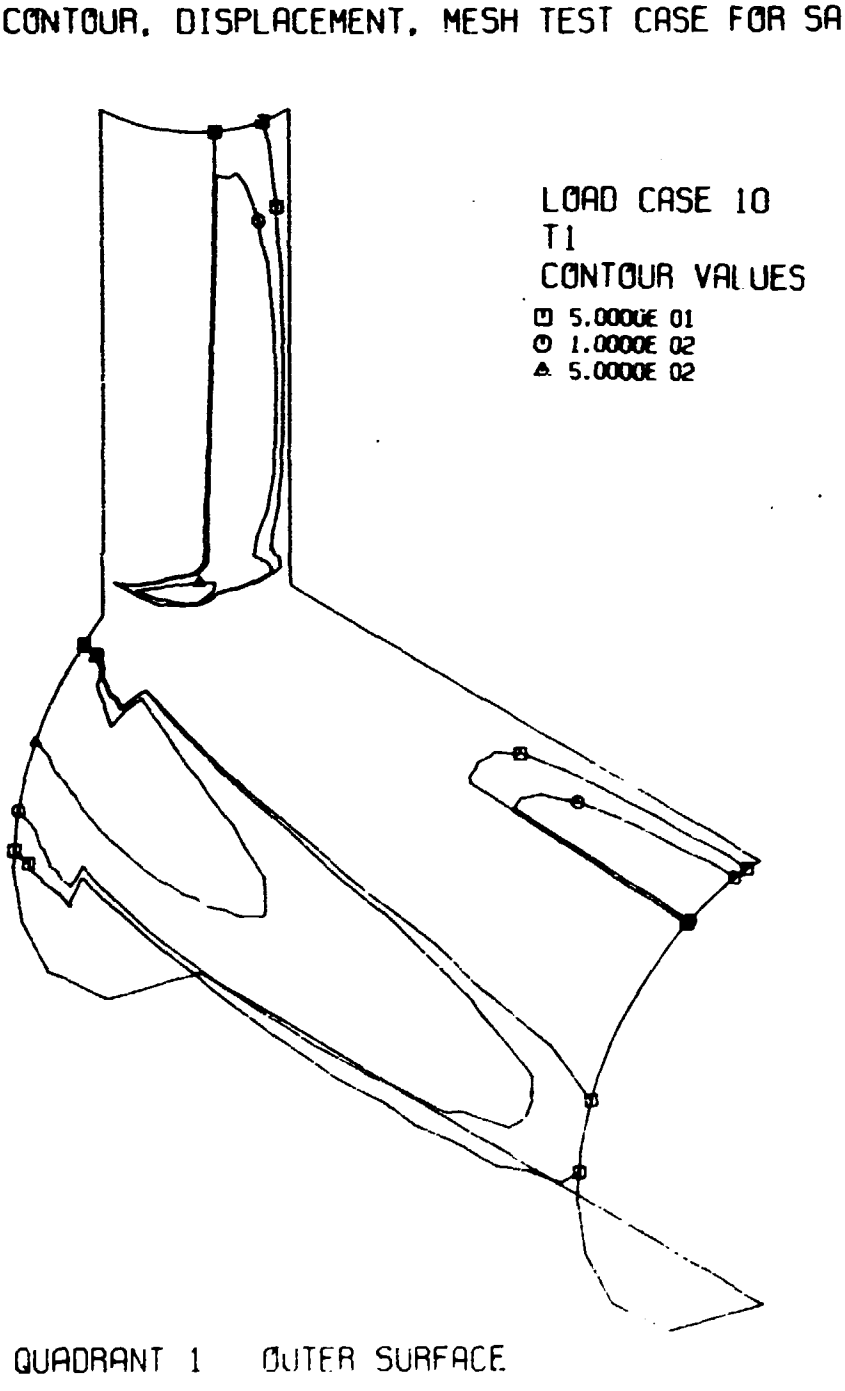
```
SA        2
NODE
 NODE LINE TEST CASE FOR SA
    1    8
    1   11    1    9
    1    0   22   18    0    0    0    1
   78   89  100  111  122  153  182  209  234  257  278  299  320  341
  362  383  404  425  446  467  488  509
   77   88   99  110  121  132  133  134  135  136  137  138  139  140
  141  142  143  144
END
XSEC
 CROSS SECTION TEST CASE FOR SA
    1    1    1    1
    7   15    7
       0.0       0.0       0.0       1.0
    1   10
    1    8
END
CONTOUR
CONTOUR, DISPLACEMENT, MESH TEST CASE FOR SA
   21  515    1    0
8.0       0.0       1.0       1.0       1.0
    0    1    0    0    0    0    0    0    0
    1   10
    3    0    0    0    0    0
50.       100.      500.
T1
    1    0       1.0
END
END
```



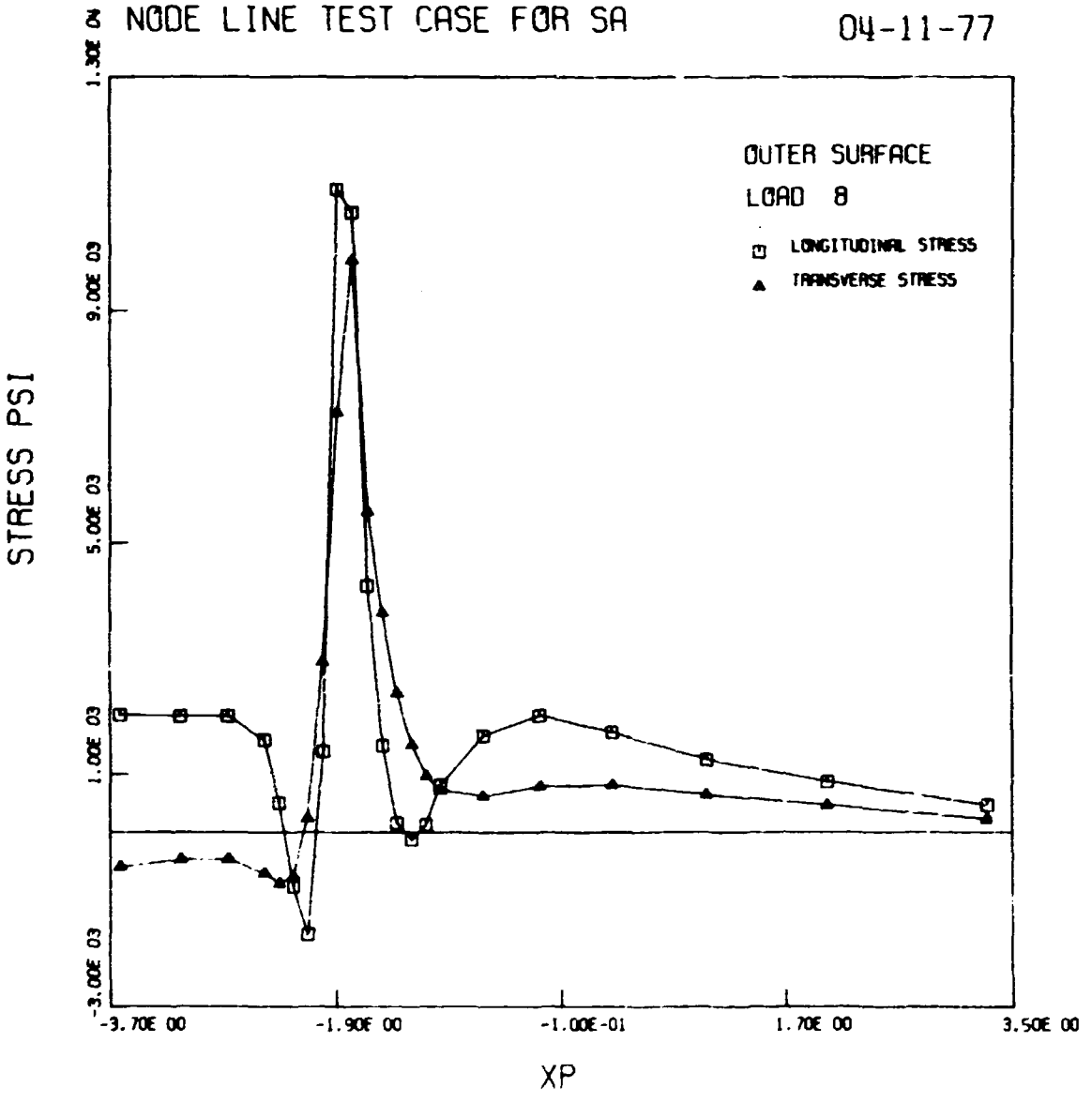
Mesh of Undeformed Tee Joint



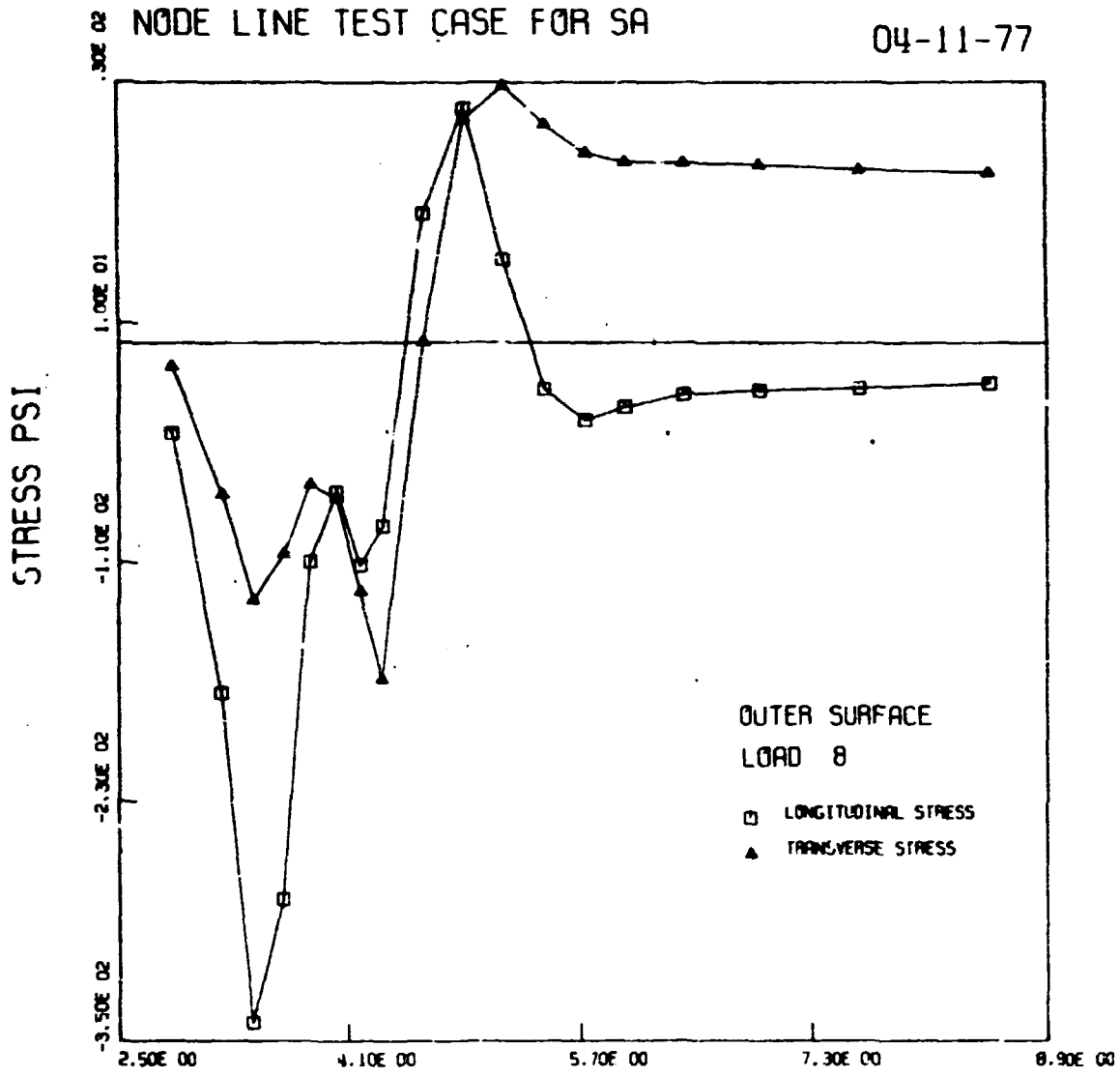
Mesh of Deformed Tee Joint



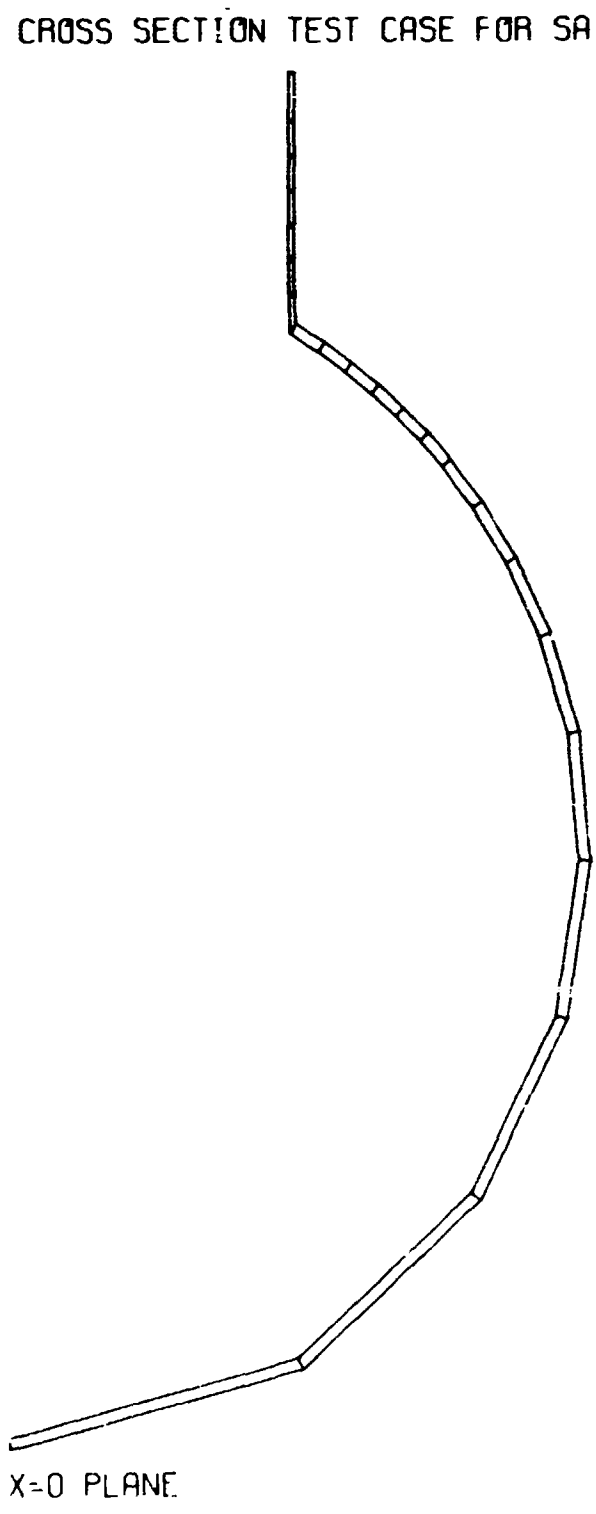
Contours Plotted on Outline of Tee Joint



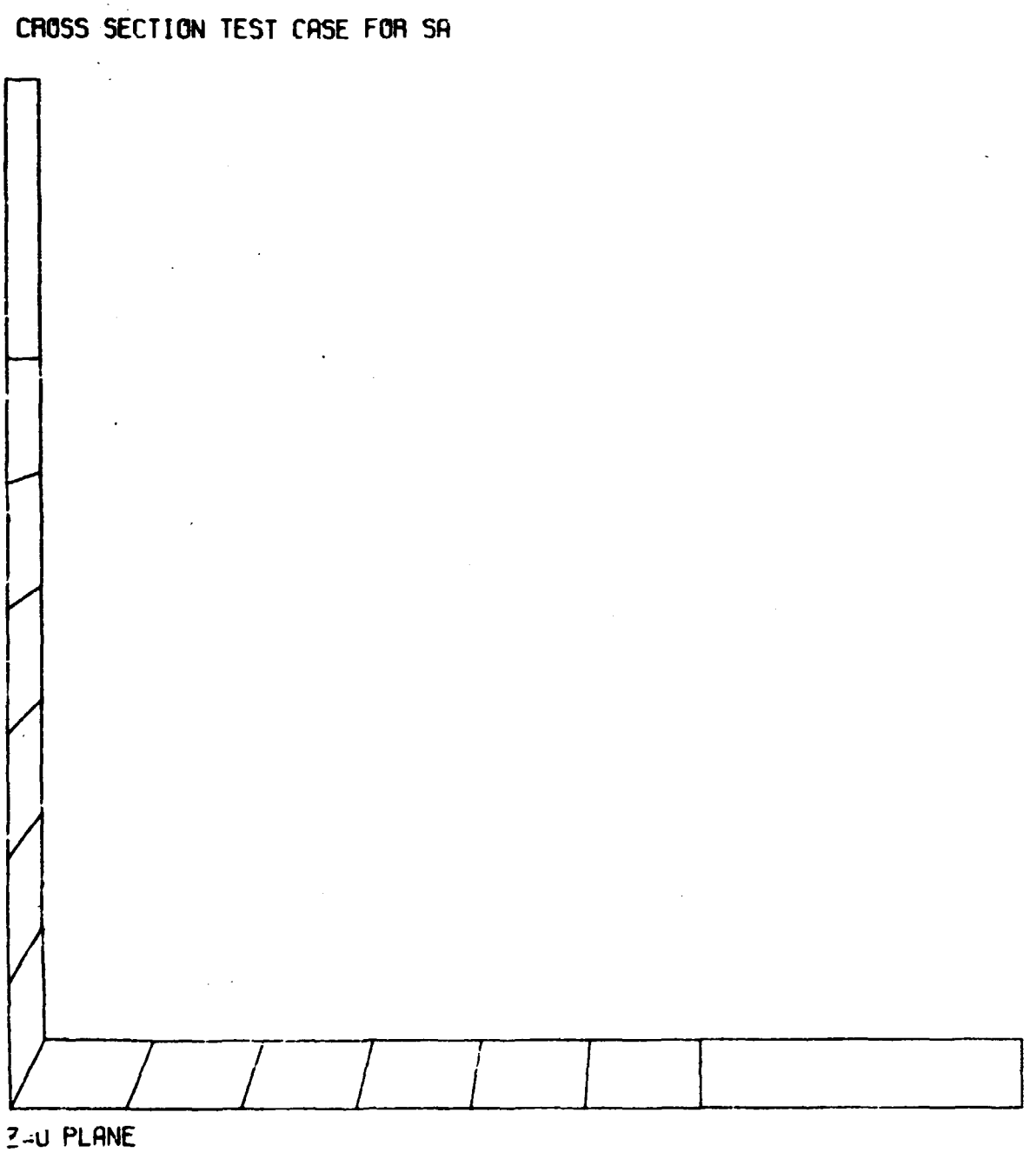
Longitudinal and Transverse Stresses Along the 0 Degree Node Line



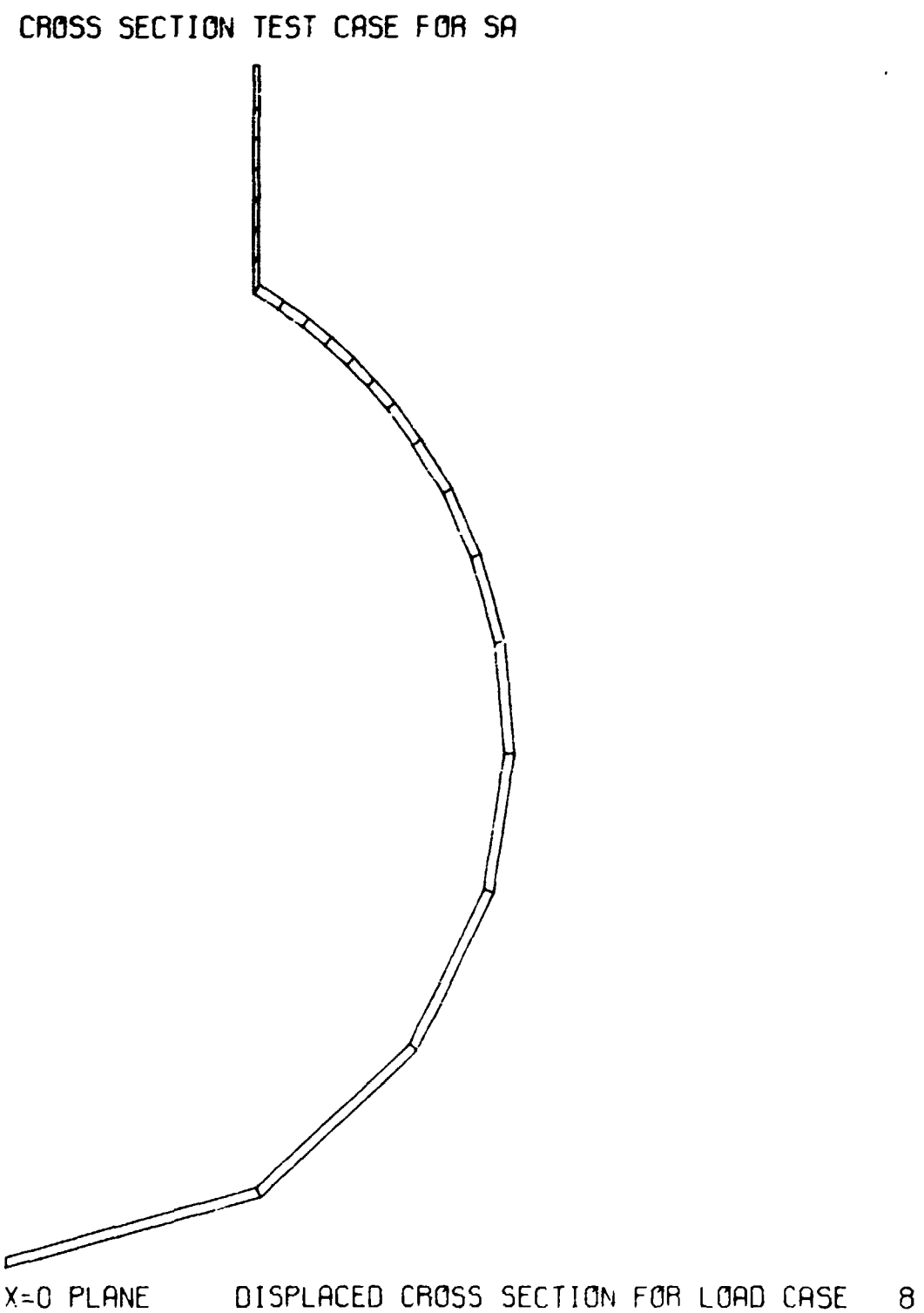
Longitudinal and Transverse Stresses Along the 90 Degree Node Line



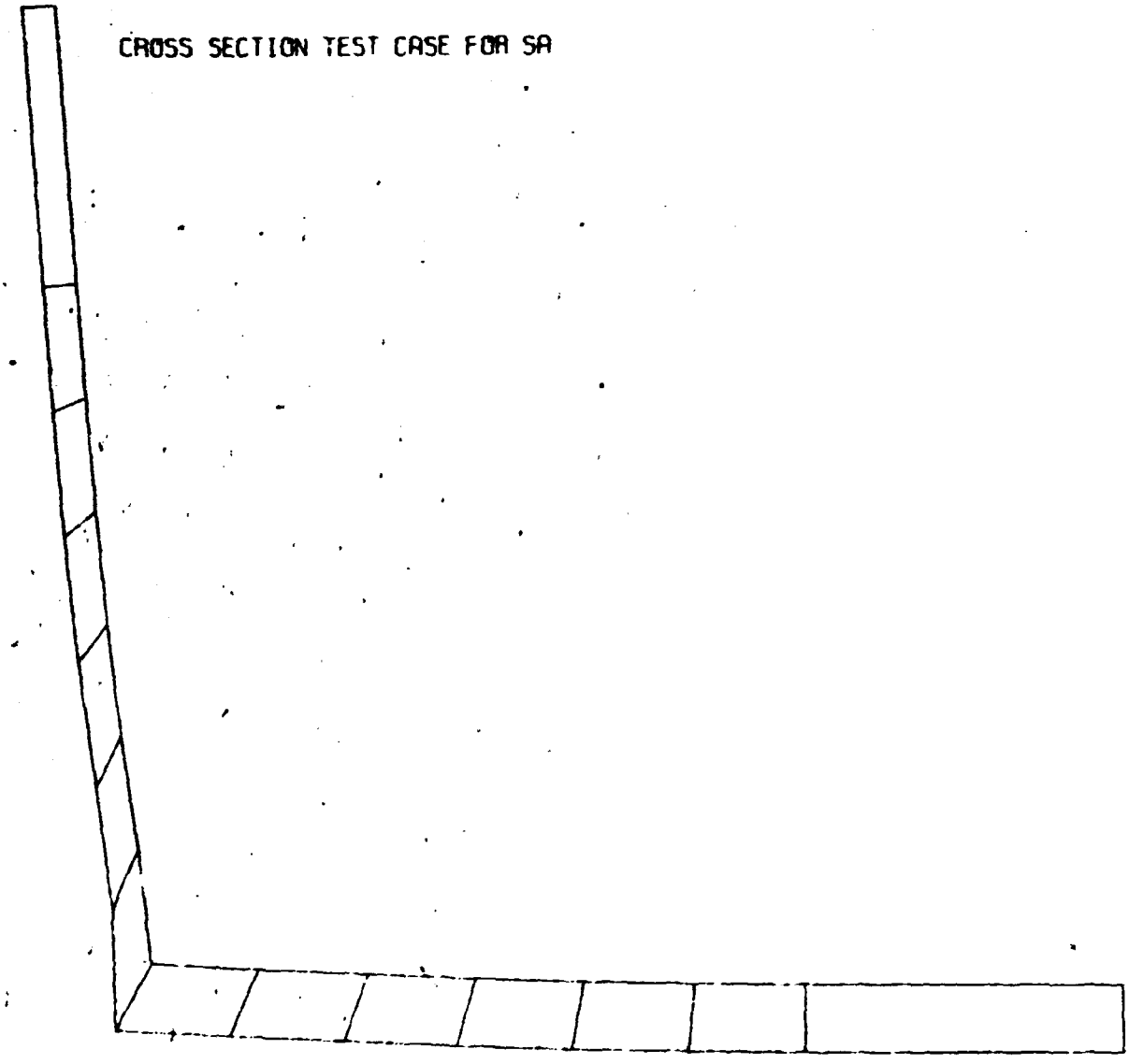
Undeformed Cross Section of the Y-Z Plane at X=0.0



Undeformed Cross Section of the X-Y Plane at Z=0.0



Deformed Cross Section of the Y-Z Plane at X=0.0



Z=0 PLANE DISPLACED CROSS SECTION FOR LOAD CASE 8

Deformed Cross Section of the X-Y Plane at Z=0.0