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BURNER LINER THERMAL/STRUCTURAL LOAD MODELING

TRANCITS PROGRAM USER'S MANUAL

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16 Abstract

The software package developed under this contract was called TRansfer ANalysis Code to Interface Thermal/Structural Problems (TRANCITS). The TRANCITS code satisfies all the objectives for transferring thermal data between heat transfer and structural models of combustor liners; in addition, it can be used as a generic thermal translator between heat transfer and stress models of any component, regardless of the geometry. TRANCITS can accurately and efficiently convert the temperature distributions predicted by the heat transfer programs to those required by the stress codes. It can be used for both linear and nonlinear structural codes, and it can produce nodal temperatures, elemental centroid temperatures, or elemental Gauss point temperatures. The thermal output of both the MARC and SINDA heat transfer codes can be interfaced directly with TRANCITS, and it will automatically produce stress model codes formatted for NASTRAN and MARC. In addition to these codes, any thermal program and structural program can be interfaced by using the neutral input and output forms supported by TRANCITS.

In summary, the TRANCITS code can be used to interface temperature data between thermal and structural analytical models. The use of this transfer module allows the heat transfer analyst to select the thermal mesh density and thermal analysis code best suited to solve the thermal problem, and it gives the same freedoms to the stress analyst without the efficiency penalties associated with common meshes and the accuracy penalties associated with the manual transfer of thermal data.

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1.0 INTRODUCTION

In aircraft turbine engine hot section components, cyclic thermal stresses are the most important damage mechanisms. Consequently, an accurate and reliable prediction of thermal loads is essential to improved durability. To achieve this goal, considerable effort has been expended over the past 20 years to (1) acquire engine temperature test data, and (2) develop accurate, reliable, efficient computer codes to predict steady-state and transient temperatures and for calculating elastic and inelastic cyclic stresses and strains in hot section components. There is a need for continued development of these codes because the availability of more accurate analysis techniques for complex configurations has enabled engine designers to use more sophisticated designs to achieve higher cycle efficiency and reduce weight.

It became apparent in recent years that a serious problem existed when interfacing output temperatures and temperature gradients from the heat transfer codes with the input to the stress analysis codes. Due to the growth in computer capacity and speed, and with the development of input preprocessors and output postprocessors, the analysis of components using hundreds or thousands of nodes in the heat transfer and stress models became economical and routine. This has aggravated the problem of manually transferring output temperatures from heat transfer nodes to stress analysis input to the point where the engineering effort required is comparable to that required for the remainder of the analysis. Furthermore, a considerable amount of approximation has been introduced in an effort to accelerate the process. This tends to introduce errors into the temperature data, thereby negating the improved accuracy in the temperature distribution achieved through use of a finer mesh.

The objective of the Burner Liner/Thermal Structural Load Modeling program was to develop a transfer module that would accurately and efficiently transfer three-dimensional temperature information from heat transfer analysis codes to stress analysis codes. This objective has been satisfied by the development of the computer code TRANCITS (TRansfer ANalysis Code to Interface Thermal/Structural Problems).

This report is a preliminary user's manual for the TRANCITS program.

2.0 GENERAL OVERVIEW

TRANCITS is a computer code developed by the Aircraft Engine Business Group of the General Electric Co. in conjunction with the NASA-Lewis Research Center to address the problem of transferring three-dimensional temperature information from numerical heat transfer analyses to numerical stress analyses. The advanced features of TRANCITS include:

- The ability to transfer temperatures between dissimilar mesh densities
- The ability to handle finite difference and finite element heat transfer codes
- Extensive user controls on the interfacing procedure
- Automatic interface to SINDA, MARC, and NASTRAN
- Internal checks on the accuracy of the transfer
- The ability to handle stress points slightly outside the heat transfer model
- Accurate and efficient transfer of temperatures
- Modular program architecture to facilitate maintenance and enhancements.

Figure 1 is a schematic of how TRANCITS is used in the thermal interfacing procedure.

It should be noted that although the interfaces between SINDA, MARC, and NASTRAN codes are Hard Wired into the TRANCITS system, the Neutral Input and Neutral Output files allow TRANCITS to be used with any combination of heat transfer codes and stress analysis codes.

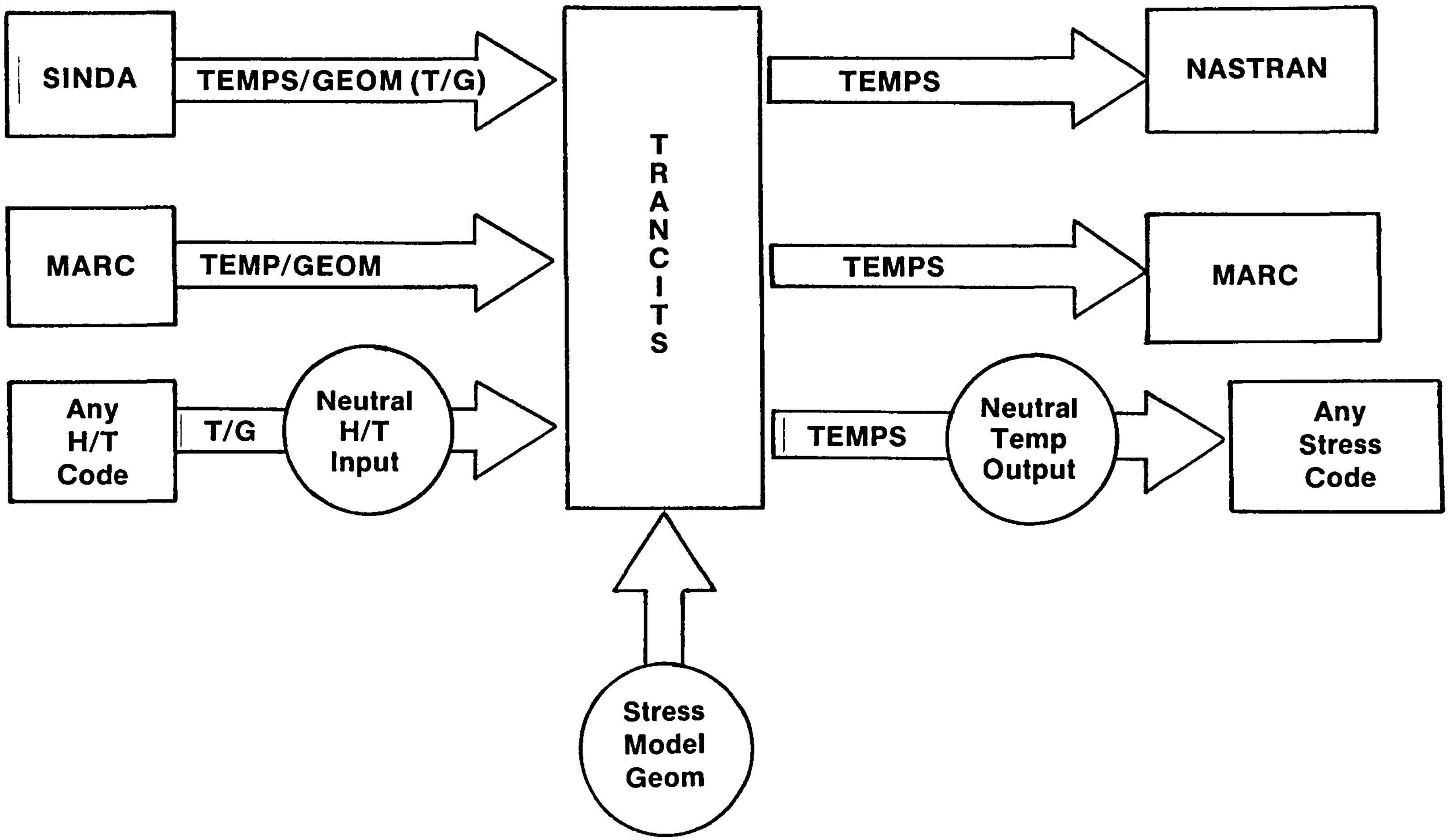


Figure 1. TRANCITS Schematic.

3.0 CURRENT LIMITATIONS

The following are the current limitations for the first release of TRANCITS (Version 1.0).

1. Heat Transfer Model Limitations

   - Maximum* number of heat transfer limitations = 5000
   - Maximum heat transfer element name = 5000
   - Maximum number of transient solutions = 500
   - Maximum number of heat transfer nodes = 5000
   - Maximum heat transfer node name = 5000
   - Heat transfer element library - 8-noded solid element

2. Stress Analysis Model

   - Maximum number of stress nodes = 5000
   - Maximum stress node name = 5000
   - Maximum number of stress elements = Unlimited
   - Maximum stress element name = Unlimited
   - Stress element library - any three-dimensional solid element

*All of the numerical limits can be easily increased by increasing the amount of temporary storage allocated to the program.

4.0 DESCRIPTION OF INPUT

TRANCITS can accept many different input forms, including the output of the SINDA and MARC programs directly. The choice of the input form depends on which heat transfer code was used to produce the temperatures. For heat transfer codes other than MARC and SINDA, a neutral heat transfer input file can be used to input the required data into TRANCITS.

Both finite difference and finite element codes can be used, but in either case the geometry of the heat transfer mode and the computed temperatures from the heat transfer analysis must be input. In addition to this information, a user control file must be entered. This file contains data that controls the interface procedure. All of these input files are described in the following sections.

4.1 NEUTRAL HEAT TRANSFER INPUT FILE

This file is either input or created internally. It contains all the geometry and temperature information for the heat transfer model. All processing of this information in TRANCITS is done using this file. If the heat transfer code used was SINDA or MARC, the output of these two programs is input into TRANCITS and the Neutral Heat Transfer Input file is created internally. On the other hand, if the heat transfer code used was some other program, the output of this program could be externally converted to the Neutral Heat Transfer Input form and then interfaced by using TRANCITS. The use of the Neutral Heat Transfer Input file allows TRANCITS to be used with any heat transfer analyzer.

This file is composed of six sets, or partitions, of data. The six are:

TITLE	PARTITION
DIRECTORY	PARTITION
NODAL	PARTITION
ELEMENT CONNECTIVITY	PARTITION
ELEMENT FACE	PARTITION
TEMPERATURE	PARTITION

Title Partition

The title partition allows the input file to have up to four 80-character titles. These titles appear on the first four records of the input file in the form:

TITLE 1	RECORD 1
TITLE 2	RECORD 2
TITLE 3	RECORD 3
TITLE 4	RECORD 4

Directory Partition

The directory partition contains count and control information about the input. It is of the form:

NSHIFT, NUMN, NUME, NUMT, NTRECS, ECODE, ACODE

where

NSHIFT	=	No. of records in the directory partition - 1 (currently NSHIFT = 0)
NUMN	=	No. of nodes in the heat transfer model
NUME	=	No. elements in the heat transfer model
NUMT	=	No. of transient solutions on the input file
NTRECS	=	No. of heat transfer elements with temperature information (usually NTRECS = NUME for ACODE = 1 or NTRECS = NUMN for ACODE = 2)
ECODE	=	Heat transfer element type code

1-4 noded 2D element
2-8 noded 2D element
11-8 noded 3D element
12-16 noded 3D element
13-20 noded 3D element

ACODE	=	Heat transfer analysis type code

1 - Finite difference
2 - Finite element

Nodal Partition

The next NUMN records compose the nodal directory. It contains the rectangular cartesian coordinates for every node in the heat transfer model. The form of this directory is:

Node	X	Y	Z	
.	.	.	.	
.	.	.	.	NUMN Records
.	.	.	.	

where NODE = Node Name

X
Y = Coordinates
Z

Element Connectivity Partition

The next NUME records in the file compose the element connectivity partition. It contains all the heat transfer element connectivity information in the form:

NE IE(L), L = 1, NUNPE

. . NUME Records

where

NE	=	Element name
IE	=	Connectivity array
NUNPE	=	No. of nodes each element

Element Face Partition

This partition is omitted if the heat transfer analysis type was finite element (ACODE = 2). If ACODE = 1 (finite difference), this partition contains NUME records of the form:

NE IFACP

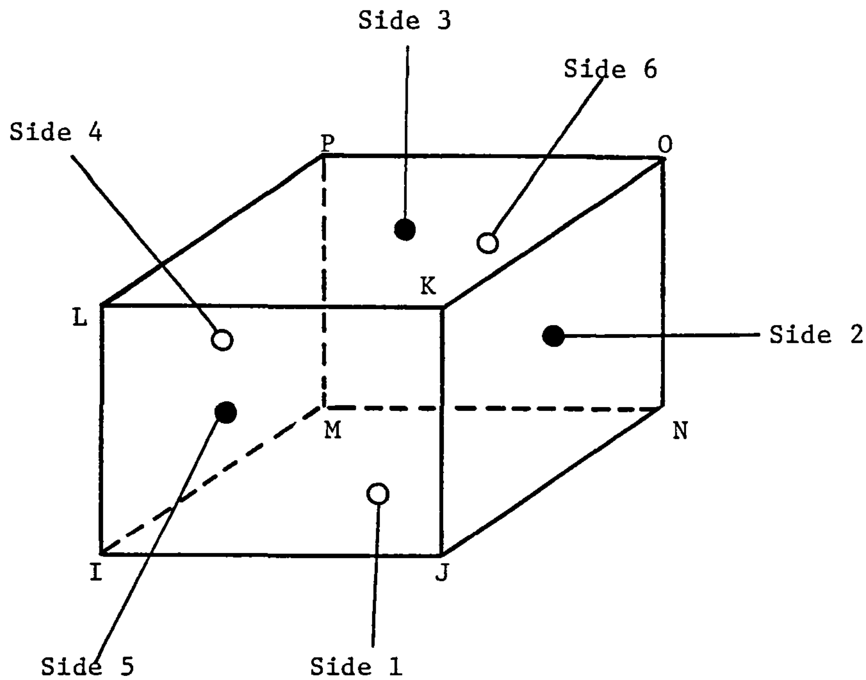
. . NUME Records

where

NE	=	Element name
IFACP	=	Packed element face number

IFACP is a six-digit integer that relates the finite difference face labels to the sides of the heat transfer element. It is required when the finite difference element has the ability to produce face center temperatures as well as element centroidal temperatures. This input allows TRANCITS to use all temperature information produced by the heat transfer element in the interfacing procedure. Figure 2 shows how IFACP is defined for an eight-noded solid heat transfer element.

SPECIAL NOTE: When the heat transfer element being used produces only centroidal temperatures, IFACP should be set to 123456. Therefore, for SINDA applications IFACP = 123456.



If Side 1 is Face 6		
2	5	
3	4	
4	3	Then IFACP = 654321
5	2	
6	1	

Figure 2. Element Face Definitions.

Temperature Partition

This partition contains all temperature information from the heat transfer analysis. It can appear in two forms, depending on the type of heat transfer analysis.

- FINITE DIFFERENCE TEMPERATURE PARTITION -
(ACODE = 1)

The form is:

```
Solution | TIMEN
   1     | NE        TMP(L),  L = 1,  NTPE
         |  .           .
         |  .           .                   (NTRES + 1) Records
         |  .           .

Solution | TIMEN
   2     | NE        TMP(L),  L = 1, NTPE
         |  .           .
         |  .           .                   (NTRECS + 1) Records
         |  .           .

   .
   .
   .

Solution |  .           .
  NUMT   |  .           .                   (NTRECS + 1) Records
         |  .           .
```

- FINITE ELEMENT TEMPERATURE DIRECTORY -
(ACODE = 2)

The form is:

```
Solution | TIMEN
   1     | NODE     TP
         |  .        .
         |  .        .      (NTRECS + 1) Records
         |  .        .

Solution | TIMEN
   2     | NODE     TP
         |  .        .
         |  .        .      (NTRECS + 1) Records
         |  .        .

   .
   .
   .
```

```
Solution |
  NUMT   |                          (NTRECS + 1) Records
```

where

```
    Time N  =  Time value of transient solution
    NE      =  Element name
    TMP     =  Temperature array
    NTPE    =  No. of temperatures each elemet
            =  5 for 2D
            =  7 for 3D
    NODE    =  Node name
    TP      =  Nodal temperature
```

An example of this file is given in Appendix B.

4.2 SINDA TEMPERATURE INPUT FILE

This file is necessary if the heat transfer analysis code was SINDA. The users of the SINDA program have the capability of formatting the output in many ways. This formatting is accomplished by including Fortran subroutines in the SINDA job stream to control the output. An example of these output routines for SINDA is given in Appendix C. The SINDA output produced by these routines is defined as the SINDA Temperature Input File. The form of this file is:

```
NUME

NE1     NE2     . . . . .  NE10 |
NE11    NE12    . . . . .  NE20 |
 .         .                 .  |      NUME
 .         .                 .  |      Elements
 .         .                 .  |

TIME1

T1      T2      . . . . .  T6   |
T7      T8      . . . . .  T12  |
 .         .                 .  |
 .         .                 .  |      NUME
 .         .                 .  |      Temperatures

TIME2

T1      T2      . . . . .  T6   |
T7      T8      . . . . .  T12  |
 .         .                 .  |
 .         .                 .  |      NUME
 .         .                 .  |      Temperatures
etc.
```

where

```
NUME    =  No. of heat transfer elements
NXX     =  Element name
TXX     =  Temperature for the element (in the same order as elements)
TIMEXX  =  Time value for this transient solution
```

This input form is the required input into TRANCITS. It can be obtained through SINDA by using the routines given in Appendix C or by external formatting of other SINDA output files. An example of the SINDA temperature input file is given in Appendix B.

4.3 SINDA GEOMETRY INPUT

This input is needed only if the heat transfer analysis code was SINDA. The SINDA output files do not contain geometry information; therefore, the SINDA GEOMETRY FILE must be input separately into TRANCITS. This file contains the coordinate information for all the nodes in the heat transfer mode as well as the connectivity of all the heat transfer elements. The form of the file is:

```
TITLE

NUMNOD          NUMELM          NUNPE
 NODE          X   Y   Z
   .           .   .   .
   .           .   .   .        NUMNOD Records
   .           .   .   .
NE, (IE(L), L = 1, NUNPE), IFACP
   .         .           .
   .         .           .      NUMELM Records
   .         .           .
```

where:

```
TITLE   =  80-Character title

NUMNOD  =  Number of nodes in the heat transfer model
NUME    =  Number of elements in the heat transfer model
NUNPE   =  Number of nodes each element
NODE    =  Node name
X,Y,Z   =  Rectangular cartesian coordinates of heat transfer nodes
NE      =  Element name
IE      =  Connectivity array of heat transfer element
IFACP   =  123456 for SINDA
```

All data in this file are free format, but each node and element record must appear on a separate line of the file. An example of this file is given in Appendix B.

4.4 MARC HEAT TRANSFER INPUT

Heat transfer information from a MARC posttape can be input to the TRANCITS program. The MARC posttape can be in either formatted or sequential binary form; however, the following limitations apply:

- Coordinate and connectivity data must be included on the posttape. This option is turned on with the postmodel definition card.
- Only eight-noded heat transfer solids (Element Type 23) are read from the tape and used in TRANCITS.
- Rezoning (that is, changes in coordinate and connectivity data) is not permitted.

The contents of the posttape are assumed to be as described in Appendix A.

MARC heat transfer input is selected by setting the variable IHTIC in the namelist input file to 2 for a formatted posttape or 3 for a sequential binary posttape.

An example of the formatted MARC postfile is given in Appendix B.

4.5 STRESS MODEL COORDINATE INPUT FILE

This file is not optional. It must be input. It contains the coordinate information for each stress node in the stress analysis model. The form of the file is:

```
Node   X Y Z
 .     . . .
 .     . . .
```

where: Node is the STRESS NODE LABEL
X, Y, Z — Rectangular Cartesian coordinates of the stress node

For an example see Appendix B.

The data are in free formatted form, but each nodal record must appear on a separate line of the file.

Every stress node in this file will be interfaced with the appropriate heat transfer element in the heat transfer model.

4.6 STRESS MODEL ELEMENT INPUT

This file is optional. It must be input only if MARC Gauss point temperatures or MARC centroid temperatures are requested. It contains the connectivity information for the stress model elements. The form of the file is:

```
         NUMETP

         NETYP        NUME
Set 1    NE   (IE(L), L = 1, NUNPE)|
         .      .                  | No. of records = No. of elements +1
         .      .                  | of this type
         .      .                  |

         NETYP        NUME
Set 2    NE   (IE(L), L = 1, NUNPE)|
         .      .                  | No. of records = No. of elements +1
         .      .                  | of this type
         .      .                  |

Set 3


Set
NUMETP
```

where

NUMETP = No. of sets of element types

NETYP = Element type code

Code	Element
1	4 noded 2D element
2	8 noded 2D element
11	8 noded 3D element
12	16 noded 3D element
13	20 noded 3D element

NE = Element name

IE(L) = Element connectivity

NUNPE = No. of nodes each element

These data are free formatted, but each element record must appear on a separate line of the file. See Appendix B for an example of this file type.

If this file is not input and if MARC temperatures are requested, only the temperatures of the stress points will be output.

4.7 USER CONTROL FILE OUTPUT

This file is not optional. It must be input. It contains input variables that control the interfacing procedure. This file is in namelist format which allows the user to input only the variables related to the problem of interest. All other variables will default to internal values set by TRANCITS. The form of the file is:

(2) (starts in Column 2)

$ZMAF

Variables

$

All variables currently available and their defaults are described in the following tabulation.

Variable Name	Valid Values	Default Value	Description
ITRAN	0	0	Do not transform heat transfer coordinates.
	1		Transform heat transfer coordinates.
XOFF	-	0	If ITRAN = 1, add the values of XOFF, YOFF, and ZOFF to the coordinates of the heat transfer nodes.
YOFF	-	0	
ZOFF	-	0	
ISL	0	0	Do not section the heat transfer model.
	1		Section the heat transfer model.
XMIN	-	-10^5	If ISL = 1, these minimum and maximum coordinates determine which heat transfer elements will be considered for the interfacing procedure. Note, if any node of a heat transfer element is outside the window defined by these min's and max's, the heat transfer element is not used. These coordinates are in the transferred heat transfer coordinate system.
YMIN	-	-10^5	
ZMIN	-	-10^5	
XMAX	-	-10^5	
YMAX	-	-10^5	
ZMAX	-	-10^5	
NUMZAP/ NZAP	-	0	This input is used to eliminate unwanted heat transfer elements. A shorthand input is available (such as the input NUMZAP/NZAP = 1, -7, -2, 12, 101, -104, 203, -218, -3) which would eliminate heat transfer elements 1, 3, 5, 7, 12, 101, 102, 103, 104, 203, 206, 209, 212, 215, and 218.

Variable Name	Valid Values	Default Value	Description
			Note, a maximum of 200 numbers may be entered using the NZAP array.
NTSTP/ TIMD	-	-1	This input is used to select the desired transient solutions from the heat transfer input file. If it is omitted or entered as NTSTP/ TIMD = -1, all solutions will be interfaced (such as the input NTSTP/TIMD = 10, 20, 31, would select three solutions 10 s, 20 s, 31 s). A maximum of 500 solutions may be selected.
NTMDO	-	999	This input allows the first NTMDO solutions to be selected. For example, NTMDO = 5 would select the first 5 solutions.
NSKIP	-	0	This input allows the first NSKIP solutions to be skipped or not processed. For example, NSKIP = 50, NTMDO = 3, would skip the first 50 solutions and process the next 3.
TIMESP	-	1E-5	This input is the tolerance between the desired time value and the time value on the heat transfer input. If TIMESP = 0.01 and TIMD = 10, any time values between 9.99 and 10.01 would be selected.
			Heat Transfer Input Code
IHTIC	0	0	Input is Neutral Heat Transfer Input file
	1		Input is SINDA temperature file
	2		Input is MARC temperature file (formatted)
	3		Input is MARC temperature file (binary sequential)
			Stress Program Output Code
ISPOC	0	0	Output is Neutral Temperature file
	1		Output is formatted for NASTRAN
	2		Output is formatted for MARC (element controid)
	3		Output is formatted for MARC (element Gauss point) 2X2X2

Note that any or all of these varaiables can be input using the User Control Input file. At least one variable must be input. It is recommended that if all defaults are desired, the input file should be:

```
$ZMAF
NTMDO = 999,
$
```

An example of the file is given in Appendix B.

5.0 OUTPUT DESCRIPTION

TRANCITS produces a variety of different output files depending on which stress analysis output code has been selected. Two files are always produced, the hard-copy file and the neutral temperature output file. The two optional output files are the NASTRAN temperature file and the MARC temperature file. The following sections describe all of these various outputs.

5.1 NEUTRAL TEMPERATURE OUTPUT FILE

The Neutral Temperature Output file is the primary output of TRANCITS. It contains the interfaced temperature for all of the stress points processed for every transient solution selected. The form of the file is:

```
                                                Formats
    TIME = XXX                                  2X, TIME, 1X, = 1X, F12.6
    NODE   TEMP                                 I8, F12.6
      .     .        First
      .     .        Solution
      .     .

    TIME = XXX
    NODE   TEMP
      .     .
      .     .        Second
      .     .        Solution
      .     .

                     Last
                     Solution
```

where

XXX = The TIME VALUE of the transient
NODE = Stress point name
TEMP = Temperature at this point

This output is always produced. It can be reformatted with simple conversion programs to produce temperature input for almost any stress analysis code.

An example of this output is in Appendix B.

5.2 NASTRAN TEMPERATURE FILE

This optional output file is produced if the stress analysis program used is NASTRAN. The stress point temperatures are formatted so that they can be directly input into NASTRAN. The form of the file is:

```
                                                            Formats

$ TIME = XXX                                        $, 1X, TIME, 1X, = 1X, F12.6
TEMP   NC NODE Temp                                 TEMP, 4X, 2I8, F8.2
  .     .   .    .
  .     .   .    .       First Solution
  .     .   .    .
  .     .   .    .

                         Last Solution
```

where

XXX = Time value of the solution

NC = Case number (1 through number of solutions)

NODE = Stress point name

TEMP = Temperature of the stress point

An example of this file is in Appendix B.

5.3 MARC TEMPERATURE FILE

This output file is produced if the stress analysis code to be used is MARC. The temperature information is generated as a set of Change State cards with a header card to indicate the time step from the heat transfer analysis. This data must be manually edited into the MARC input.

Since MARC is a somewhat unique code in that it requires either centroid or integration point temperatures, an element connectivity file must also be included as input to TRANCITS. Currently, temperature input is available only for eight-noded stress solid elements (Element Type 7).

5.4 HARD-COPY OUTPUT DESCRIPTION

The hard-copy output of TRANCITS has basic information about the heat transfer model and the stress model to be interfaced. It starts with a TRANCITS header page, then it prints counts of the number of nodes and elements in the heat transfer model. It also prints the total number of solution time steps and the number of solutions processed for the run.

Next, it prints a header line saying "The following stress points were not contained by any heat transfer element" and that "SNOD XO YO ZO NEARE XN YN ZN DIST IWARN."

If no numbers appear under this header, all stress points in the stress analysis model were inside a heat transfer element. Any stress point outside of the heat treat elements will appear under the header. The definitions of each of the columns are:

SNOD = Stress node name outside all heat transfer elements

XO, YO, ZO = Original coordinates of this stress point

NEARE = Heat transfer element name nearest to this stress point

XN, YN, ZN = Surface coordinates on nearest heat transfer element for which the temperature of this stress point was computed.

DIST = Distance between (XO YO ZO) and (XN YN ZN)

IWARN = 0 - Surfacing procedure converged normally

= 1 - Surfacing procedure had difficulty in converging. (Check temperatures at this stress point.)

NOTE: The two main points to look for in this printout are the magnitude of the distance parameter (if it is large, then the stress point was far outside the heat transfer model) and the IWARN parameter.

The last portion of the hard-copy output deals only with finite-difference heat transfer codes. The header reads:

"Corner Node Comparison For Time = XXX"
"TCRITICAL For This Case Is Set to 99°"

"NODE # MAXOT TBAR **COMMON H/T ELMS **"

This printout is a consequence of the heat transfer element corner node calculation. Since the finite difference codes yield temperatures at the element controids and the element face centers, TRANCITS uses these temperatures to compute the element corner temperatures for each element. These corner temperatures are compared and if the difference of the temperature at the same corner is greater than 99°, then that corner is flagged in this printout. The column definitions are:

Node No.	=	Heat transfer corner node name
Max PT	=	Maximum delta temperature at that corner
TBAR	=	Average temperature at that corner
Common Heat Transfer Elements	=	Heat transfer elements bounding the corner

If this type of printout occurs it is an indication of large thermal gradients in the heat transfer model. If the MAXDT value is large there is a potential problem with the adequacy of the mesh density of the heat transfer mesh. When this situation occurs it is recommended that the heat transfer analyst be consulted about the validity of the results in the high gradient area.

The last message printed is

"THE INTERFACING PROCEDURE HAS BEEN COMPLETED."

6.0 RUN COMMANDS

The current version of TRANCITS (Version 1.0) is operational on the NASA-Lewis IBM 370 system.

Upon release of this user's TRANCITS manual, a formal procedure will not have been set up to run in production mode at NASA-Lewis. This procedure will be established in the near future and will be communicated to all users.

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APPENDIX A

CONTENTS OF MARC POSTTAPE - VERSION K.1

This appendix contains the documentation of the MARC Heat Transfer Input. Refer to the MARC manuals for more information.

APPENDIX A

CONTENTS OF MARC POSTTAPE - VERSION K.1

The following describes the contents of the 10 blocks found on the posttape. This information is the same for either the binary or the formatted posttape.

BLOCK NUMBER	DESCRIPTION
BLOCK I	TITLE
NR;80A1;(TITLE(J),J=1,70)	TITLE(J) is Jth character
BLOCK II	CONTROL INFORMATION
NR;6I3;INUM	Number of variables each element
LNUM	Number of nodes in mesh
MNUM	Number of elements in mesh
NDEG	Number of degrees of freedom each node
NSTRES	Maximum number of integration points each element. NSTRES = 1 if ALL POINTS is not flagged. NOTE: For constant strain elements having only one integration point NSTRES = 2 if ALL POINTS is flagged.
INOD	Number of nodal variables - see note below.
IPSTCC	Connectivity and coordinate flag (0-none; 1-given)
IPSTYP	Type of tape (0 - binary, 1 - formatted, 2 - both)
NCRD	Number of coordinates each node
NNODMX	Maximum number of nodes each element

IANTYP	Analysis Type Flag: 1 = Displacement - without reaction forces 2 = Displacement - with reaction forces 3 = Dynamics - without reaction forces 4 = Dynamics - with reaction forces 5 = Heat transfer 6 = Rigid plastic flow - without reaction forces 7 = Rigid plastic flow - with reaction forces 8 = Harmonic analysis - without reaction forces 9 = Harmonic analysis - with reaction forces 10 = Harmonic analysis with dynamics - without reaction forces 11 = Harmonic analysis with dynamics - with reaction forces 12 = Heat transfer with fluxes 13 = Joule heat 14 = Bearing 15 = Eigenvector (modal) 16 = Eigenvector (buckle)
ICOMPL	Set to 0 if real analysis Set to 1 if complex analysis
NBCTRA	Number of nodes with transformations
IPOSTR	Posttape revision number, 1 for this release (J3)
IDM4 IDM5 IDM6 IDM7	Not used; reserved for future expansion

Note:

INOD = {NDEG}*JNODE

IF IANTYP =		JNODE =
1;		1
2	on	2
3		3
4		4
5		1
6		1
7		2
8		1
9		2
10		3
11		4
12		2
13		3
14		5
15		1
16		1

IANTYP = 15 only appears during subincrements
IANTYP = 16 only appears during subincrements
If IANTYP = 8 and ICOMPL = 1 JNODE = 2
If IANTYP = 9 and ICOMPL = 1 JNODE = 4

BLOCK III	CODE NUMBERS ASSOCIATED WITH ELEMENT VARIABLES
	INUM records; J=1,INUM
NR;6I3;JPLOT(J)	Element variable code (see MARC Manual Volume C, p C3.10-7)
BLOCK IV	CONNECTIVITY LIST
	If IPSTCC is zero this block will be omitted
	MNUM records; J=1,MNUM
NR;6I3;LM(1)	Element type
LM(2)	Number of nodes in this element
LM(3)	First node of Element J
LM(NNODMX+2)	Last node of Element J
BLOCK V	COORDINATE LIST
	If IPSTCC is zero this block will be omitted.

	LNUM Records; J=1,LNUM
NR;6E13.6; SUM(1)	First coordinate of Jth node
SUM(2)	
SUM(NCRD)	Last coordinate of Jth node

BLOCK VI	TRANSFORMATION LIST
	If NBCTRA is zero or if IPSTCC is zero, this block will be omitted.
	Binary 1 record Formatted (NBCTRA-1)/6 + 1 records
NR;6I13; LM(I)	List of nodes which have transformations applied.

BLOCK VII	TRANSFORMATION - DIRECTION COSINES
	If NBCTRA is zero this block will be omitted.
	One record for each node listed in Block VI if binary tape.
NR;6E13.6; D(1,1) D(2,1) D(3,1) D(1,2) D(2,2) D(3,2) D(1,3) D(2,3) D(3,3)	Two records each node if formatted tape. Transformations are for local to global system.

Blocks VIII, IX, and X are repeated for each increment.

BLOCK VIII	INCREMENT, TIME, AND FREQUENCY
NR;6E13.6 X1(1)	Transient Time
X1(2)	Increment number is a real formed as I + J/100
	I is the static increment number J is either the harmonic subincrement or the Eigenvector number.
X1(3)	Frequency

X1(4)	Flag to read new Blocks II, III, IV, V, VI, VII. Set to 1 to read these blocks again. This is only used in a rezoning analysis.
X1(5)	IANTYP analysis type flag
X1(6)	Not used; reserved for future expansion.

<u>BLOCK IX</u> — <u>VALUES OF ELEMENT VARIABLES</u>

If INUM is zero, this block is omitted.

If IANTYP=15 or IANTYP=16, this block is omitted.

MNUM*NSTRES Records

```
DO 411 II=1,MNUM
DO 413 JJ=1,NSTRES
```

NR;6E13.6; SUM(1)	Value of 1st element variable for Element II, Integration Point JJ.
.	
.	
.	
SUM(INUM)	Value of INUMth element variable for Element II, Integration Point JJ.

```
413   CONTINUE
411   CONTINUE
```

<u>BLOCK X</u> — <u>VALUE OF NODAL VARIABLES</u>

If INOD is zero, this block is omitted.

LNUM records

NR;6E13.6; SUM(1) SUM(NDEG) SUM(NDEG+1) SUM(2*NDEG) SUM(INOD)	Nodal displacements, velocities, accelerations, and reactions

<u>During static or dynamic increments:</u>

The first NDEG quantities are:

IANTYP = 1, 2, 3, 4, 8, 9, 10, 11
Total nodal displacements

IANTYP = 6, 7
Total nodal velocity

IANTYP = 5, 12, 13,
Total nodal temperature

IANTYP = 14
Pressure

The second NDEG quantities are:

IANTYP = 2, 7, 9
Nodal reactions at boundary conditions; residual load correction elsewhere

IANTYP = 3, 4, 10, 11
Nodal velocity

IANTYP = 12, 13
Fluxes

IANTYP = 14
FORCEX

The third NDEG quantities are:

IANTYP = 3, 4, 10, 11
Nodal accelerations

IANTYP = 13
Nodal voltages

IANTYP = 14
FORCEY

The fourth NDEG quantities are:

IANTYP = 4, 11
Nodal reactions at boundary conditions; residual load correction elsewhere

IANTYP = 14
FORCEZ

The fifth NDEG quantities are:

IANTYP = 14
MASS FLUX

During subincrements:

The first NDEG quantities are:

IANTYP = 15
Nodal components of dynamic mode

IANTYP = 16
Nodal components of buckle Eigenvector

IANTYP = 8, 9, 10, 11
Real components of harmonic displacement

The second NDEG quantities are:

IANTYP = 9, 11, and ICOMPL = 0
Real components of harmonic reaction force

IANTYP = 8, 9, 10, 11, and ICOMPL = 1
Imaginary components of harmonic displacement

The third NDEG quantities are:

IANTYP = 9, 11, and ICOMPL = 1
Real components of harmonic reaction force

The fourth NDEG quantities are:

IANTYP = 9, 11, and ICOMPL = 1
Imaginary components of reaction force

NOTE: There will always be INOD quantities; the record may be padded with zeroes in subincrements.

IF IANTYP = 14, same as INCREMENTS.

NOTES:

NR	Indicates the beginning of a new record for the binary posttape.
NR;Format	Indicates the beginning of a new set of information which is to be read with the following format.

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APPENDIX B

This Appendix shows examples of the following file formats:

- Neutral Heat Transfer Input
- SINDA Temperature Input
- SINDA Geometry Input
- MARC Postinput
- Stress Model Coordinate Input
- Stress Model Element Input
- User Control Input
- Neutral Temperature Output
- NASTRAN Temperature Output

NEUTRAL HEAT TRANSFER INPUT FILE

This is the Test Case data. This is the new file form to be delivered for NASA's version -- we are using a very simple test case, as follows:

TITLE

```
09-15-83  (SR MARTIN)
 0  54 20 1 20 11 1                                    DIRECTORY
   1    1.000000    1.000000    1.000000
   2    1.000000    2.000000    1.000000
   3    1.000000    3.000000    1.000000
  11    2.000000    1.000000    1.000000
                                                       NODAL
 243    5.000000    3.000000    3.000000
 251    6.000000    1.000000    3.000000
 252    6.000000    2.000000    3.000000
 253    6.000000    3.000000    3.000000
  1     1     2    12    11   101   102   112   111
  2     2     3    13    12   102   103   113   112
 11    11    12    22    21   111   112   122   121     ELEMENT
 12    12    13    23    22   112   113   123   122     CONDUCTIVITY
 21    21    22    32    31   121   122   132   131
 22    22    23    33    32   122   123   133   132
 31    31    32    42    41   131   132   142   141

141   141   142   152   151   241   242   252   251
142   142   143   153   152   242   243   253   252
  1      123456                                        ELEMENT
  2      123456                                        FACE
 11       123456
 12       123456
 21       123456
 22       123456

 132      123456
 141      123456
 142      123456
       0.
   1  200.0  100.0  200.0  300.0  200.0  200.0  200.0
   2  200.0  100.0  200.0  300.0  200.0  200.0  200.0
  11  400.0  300.0  400.0  500.0  400.0  400.0  400.0
  12  400.0  300.0  400.0  500.0  400.0  400.0  400.0  TEMPERATURE
  21  600.0  500.0  600.0  700.0  600.0  600.0  600.0
  22  600.0  500.0  600.0  700.0  600.0  600.0  600.0
  31  800.0  700.0  800.0  900.0  800.0  800.0  800.0
```

SINDA TEMPERATURE FILE

LIST OF ELEMENTS

```
255
   101     102     103     104     105     106     107     108     109     110
   111     112     113     114     115     116     117     118     119     120
   121     122     123     124     125     126     127     128     129     130
   131     132     133     134     135     136     137     138     139     140
   141     142     143     144     145     146     147     148     149     150
   151     152     153     154     155     156     157     158     159     160
   161     162     163     164     165     166     167     168     169     170
   171     172     173     174     175     176     177     178     179     180
   181     182     183     184     185     201     202     203     204     205
   206     207     208     209     210     211     212     213     214     215
   216     217     218     219     220     221     222     223     224     225
   226     227     228     229     230     231     232     233     234     235
   236     237     238     239     240     241     242     243     244     245
   246     247     248     249     250     251     252     253     254     255
   256     257     258     259     260     261     262     263     264     265
```

LIST OF TEMPERATURES

```
   371     372     373     374     375     376     377     378     379     380
   381     382     383     384     385
0.39160E 04
0.50459E 03 0.49561E 03 0.50522E 03 0.49601E 03 0.50756E 03 0.49754E 03
0.50943E 03 0.49770E 03 0.51147E 03 0.50010E 03 0.50953E 03 0.49697E 03
0.50257E 03 0.48827E 03 0.50192E 03 0.49241E 03 0.48952E 03 0.49366E 03
0.48742E 03 0.49050E 03 0.48658E 03 0.48898E 03 0.48728E 03 0.48889E 03
0.48962E 03 0.48934E 03 0.49032E 03 0.48958E 03 0.49024E 03 0.48975E 03
0.48925E 03 0.48939E 03 0.48886E 03 0.48839E 03 0.48949E 03 0.48881E 03
0.49317E 03 0.49163E 03 0.49448E 03 0.49218E 03 0.49500E 03 0.49246E 03
0.49543E 03 0.49286E 03 0.49601E 03 0.49391E 03 0.47638E 03 0.47640E 03
0.47225E 03 0.49114E 03 0.48905E 03 0.48474E 03 0.49605E 03 0.49548E 03
0.49394E 03 0.49825E 03 0.49749E 03 0.49597E 03 0.49986E 03 0.49865E 03
0.49692E 03 0.50156E 03 0.49935E 03 0.49653E 03 0.50273E 03 0.49954E 03
0.49590E 03 0.50356E 03 0.49991E 03 0.49590E 03 0.50445E 03 0.49964E 03
```

SINDA GEOMETRY FILE INPUT

```
SINDA GEOMETRY FILE - 3D COMBUSTOR LINER MODEL
  500   255    8
    1          0 28640        15 75804          0.
    2          0 28870        15 79200          0.
    3          0 53550        15 74303          0.
    4          0 53780        15.77885          0.
    5          0 29100        15 82606          0.
    6          0 54010        15 81478          0.
    7          0.78450        15 72802          0.
    8          0.78690        15 76570          0.
    9          0.78930        15 80339          0.
   10          1 03360        15 71301          0.
   11          1.03600        15.75256          0.
   12          1.03840        15.79210          0.
   13          1.10760        15 70856          0
   14          1 11090        15 76312          0.
   15          1.11410        15 81757          0
   16          1.16370        15 70524          0
   17          1 16690        15.75970          0.

  717          2 02520        14 86239          5 40947
  718          2.11210        14 93652          5 43645
  719          2.11230        14 91201          5 42753
. 720          2 11250        14 86749          5.41860
  721          2.11270        14 86307          5.40972
  722          2.19960        14 93681          5.43656
  723          2 19980        14 91239          5.42767
  724          2 20000        14 88807          5 41882
  725          2 20020        14 86365          5 40993
  101   203   204   202   201     3     4     2     1   123456
  102   204   206   205   202     4     6     5     2   123456
  103   207   208   204   203     7     8     4     3   123456
  104   208   209   206   204     8     9     6     4   123456
  105   210   211   208   207    10    11     8     7   123456
  106   211   212   209   208    11    12     9     8   123456
  107   213   214   211   210    13    14    11    10   123456
  108   214   215   212   211    14    15    12    11   123456
  109   216   217   214   213    16    17    14    13   123456
  110   217   218   215   214    17    18    15    14   123456
  111   221   222   217   216    21    22    17    16   123456
  112   222   223   218   217    22    23    18    17   123456
  113   228   229   222   221    28    29    22    21   123456
  114   229   230   223   222    29    30    23    22   123456
  115   234   235   229   228    34    35    29    28   123456
  116   235   236   230   229    35    36    30    29   123456
  117   224   220   218   223    24    20    18    23   123456
  118   220   219   215   218    20    19    15    18   123456
  119   227   226   220   224    27    26    20    24   123456
  120   226   225   219   220    26    25    19    20   123456
  121   233   232   226   227    33    32    26    27   123456
  122   232   231   225   226    32    31    25    26   123456
  123   239   238   232   233    39    38    32    33   123456
  124   238   237   231   232    38    37    31    32   123456
  125   238   239   242   241    38    39    42    41   123456
  126   237   238   241   240    37    38    41    40   123456
  127   241   242   245   244    41    42    45    44   123456
  128   240   241   244   243    40    41    44    43   123456
```

<u>MARC POSTFILE/TAPE INPUT</u>

```
COMBUSTOR MARC POST FILE SIMULATION
  0500255   1   8   1
   1   1   3   8   5   0
   0   1
  43   8   3   4   2   1
128129127126
  43   8   4   6   5   2
129131130127
  43   8   7   8   4   3
132133129126
  43   8   8   9   6   4
133134131129
  43   8  10  11   8   7
135136133132
  43   8  11  12   9   8
136137134133
  43   8  13  14  11  10
```

```
495494490491
  43   8369368364365
494493489490
  43   8375374370371
500499495496
  43   8374373369370
499498494495
  43   8373372368369
498497493494
 0 286400E 00 0 157580E 02 0
 0 288700E 00 0 157920E 02 0
 0 535500E 00 0 157430E 02 0
 0 537800E 00 0 157789E 02 0.
 0.291000E 00 0 158261E 02 0.
 0 540100E 00 0 158148E 02 0.
 0 764500E 00 0 157280E 02 0
```

```
 0 211230E 01 0 149120E 02 0 542753E 01
 0 211250E 01 0 146875E 02 0 541860E 01
 0 211270E 01 0 148631E 02 0 540972E 01
 0 219960E 01 0 149368E 02 0 543656E 01
 0 219980E 01 0 149124E 02 0 542767E 01
 0 220000E 01 0 148881E 02 0 541882E 01
 0 220020E 01 0 148637E 02 0 540993E 01
 0 393700E 04 0 100000E 01 0              0              0 500000E 01
 0.510434E 03
 0 499432E 03
 0 512448E 03
 0 500855E 03
 0 490034E 03
 0 491059E 03
 0 509778E 03
 0 496518E 03
 0 485630E 03
 0.510112E 03
 0.494647E 03
 0.482880E 03
```

STRESS MODEL COORDINATE INPUT FILE

1	1 34980	15 86580	0.
2	1.34950	15 83830	0.
3	1.34950	15 80435	1.03643
4	1 34980	15 83179	1.03823
5	1.39740	15 80455	1 03644
6	1.39753	15 83169	1 03822
7	1.39740	15 83850	0.
8	1.39753	15 86570	0.
9	1.34920	15 81080	0.
10	1.34920	15 77691	1.03463
11	1 39727	15.77731	1.03465
12	1.39727	15 81120	0.
13	1.34920	15 67554	2 06372
14	1.34950	15 70280	2 06731
15	1 34980	15 73007	2 07090
16	1 39727	15 67593	2 06378
17	1 39740	15 70300	2 06734
18	1.39753	15 72997	2 07089
19	1 44533	15 67633	2 06383
20	1 44533	15 77771	1 03468
21	1 44533	15 81160	0
22	1 44530	15 70310	2 06735
23	1.44527	15.72997	2 07089
24	1.44530	15 80465	1.03645
25	1.44527	15 83169	1.03822
26	1.44530	15 83860	0.
27	1.44527	15 86570	0
28	1.34920	15 50711	3.08399
29	1 34950	15 53408	3 08936
30	1 34980	15 56105	3 09472
31	1.39727	15 50750	3.08407
32	1 39740	15 53428	3.08940
33	1 39753	15 56095	3 09470
34	1.44533	15 50789	3 08415
35	1.44530	15 53437	3 08942
36	1.44527	15.56095	3 09470
37	1.49340	15 50828	3 08423
38	1 49320	15 53457	3 08945
39	1.49300	15 56086	3 09468
40	1 49340	15 67673	2 06388
41	1 49340	15 77811	1 03471
42	1.49340	15 81200	0.
43	1.49320	15 70330	2.06738
44	1 49300	15 72987	2 07088
45	1 49320	15 80485	1 03646
46	1.49320	15 83860	0.
47	1.49300	15 83159	1.03821
48	1.49300	15 86560	0.
49	1 34920	15 27206	4 09214
50	1.34950	15 29862	4 09925
51	1.34980	15 32519	4.10637
52	1.39727	15 27245	4.09224
53	1.39740	15 29882	4 09931

STRESS MODEL ELEMENT INPUT FILE

11	452							
1	790	789	786	788	787	785	783	784
2	789	782	781	786	785	780	779	783
3	782	763	762	781	780	761	760	779
4	763	726	725	762	761	724	723	760
5	786	786	777	778	784	783	775	776
6	786	781	770	777	783	779	769	775
7	781	762	759	770	779	760	758	769
8	762	725	722	759	760	723	721	758
9	778	777	753	754	776	775	751	752
10	777	770	750	753	775	769	749	751
11	770	759	736	750	769	758	735	749
12	759	722	717	736	758	721	716	735
13	787	785	783	784	774	773	771	772
14	785	780	779	783	773	768	767	771
15	780	751	760	779	768	757	756	767
16	761	724	723	760	757	720	719	756
17	784	783	775	776	772	771	765	766
18	783	779	769	775	771	767	764	765
19	779	760	758	769	767	756	755	764
20	760	723	721	758	756	719	718	755
21	776	775	751	752	766	765	747	748
22	775	769	749	751	765	764	746	747

427	497	496	492	493	457	456	452	453
428	496	495	491	492	456	455	451	452
429	658	638	637	657	630	629	627	628
430	638	608	607	637	629	600	599	627
431	608	571	570	607	600	560	559	599
432	657	637	636	656	628	627	625	626
433	637	607	606	636	627	599	596	625
434	607	570	569	606	599	559	558	598
435	656	636	635	655	626	625	623	624
436	636	606	605	635	625	598	597	623
437	606	569	565	605	598	556	557	597
438	655	635	631	651	624	623	621	622
439	635	605	601	631	623	597	596	621
440	605	565	561	601	597	557	556	596
441	630	629	627	628	595	594	592	593
442	629	600	599	627	594	591	590	592
443	600	560	559	599	591	555	554	590
444	628	627	625	626	593	592	588	589
445	627	599	598	625	592	590	587	588
446	599	559	558	598	590	554	553	587
447	626	625	623	624	589	586	585	586
448	625	598	597	623	588	587	584	585
449	598	558	557	597	587	553	552	584
450	624	623	621	622	586	585	582	583
451	623	597	596	621	585	584	581	582
452	597	557	556	596	584	552	551	581

<u>USER CONTROL FILE</u>

2

```
$ZMAF
IHTIC=1,
ISPOC=1,
NTMDO=3,
NUMZAP/NZAP=1,-11,-2,51,
NTSTP/TIMD=10,30,51,
$
```

NEUTRAL TEMPERATURE OUTPUT FILE

SOLUTION 1

TIME =	3916 000000
1	472 251175
2	475 362076
3	473 061939
4	472 954638
5	477 105648
6	477 014626
7	479 731720
8	476 416409
9	476 380043
10	476 101242
11	480 371784
12	481 297924
13	477 889193
14	475 659309
15	473 984970
16	482 275578
17	479 575298
18	477.891411
19	487 512489
20	485 714573

SOLUTION 2

TIME =	3947 000000
1	913 990150
2	914 288366
3	912 673592
4	912 720978
5	921 552902
6	921 516510
7	925 217186
8	923 021370
9	914 720711
10	912 963562
11	923 802025
12	925 043915
13	911 039658
14	910 560577
15	910 516815
16	922 914963
17	919 726219
18	918 977898
19	937 802277
20	937.246773

SOLUTION 3

TIME =	4055 000000
1	1027 800430
2	1028 450317
3	1028 727051
4	1028 784714
5	1044.299011
6	1044 251038
7	1045 390854
8	1043 329132
9	1027 999115
10	1029 331284
11	1045 346954
12	1046 459641
13	1030.756836
14	1030.794373
15	1030 319687
16	1048 565552
17	1046.791626
18	1045 744339
19	1077 498398
20	1074.421783

<u>NASTRAN TEMPERATURE FILE</u>

$ TIME = 3916 000000

TEMP	1	1	472 25
TEMP	1	2	475 36
TEMP	1	3	473 06
TEMP	1	4	472 96
TEMP	1	5	477 11
TEMP	1	6	477.01
TEMP	1	7	479 73
TEMP	1	8	476 42
TEMP	1	9	476 33
TEMP	1	10	476 10
TEMP	1	11	480 37
TEMP	1	12	481 30
TEMP	1	13	477 87
TEMP	1	14	475 66
TEMP	1	15	473 98
TEMP	1	16	482 28
TEMP	1	17	479 58
TEMP	1	18	477 89
TEMP	1	19	487.51
TEMP	1	20	485 71
TEMP	1	21	487 03
TEMP	1	22	484 75
TEMP	1	23	483 24
TEMP	1	24	482 65
TEMP	1	25	482 58
TEMP	1	26	485 24
TEMP	1	27	482 10
TEMP	1	28	479 20
TEMP	1	29	476.49
TEMP	1	30	476 07
TEMP	1	31	483 04
TEMP	1	32	480 08
TEMP	1	33	479 67
TEMP	1	34	487 76
TEMP	1	35	484.96
TEMP	1	36	484 60

APPENDIX C

SINDA FORTRAN OUTPUT SUBROUTINES

This appendix contains listings of the SINDA Fortran output subroutines used to produce the SINDA Temperature Input File. Refer to the SINDA Manual for proper use of these routines.

```
*********************************************                          C
      BCD 3EXECUTION                                                   C
*********************************************                          C
                                                                       C
   ASSIGN DYNAMIC STORAGE REQUIREMENTS                                 C
    SIZE OF X DEPENDS ON NUMBER OF NODES, SOLUTION ROUTINE,            C
    AND SUBROUTINES CALLED                                             C
                                                                       C
      COMMON/LOGIC/LNODE,LCOND,LCONST,LARRAY                           F
      DIMENSION X(200)                                                 F
      NDIM=200                                                         F
      NTH =0                                                           F
                                                                       C
   THE FOLLOWING CODE FILLS THE DYNAMIC STORAGE ARRAY 'X' ('NX')       C
    WITH THE NODE NUMBERS IN THE SAME ORDER AS THE 'T' ARRAY.          C
    THEN BEGINNING WITH THE FIRST NODE NUMBER, THE NODES ARE           C
    WRITTEN TO THE FILE USED BY 'TEMPSCAN'.   Not in my manual.        C
    $$$ REFER TO SINDA USER'S MANUAL, PAGE 5-3  $$$  Yours may be newer.  C
                                                                       C
    NOTE:  THIS HAPPENS ONLY ON THE FIRST CALL TO EXECUTION DUE        C
           TO THE CHECK ON THE STATUS OF 'LNODE'.                      C
      IF(LNODE.GE.0) GO TO 200                                         F
      LOC = NTH                                                        F
      LEN = NDIM                                                       F
      CALL NNREAD(1)                      SIC. Execution               F
                                                                       C
      WRITE(23,100)NNT   Total number of   is only called once.        F
                                                                       C
 100  FORMAT(I5)         Nodes                                         F
                                                                       C
      WRITE(23,110) (NX(I+NDIM),I=1,NNT)  Write cross reference table  F
 110  FORMAT(10I8)                                                     F
                         Offset to pointer array                       C
                                                                       C
 200  CONTINUE                                                         F



   EXECUTE PROGRAM                                                     C
           CNFRWD
           CSGDMP
       END                                                             C
*********************************************                          C



*********************************************                          C
      BCD 3VARIABLES 2
*********************************************                          C
      END
                                                                       C
*********************************************                          C
      BCD 3OUTPUT CALLS
*********************************************                          C
                                                                       C
           TPPNTF
                                                                       C
     WRITE NODE TEMPERATURES TO TAPE                                   C
      KTEST=KTEST+1                                                    F
      WRITE(6,130)KTEST,TIMEN                                          F
 130  FORMAT(5X,"$$$ NOTE- DATA SET =",I5," WRITTEN TO TEMPSCAN",      F
     *        " FILE AT TIME = ",F10 3)                                F
      WRITE (23,140) TIMEN        WRITE TIME TO OUTPUT FILE            F
      WRITE(23,140)(T(I),I=1,NNT)                                      F
 140  FORMAT(6E12.5)              Write relative temperatures to       F
                                                                       C
      END                         file.                                C
*********************************************                          C
```

End of Document